Strengthening Disaster Resilience in Small States

Commonwealth Perspectives

Edited by Wonderful Hope Khonje and Travis Mitchell

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Foreword

Strengthening Disaster Resilience in Small States: Commonwealth Perspectives is published at a time when small states' vulnerabilities are exacerbated by recent natural disasters experienced in many parts of the world. It follows from evidence that the extent to which natural disasters continue to adversely affect small states calls for more concerted efforts to review and address the international architecture for managing natural disasters. As the longstanding champion of the international recognition of the inherent vulnerabilities of small states, the Commonwealth Secretariat – through its inaugural Research Conference for Small States – initiated a collaboration among academics and international partnersto further investigate how we can work together to build and strengthen the resilience of these countries to natural disasters.

The Commonwealth Secretariat's call for papers on this topic sought to explore cutting-edge disaster risk reduction techniques useful for informing small states' economic and disaster risk management policies, with the aim of collating and sharing important lessons with member governments, and galvanising international efforts for reducing the impact of natural disasters.

Readers will find most useful the thought-provoking ideas on the utilisation of existing data and technologies for significantly enhanced natural disaster preparation – a leading theme of the conference and publication. These would include, among others, mobile and satellite data for geospatial mapping; sensor technologies for the advancement of early-warning systems; and the application of blockchain technology for improved insurance products – a necessary and sorely needed financial mitigation resource. In the chapters that follow, you will also be exposed to perspectives on the need to mainstream gender in disaster risk reduction; lessons from past experiences with responding to natural disasters; and expert advice on how to manage and make use of existing knowledge for better disaster preparation.

The authors' perspectives on these issues were presented for further deliberation at the Commonwealth's Fifth Global Biennial Conference on Small States, held in March 2019 in Apia, Samoa. Faced with new research evidence and proposals, senior officials from small states and development partners provided their own perspectives regarding the urgent need for a fresh and concerted approach for managing and reducing the impact of natural disasters in small states.

Arising from the papers and their conclusions, as well as from the key discussions held with academics, international partners and member governments, are suggestions on small states' governments; the Commonwealth and other international partners can re-organise themselves to ensure that the legal, physical and technological infrastructure is put in place to effectively support the development of appropriate

mechanisms for addressing natural disaster risks in small states. These are provided for your own reflection.

With that brief prelude I am pleased to hand over this unique publication, which provides a focused set of contributions from small states' academics and experts, whose aim it is to foster a better understanding of the dynamics of natural disasters, and ways in which we can work together to ensure enhanced and effective risk reduction in these countries.

Note that this collection of papers is intended as a reference document for small states' policy-makers and stakeholders within the fields of social, environment and economic policy making. The contribution of various experts in this field, including that of Secretariat staff, is duly noted and highly appreciated.

Pamella McLaren
Acting Director
Economic, Youth and Sustainable Development Directorate

Preface

Despite their differences in terms of geographic regions, incomes and culture, small states share several common characteristics and tend to have similar development priorities such as reduction of high debt levels, access to concessional development finance, disaster risk reduction (DRR), climate financing, economic diversification and management of ocean and other natural resources.

Small states face similar constraints and challenges in their endeavour to achieve the aforementioned priorities. For instance, small states are highly susceptible to natural disasters – a challenge exacerbated by climate change – and face resilience infrastructure costs that are prohibitive to effective disaster preparation and generally disproportionately expensive for these countries. Furthermore, their small populations in effect means limited human and institutional capacity, resulting in high per capita costs for infrastructure and the delivery of public services. As a result of narrow export bases, small states also tend to have highly open economies that lead to high exposure to exogenous economic and environmental shocks – particularly from natural disasters.

Such is now fairly well known following years of advocacy around small states' vulnerabilities, and the need for special treatment given their peculiar circumstances. Overlooked, however, is the extent to which their limited human resource capacity hampers their ability to respond to multiple demands, to make substantive representation at regional/global events and to acquire in-depth and specialist knowledge on which to base policy decisions. Also unaccounted for, is the fact that small states will usually face higher per unit costs with regards monitoring and evaluation, thus affecting their ability to progress on important global agendas, including the Sustainable Development Goals, Paris Agenda and the Sendai Framework for Disaster Risk Reduction.

This publication and resources such as these help small states acquire essential knowledge without the costs incurred in attending events, and in the absence of adequate knowledge bases and monitoring and evaluation frameworks.

Working with national, regional and international partners, the Commonwealth has, in addition, delivered carefully thought-out programmes tailored to the specific needs and priorities of small states on topics such as trade; vulnerability and resilience; climate change; debt; and tourism. The Commonwealth has also facilitated global platforms for advocacy and advancement of small states' development priorities.

A key and recent Commonwealth intervention that helps to promote capacity-building, research and small states advocacy is the Commonwealth Small States

Centre of Excellence (SSCOE). It is a joint initiative of the Government of Malta and the Commonwealth Secretariat established to support and provide capacity to small states in their attainment of national and international development goals. Based in Malta, and with a co-ordinating office at the Commonwealth Secretariat in London, the Centre has linkages across the world, primarily through the 31 small states of the Commonwealth. In carrying out its mandate, the SSCOE seeks to extend support by serving as a focal point for sharing best practices in areas that benefit small states. The Centre draws from the work of international agencies, research institutions, information networks, including national, regional and international processes to generate consensus positions, facilitate information and knowledge sharing, and to develop capacity-building programmes.

The SSCOE has a unique value added role since there is no clearly identifiable institution at this time focused exclusively on knowledge management for problem solving in small states. While many existing entities producing knowledge share their findings and recommendations, they do not usually follow through to see whether the knowledge is used, how and what lessons are learned in terms of its value, limitations and what else might be required.

In July 2019, the Commonwealth Secretariat in support of the Centre's work issued a call for papers from practitioners, experts and academicians on the role of DRR in strengthening the resilience of small states. These papers in responding to the theme 'Strengthening Resilience through Disaster Risk Reduction in Small States' had the aim of addressing a select number of topics, including environmental governance; information and communication technologies (ICT); capacity-building; gender; and blockchain. The shortlisted papers were presented at the inaugural Annual Research Conference on Small States (ARCSS), which took place in Marlborough House, London, on 25–26 February 2019. The objective of this research conference was to facilitate academic dialogue on small states challenges and priorities in the area of DRR with the aim of creating, storing and disseminating knowledge for use and application by small states' governments. These papers, including outcomes generated by the research conference informed discussions of the Commonwealth's Fifth Global Biennial Conference on Small States (GBCSS), held in Apia, Samoa, 25–29 March 2019.

This publication is the collation of the finalised papers aimed at contributing to the knowledge gap in DRR. The 11 papers in this volume are organised into five sections as follows: science-based approaches to DRR; leveraging ICT to manage natural disasters; using blockchain to reduce disaster risk; environmental governance for managing natural disasters; and gendered responses to natural disasters.

In attempting to understand the divide between science/research and policy/use in DRR, Chapter 1, by Denyse Dookie, Markus Enenkel and Jacqueline Spence, underscores the challenge of disasters within the Caribbean region, defines climate information, reviews its nature and utility globally and discusses the variability in verified climate information for highly climate-vulnerable but data-poor countries. Chapter 2, by Richard Teeuw and Mathias Leidig, illustrates how freely downloadable remotely sensed data and free open source GIS mapping software can be applied to DRR in small states.

In Chapter 3 Ankie Scott-Joseph assesses the use of ICT in the early stages of the disaster life cycle, particularly for DRR and disaster risk management (DRM), and for building e-resilience in small states.Roopesh Kevin Sungkur and Ashveen Kissoonah continue the discussion in Chapter 4 withconsiderations for the adoption of ICT for Disaster Management and Emergency Telecoms in the Republic of Mauritius.

In Chapter 5 is Christopher Sandland, Dale Schilling and Alastair Markeassess the role of Blockchain-Based Parametric Insurance as a mechanism for addressing the efficiency and transparency gap concurrent in traditional insurance products. Similarly, Jean-Paul Fabri and Stephanie Fabri demonstrate in Chapter 6 that as an enabling technology, blockchain can support resilience building in small states in the field of DRR by reflecting on key vulnerabilities of these countries in relation to disaster risk.

In Chapter 7 Barbara Carby, laments the lack of evidence in risk assessments for informing DRR, despite advances in risk assessment methodology, data and information on risk, and calls for translation of data and information into knowledge that is understandable and usable. Chapter 8, by Nirmal Betchoo, discusses the relevance of capacity-building at the community level in Mauritius to enhance learning through knowledge and solution exchanges, by focusing on addressing systemic gaps and topics in risk reduction. In Chapter 9, John Lain Roberts and Gina Bonne examine the high levels of missing data in reports from small states on MDGs, the low levels of completion of data in the more extensive SDGs, and the weak response in the early reports from the Sendai Framework database and calls for more explicit estimates of the long-term economic and social impact of disasters.

In Chapter 10, Roberta Lepre and Isotta Rossoni argue for the inclusion of a gender-centred and intersectional perspective in DRR initiatives in Malta and discuss the numerous opportunities available in the Maltese context to marry DRR with the battle for gender equality.

While in Chapter 11, Siddier Chambers looks at the gaps in addressing strategic gender needs in DRR in Jamaica and calls for openness regarding issues affecting men as indicated by evidence of men's vulnerabilities during and after a disaster.

Conclusion

The inaugural ARCSS brought together a wide range of experts from academia and national, regional and international organisations to discuss small states' priorities and needs for natural DRM. At this conference, participants examined and discussed papers prepared by experts on the subject to highlight key elements in natural disasters as they pertain to small states.

From the discussion that ensued, including the findings of the papers in this volume, it is clear that there are enormous opportunities and applications of cutting-edge approaches to DRR, such as blockchain-based parametric insurance; satellite technology; remote sensing; risk-layering and catastrophe risk pooling. These are yet to be fully utilised by small states.

However, there are also policy gaps within the countries' DRR and DRM frameworks that requires urgent attention from small states themselves as well as the international community. The papers highlighted the need to consider new types of risks; account for the effects of improper use of financial instruments and underinsurance; address the underutilisation of climate information; acknowledge the strength of human resilience; and address the poor diffusion of knowledge (absorptive capacity challenges).

The issue of availability of reliable, timely and consistent data for informed decision-making remains a concern for small states. These countries require transformative ideas to overcome this burden and, as important as this topic is, the adequacy and access to crucial data cannot be overemphasised. As such, South–South co-operation, including pooling of resources, in this area will be vital for knowledge and information exchange.

Some of the key recommendations that stemmed from discussion of the conclusions of these papers included the following:

- Finance mechanisms: Increase regional instruments but also give serious consideration to the sequencing of such instruments, risk layering and operational design for effective DRR responses.
- ICT as a blueprint: Technology is moving swiftly but costs and other challenges still exist. A combination of available satellite and sensor tools are an effective short-term response.
- Potential for blockchain technology: Application most useful for the affected poor. Complicated at the core but useful and simple at the end product.
- Governance issues: An effective governance system (information; evaluation; incentive) is needed for effective DRR.
- Emerging issues: Sharing data and resources can significantly improve DRR responses. In particular, anonymised cellular data.
- Gender-responsive approaches: These are important for DRR as half affected are women.
- Role of capacity building: Bottom-up approach (community engagement) and ICT earlier in the response process to build community capacity to respond to risks.

There were also some recommendations for the Commonwealth Secretariat, including:

- Work with member countries, cellular phone companies and regulators towards making anonymised cellular data available for DRR.
- Promote data and human resources sharing among governments and various stakeholders to tackle DRR, such as the Pacific Resilience Partnership approach.
- Promote parametric approaches to DRR to improve countries access to low cost disaster insurance.
- Review the coverage of the Sendai Framework to assess its adequacy for achieving DRR.

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Contributors

Dr Nirmal Kumar Betchoo is Dean of Faculty of Business and Management at the Université des Mascareignes. He is the author of 11 books published nationally and internationally. He has published over 50 peer-reviewed articles in international refereed journals. He is external editor for the *Journal of Mass Communications* (USA) and editorial board member the *Journal of Management and Engineering Sciences* (JMEST), Germany, and the *European Scientific Journal* (ESJ). He has reviewed some 100 papers. He is panel specialist for the Tertiary Education Commission (TEC) in Mauritius for post-graduate programmes in management.

Gina Bonne holds a MSc in Agronomy (Plant Protection). She has 26 years of professional experience in Agriculture, Environment and Climate Change including 12 years of experience in the public service and 14 years in regional co-operation. She has held several high-level positions at the Ministry of Agriculture and Natural Resources of the Republic of Seychelles as Head of the Plant Protection Laboratory, Assistant Director of the Plant Protection Section and Director of Agricultural Planning. Ms Bonne is currently the Officer in Charge and Head of the Environment and Climate Department of the Indian Ocean Commission during which she has been developing and managing regional programs in pPlant protection, fisheries surveillance, marine pollution in relation to combatting oil spills, Earth observation for coastal and marine services, coastal zone management, biodiversity management, climate Change and disaster risk reduction.

Dr Barbara E Carby is the Director of the Disaster Risk Reduction Centre (DRRC) of the University of the West Indies. Formerly the Director General of Jamaica's Office of Disaster Preparedness and Emergency Management (ODPEM), Dr Carby is credited with placing risk reduction on Jamaica's national agenda and pioneering the development of a national mitigation policy. She also expanded the hazard mapping programme and fostered the use of hazard maps by parish councils in their development planning. She was one of the experts selected to the UN's Scientific and Technical Committee of the International Decade for Natural Disaster Reduction and a member of the Advisory Board for the UN Central Emergency Response Fund.

Dr Siddier Chambers is a gender and development practitioner and researcher with over 17 years of experience. She has contributed to the development of Jamaica's National Policy for Gender Equality, National Anti-Sexual Harassment Policy and the National Strategic Action Plan to Eliminate Gender-Based Violence in Jamaica 2017–2027. Dr Chambers is currently the Acting Director for the Community Liaison Branch at the Bureau of Gender Affairs in the Ministry of Culture, Gender, Entertainment and Sport. She is also a Research Associate with

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Denyse S Dookie is a candidate of the PhD program in Sustainable Development at the School of International and Public Affairs, Columbia University. A national of Trinidad and Tobago, Ms Dookie is interested in solutions to reduce local vulnerability and enhance resilience in the wake of disasters and climate change within the Caribbean and other small island developing states. Her recent research focuses on the role of climate information-sharing in the context of disaster preparedness and early action, as well as the value of remotely-sensed data in data-scarce regions and improving the general science-policy dialogue.

Dr Markus Enenkel is a Fellow at the Harvard Humanitarian Initiative where he concentrates on the use of earth observation data to detect patterns between extreme weather/climate events, social conflict, food security and migration. He leads one of the World Bank's projects on drought risk reduction and related financial instruments. Dr Enenkel is the co-founder of an ESA-funded start-up named Perigee, which focuses on predictive emergency fundraising, and supports the Global Emergency Response Team of SOS Children's Villages International as disaster risk management co-ordinator. He has worked with other humanitarian aid organisations such as Doctors without Borders, Red Cross, UN WFP/OCHA, as well as space agencies, UNDP, UN FAO, and UN SPIDER.

Jean Paul Fabri is an economist who currently leads the Economic and Management Advisory Unit and the Digital Economy Unit at ARQ. Prior to joining ARQ, Mr Fabri formed part of the private cabinet of the Prime Minister of Malta and Governor of the Central Bank of Malta. He has international policy advisory experience having advised nine governments on economic development. Mr Fabri is a certified blockchain strategy advisor from Said Business School, Oxford University and holds an International Certificate in Investor Relations from the IR Society in the United Kingdom. He is also a visiting lecturer in economics and public policy at the University of Malta.

Dr Stephanie Fabri is an economist who works in both the private and public sectors. Dr Fabri forms part of the academic staff of the Department of Management at the University of Malta and has been lecturing in various departments at the university for more than eight years. Dr Fabri read for her PhD at the Warwick Business School where her dissertation looked at strategic management in British companies. In her dissertation, she applied mathematical models used in artificial intelligence (fuzzy-logic methods) to the social sciences. Prior to receiving her doctorate, Dr Fabri graduated with a MSc in Public Sector Economics from the University of York, and read for her first degree in economics from the University of Malta.

Dr Mathias Leidig is a Post-Doctoral Research Fellow in the School of Earth and Environmental Sciences at the University of Portsmouth. He has over 10 years of experience in geographic information systems and remote sensing. Initially working in high mountain regions (Nepal), on erosion and river-profile modelling, he shifted

focus to coastal regions of developing countries (i.e. Sri Lanka and Dominica) during his PhD research. After receiving his PhD Dr Leidig worked as a catastrophe modeller for MS Amlin in London before returning to the University of Portsmouth. His current research focus is on data poverty and low-cost approaches to using satellite imagery for assessing hazards, vulnerability and risk. Since January 2018, Dr Leidig has been part of the Risk Science team in the CommonSensing project, which aims to use satellite imagery for disaster risk reduction and climate change adaptation applications in Pacific Small Island Developing States (Fiji, Solomon Islands and Vanuatu).

Roberta Lepre is currently the Managing Consultant at Weave Consulting, where she engages the business community to adopt sustainable practices to have a more positive impact on society and the environment and to contribute to the achievement of the Sustainable Development Goals. Graduated Doctor of Laws from the University of Malta in 2003, Ms Lepre has acquired substantial experience in the social sector in Malta, having served on public bodies, as well as in the non-profit sector. Her skills and expertise include legal drafting, policy development, project drafting and implementation.

Alastair Marke is currently the Director-General of the Blockchain Climate Institute and Regional Director for Western Europe of the Blockchain Commission for Sustainable Development, where he works with a number of UN agencies to deploy blockchain in achieving SDGs. In the UK, he chairs the Energy, Climate Change and Green Finance Committee of the British Blockchain Association and serves as an ad hoc Expert Advisor (Energy and Environment) to the All-Party Parliamentary Group on Blockchain. Mr Marke is a drafter of the ISO 14097 climate finance, as well as ISO TC307 blockchain use case and governance standards.

Dr John Laing Roberts is an international consultant on macroeconomics and sustainable development, working with the Indian Ocean Commission (IOC), the Commonwealth Secretariat, COMESA and the Government of Mauritius. He has Master's and PhD degrees from University of Birmingham, and has been an adviser to the WHO, World Bank and the EU. He has contributed to the UNEP's Global and African Environment Outlook series, and case studies on malaria eradication and cyclones. He is a co-author of the several Commonwealth Secretariat and the IOC publications on small states including *Saving Small and Island States* (2010), *The Big Divide (*2012) and *The Divided Region* (2014). He is currently acting as an adviser to the IOC on Climate Change and Disaster Risk Reduction.

Isotta Rossoni is a research associate at Weave Consulting. She holds an MSc in Criminology and Criminal Justice from the University of Oxford. Her main interests lie in the fields of gender, violence, victimisation and crimmigration. Between 2015 and 2018 she worked as researcher, project manager and consultant for various NGOs in Malta and at the University of Malta. At present, aside from her collaboration with Weave Consulting, she works as a researcher for the Bruno Kessler Foundation and for Transparency International Italy. She also collaborates with the Italian Centre for the Promotion of Mediation (CIPM) on a service for sex offenders and victims.

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Dr Ankie Scott-Joseph currently works as a Lecturer in Economics at the University of the West Indies.Previously she worked as an Economic Statistician in the Canada/Eastern Caribbean Central Bank Debt Management Advisory Services Unit (DMAS). Prior to joining the ECCB, she served as an economist in the Ministry of Finance, St Vincent and the Grenadines. As a consultant, Dr Scott-Joseph has published articles in regional and international journals on macroeconomics with emphasis on fiscal policy and debt sustainability. Dr Scott-Joseph currently serves as a Research Associate of the *Journal of Business, Finance and Economics in Emerging Economies*. In 2007 Dr Scott-Joseph received the International Association for Official Statistician, New Zealand, prize for the best papers written by young official statisticians.

Jacqueline Spence has been employed at the Meteorological Service, Jamaica for over 15 years where she currently manages the Climate Branch. She has represented Jamaica at various international and regional meetings, including the Intergovernmental Panel on Climate Change (IPCC) meetings for which she is the Focal Point for Jamaica. Ms Spence's passion is working with the various sectors to create climate products and services to assist in decision-making in the climate change context and in so doing working to create a culture of dependency on research-driven solutions to become more resilient to climate change impacts. She holds an MSc degree in chysics and climatology from the University of the West Indies, Mona.

Roopesh Kevin Sungkur is currently senior lecturer at the Department of Software and Information Systems, Faculty of Information Communication and Digital Technologies, University of Mauritius. He has been acting as consultant for major organisations such as the Common Market for Eastern and Southern Africa (COMESA), Southern African Development Community (SADC), the Global e-Schools and Communities Initiative (GESCI) and the Bill and Melinda Gates Foundation. He has also been the team leader for 'Working Groups for ICT Project – ICT4DM, Disaster Management and Emergency Telecoms – Preparation, Mitigation and Recovery'. The project was carried out at national level in line with the government's vision to position the Republic of Mauritius as a regional ICT Hub and to better prepare the country towards disaster resilience through the proper use of ICT.

Dr Richard Teeuw runs the Crisis and Disaster Management MSc course at the University of Portsmouth. His research focuses on low-cost uses of remote sensing

for assessing hazards, vulnerability and risk, as well as geoinformatic capacity-building in low-income countries. His research includes industry-funded projects, from mapping of urban flood vulnerability, to satellite remote sensing of oil pollution in the Niger Delta. He led a NERC-funded team surveying impacts of Hurricane Maria in Dominica, using satellite data, drone photography and GIS for a forensic geomorphological analysis of fatality locations. He leads the Risk Science activities of the UK Space Agency-funded CommonSensing project, using satellite imagery for climate change adaptation and disaster risk reduction applications.

Chapter 1

Uses of Free Geoinformatics for Disaster Risk Reduction in Small Island Developing States – A Case Study from Honiara, Solomon Islands

Richard M Teeuw and Mathias Leidig

Abstract

An increasingly wide range of geoinformatic data and software is available for the mapping and monitoring of hazard zones, vulnerable/exposed features and areas of risk. Unfortunately, there is a major cost barrier: high-resolution satellite imagery and the commercial geographic information system (GIS) software to process that data, can each cost many thousands of dollars. This study provides examples of low-cost or freely downloadable remotely sensed data and free Open Source GIS mapping software, applied to disaster risk reduction in small island developing states (SIDS). Examples are presented from Solomon Islands of hazard and vulnerability mapping based on free satellite data, with the data processing carried out using GIS freeware (QGIS). Strategies are discussed for improving the capacity in SIDS for accessing and effectively utilising free geoinformatics data and GIS freeware. The benefits of Open Data Cubes and their Analysis Ready Data layers for disaster risk reduction applications are considered, with particular regard to the challenges that many SIDS face. Universities, colleges and secondary schools are highlighted as being central to both improved capacity and improved outreach to remote communities.

1.1 Introduction

The annual cost of natural hazards has increased notably in recent decades, driven by pressures from growing populations, particularly in urban environments, as well as increases in the frequency and magnitude of climate-driven hazards (Hyndman 2017; Tomás and Li 2017). Improved decision-making for disaster risk reduction and climate change adaptation requires better knowledge to characterise, monitor and model geohazards and then mitigate their impacts on people and the environment (Pandian, Yarrakula and Chaudhury 2018).

The effects of global warming are uneven, with poor regions in the tropics and subtropics being most vulnerable, particularly small island developing states (SIDS). SIDS tend to have limited financial and human resources to prepare for shifts in

temperature, precipitation and sea-level rise, yet they are expected to face bigger climate changes than mid-latitude countries and experience those changes earlier (Mora et al. 2013; Storlazzi, Elias and Berkowitz 2015; Schiermeier 2018). Future extreme sea level (ESL) events, such as storm surges, pose a further challenge to SIDS because ESL events occur randomly, and precise forecasts are limited to days or hours.

With regard to disaster risk reduction, urban areas are of particular concern, partially because of an increased urbanisation because of population growth and social-economic pressures, but also because of the associated growth of informal communities that are often located in hazardous terrain, such as floodplains. A further pressure comes from migration caused by climate change. In the Pacific, Fiji, Kiribati and Solomon Islands have several examples of climate change-related relocations from small islands to bigger islands (Locke 2009; Barnett and McMichael 2018; Newark and Reuters 2007; Gharbaoui and Blocher 2018). Moreover, due to challenging land-ownership systems, urban areas are likely to experience an increased amount of unplanned developments.

Satellite remote sensing, also termed Earth Observation (EO), has been widely applied to risk management at the preparedness, response and recovery stages of the disaster cycle. However, there has been a tendency to focus on disaster response (reactive approaches) rather than disaster preparedness (proactive approaches), with little attention paid to post-disaster recovery and rehabilitation, such as the design of effective 'build back better' strategies. This chapter examines how satellite remote sensing can assist with disaster risk reduction and climate change adaptation within SIDS, focusing on challenges associated with the ease of data supply, data management and public understanding of satellite-derived information. Those challenges will be discussed with regard to the example of Honiara, the capital of Solomon Islands.

1.2 Case Study: Honiara, Solomon Islands

1.2.1 Location and hazard setting

Solomon Islands is a Pacific state consisting of six major islands and more than 900 smaller islands (Figure 1.1). With a population of about 620,000 (Worldmeters 2018) spread across 28,000 km^2, Solomon Islands are among the most sparsely populated of the Pacific SIDS. Despite this low population density, the majority of human settlements are located in low-lying coastal areas, which are becoming increasingly densely populated (Albert et al. 2016). Solomon Islands capital, Honiara, located on the north coast of Guadalcanal island, had a population of 84,520 in January 2017 (Countrymeters 2018). Figure 1.2 illustrates the rapid growth of Honiara's urban and peri-urban areas since 2008.

1.2.2 Data access

A needs assessment and gap analysis were carried out in Honiara during March 2018, regarding availability of geospatial data for Solomon Islands, via interviews with geoinformatics practitioners. The main data challenges were found to be: a widespread lack of digital maps; limited sets of thematic maps, such as geological

Figure 1.1 Location of Solomon Islands and the capital city, Honiara (arrow)

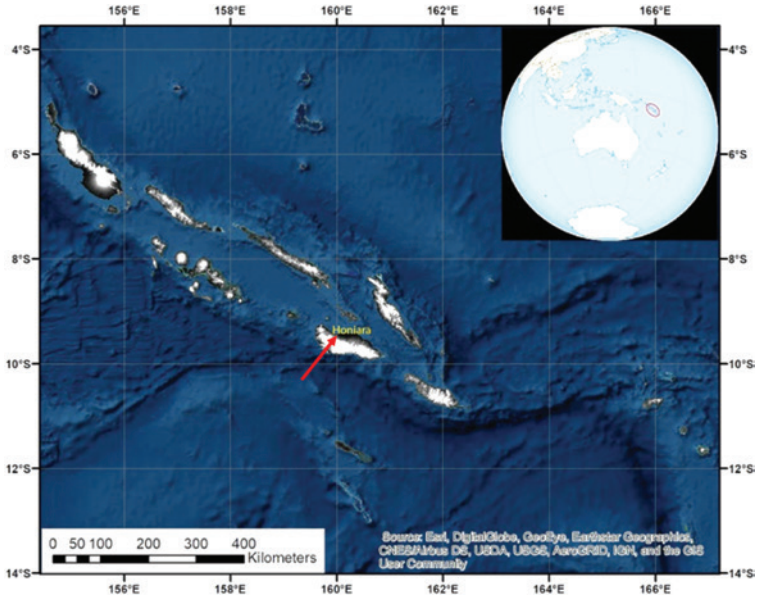
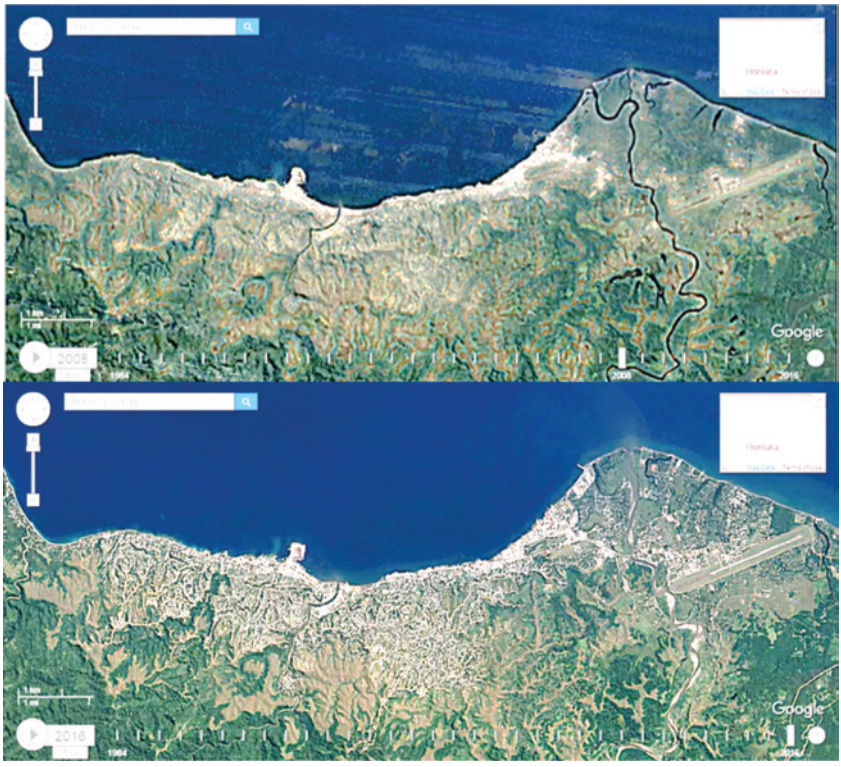


Figure 1.2 Landsat imagery of Honiara, illustrating the rapid urbanisation from 2008 (top) to 2016 (bottom), as seen on Google Earth Engine. Such rapid urbanisation inevitably leads to a number of informal settlements



maps, many of which were colonial-age printed maps; limited Internet access; minimal sharing of geospatial data between organisations; and the much more limited access to geospatial information in the smaller islands of the archipelago. Topping the list of geospatial needs in Solomon Islands were requests for a national digital elevation model (DEM), at a scale that could be of use at the district and community levels; next were requests for land-use and land-cover (LULC) change maps; then maps of hazards, vulnerability and risk. Another fundamental problem was a lack of geoinformatic expertise regarding GIS applications and, particularly, remote sensing (from image interpretation, through to data processing). Geoinformatic capacity building, via awareness raising and technical training, is a major need among Solomon Island government agencies, non-governmental organisations (NGOs), education establishments and businesses.

Solomon Islands' lack of digital maps, along with the limited or slow internet access, results in severe 'data poverty' (Leidig and Teeuw 2015; Leidig et al. 2016); geospatial data poverty is a major challenge for disaster risk reduction activities which hinders sustainable development (Teeuw et al. 2012).

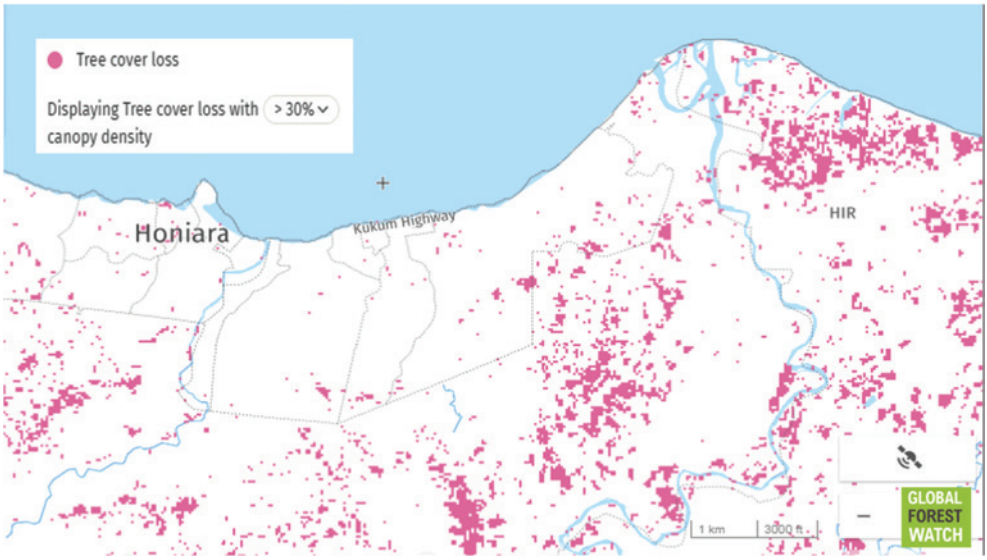
A freely available new technology that has great potential for reducing data poverty and assisting disaster risk reduction activities, is the development of Open Data Cubes derived from satellite imagery (CEOS 2017). Tens (or even hundreds) of satellite images covering a given area are automatically processed ('sieved' or 'diced') to remove unwanted features, such as cloud cover (Figure 1.3). Various algorithms are then run on those imagery data layers to produce sets of Analysis Ready Data, which form the basis for further layers such as maps showing areas of deforestation. As part of an international initiative to develop Open Data Cubes for all countries, the source code of algorithms for mapping has been made open and freely available for the following features: cloud-free mosaics, vegetation cover, urbanisation, surface water detection, surface water quality (turbidity), landslides and coastal changes, such as erosion or deposition (CEOS 2017).

One of the most effective systems for data cube processing of large archives of satellite imagery, such as NASA's four decades of global Landsat data, is Google Earth Engine

Figure 1.3 Schematic illustrating how satellite image data cubes work

Source: https://www.opendatacube.org/ceos

Figure 1.4 An Analysis Ready Data layer: tree cover loss in Honiara region (2001–17)



HIR: Honiara International Airport.
Source: Global Forest Watch, available at: https://www.globalforestwatch.org/dashboards/global

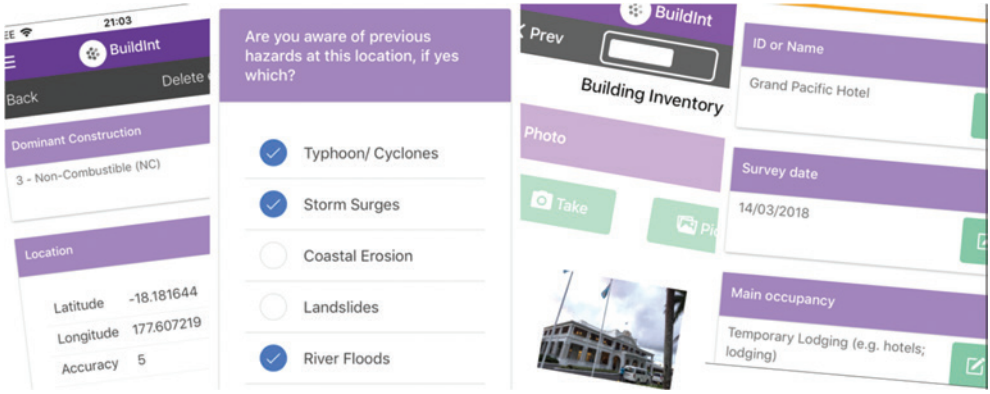
(available at: https://earthengine.google.com/), which was used to examine the recent rapid urban expansion of Honiara (Figure 1.2). An example of the application of Google Earth Engine, in conjunction with other data sources, is Global Forest Watch (available at: https://www.globalforestwatch.org/), which produced a map showing deforestation in Honiara district from 2001 to 2017 (Figure 1.4).

1.3 Methodology

A wide range of free satellite imagery has been used in this project, with district-level land-cover mapping based on the visible and infra-red wavelengths of Landsat and Sentinel-2, as well as analysis of digital elevation models (DEMs) from the shuttle radar topography mission (STRM: 30m pixels) and ALOS-PALSAR (12.5m pixels). To get an impression of the risk situation and the exposure of Honiara to hazards such as storm surges or tsunami, the DEM data were processed to map elevation, slope steepness and potential coastal inundation areas, with assumed wave heights of 5m and 10m (Figure 1.6). Free satellite images from Landsat-8 and Sentinel-2 (with 30m and 10m pixels respectively), as well as commercial high-resolution images from Planet.com (with 3.5m pixels), were processed to map near-shore relative bathymetry, using a bottom albedo-independent bathymetry algorithm developed by Stumpf and Holderied (2003).

The availability of vector data is limited and is primarily based on OpenStreetMap data and information digitised from scanned and georeferenced tourist maps. The OpenStreetMap data were simplified by removing all empty columns from the

Figure 1.5 Example outputs from the prototype mobile phone app for collecting COPE building details and information about local geohazards, for the Honiara GIS archive



attribute table and summarising others to end up with only 'osm_ids', 'occupancy', 'construction' and 'stories'. Not only could the missing information for these elements be easily collected by local authorities, via volunteered geographic information (VGI) campaigns, or via university and secondary school courses, but it also provides some essential vulnerability and exposure information for disaster risk reduction assessments.

The insurance industry COPE ('construction, occupancy, protection, exposure') classification system was used to classify the buildings entered into the GIS archive. A prototype mobile phone app was created for the collection of geospatial information about hazard zones, buildings and infrastructure in Honiara (Figure 1.5). The app could enable crowd-sensing verification of hazard zones and vulnerable features. Because the app is not dependent on internet access or phone networks, off-line data storage should enable the app to be utilised in remote locations.

At the time of this study, there were no digital maps available from official Solomon Islands sources. To assess risk-related features in and around Honiara, the available data sets, obtained from the internet and scanned paper maps, were combined in a GIS inventory (Table 1.1). To ensure maximum compatibility with Open standards, QGIS was selected as the GIS software. Ground-truth surveys to verify the resultant maps were carried out during March 2018.

1.4 Results

The use of freely available data in conjunction with freely available GIS software, such as QGIS, enables the mapping, visualisation and communication of critical infrastructure and building locations, both formal and informal, in low-lying coastal areas that might be prone to coastal flooding.

Relative coastal bathymetry can be extracted using freely available satellite data, such as Sentinel-2 (Figure 1.6). That satellite-derived bathymetry map provides a

Table 1.1 Datasets used in the initial GIS archive for Honiara

Dataset	Spatial resolution	Application/derived product
Digital elevation models		
SRTM https://earthexplorer.usgs.gov	30m and 90m	– slope hazard maps
ALOS PALSAR https://vertex.daac.asf.alaska.edu	12.5m	
Optical satellite data		
Landsat-8 https://earthexplorer.usgs.gov	15m to 30m	– nearshore bathymetry for run-up hazard maps
Sentinel-2 https://scihub.copernicus.eu/dhus/	10m	– land use and land cover
Planet https://www.planet.com/products/planet-imagery/	3.5m	
Scanned maps		
Honiara geological map	1:50,000	
Tourist map	ca. 1:10,000	– with some COPE annotations
Base-map		
OpenStreetMap https://www.openstreetmap.org	Variable, from 1:10,000	– vector files containing e.g. digitised building locations, infrastructure locations

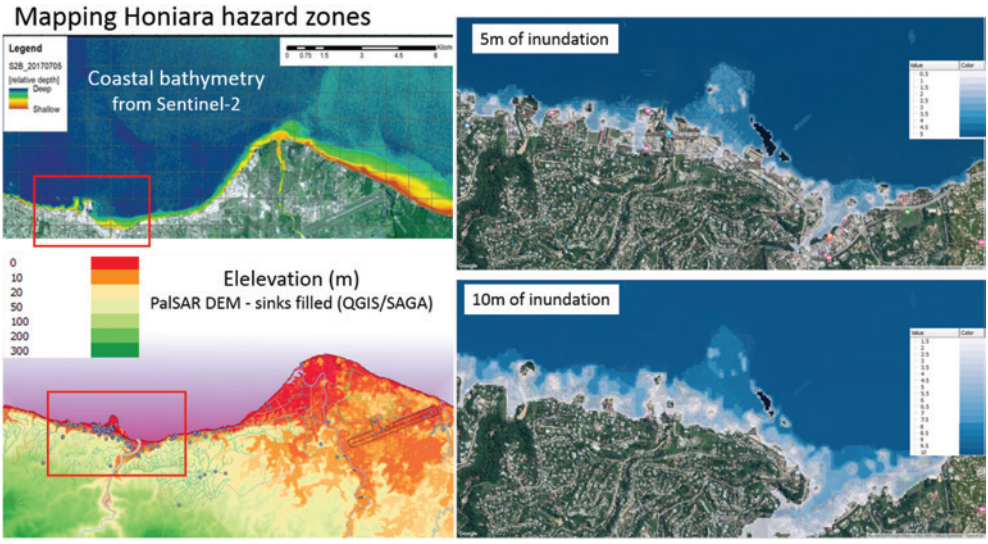
useful indication of the coastal geohazards, although it is not suitable for navigation purposes (Collin et al. 2017; Parente et al. 2018). If there are extensive coastal areas with shallow water and low gradients, then the run-up effects with storm surge waves or tsunami waves will be exacerbated. With reference to Figure 1.6, the coastline to the east of Honiara city has a more severe run-up hazard.

Of the features at risk of coastal flooding, Honiara's main hospital is of particular concern: it is located on the seafront in the low-elevation coastal zone. Also at high risk are the prime minister's office, the Japan International Cooperation Agency (JICA) office, many embassies, as well as the National Disaster Management Office (NDMO). Moreover, considering the rapid urbanisation of Honiara in the past decade (Figure 1.2), there are many informal urban developments in flood-prone low-elevation coastal zones, notably along the Mantaniko River, where flooding killed almost 20 people in 2014.

1.5 Discussion

Honiara provides an example of the limitations that severe data poverty places on disaster risk reduction activities. There is a lack of up-to-date digital maps at the local or district scales, a very limited number of geoinformatics experts (especially with regard to remote sensing), limited finances, and limited resources for mapping and

Figure 1.6 Use of geoinformatics to map Honiara's hazard zones. Bottom left: Elevation map derived from ALOS PALSAR DEM data, with some examples of critical infrastructure locations and areas flooded by the Mataniko River in 2014. Top left: Honiara coast: relative near-shore bathymetry (red: shallow water; to blue: deep water), derived from Sentinel-2 imagery of 5 July 2017. Right: Use of QGIS to map areas of coastal flooding, for 5m and 10m of inundation (detail of the area indicated by the red box)



risk assessments. Unfortunately, such a situation is typical in many SIDS and low-income countries. Furthermore, as soon as rural areas or remote islands in SIDS are considered, the situation with regard to any type of maps, data and information tends to be even worse.

The distinction of settlements as being 'formal' and 'informal' is not always possible by satellite remote sensing: such assessments require local expert knowledge. Some of the required local expert knowledge could be collected via volunteered geographic information (VGI) and crowd-sensing, as illustrated in the mobile app developed for this project (Figure 1.5). The approach presented facilitates monitoring areas of fast urban growth, which may be in areas previously avoided for settlement because of geohazards, such as steep slopes or floodplains.

With an increasing amount of freely available satellite remote sensing data, analysed using freely available software, there are now many ways to rapidly map the elevation, coastal bathymetry and land-cover types of previously poorly-mapped districts. That can greatly assist climate change adaptation and disaster risk reduction initiatives, by highlighting geohazard zones, vulnerable features and high-risk locations, assisting decision-makers in the preparedness phase of emergency management by targeting often limited resources towards areas at greatest risk of disaster (e.g. Teeuw et al. 2012; van Westen 2013; UNOOSA 2017; UN ESCAP 2017; World Bank 2018). The data collected for risk assessments also support disaster response and provide

a baseline for damage assessment and reconstruction, or more generally for risk-informed planning (Deichmann et al. 2011).

The freely available datasets considered here could potentially be incorporated in an Open Data Cube (ODC) for Fiji, which is currently being developed by the CommonSensing project, funded by the UK Space Agency (Reliefweb 2018), with follow-on ODCs envisaged for Vanuatu and Solomon Islands. An ODC is also being developed for Samoa by Australia's Commonwealth Scientific & Industrial Research Organisation (CSIRO). Two of the satellite-derived Analysis Ready Data layers being tested in the CommonSensing project could become new additions to the Open Data Cube family: (i) a DEM layer, from which slope-related hazard zones (i.e., landslides and flooding) can be mapped; and (ii) satellite-derived nearshore bathymetry data, from which run-up hazard maps can be produced.

This preliminary study, using freely available geospatial data along with local expert knowledge, provides a promising outlook for the continuation of this work. Ensuing research aims to update the initial Honiara GIS archive with relevant data for disaster preparedness, mapping the exposure of properties to coastal geohazards, selecting safe sites for shelters, and helping emergency planners to make informed decisions about future developments of critical infrastructure and settlements.

As illustrated above, free satellite imagery, particularly when provided as Analysis Ready Data (ARD) layers within Open Data Cubes (ODCs), offers many rapid and cost-effective ways of detecting and monitoring features of use in disaster risk management. However, there are some limitations, as mentioned by Guiliani et al. (2017). In general, there are the Big Data management issues, the complex system architecture and the associated high costs of building an ODC.

There are also some geographical limitations in the availability of satellite data coverage that are common to SIDS: mountainous islands often have cloud cover, or at least frequently cloud-covered hinterland hills, which limits applications dependant on visible and infra-red sensors. Some SIDS are in remote settings relative to the main land masses to which most satellite data capture is focused. Satellite data coverage is a particular problem for Pacific SIDS, where there is very limited Landsat data coverage during 1987 to 1999 for Vanuatu, Nauru and Solomon Islands (Guiliani et al. 2017). There is also a challenge with ODCs and ARD layers being a new technology for which capacity building is needed: this is an issue that the CommonSensing project will address in Fiji, Vanuatu and Solomon Islands, via workshops for awareness raising and technical training.

Another limitation is a given country's access to digital data and the issue of relative data poverty (Leidig et al. 2015). As of 2019, both Fiji and Vanuatu have high-speed/high-volume data links via submarine fibre-optic cables, but Solomon Islands is limited to relatively slow, low-volume satellite data links. Joining Solomon Islands to regional submarine fibre-optic cables, such as the Coral Sea Cable System or the Interchange Cable Network 2, both expected by 2020, should help to alleviate this issue and enable greater use of geoinformatics for disaster risk management applications.

Even with access to internet-deliverable Analysis Ready Data, from data cubes and other geoinformatics data archives, there are still data poverty issues with regard to remote communities, particularly those on small islands in archipelago states, located far from islands with cities that have easy access to the internet and phone networks. Recent discussions with emergency planners and representatives of NGOs involved with disaster risk reduction, in Pacific SIDS (Fiji, Samoa, Solomon Islands, Vanuatu), Caribbean SIDS (Barbados, Dominica) and low-income small states (Sierra Leone, El Salvador), have highlighted that local universities, colleges and secondary schools are central to both improved geoinformatic capacity and better outreach to remote communities.

1.6 Conclusion

An increasingly wide range of geoinformatic data and software is available for the mapping and monitoring of hazard zones, vulnerable/exposed features and areas of risk. Unfortunately, there is a major cost barrier: high-resolution satellite imagery and the commercial GIS software to process that data, can each cost many thousands of dollars.

This study provides examples of freely downloadable remotely sensed data and free Open Source GIS mapping software, applied to disaster risk reduction in Solomon Islands, a low-income island state. Moderate resolution satellite imagery, with pixel sizes ranging from 10m to 30m, was used to map hazardous terrain and vulnerable features in the district around the capital city, Honiara. Google Earth Engine has been used to monitor and map changes in urban area and tree cover since 2008.

A dedicated Open Data Cube (ODC) is currently being developed for Fiji by the UKSA-funded *CommonSensing* project, with further ODCs envisaged for Vanuatu and Solomon Islands. An ODC is also being developed for Samoa via Australian technical assistance. Two new data layers for use in ODCs have been tested on Honiara district, a DEM-based slope hazard layer and a coastal run-up hazard layer based on satellite-derived bathymetry – the preliminary results of this are encouraging.

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Chapter 2

From Science to Science-based: Using State-of-the-Art Climate Information to Strengthen DRR in Small Island States

Denyse S Dookie, Markus Enenkel and Jacqueline Spence

Abstract

While weather and climate-related hazards have historically taken a toll on Caribbean small islands, the impacts of recent storms have prompted urgent dialogue on updating and improving the way the region understands, prepares for and responds to disasters. As the region convenes on issues related to boosting environmental governance, developing key technology systems and building resilient infrastructure, it is imperative that consideration be offered to the potential of using climate information, most of which is freely available, for the effective strengthening of disaster risk reduction (DRR). Enhanced awareness and use of a wide range of weather- and climate-related information can empower small states with data to make appropriate and impactful decisions towards advanced disaster preparedness, disaster risk reduction and future resilience.

In attempting to understand the divide between science/research and policy/use in disaster risk reduction in small states, this chapter aims to underscore the potential value and utility of climate information. We define climate information, review its nature and utility globally, and discuss the variability in verified climate information for highly climate-vulnerable but data-poor countries. Such a chapter has the potential to engage the science-policy dialogue of encouraging the development and use of climate information, especially at this time when governments and various agencies are interested in building and fostering resilience following recent disasters and impacts, and within the context of a region whose vulnerability will increase with climate change.

2.1 Introduction

Between 1900 and 2018, the insular Caribbean was affected by at least 599 natural hazard-based declared disasters (EM-DAT 2018). Of these, 543 were weather-related events (storms, floods, landslides and drought), contributing to some US$135 billion in estimated damages and affecting more than 51 million people within the region. Despite a potential reporting bias, it is a concern that more than half of these events occurred within the past 20 years alone. The increasing density of population and

infrastructure in this period, especially along coastal areas, has amplified the region's exposure to climate-related hazards, including impacts on people and damages to infrastructure. While the projected effects of climate change on temperature and precipitation changes, as well as sea-level rise, within the region are already alarming (Nurse et al. 2014), scientific experts have recently forewarned of the worsening impacts of climate change (IPCC 2018), manifested for instance by a likely coupling with increased intensities of tropical storms (Fountain 2018).

Responding to the many events within the recent past, Caribbean agencies in the areas of meteorology, water resources and disaster risk management seem committed to build resilience within the region to reduce its vulnerability to weather-related disasters. It is timely, then, that this study seeks to ensure that within these efforts must be the focus on building capacity for the understanding, development, effective use, dissemination and interpretation of climate information. However, while climate sciences have made enormous progress in recent decades, only a few key findings 'trickled down' into operational disaster risk reduction (DRR) programmes, leaving decision-makers wondering about 'acceptable uncertainties' in forecasts (Coughlan de Perez et al. 2015), the benefits of early action compared to the costs of inaction, or the links between socioeconomic vulnerabilities/coping capacities in the face of chronic climatic threats.

In attempting to understand the divide between science/research and policy/use in disaster risk reduction in small states, this chapter aims to underscore the potential utility and added-value of climate data/information/services, as well as to identify current limitations. We define climate information, review its nature and utility globally, and discuss the variability in verified climate information for highly climate-vulnerable but data-poor countries. In a case study, we focus on available information for Jamaica. Like many other island regions, Jamaica is highly vulnerable to the impacts of climate change, variability and related extreme events. While significant efforts are currently underway to improve the availability of climate data through the installation of automatic weather stations, there are still gaps in terms of a long time series of ground-truthed weather station data for all of the island. Satellite and modelled data have the potential to complement and partly replace in-situ observations (Dinku et al. 2018) but different factors (such as island location and topography) result in highly heterogeneous validation results, leading to uncertainties regarding their operational added-value. Hence, identifying the strengths and weaknesses or specific climate datasets, their usefulness to track and forecast extreme events, their integration into existing decision-making workflows and links to socioeconomic conditions (e.g. changes in livelihoods) are a necessary step towards advanced disaster risk reduction in Jamaica and the wider Caribbean.

Noting that climate data and, ideally, resulting actionable climate knowledge are but one key component that should be developed and better utilised within the context of disaster resilience within the region, we also discuss the requirements that are needed to enhance its use. We attempt to describe advanced visualisation techniques, metalevel studies that summarise the applicability of climate data in particular regions (including calibration and validation studies), and operational projects that use 'high-level' climate data (i.e. the opposite of raw data) to develop or improve

climate services or related applications (such as financial instruments/parametric insurance). This discussion also includes the role of improved dialogue between key agencies within countries, regional counterparts and also international agencies.

This study aims to broaden the discussion of DRR and building resilience by preparing countries for advanced risk management using available data and information products. These discussions are complementary to the concerns of environmental governance, technology, resilient infrastructure and stimulated investments, and can enhance such directives and actions. As they rebuild, it is important to empower small states with applicable and actionable data and information to make appropriate and impactful decisions that minimise disaster impacts and increase resilience to future risk.

2.2 The Caribbean: Vulnerability and disasters in context

While countries categorised as small island developing states (SIDS), such as many of those in the Caribbean region, exhibit heterogeneous vulnerability profiles, it is widely accepted that there are several common characteristics that are likely to increase their vulnerability and pose a risk to sustainable development (UNFCCC 2005). Such challenges may be due to geographic factors such as location, remoteness, small land masses, geomorphological structures and exposure to natural hazards, as well as socioeconomic features, including small economic sizes and populations, dependence on primary industries, and yet-developing economic and governance systems (e.g. see Kruczkiewicz et al. 2018). The concept of this particular vulnerability as experienced by SIDS has been well-discussed by many (e.g. see Briguglio 1995; Pelling and Uitto 2001; Briguglio et al. 2006; Lewis-Bynoe 2014, 2016) and has also been challenged for increased perspective (e.g. see Barnett and Waters 2016). The complexity of this inherent vulnerability is specifically highlighted in times of disasters. The susceptibility of Caribbean islands to a variety of natural hazards, coupled with the increasing exposure of Caribbean societies (due to increasing population sizes and relative number of persons living on or near coastal/low-lying areas or otherwise hazard-prone locations) and ecological systems further increases the risk of severe disaster impacts.

Some economic literature has offered insights into the relative disproportionate nature of disaster impacts on small islands. Kahn (2005) finds that even though developed countries experienced disasters of similar frequency and severity, there were less disaster-related deaths in these countries. As well, disaster impact may also be lower in situations of stable political systems or improved institutional conditions (Kahn 2005; Toya and Skidmore 2007). In terms of the connection between disasters and development, many recent studies suggest that disasters may play a role in observable adverse macroeconomic impacts, leading to negative long-term growth and development consequences (e.g. see Hsiang and Jina 2014), particularly in low-income countries (Benson and Clay 2004; Zapata and Madrigal 2009; Strobl 2012).

While these studies have been generally global in nature or wider in scope, region-specific socioeconomic research has only recently begun to focus on the impact of weather, climate and disasters within the macroeconomic context. Of interest, Strobl

(2012) looks at the particular impacts of hurricanes on macroeconomic outcomes in the wider Central American and Caribbean region, finding an inverse relationship between average damages caused by hurricanes and economic output. Moore et al. (2016) perform general equilibrium framework model simulations which suggest that not only do output losses due to hurricanes have economy-wide effects, but rural regions may suffer most. Recent satellite-based night time light observations before and after hurricane Maria struck Puerto Rico confirm these findings (NASA 2018).

The number of research papers looking at the socioeconomic nature of disasters within the Caribbean is limited, especially given the frequency and impact (both monetary and on persons) of these events. As shown in Table 2.1, which summarises data for the Caribbean over the period 1900 to 2018 using data from the EM-DAT disaster database,[1] while more than 80 per cent of the disasters reported were natural hazard-based, these events have led to more than 99 per cent of the damages and impacts on people. Of these reported disasters, approximately 75 per cent are due

Table 2.1 Disasters in the Caribbean, 1900–2018

Disaster group	Disaster type	Occurrence	Total deaths	Total affected	Total damages (million US$)
Hydrological	Flood	151	6,368	7,494,812	992.68
	Landslide	7	443	2,435	–
Meteorological	Storm	353	31,482	35,848,533	133,831.75
Climatological	Drought	29	–	8,331,762	283.64
	Wildfire	5	–	–	1.00
Biological	Epidemic	30	7,594	749,291	-
Geophysical	Earthquake	15	223,988	3,837,599	8,075.00
	Mass movement (dry)	1	40	–	–
	Volcanic Activity	10	31,599	110,403	8.00
Technological	Industrial Accident	8	59	5,290	22.40
	Miscellaneous Accident	24	657	524,518	50.30
	Transport Accident	98	6,397	2,532	–
ALL DISASTERS TOTAL		**731**	**308,627**	**56,907,175**	**143,264.77**
Subtotal hyd/met/clim disaster groups		545	38,293	51,677,542	135,109.07
% of all disaster total		74.6%	12.4%	90.8%	94.3%

Source: Data compiled from EM-DAT database (update as at: 29 January 2019), available at: www.emdat.be

Note: 'Subtotal hyd/met/clim disaster groups' is the total of the hydrological, meteorological and climatological disaster groups.

primarily to events such as floods, landslides, storms, droughts and wildfires – in other words, most of the disasters in the Caribbean are largely due to weather and climate events. These events have led to an estimated death toll of more than 38,000 people, generally affected more than 51.6 million people, and resulted in economic damages upwards of US$135 billion. Between 2014 and 2018, storms, floods and droughts have contributed the most to those affected by disasters, as well as economic damages. In 2017 alone, 26 storm disaster events throughout the Caribbean affected 11 million people and led to US$93.4 billion in damages. These numbers are particularly concerning because SIDS are among the least responsible of all nations for climate change, but suffer strongly from its adverse effects (UNFCCC 2005).

The frequency and compound nature of such disaster events and their impacts on people and economies reinforce the local vulnerability and viability for development and resilience. Furthermore, the projected effects of climate change and variability certainly add to this vulnerability dimension. For Caribbean small islands, the Intergovernmental Panel on Climate Change's (IPCC's) 5th Assessment Report indicates that under the Representative Concentration Pathway 4.5 Scenario, the annual projected change for 2081–2100, relative to 1986–2005, is a likely 1.4°C average increase in temperature, 5 per cent decline in rainfall and 0.5–0.6 metre sea level rise (IPCC 2014). Inter-annual climate phenomena, such as the El Niño-Southern Oscillation (ENSO), have also affected the frequency and severity of rainfall and extreme events, including droughts, storms and floods.

It is worth noting that the Climate Studies Group at the University of the West Indies, Mona, Jamaica, has been prolific in research to better understand the historical observations and future climate projections using regional climate models, such as that of the Hadley Centre Providing Regional Climates for Impacts Studies. In addition, their research has opened an understanding of a regional system of Caribbean climate drivers, which include the Atlantic warm pool (AWP), the Caribbean low-level jet (CLLJ), and the Atlantic multidecadal oscillation (AMO) signal of the North Atlantic surface sea temperatures (for example, see Peterson et al. 2002; Campbell et al. 2011; Taylor et al. 2011; Taylor et al. 2012; Karmalkar et al. 2013; Stephenson et al. 2014). Also of interest is the continuing work regarding simulations estimating when ongoing warming might exceed the bounds of historical climate variability, such as Camilo et al. (2013) wherein it is discussed that '[u]nprecedented climates will occur earliest in the tropics and among low-income countries, highlighting the vulnerability of global biodiversity and the limited governmental capacity to respond to the impacts of climate change'.

Development agencies have long advocated that minimising such disaster impact is likely plausible through an emphasis on strategies focused on risk reduction, resilience and building adaptive capacity (e.g. see Mochizuki et al. 2014); such a focus may in tandem play a role in fostering and sustaining livelihoods, economic development and growth (e.g. World Bank 2013). As offered by the United Nations International Strategy for Disaster Reduction (UNISDR), disaster risk reduction policies may include 'reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment, and improving preparedness and

early warning for adverse events' (UNISDR n.d.). In this regard, utilising available information and data about the weather/climate, as well as how the weather/climate has historically affected countries and the changing nature of this in the future, and designing strategies to best incorporate and communicate such information, could be a pivotal way to improve society's response and resilience to climate change and variability, including hazards relating to extreme weather and climate events.

2.3 Understanding weather and climate information

As per Singh et al. (2018), scientific weather and climate information 'refers to processed data, products and/or evidence-based knowledge about the atmosphere-ocean system across short (hours to days) and long (seasons to decades) timescales'. Generally, it refers to data describing historical, current and future climate conditions, including hydrometeorological ('hydromet') variables, either from ground-based observations, satellites or models that improve our understanding of interaction between natural and human systems. For instance, on a global climate scale, climate information products may include 'global emission scenarios and climate model outputs to information about local impacts and vulnerability to climate change', incorporating 'meteorological, hydrological, oceanographic, terrestrial (collectively, the Essential Climate Variables, or ECVs)', and socioeconomic and other data (see Adaptation Community n.d.). The focus on the use of the term 'information' vis-à-vis solely data 'implies that it has meaning and relevance within a given context', and as such climate information can be used to assist agencies and governments key data in informing short-, medium- and long-term decisions relating to priority topics within the region (Singh et al. 2018).

Short-term weather and climate information, on the timescale of days to weeks, can include observed and forecasted rainfall and temperature, alongside early warning of extreme events such as floods, dry spells or droughts, if auxiliary data, such as updated socioeconomic vulnerability profiles or digital elevation models, are available. Key short-term discussions based on this data could refer to disaster risk management decisions on how to protect people and infrastructure from impending events, and concerns of risk communication to and response within the most vulnerable areas. Also, the development and revision of targeted contingency plans and the triggering of advanced financial instruments, such as parametric insurance, fall into this category.

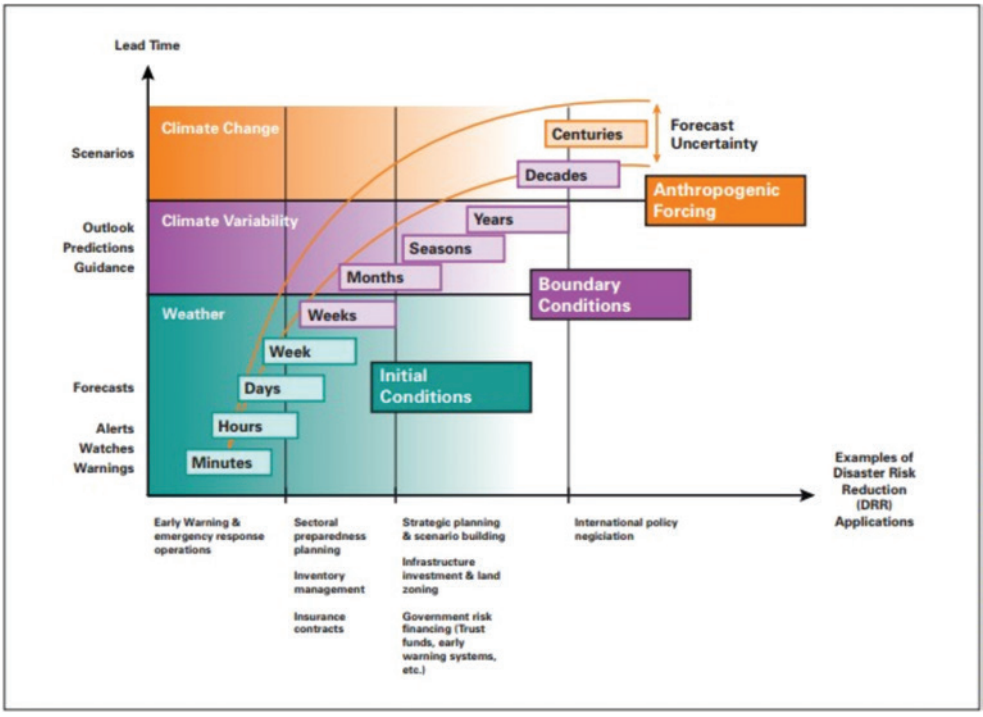
While medium-term decisions can include stocking of essential supplies or the revision of evacuation plans, water resource management may respond to sub-seasonal (two weeks to two months) timescales. Seasonal (>two months) information can be used to inform decisions about investments in irrigation and drainage systems, possible relocation of vulnerable persons to safer areas, and other decisions to improve the overall resilience of an area and population to hazardous events. However, independently of the timescale, decisions need to be based on data that are adapted to the decision-making context, as well as the decision-maker's expertise, objectives and willingness to use climate information.

At the global level, the advancement in scientific investigation and knowledge about past climatic conditions and encouragement of data acquisition and analysis

of current data have offered improvements in scope about how we understand and make projections about future climatic conditions. Climate information thus plays a vital role in the development and process of climate services, which 'involve the production, translation, transfer, and use of climate knowledge and information in climate-informed decision making and climate-smart policy and planning' (Hewitt et al. 2012). In general, the 'aim of climate services is to provide people and organisations with timely, tailored climate-related knowledge and information that they can use to reduce climate-related losses and enhance benefits, including the protection of lives, livelihoods, and property' (Vaughan and Dessai 2014). **Figure 2.1** highlights a variety of climate information options at different lead times, together with relevant climate services and risk management applications.

While climate services projects and partnerships are evident across the globe covering a broad range of thematic areas, the World Meteorological Organisation's Global Framework on Climate Services (GFCS) specifically focuses on five priority topics: Agriculture and Food Security, Disaster Risk Reduction, Energy, Health and Water (see: https://www.wmo.int/gfcs/projects- map for a map of projects). As described by the GFCS, the focus on climate services that specifically relate to disaster risk reduction encourages the utilisation of quantitative risk-based climate information, which can assist countries to 'develop risk management strategies using early warning

Figure 2.1 Summary of climate information and climate services



Source: WMO Disaster Risk Reduction Programme, available at: https://www.wmo.int/pages/prog/drr/documents/Climate_DRR-FactSheet_EN.pdf

Figure 2.2 Idealised overview of climate information products and providers

Climate Information Products	Climate Information Providers: Meteorological services	Research institutes	Global web-based climate information portals	Consultancy firms	Insurance companies/ private enterprises	Government departments (excl. meteoro-logical services)	WMO
Raw data on Essential Climate Variables	X		X			X	X
Emission scenarios		X	X				
Global models	X	X	X				
Downscaled/regional models	X	X	X	X	X		X
Seasonal and decadal forecasts and predic-tions	X	X	X				X
Impact, risk and vulnerability assess-ments		X	X	X	X	X	
Local knowledge/ historical records		X	X	X	X	X	

Source: Adaptation Community 2013.

systems to reduce casualties; medium and long-term sectoral planning (such as land zoning, infrastructure development, water resource management, and agricultural planning) to reduce economic losses and build livelihood resilience; and weather index insurance (WII) and risk financing mechanisms to transfer the financial impact of disasters' (GFCS 2018).

In the growing field of climate information, there are now a variety of actors producing and encouraging the use of a variety of types of climate information, which is further supported by a variety of agencies, including national research institutes, National Meteorological and Hydrological Services (NMHSs), and global and regional information platforms (Adaptation Community 2013). For example, it is noted that more and more governments are customising climate information for specific users towards more targeted local decision-making, utilising their experiences with weather forecasting (ibid). **Figure 2.2** highlights some climate information products and the providers that may be associated with them.

In this context, it is essential to note that there is sometimes a mismatch of what providers may consider as important compared to the needs of climate information users. As such, it is important for users/decision-makers to be actively aware of the availability, relevance and levels of uncertainty of climate information, and how such data may be used appropriately in the context of given priorities and needs.

2.4 The availability and utility of climate information for DRR: Jamaica case study

Evidence from climate services projects and programmes highlights that 'in order to make a well-informed adaptation decision, decision-makers and their advisors have

to make use of climate information' (Adaptation Community 2013). For islands in the Caribbean, which have historically been affected by natural hazard threats, noting the relevance and utility of using climate information to better understand and prepare for such threats may be a key step towards improving disaster risk resilience. While climate services projects have existed within the Caribbean, the authors of this chapter suggest that climate information is currently not being used to its fullest potential within the region, especially within the context of disaster risk reduction and resilience. In this regard, utilising available information and data about the weather/climate, as well as how the weather/climate has historically affected countries and the changing nature of this in the future, and designing strategies to best incorporate and communicate such information, could be a proactive pivotal way to improve society's response and resilience to climate change and variability, including hazards relating to extreme weather and climate events.

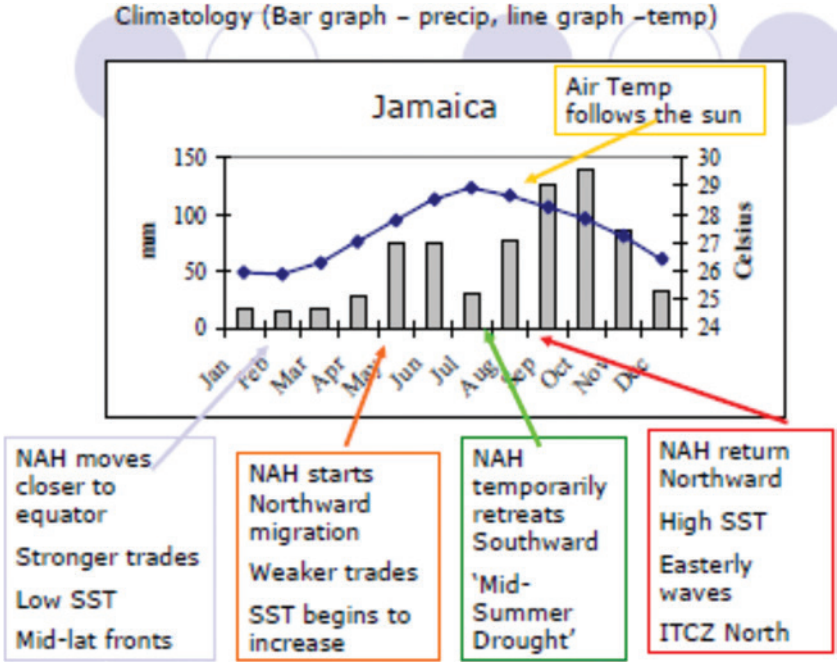
To offer context to how climate information can be used within the Caribbean region, we will review the availability and utility of information for the island of Jamaica, to underscore how such data could be beneficial for disaster risk resilience. Jamaica, like other small states, is highly vulnerable to the impacts of climate change, variability and related extreme events, and has been making strides towards policy and implementation of action to address pressing challenges (see Climate Change Policy Framework for Jamaica, GOJ 2015). Additionally, while there have been significant efforts to improve the availability of climate data through the installation of automatic weather stations, there are still gaps in terms of a long time series of observational weather station data for all of the island. Satellite and modelled data have the potential to complement and partly replace in-situ observations, but different factors (such as island location and topography) impede the clear identification and communication of these datasets' strengths, limitations and resulting uncertainties regarding their operational added-value.

2.4.1 The physical and human geography of Jamaica

The island of Jamaica is situated in the western Greater Antilles region within the archipelago of Caribbean islands, to the southeast of Cuba and west of Haiti. Its land area of approximately 10,911 km^2 (4,213 square miles) was originally evolved from volcanic formation, with thick limestone layers present due to periods of submersion. In terms of topography, there are three landform regions: the eastern mountains, the central valleys and plateaus, and the coastal plains. Within the eastern mountains are the highest areas of the island, the Blue Mountains, which peak at 2,256 metres (7,402 feet) and which rise dramatically from the coastal areas, creating one of the steepest general gradients in the world (see Hamilton 2005). Almost two-thirds of the island is considered to be limestone plateau – karst landscape (including sinkholes, caves and caverns) is thus present and typified well within the Cockpit Country area to the west of the mountains. The coastal areas differ across the island – most of the large stretches of coastal plains can be found in the southwest of the country and, in general, most of the best beaches can be found along the western coastline.

The *State of the Jamaican Climate 2012* report, as prepared by the Climate Studies Group of the University of the West Indies, Mona Campus, shares that the surface

Figure 2.3 Rainfall (bar) and temperature (line) climatologies for Jamaica

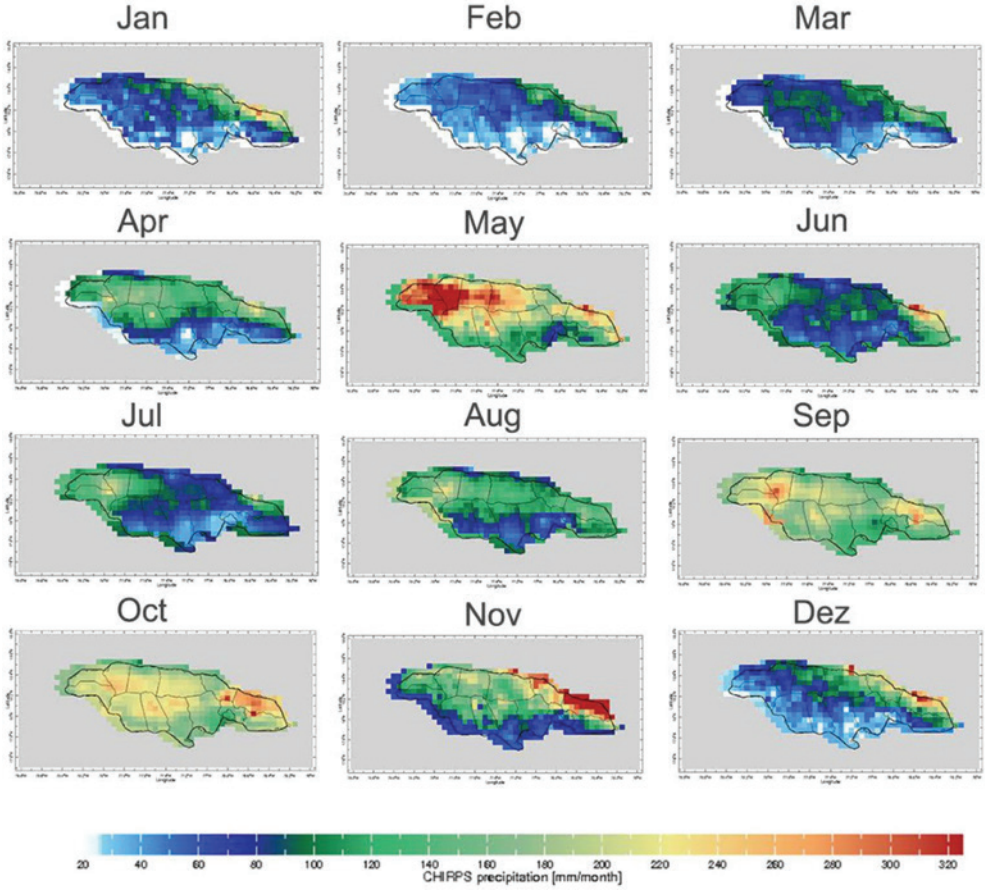


Source: Climate Studies Group, Mona 2012.
Note: NAH = North Atlantic High Pressure system; SST = sea surface temperature; ITCZ = Inter-Tropical Convergence Zone.

temperature in Jamaica is largely controlled by the variation of solar insolation, as shown in Figure 2.3. While there is some precipitation variation from year to year, there is an evident bimodal rainfall pattern on the island consisting of two peak periods of higher rainfall and corresponding periods of lower rainfall amounts (Climate Studies Group 2012). We can get a more detailed picture of this by compiling the mean monthly rainfall over the 35-year period, 1983–2018, using a free satellite precipitation dataset, the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) from the University of California Santa Barbara. As shown in Figure 2.4, there are two peaks, in October and May, with rainfall amounts at their lowest during February and March. There is also a second, but brief, drier period in July (often referred to as a midsummer drought; other Caribbean islands experience a similar Indian Summer or *Petit Carême*, though at different times of the year).

Such a physical environment should be considered alongside the context of the country's socioeconomic reality. Traditionally an agriculture-based economy, with sugar, bananas and tobacco as historical main draws of the labour force, Jamaica now receives most of its revenue from tourism and remittances. In 2018, the World Travel and Tourism Council ranked Jamaica as number 19 in the world in terms of contribution of tourism to gross domestic product (GDP) based on relative economy size: tourism directly contributed[2] to 10.3 per cent of GDP in 2017 (32.9% in terms of total direct and indirect contributions[3]) and directly supported 9.2 per cent of total

Figure 2.4 Mean monthly rainfall distribution map for Jamaica, 1983–2018



Source: Authors' compilation using a free satellite precipitation dataset, Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) from the University of California Santa Barbara, averaged by month over the period 1983–2018. For more information, see: http://chg.geog.ucsb.edu/data/chirps/

employment (29.8% of wider travel and tourism employment) (WTTC 2018). These, alongside visitor exports and investments in travel and tourism, were forecasted to grow in 2018 as well as over the next ten years.

While severe floods and other adverse weather events took a toll on Jamaica's economic health during the first half of 2017, expansion in the mining and quarrying sector (due to the continued focus and development of the country's bauxite-alumina industry), as well the aforementioned good performance in the tourism sector, stimulated economic rebound and growth of about 1.7 per cent in the first half of 2018 (World Bank 2018). The World Bank also reports that there has been a decline in the poverty rate, from 21.1 per cent in 2015 to 17.1 per cent in 2016 (with projected future decline), declines in overall and youth unemployment (at 25.8%, youth unemployment is at its lowest rate since 2007), as well as growth in total employment.

Despite these positive changes, it must be considered that with a population of about 2.7 million in 2018 (STATIN 2018), there are still large numbers of people in vulnerable contexts. As such, these trends would need to continue to address deeper rooted issues – crime and violence levels are as yet high, signalling the role and further encouragement of education, social cohesion and youth employment programmes, while sustained poverty reduction requires stronger and more resilience economic growth. The country is pursuing efforts towards economic stabilisation, debt reduction and growth through an ambitious reform programme encouraging development policy and investment financing in support of private sector-led growth, public sector transformation and building social and climate resilience. However, in this context, Jamaica's susceptibility to natural hazards and other external shocks within such a high debt/low growth context encourages a heightened attention to understanding and appropriately utilising climate information towards reducing risk and building resilience.

2.4.2 Climate information for Jamaica

The *State of the Jamaican Climate 2015* (Climate Studies Group 2017) highlights the necessary role of climate information specific to Jamaica for the purposes of planning, local action and decision-making. Such a role has been encouraged within projects such as the *Improving Climate Data and Information Management Project* (ICDIMP) of Jamaica's Pilot Programme for Climate Resilience (PPCR) (financed by the Climate Investments Fund [CIF] and administered by the World Bank), as it specifically 'targets improving the quality and use of climate-related data and information for effective planning and action at local and national levels'. At the same time, understanding the scope of climate information in Jamaica is consistent with Outcome 14 (Climate Change Adaptation and Hazard Risk Reduction) of the Vision 2030 Jamaica National Development Plan (Climate Studies Group 2017).

The *State of the Jamaican Climate 2015* report has stated that it is 'intended as a first reference point with respect to climate information for Jamaica', and includes local primary data relating to the island's climatology and observed variability, trends and extremes (including for variables such as temperature, rainfall, hurricanes, droughts and floods, and sea levels), in addition to climate scenarios and projections using a variety of global and regional climate models. The report offers information on some region-specific impacts and sectoral profiles, in addition to tables of climate tools, products and services which offer wider and agricultural-specific information to 'allow decision makers and policy makers to make informed decisions on climate-sensitive projects'. Such research is invaluable to document and understand the mean patterns and baseline conditions of climate within the country, towards an improved awareness of how likely impacts may affect the present and future climate vulnerabilities of the island and the relevant decision-making necessary to take precaution. The report also notes existing gaps, Including: '(i) inadequate climate observation station coverage over the island in general and glaring gaps in (among other places) St Ann and Portland; (ii) the need for more ensembles of regional models run using the Representative Concentration Pathways (RCP) scenarios to provide sub-island data; (iii) the need for more targeted research on climate impacts on some

understudied sectors including education, the private sector and biodiversity; and (iv) processes for translating the science into real plans and then into actions'.

In light of these advised gaps in climate observation coverage and the role of targeted insights to relate climate information within the science/policy dialogue process, and the potential for using state-of-the-art climate information to strengthen DRR, generally and also particularly in small island states, this chapter highlights a few additional examples of Jamaica-relevant satellite data/climate information and disaster/knowledge portals of potential interest and use. Complementing the climate information products sourced within the *State of the Jamaican Climate 2015* report, Table 2.2 covers a wide range of mostly satellite-derived products: rainfall, surface soil moisture, root-zone soil moisture, evaporative stress, agricultural stress, ENSO forecasts, sub-seasonal and seasonal rainfall and temperature forecasts, flood forecasting, drought information, food insecurity, deforestation, extreme rainfall forecast, groundwater, land cover, emergency/damage response data, as well as a host of databases offering products catering to wider climate monitoring, climate services and global earth visualisations (such as Google Earth Engine and the related Earth Engine Data Catalog). As these products evolve and develop, new technologies such as machine learning can assist in providing new ways of looking into the complex relationships between hazard and impact, and provide more accurate, efficient and useful answers (e.g. GFDRR 2019).

Ahead of that, it is important to catalogue climate information resources to create an awareness of the availability of datasets, which are mostly and usually free for public use, to encourage their integration into public and private decision-making workflows. While there are some challenges in using these, as outlined in the next section, this awareness of the potential for supplementing evident gaps in local observation coverage is a pivotal step to empower local teams with knowledge. Such knowledge development can encourage appropriate activism and action based on pertinent needs and engender innovation within small states to transform communities from being vulnerable and/or passive victims, to veritable agents and actors for change. Furthermore, combined with additional information, such as socioeconomic and related data, evaluated climate information could be used to better understand local areas and pockets of the population that are at an increased risk of vulnerability to natural hazards and extreme weather events. For instance, Figure 2.5, Figure 2.6, Figure 2.7 and Figure 2.8 offer additional context of risk in Jamaica that could be considered alongside available climate information to hone in on actions needed to support local priorities.

While these resources are based on agricultural priorities, they could also be used to highlight the potential challenges for disaster risk reduction. A more targeted focus on the use of climate information and related socioeconomic data in various contexts could prove beneficial for understanding and monitoring natural hazards and extreme weather events and, ideally, informing relevant decisions. However, limitations arise not only on a data level, but in different sectors like technical capacities, awareness of freely available datasets, data processing and storage, or trained personnel. In the case of Jamaica, which is highly dependent on weather- and

Table 2.2 List of satellite products relevant for Jamaica/Caribbean context

Type of dataset	Name	Source/comment	URL
Rainfall	Climate Hazards group InfraRed Precipitation (CHIRP)	Satellite-derived; 1981–present; 0.05°; pentad, decadal, monthly	http://chg.geog.ucsb.edu/data/chirps/
Rainfall	CHRS/UC Irvine Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN)	Satellite-derived; Mar 2000–present; 0.25°; 30-minute	https://climatedataguide.ucar.edu/climate-data/persiann-cdr-precipitation- estimation-remotely-sensed-information-using-artificial
Rainfall	CPC Morphing Technique (CMORPH)	Satellite-derived; Dec 2002–present; 0.25°; 3-hourly	http://www.cpc.ncep.noaa.gov/products/janowiak/cmorph_description.html
Rainfall	Global Satellite Mapping of Precipitation / JAXA Global Rainfall Watch	Satellite-derived; 2000–present; 0.10°; hourly	https://sharaku.eorc.jaxa.jp/GSMaP/index.htm
Rainfall	SM2Rain	Rainfall estimated via satellite-derived soil moisture	http://hydrology.irpi.cnr.it/research/sm2rain/
Surface soil moisture	ASCAT (Advanced Scatterometer) soil moisture	Satellite-derived; available in near real-time (within 135 min)	https://navigator.eumetsat.int/product/EO:EUM:DAT:METOP:SOMO25
Surface soil moisture	ESA Climate Change Initiative (CCI) soil moisture	Derived from multiple satellite-based sensors (RADAR/radiometer)	https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-soil- moisture?tab=overview

Table 2.2 List of satellite products relevant for Jamaica/Caribbean context (*Continued*)

Type of dataset	Name	Source/comment	URL
Surface soil moisture	Sentinel-1 a/b	Satellite-derived (Synthetic Aperture Radar – SAR), high resolution	https://sentinel.esa.int/web/sentinel
Root-zone soil moisture	Soil Water Index (SWI)	Infiltration model applied to satellite-derived surface soil moisture	https://land.copernicus.eu/global/products/swi
Evaporative stress	Evaporative Stress Index (ESI)	Satellite-derived land-surface temperature	http://catalogue.servirglobal.net/Product?product_id=198
Agricultural stress	UN FAO Agricultural stress index system (ASIS)	Satellite-derived vegetation and land-surface temperature estimates	http://www.fao.org/giews/earthobservation/asis/index_1.jsp?lang=en
ENSO forecast	IRI (International Research Institute for Climate and Society, Columbia University) ENSO forecast	Based on the NINO3.4 index	https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/
Sub-seasonal rainfall / temperature forecast	IRI sub-seasonal forecast	Multi-model ensemble forecasts (lead time up 40 days)	http://iridl.ldeo.columbia.edu/maproom/Global/ForecastsS2S/precip_subx.html?S=0 000%204%20Jan%202019
Seasonal rainfall / temperature forecast	IRI seasonal forecast	Multi-model ensemble forecasts (lead time up 6 months)	http://iridl.ldeo.columbia.edu/maproom/Global/Forecasts/index.html
Flood forecasting	Global flood awareness system	Coupled weather forecasts and hydrological model	http://www.globalfloods.eu/
Global drought information	Global Drought Observatory	Satellite-derived precipitation (also SPI) and soil moisture anomaly	http://edo.jrc.ec.europa.eu/gdo/php/index.php?id=2001

(*Continued*)

Table 2.2 List of satellite products relevant for Jamaica/Caribbean context (*Continued*)

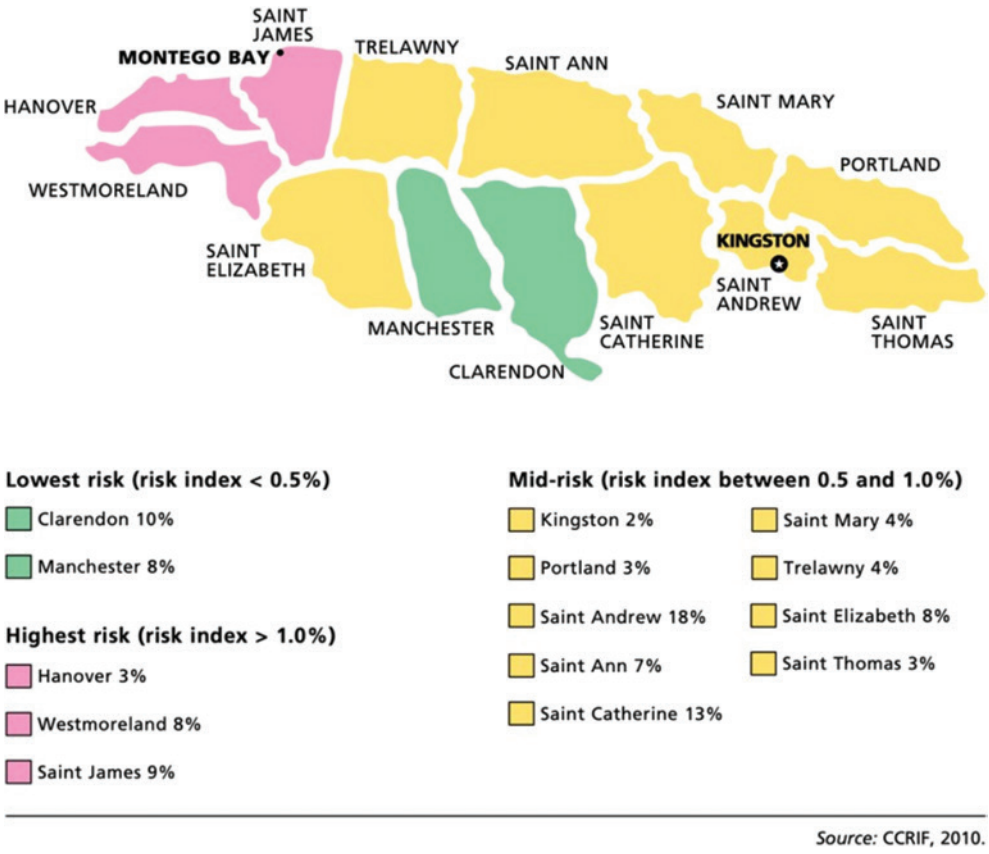
Type of dataset	Name	Source/comment	URL
Global drought information	Standardised Precipitation Evapotranspiration (SPEI) drought index	Gridded station data	http://spei.csic.es/map/maps.html#months=1
Global drought forecast	6-month Forecasted Standardised Precipitation Index (SPI), IRI	3 months of observed precipitation linked to 3 months of seasonal rainfall forecasts	http://iridl.ldeo.columbia.edu/maproom/Global/World_Bank/Drought_Monitor/index 3.html
Food insecurity	Famine Early Warning Systems Network (FEWS NET)	Various input sources (satellite-derived, socioeconomic, economic)	http://www.fews.net/
Deforestation	Global forest watch	Satellite-derived	http://data.globalforestwatch.org/
Extreme rainfall forecast	International Federation of Red Cross and Red Crescent Societies: Forecasts in Context	Daily ensemble-mean forecast precipitation totals; contextualised for humanitarian decision-making	http://iridl.ldeo.columbia.edu/maproom/IFRC/index.html
Groundwater	Gravity Recovery and Climate Experiment-Follow- On (GRACE-FO)	Satellite-derived (soon available)	https://podaac.jpl.nasa.gov/GRACE-FO
Land cover	ESA CCI land cover	Satellite-derived	https://maps.elie.ucl.ac.be/CCI/viewer/
Emergency data portal	Copernicus Emergency Management System	Satellite-based emergency/damage and risk mapping	https://emergency.copernicus.eu/

Table 2.2 List of satellite products relevant for Jamaica/Caribbean context (*Continued*)

Type of dataset	Name	Source/comment	URL
Knowledge portal	United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN SPIDER)	Description and database of satellite-derived products (focus on emergency applications)	http://www.un-spider.org/ http://www.un-spider.org/links-and-resources/data-sources
Crowdsourcing / data collection platform	Kobo Toolbox	Open-access, fully customisable software/app platform	https://www.kobotoolbox.org/
Various	Copernicus global land	Collection of satellite-derived datasets	https://land.copernicus.eu/global/index.html
Various	Sentinel data hub	Collection of satellite-derived datasets	https://scihub.copernicus.eu/
Various	US Geological Survey (USGS)–Global Visualization Viewer (GLOVIS)	Collection of satellite-derived datasets	https://glovis.usgs.gov/app?fullscreen=1
Various	USGS Earth Explorer	Collection of satellite-derived datasets	https://earthexplorer.usgs.gov/
Various	NASA Earth Observations (NEO)	Collection of satellite-derived datasets	https://neo.sci.gsfc.nasa.gov/
Various	NASA Earth Data	Collection of satellite-derived datasets	https://earthdata.nasa.gov/
Various	UNITAR (United Nations Institute for Training and Research)/UNOSAT	Collection of satellite-derived datasets/emergency maps	https://unitar.org/unosat/maps
Various	Disaster Charter	Satellite-derived; datasets/maps/reports only available after Charter activation	https://disasterscharter.org/web/guest/home
Various	Earth Engine Data Catalog	Collection of variety of standard Earth science raster datasets (public data catalogue)	https://developers.google.com/earth-engine/datasets/catalog/

Source: Authors' compilation.

Figure 2.5 Geographical distribution of climate-related risk in Jamaica

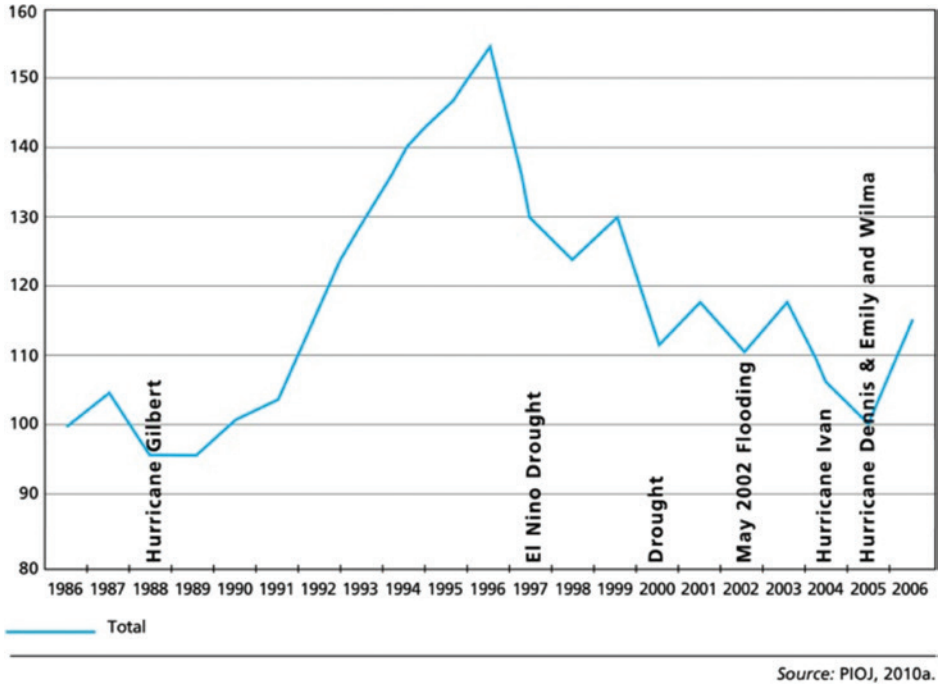


Source: FAO 2013, as sourced from Caribbean Catastrophe Risk Insurance Facility (CCRIF).

climate-related activities such as tourism and agriculture, and where weather-related hazards dominate past disaster events, understanding the availability and relevance of such climate information is essential in minimising disaster risks. Additionally, further to the awareness of available information and related services, it is also important to evaluate the usefulness of such climate information, rather than assume its feasibility for a particular region or context, to ascertain the appropriateness and relevance of use and context.

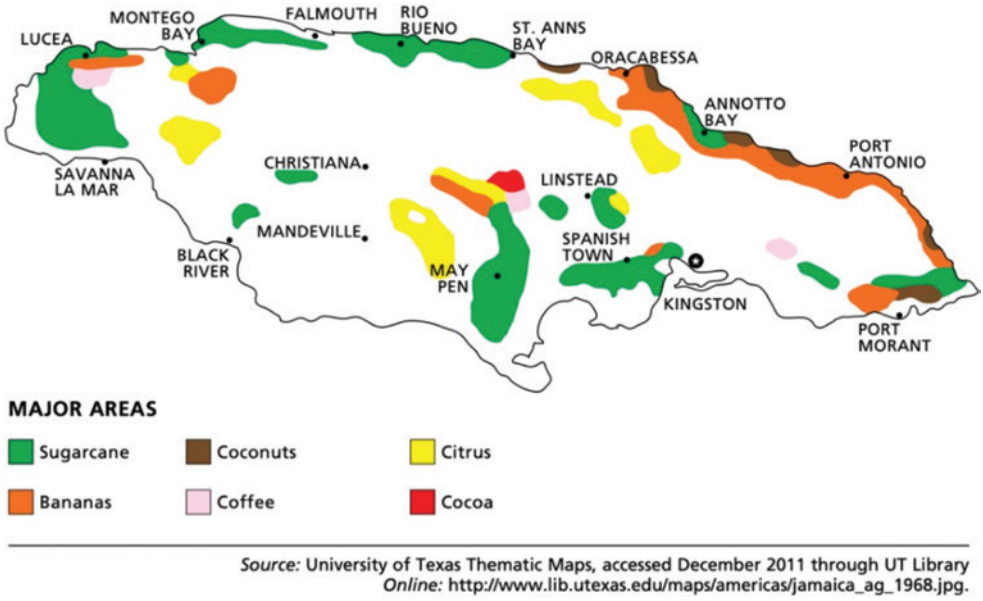
In addition to investing in public sector transformation and encouraging private sector-led growth, and focusing on infrastructural needs in times of disaster response, 'fixing' policy and governance directives to ensure resilience should also be a priority. In a review of climate services governance structures in Jamaica, Kruczkiewicz et al. (2018) highlight challenges to using agro- meteorological climate products and services in the country, including unclear funding to support development of the products, unclear co-ordination, consistency and leadership, in addition to the unavailability of a formalised mechanism to acquire, categorise and effectively utilise feedback on promoted data products (although informal sources may exist).

Figure 2.6 Agricultural Production Index (API) and major events in Jamaica, 1986–2006



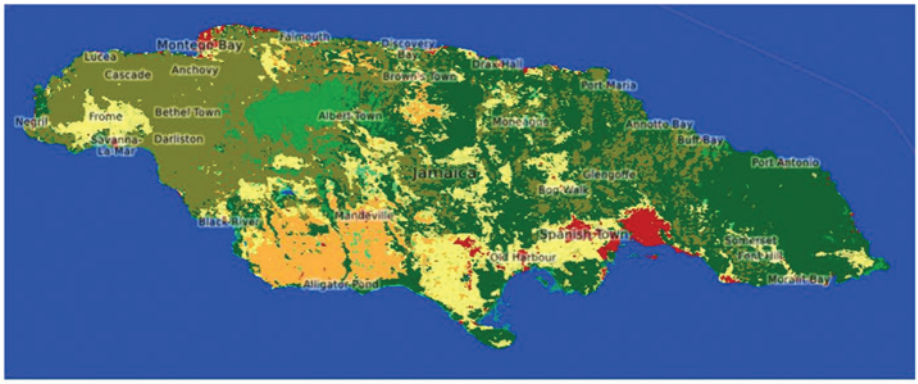
Source: FAO 2013, as sourced from Planning Institute of Jamaica (PIOJ).

Figure 2.7 Spatial distribution of crops in Jamaica



Source: FAO 2013, as sourced from University of Texas.

Figure 2.8 Land-cover distribution in Jamaica, using ESA Climate Change Initiative datasets



Label	Color
No Data	
Cropland, rainfed	
Herbaceous cover	
Tree or shrub cover	
Cropland, irrigated or post-flooding	
Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	
Tree cover, broadleaved, evergreen, closed to open (>15%)	
Tree cover, broadleaved, deciduous, closed to open (>15%)	
Tree cover, broadleaved, deciduous, closed (>40%)	
Tree cover, broadleaved, deciduous, open (15-40%)	
Tree cover, needleleaved, evergreen, closed to open (>15%)	
Tree cover, needleleaved, evergreen, closed (>40%)	
Tree cover, needleleaved, evergreen, open (15-40%)	
Tree cover, needleleaved, deciduous, closed to open (>15%)	
Tree cover, needleleaved, deciduous, closed (>40%)	
Tree cover, needleleaved, deciduous, open (15-40%)	
Tree cover, mixed leaf type (broadleaved and needleleaved)	
Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	

Label	Color
Mosaic herbaceous cover (>50%) / tree and shrub (<50%)	
Shrubland	
Evergreen shrubland	
Deciduous shrubland	
Grassland	
Lichens and mosses	
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	
Sparse tree (<15%)	
Sparse shrub (<15%)	
Sparse herbaceous cover (<15%)	
Tree cover, flooded, fresh or brakish water	
Tree cover, flooded, saline water	
Shrub or herbaceous cover, flooded, fresh/saline/brakish water	
Urban areas	
Bare areas	
Consolidated bare areas	
Unconsolidated bare areas	
Water bodies	
Permanent snow and ice	

Source: European Space Agency Climate Change Initiative land-cover datasets are satellite-derived and freely available at: http://maps.elie.ucl.ac.be/CCI/viewer/. It should be noted that current data on land cover, as created by Jamaica's Forestry Department, may not be as freely accessible.

As such, 'the efficacy and reliability of the [agro-meteorological climate] bulletins thus remains unknown and contributes to the persistence of a gap between user perception and producer perception of value. This holds true for both value of the information and functionality of dissemination modalities'. This challenge of limited governance structures must be addressed if the country is to encourage the effective utility of climate information use/services for a wide range of benefits.

2.4.3 Using climate information for DRR in Jamaica

Like in many other SIDS, the largest part of Jamaica's GDP (roughly 90%) is generated close to its 1,200km-long shoreline, in which also agriculture, fishery and tourism are concentrated. According to USAID (2018), it is also particularly these areas that have been struggling with the impacts of hydro-meteorological extreme events. Droughts, floods and tropical storms have affected not only agriculture, fishery and tourism, but general water supply, and energy and transport infrastructure. Long-term below-average rainfall has led to the country's dependence on groundwater, whereas issues like the seawater intrusion of aquifers have further diminished the freshwater supply for drinking water and irrigation purposes. In addition, health issues that are related

to extreme climate events and rapid urbanisation (e.g. Leptospirosis) are on the rise (Peters et al. 2017).

Climate projections related to sea-level rise (0.4 to 0.7 meters until 2090), increasing average temperatures (1 to 1.4°C until 2050), an up to 7.2 per cent decrease in average annual precipitation and an increase in consecutive dry days by up to 15 per cent until 2050 (USAID, 2018), led to the development of a long-term National Development Plan (Planning Institute of Jamaica 2009) and a Climate Change Policy Framework (Government of Jamaica 2015). This study aims to discuss the role of available weather, climate and emergency data and how they can be translated into actionable knowledge via research-based approaches to strengthen overall resilience, early warning and early action. We focus particularly on the use of publicly available weather/climate monitoring/forecasting data/services, which can be used individually or combined to cover key elements of the hydrological cycle.

While research on climate data and services has made good progress in recent decades, their operational use is limited in Jamaica for a variety of reasons. First, the island's topography and geography tend to increase errors in datasets, which, if not handled properly, can propagate into data-driven services and decision-support systems. Second, data, services and decision-making workflows seem decoupled, partly due to unclear responsibilities, lack of training, staff and funding for the adaptation of existing products, and the non-existence of formal feedback mechanisms between data/service providers and users/responsible agencies. Third, there are large gaps with regard to records of historical impacts related to extreme weather and climate events, which impede the calibration of monitoring and forecasting systems as well as the services that depend on these data. Despite the existence of low-cost, low-effort mobile data collection tools, socioeconomic data and records of risk perception, if available at all, are generally decoupled from climate information. Fourth, financial instruments, such as the existing tools of the CCRIF SPC (formerly the Caribbean Catastrophe Risk Insurance Facility; see: https://www.ccrif.org/), are neither optimised for SIDS like Jamaica, nor capable of supporting the required level of coverage after major droughts or hurricanes. This is particularly critical, because Jamaica will likely face more frequent droughts and more intense hurricane events (Government of Jamaica 2015). Fifth, while drought maps and other drought-related information exist (see, for example: https://www.jamaicaclimate.net/drought-forecast-map/), there are uncertainties regarding the operational uptake of such information, potentially limiting its added-value for communities at risk. In addition, Jamaica's drought monitoring system is largely based on the Standardised Precipitation Index (SPI). This might leave critical gaps with regard to impacts caused by extreme temperatures (and related increases in evapotranspiration), which can equally lead to crop failure, or socioeconomic information to contextualise the climate hazard based on up-to-date profiles of vulnerabilities and coping capacities.

As mentioned, Table 2.2 represents a non-exhaustive list of datasets, data portals, services, tools and knowledge platforms that can be used in the context of climate-related disaster risk management. In the context of drought risk management, we suggest the consideration of multiple standardised datasets that can be combined to

enhance the spatiotemporal understanding of atmospheric/land-surface anomalies (Enenkel et al. 2018; Enenkel et al. 2019), along with information about socioeconomic conditions, updated at high temporal frequencies (ideally sub-monthly). Satellite-derived estimates of rainfall, (root-zone) soil moisture, land-surface temperature, and evaporative and agricultural stress are available free of charge, with an acceptable timeliness, spatial and temporal resolution (for drought monitoring). Usually, different drought types do not appear in parallel. As a consequence, rainfall can be used to keep track of atmospheric deficits (watch level), soil moisture and/or evapotranspiration to monitor anomalies related humidity on the land surface (warning level) and vegetation health estimates to detect agricultural impacts (Sepulcre-Canto et al. 2012; Enenkel et al. 2016). The same approach could be used to strengthen financial instruments like Weather Index Insurance (WII) or Risk Contingency Credit (RCC), which depend equally on the accuracy of drought hazard information, agricultural parameters (start of season, type of crop planted, etc.) and knowledge of risk perception that guide management decisions. Free software packages/mobile apps for georeferenced, low-cost, low-effort, socioeconomic data collection are available (see, for example: https://www.kobotoolbox.org/).

In addition to building capacities to exploit the added-value of existing and new weather, climate and emergency data via dedicated projects, one of the most promising short-term approaches might be to enhance existing drought monitoring strategies, which rely mainly on rainfall estimates (SPI), with state-of-the-art satellite-derived estimations of soil moisture and vegetation greenness as a proxy for vegetation health. Standardised environmental variables could be weighted via the integration of socioeconomic information to avoid the underestimation of subsequent moderate drought events or to highlight areas in which other factors than climate might influence agricultural production (e.g. pests). Integrating information about changes in livelihood conditions via incentivised mobile data collection strategies can result in two major advantages. First, smart incentives help to limit 'strategic reporting'. Second, mobile devices serve as a two-way communication channel. They can be used to communicate added-value information, such as drought hazard data contextualised with information about livelihood conditions, back to data suppliers in affected communities. In parallel, the SPI, which is operationally produced by the Caribbean Agro-Meteorological Initiative (CAMI) programme, can be forced with observed and sub-seasonal forecasts of the same variable (rainfall) (e.g. see IRI 2019a). An initial test at the International Research Institute for Climate and Society (IRI) with seasonal rainfall forecasts has already been successful (see IRI 2019b). Realistic scenarios can help users to integrate such new drought monitoring and forecasting into existing decision-making frameworks.

2.5 The way forward

The essence of this chapter is to highlight the nature and potential role of using climate information for strengthening disaster risk reduction and resilience efforts in small states. Enhanced awareness and use of a wide range of weather- and climate-related information, most of which is freely available, can empower small states with data to

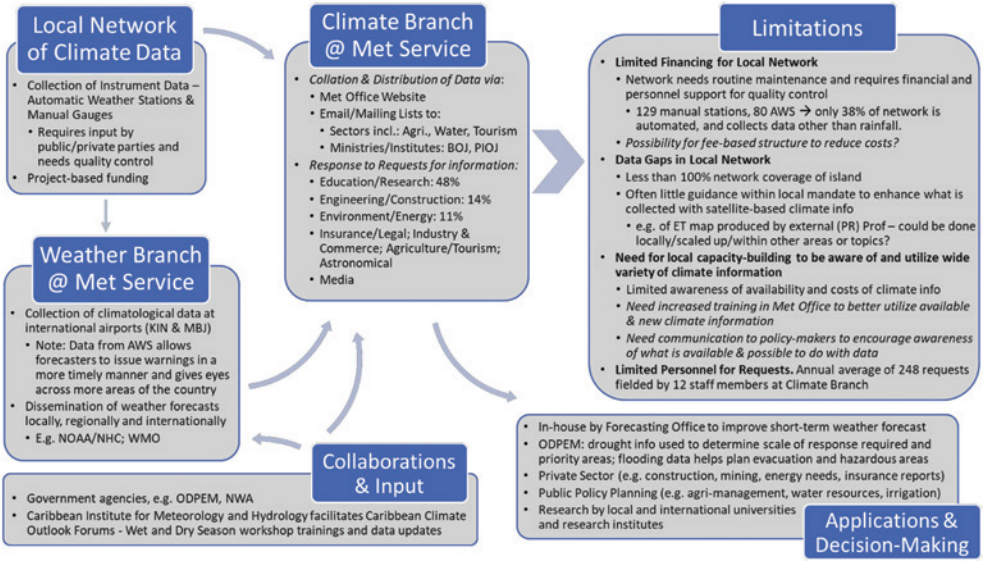
make appropriate and impactful decisions towards advanced disaster preparedness, disaster risk reduction and future resilience.

In the previous section, we have highlighted how some of the sources offered in Table 2.2 could be practically used in the context of Jamaica, but this is certainly applicable to other island nations within and outside of the Caribbean. For example, in the case of drought risk management, we suggest the consideration of multiple standardised datasets that can be combined to enhance the spatiotemporal understanding of atmospheric/land-surface anomalies and, if this information could be further combined with socioeconomic details of changes in livelihood conditions, it would create a richer dataset for targeted disaster preparedness and response. A potential follow- up study, in collaboration with the Climate Branch of the Jamaica Met Service, could specifically focus on the nature of this data, the applicability to a variety of small states, as well as the practical steps that countries could take in utilising this resource.

The list of climate information sources within Table 2.2 is not an exhaustive one and we will work to update this list and share with relevant parties within the Caribbean, including the Climate Branch of the Jamaica Met Service and also the Caribbean Institute for Meteorology an Hydrology (CIMH), which is based in Barbados and convenes biannual Caribbean Climate Outlook Forums. While we are mindful that new and updated climate information is already shared within these forums, collaboration with CIMH could help to ensure that countries are routinely aware of which data product or existing climate service may be most appropriate and relevant for specific disaster risk management activities. This may require additional regional and/or local validation efforts to evaluate the spatiotemporal characteristics, local utility and feasibility of climate information, as well as capacity building with a focus on the integration of climate data into existing decision-support workflows.

However, as previously mentioned, limitations arise not only at the data level, but also in terms of technical capacities, awareness of free datasets, data processing and storage, and/or trained personnel. To better understand this, Figure 2.9 illustrates the climate information flow to and from the Climate Branch of the Jamaica Met Service. As shown, while the branch does its best to collect and share weather- and climate-related information, there are various challenges which persist and prevent further effective utility of climate information. A salient front-burner challenge faced by the Climate Branch of the Jamaica Met Service is that of the fundamental awareness of the climate information sources, by the office itself but also within various disaster and governmental agencies. There is often little guidance within the local mandate to enhance what kind of knowledge is derived from satellite-based climate information. We highlight the need to connect science and policy-making through the encouragement of workshops involving a wide variety of stakeholders, including decision-makers and those affected by a wide range of disasters, to become better aware of information flows and needs. Climate scientists should continue to work with local partners to better utilise freely available sources as needed. This could stimulate the drive for demanding improved sources of information and, in so doing, enhanced hydromet service delivery.

Figure 2.9 Schematic of flow of climate information to/from Climate Branch of Jamaica Met Service



Source: Authors' compilation and design.
Note: AWS: Automatic Weather Station; BOJ: Bank of Jamaica; PIOJ: Planning Institute of Jamaica; NHC: US National Hurricane Center; NOAA: US National Oceanic and Atmospheric Administration; NWA: National Works Agency (Jamaica); ODPEM: Office of Disaster Preparedness and Emergency Management (Jamaica); PR: Puerto Rico; WMO: World Meteorological Organisation.

In addition, we have noted that Jamaica has been making strides towards action on climate change: the Climate Change Policy Framework for Jamaica was adopted in September 2015 (GOJ 2015), and work is currently underway to develop and implement the action plan.[4] As well, the Ministry of Economic Growth and Job Creation (created in March 2016 due to a change in political administration) has a vision to drive economic growth and sustainable development for the country, and climate change is listed as a critical portfolio activity and headlines a core division of this ministry, alongside divisions of Environment and Risk Management, and Development Planning Policy and Monitoring.[5] It would be vital to share this work with these divisions to holistically encapsulate the wider potential for using climate information for disaster and climate risk management and resilience-building.

To assist this, we highlight the work of World Bank-related projects such as the Climate Risk and Early Warning Systems (CREWS) initiative and the Small Island States Resilience Initiative (SISRI), which are aligned to the Global Facility for Disaster Reduction and Recovery (GFDRR) and which may be pivotal in assisting such development, if it is particularly requested. Another suggestion in this regard could be a possible collaboration with NASA's Applied Remote Sensing Training (ARSET) programme, which provides in-person and online trainings focusing on the access and applications of remote sensing observations for disaster management (see: https://arset.gsfc.nasa.gov/disasters). Their webinars, such as 'Remote Sensing

for Disasters Scenarios' which focuses on the applications of remote sensing for tropical storms, floods, earthquakes and landslides, could be quite useful for regional colleagues, and we would advocate for a course specifically tailored for the Caribbean region.

However, we note that data gaps in the network, limited financing to maintain the network, and limited personnel and technical capacity to better respond to queries of information, can hinder the potential of sourcing and connecting localised information to satellite products to enhance the base of information. Claiming that data should be 'better' utilised is not enough if neither the infrastructure, nor the staff or the technical capacities, exist. On the one hand, Jamaica would benefit from dedicated resources to translate existing data/services into decision-support tools or to combine them into new ones. On the other hand, it is also up to data/service providers to update users about the strengths and limitations of their products. Both bottom-up and top-down approaches will be required to strengthen Jamaica's capacities to mitigate the impacts of climate change, communicate early warning information to communities at risk as timely and comprehensibly as possible, teach these communities how to use climate information in the face of uncertainties, and to link quantitative climate information to qualitative socioeconomic assessments about risk perception, agricultural practices or (traditional) coping capacities.

In the context of disaster risk reduction and strengthening resilience, a focus on climate information complements initiatives linking finance and investment, developing technology, improving infrastructure, and promoting environmental governance. Empowering the region with such knowledge could be an essential step towards ensuring local awareness of disaster risks and what could realistically be done with current capacity, signalling leadership and capacity to where assistance is needed, and encouraging dialogue and co-operation to effectively strengthen DRR, minimise disaster and climate risk, and foster resilience.

Notes

1 It should be noted that the EM-DAT database includes all disasters from 1900 until present which fit at least one of the following criteria: 10 or more people dead; 100 or more people affected; declaration of a state of emergency; call for international assistance.

2 The direct contribution of travel and tourism to GDP reflects the 'internal' spending on travel and tourism (total spending within a particular country on travel and tourism by residents and non-residents for business and leisure purposes), as well as spending by government 'individual' spending – i.e. government spending on travel and tourism services directly linked to visitors, such as cultural (e.g. museums) or recreational (e.g. national parks) services (WTTC 2018).

3 The total contribution of travel and tourism includes its 'wider impacts' (i.e. the indirect and induced impacts) on the economy. The 'indirect' contribution includes the GDP and jobs supported by: travel and tourism investment spending; government 'collective' spending; and domestic purchases of goods and services by the sectors dealing directly with tourists. The 'induced' contribution measures the GDP and jobs supported by the spending of those who are directly or indirectly employed by the travel and tourism industry (WTTC 2018).

4 See: https://jis.gov.jm/govt-driving-climate-change-policy/ (accessed 28 April 2019).

5 See: https://megjc.gov.jm/divisions-and-branches/ (retrieved 28 April 2019).

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Chapter 3

#Betterfit# Building Resilience Through Information and Communications Technologies: An E-resilience Approach for Small Island Developing States

Ankie Scott-Joseph

Abstract

Financing for disaster risk reduction has increased significantly. The United Nations Environment Programme's (UNEP)2014 *Adaptation Gap Report* estimates the cost of adaptation alone will increase to US$200 –300 per annum by 2030. However, increasing the overall funding volume does not guarantee that countries are better prepared to cope with climate change and natural disasters in general. Access to climate finance is a prerequisite for addressing the unavoidable impact of natural disasters, but what is more critical is how that finance is spent to impact change. Governments across the globe have been making substantial commitments to reduce disaster risk and need to find more effective ways to maximise the finance. Globally, there is a growing awareness of the importance of information and communication technologies (ICT) for disaster risk reduction (DRR). Experience from the Caribbean and around the world has proved that disaster risk reduction and preparedness are far more effective and less costly than response, relief and recovery efforts. An approach that allows countries to enhance their capacity to withstand, adapt and recover from natural disasters through ICT is therefore, a useful one.

The objective of this chapter is to assess the use of ICTs in the early stages of the disaster lifecycle, particularly for disaster risk reduction (DRR) and disaster risk management (DRM) and for building e-resilience[1] in small island developing states. This study puts forward a discussion that heavily promotes the use of ICT as a preventative mechanism. Platforms for enhancing the education levels of disaster risk of the most vulnerable societies – children, women, people with disability – are highlighted. Strategies such as 'e-education for resilience', 'trash tracker', 'blocked drains trackers', microchips to immediately shut off electricity in floods, hurricanes, and other natural disasters, are presented. Financing structures have in some way been too focused on risk transfer and retention and not sufficiently on DRR. Governments urgently require technical support within the planning phase, which includes equipping their citizens and tools to build e-resilience.; that is, they need technical support for the utilisation of ICT to boost societal resilience to natural disasters.

Most studies have focused on the use of technology as a mechanism to assess the effects of a disaster, that is, after the event has occurred. Essentially, the efforts linked to ICT have been directed fundamentally to financing for the monitoring strategies: namely, conventional communication tools (radio, television, etc) and non-conventional forms of communication (Facebook, Twitter etc) have been useful. Communications networks often become congested with exceptionally high levels of data traffic during and after a disaster. It is therefore critical to promote the use of ICT at the mitigation stage of the disaster lifecycle. However, for effective DRR, an integrated communication system is indispensable at all stages of the disaster lifecycle.

3.1 Introduction

Small island developing states (SIDS) are exposed to most categories of natural hazards. Twenty-one (21) of the 39 countries and territories officially recognised as SIDS by the United Nations Department of Economic and Social Affairs (UNDESA) are among the global top 50 most vulnerable countries (IMF 2016). Haiti was identified in the 2016 Climate Risk Index reports as the country most affected worldwide by extreme weather events. It recorded losses in gross domestic product (GDP) of an estimated 7.24 per cent and associated death of 5.56 per 100,000 inhabitants (Eckstein et al. 2018). Hurricane Maria devastated the US Virgin Islands (Saint Croix), Puerto Rico, Guadeloupe, Martinique and the Eastern Caribbean island of Dominica on 20 September 2017.It was the strongest hurricane on record to strike Dominica: the island suffered damages amounting to 226 percent of GDP. It destroyed crops, disrupted power, water supplies and caused landslides that blocked roadways (Reliefweb 2018)

The greater exposure has high macroeconomic implications for SIDS, development challenges and leads to a volatile revenue base. Between the years 1950 and 2014, an estimated 460 disasters occurred in SIDS. This coincided with an approximate cost equivalent of 13 percent of GDP on average for small states, compared to less than 1 percent of GDP for larger states (IMF 2016).

Some countries lack sufficient access to knowledge and information that would allow a wide cross-section of society to participate in disaster risk management and the public sector to improve the outcome of disaster risk reduction initiatives. Information and communication technologies (ICTs) provide a fundamental solution. Modern ICT infrastructure can potentially contribute to a transformation in disaster resilience. Increased access to knowledge and information via the internet and other telecommunication technologies can help accelerate efforts by inducing knowledge. This requires access to finance to build technological capacity, create knowledge and disseminate information. Global commitments to climate finance are increasing through investments in low-carbon and climate-resilient growth, renewable energy, early warning systems and climate-smart agriculture investment plans. Financing structures have in some way been too focused on risk transfer and retention and not sufficiently on DRR.

Governments urgently require technical support within the planning phase, which includes equipping their citizens with tools to build resilience. Increasingly

large-scale investments in e-resilience are required to set SIDS on a more sustainable development path to address the unavoidable and worsening impacts of climate change. A critical addition to this agenda is financing for and integrating the use of ICTs. Governments must make substantial commitments to reduce disaster risk through the use of ICT, as ICTs can instantaneously connect large networks of individuals and organisations across geographic distances, to facilitate fast flows of information and ideas. In particular, computers, the internet and mobile phones have become essential tools for collaboration. There is the potential to reduce disaster risk through early warnings, co-ordinating resources, recording and disseminating knowledge and experiences, through online learning tools that make use of the internet, and multimedia technologies to impart DRM and mitigation knowledge. One example is the World Bank Institute's distance learning programmes on DRM, including courses on mitigation topics such as 'Safe Cities', 'Community-Based Disaster Risk Management' and 'Risk-Sensitive Land-Use Planning'. Another example is the role of social media to help raise awareness, attract volunteers and facilitate crowd funding, as well as publish on-the-spot citizen reporting. Examples of applications of ICT includes text messages being disseminated to warn of disasters.

Globally, there is a growing awareness of the importance of information and communication technology (ICT) for disaster risk reduction, but the emphasis has been on utilising ICT to develop early warning signals and mechanisms to support disaster response and recovery efforts. Experience from the Caribbean and around the world has proved that disaster risk reduction and preparedness are far more effective and less costly than response, relief and recovery efforts. as. ICTs can instantaneously connect large networks of individuals and organisations across geographic distances, to facilitate fast flows of information and ideas.

3.2 Theoretical framework

Particularly important in the context of e-resilience are the links between the disaster lifecycle, public expenditure management, governance, information management and communication, and disaster risk reduction. The influence of public expenditure management shows climate financing tends to be spent on the provision of goods, services and regulation, both directly and indirectly. Funding is limited, hence, governments must minimise costs and maximise the use of their resources. Poor financial management could have serious repercussions for a government's efforts. The effective and efficient use, as well as distribution, of resources prior to, during and after a disaster is therefore critical to managing financial risk. This implies that new and innovative approaches –such as the use of ICT – must be considered. Ideally, this can help support climate and disaster resilience and ensure the citizens' welfare is met optimally.

3.2.1 Risk reduction and disaster lifecycle

Disaster risk management (DRM) and disaster risk reduction (DRR) have emerged as systematic approaches that are broader in application than climate, but are relevant to climate hazards. The primary focus of disaster management is to prevent disasters

whenever possible or to mitigate those which are inevitable. The disaster lifecycle is an ongoing process that focuses on designing and implementing a sequence of strategies that can be used to reduce or avoid the potential losses from hazards, assure prompt and appropriate assistance to victims of disaster, and achieve rapid and effective recovery. The entire disaster management cycle includes four phases: mitigation, preparedness, response and recovery.

According to UNISDR, disaster-risk management is the systematic process of using administrative directives, organisations, and operational skills/capacities to implement strategies, policies and improved coping capacities; in order to lessen the adverse impacts of hazards, and the possibility of disaster. Disaster management focuses on the organization and management of resources and responsibilities to address all aspects of emergencies and disasters; including preparedness, response and initial recovery steps. While emergencies are events that can be managed with local resources, disasters are by definition those events that surpass the responders' capacity on the ground to manage them locally, hence requiring external assistance to be managed. Emergency and disaster management encompass three types of phases: response, rehabilitation and recovery[2]. Preparedness: planning how to respond includes the set of activities and precautions that a community collectively takes before a disaster occurs in order to reduce the impact of a hazards and to cope with its effects.

- Response: the implementation of strategies to minimise the hazards created by a disaster and the recovery phase.
- Mitigation: implies minimising the effects of disaster or the reduction of risk of any disaster or its severity or consequences.

Researchers have developed a number of models to evaluate the impact of disaster management (DM). The models generally fall into four categories (Churilov et al. 2006): logical, integrated, cause and other. There are two phases of the logical DM models: the pre- and post-disaster. The pre-disaster is subdivided into prevention, mitigation and preparedness while the post-disaster is subdivided into response, recovery and rehabilitation. The main objective of emergency preparedness programmes is to achieve a satisfactory level of readiness to respond to any emergency situation through programmes that strengthen the technical and managerial capacity of government organisations and communities. These measures can be described as 'logistical readiness'.

The second category is the integrated models. An integrated model assesses how activities are organised to ensure effective and efficient implementation. Four elements are explicitly considered in this type of model: hazard assessment, risk management, mitigation and preparedness. Cause models do not consider stages, but suggest that there are some underlying causes of disasters. An example is 'The Crunch' model, which proposes a frame to understand the causes of a disaster (ADPC 2000; Cannon 2004; Heijmans 2001; Marcus 2005). This model is based on the belief that there are some factors that affect the vulnerability to disasters by mainly highlighting components at risk, such as lives and properties of humans, the environment and infrastructure. The 'other' category is a combination of the logical, integrated and cause models, for instance the Cuny model (Cuny 1998).

3.2.2 Public expenditure management and governance

Natural disasters can cause significant budgetary pressures, with both short-term impacts and long-term fiscal implications. Public resources are severely limited in capacity, but government can factor mitigation activities into its budgetary process and allocation to help lessen the financial impact. This can be achieved through public expenditure management (PEM) – the processes and procedures used when governments raise revenues, allocate, spend and account for public funds (Đurović-Todorović, J., Vuković, M. 2016).

Disasters themselves can trigger changes in policy that affect budgetary outcomes. Temporary adjustments in fiscal policy may be necessary to prompt fundamental changes. Governance problems can weaken a government's capacity to manage fiscal policy. Traditionally, the role of public expenditure management systems was purely to provide mechanisms for financial control. This has evolved into a budget process that is affected by governance: i.e., the behaviour of the government in relation to how its budget is governed, formulated and executed. A key PEM rule is to use the appropriate scope for public expenditure alongside private expenditure when deciding how to allocate public finances.

Without fiscal discipline, it is impossible to achieve effective prioritisation and implementation of climate and disaster resilience policy and programmes. Fiscal discipline requires overall expenditure control, with expenditure estimates based on realistic revenue forecasts, and the capacity to set up fiscal targets and enforce them. The elements and main characteristics of public expenditure management systems are summarised in the: (i) positive theory of public expenditure, (ii) normative theory of public expenditure, and in (iii) two behavioural hypotheses: the Wagner hypothesis and the Peacock-Wiseman hypothesis.

The positive theory of public expenditure focuses on how government policies affect the economy. This approach attempts to establish any cause-and-effect relationships or behavioural associations which can help ascertain expected outcome. It relies on objective description, quantification and explanation of economic developments, expectations and associated phenomena. By contrast, normative economics focuses on the ideological, opinion-oriented, prescriptive, value judgments and 'what should be' statements. Normative theory aims to summarise people's desires and focuses on how government policies should be designed to attain certain objectives. It promotes a management culture that is customer oriented and results focused. There is emphasis on the separation of policy-making from service delivery.

The Wagner hypothesis states that a cause-and-effect relationship exists between the growth of the economy and relative growth of public sector (Adil M. B., Ganaie A. A. & Kamaiah B., 2016). The main reasons for this tendency are social problems, expansion of traditional functions of the state, growth of population, urbanisation, rise in prices and national income. In addition to Wagner's law, another famous theory on the determinants of public expenditure is Peacock and Wiseman's 'displacement effect'. They hypothesise that government expenditure tends to evolve in a step-like pattern, coinciding with social upheavals, notably wars. Magazzino et al. (2015) suggested two

complementary approaches to the empirical analysis of public expenditure growth: factor analysis at the general econometric level and the development of models of group behaviour. Notably, decisions about public expenditure on different plans can be influenced by the political directorate, civil society or any aspect of the private sector that can pressure government. Hence, it is important to understand governance – the manner in which public expenditure is administered, accountability relations and how various actors impact government efforts to manage and reduce disaster- and climate-related risks.

Governance is generally understood to be rules, laws, regulations and policies that distribute roles and responsibilities among actors (Brinkerhoff and Morgan 2010). The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) defines governance as the 'process of decision-making and the processes by which decisions are implemented or not implemented'. The process attributes, including transparency, accountability and control of corruption, must be enforced. Poor governance can hinder the process and lead to unintended effects/outcomes. The implementation process must also be transparent enough such that the public can scrutinise public expenditure to minimise resource leakages. Knowledge is vital; ICTs can add value by increasing the country's capabilities to acquire, apply and create knowledge, with respect to PEM.

3.2.3 Information management and communication

The use of information and communication technologies (ICT) has emerged as an integral part of disaster risk reduction studies. It plays a valuable role in facilitating the different stages of the disaster management lifecycle, allowing countries to induce technological change, empower people and increase access to knowledge. CT can help build resilience during the mitigation stage of the lifecycle, help educate the public about disaster preparedness, check approaching hazards, collect information, and co-ordinate resource sand activities.

ICTs have been defined as any product that will store, retrieve, manipulate, transmit or receive information electronically in a digital form (Hughes et al. 2002). ICT provides access to relevant data and information that is first processed at an individual level and can facilitate communication and interaction between wide ranges of stakeholders. CT innovations are powerful tools that have the potential to help programmes for disaster reduction become more inclusive and sustainable. New ideas, concepts, processes and ways of doing things can be diffused through various communication channels (Rogers 2003, 5).

Radio, television, newspapers and magazines are the conventional ICT. New methods, such as computers, tablets, smart phones, cable television and satellite systems, enable the provision of other communication services that were once inaccessible or costly. Mobile phones allow individuals to take an active role in corroborating information with multiple sources. Mobile phones and tablets are more accessible than other alternatives in terms of cost, geographic coverage and ease of use. They allow users to obtain information immediately and on a regular basis, rather than waiting for radio broadcasts, newspapers or magazine.

Access to the internet, availability and affordability are essential to the development of ICT. Lack of connectivity prevents widespread use in many countries. Governments must work to reform tax and incentivise the private sector to develop high-quality, low-cost devices. There are groups in society that will not have access due to costs; therefore, public access via libraries, community centres and public Wi-Fi schemes is critical to deliver access to these populations.

Technology transfer can be explained as the process when technology, know-how or technical knowledge moves from one organisational setting to another (Bozeman 2000, 629). ICT can support numerous processes in the mitigation stage of the disaster lifecycle and this is an area where successful technology transfer may be critical. One way to understand the potential contribution is to recognise the usefulness of ICT as a tool for supporting human capital, financial capital and formal institutions. A powerful example is the use of ICT in education, training, public awareness and research.

3.3 Literature review

Generally, the literature indicates ICTs to be an invaluable tool in DRM as they have become essential for co-operation and collaboration UN Economic and Social Commission for Asia and the Pacific (2015a). Moreover, countries can benefit from reduced costs and fewer inconsistencies with the implementation of ICT. The revolutionary potential of ICTs resides in their ability to instantaneously connect immense networks of individuals and organisations across geographic spheres, and to facilitate a rapid stream of information, capital, ideas, people and products (Hanna 2011).

Conceptually, the literature notes that ICT can be an effective management tool to disseminate information and receive communication (Lindsay 2011; Rodriguez et al. 2007). It also argues that the provision of data can aid adaptation, decision-making and help gather information to conduct vulnerability assessments (Ospina and Heeks 2010b; Shabajee et al. 2014). The internet provides a useful platform. It facilitates opportunities to enhance the capabilities of risk management practices before, during and following emergency events. Web sites provide an increasing array of information.

A country's level of vulnerability can be influenced by the level of risk management, that is, its capacity to anticipate, cope with, resist and recover from the impact of a natural hazard (Wisner et al. 2004). Explicitly, in terms of the use ICT, its main roles are to educate the public about disaster preparedness, check for approaching hazards, alert authorities and the public, warn the public of the areas most likely to be affected, assess damage, collect and supply information and resources, co-ordinate resources and relief activities, and motivate the public and institutions.

In addition, the literature recognises that ICT can be enacted at all levels of the disaster lifecycle: mitigation, preparedness, response and recovery. During the mitigation

stage, ICTs can be a particularly useful tool to collect data; share knowledge; build models; provide geographic information systems (GIS); and prepare maps which illustrate areas that are at high risk for specific hazards, such as flooding and landslides. Individuals can mitigate disasters through the application of recent technologies, such as social media (Zemp 2010). Examples of social media include Facebook, Twitter and blogs. Social media have the potential to allow for greater participation of the population during the mitigation stage. For example, the platform can be used to gather ideas, opinions and information from the community about potential human-made factors/issues and actions, such as improper garbage disposal, that can increase the risk of blocked drains, floods and landslides. Through education, ICT is seen as a mechanism to raise awareness of climate-related risks and encourage and support participation in developing policies.

In the preparedness stage, ICTs can be used to facilitate the co-ordination of early warning systems, help predict the effect of the impact, and to position resources in locations where they will be most useful during the response effort. ICT innovation can be harnessed for early warning systems for flooding, resulting in timely evacuations. It can be used to alert the population of an impending disaster through a variety of technologies including mobile phones, ultra-high-frequency radio, warning sirens, and social and traditional media outlets United Nation (2010) argued that the existence of information alone is not sufficient to ensure its effective dissemination: an early warning information system does not guarantee of the activation of preventive mechanisms. It is therefore possible for communities in the path of a hazard to still remain vulnerable to taking no action until it is too late.

The capacity to take action is characterised by the presence of three main generic features: (i) the resources available to cope with exposure; (ii) the distribution of these resources (social and natural) across the system; and (iii) the institutions that mediate resource use and coping strategies (Adger 2005). These suggest that, in addition to ICT resources available in the pre-disaster stage are important. Experience from the Caribbean region and around the world has proved that disaster risk reduction and preparedness are far more effective and less costly than response, relief and recovery efforts. Communications networks often become congested with exceptionally high levels of data traffic during and after a disaster. It is therefore critical to promote the use of ICT at the early stages, building resilience. However, for effective DRR, an integrated communication system is indispensable at all stages of the disaster lifecycle.

The rehabilitation phase of the disaster management cycle may benefit from ICT to monitor, evaluate, and collect accurate and appropriate information that is required to perform damage and loss assessments, as well as for decision-making regarding recovery and reconstruction. Wastell and White (2013) refer to ICT intervention as 'change levers'. This is partly because of an efficacy of information sharing on the platform of some ICT components, particularly mobile phones. Such effectiveness in information dissemination is required most in the event of a disaster to enable people to evacuate or take necessary precautions.

ICTs is recognised to be an essential component of the rescue and response phase to facilitate communication between the disaster office and emergency personnel, as well as with members of the public, the media and the government. The infrastructure can assist in responding to disasters by tracing missing people, linking donor groups and finding temporary shelters Wattegama (2007). Disaster recovery can occur through the use of different types of software that facilitate the gathering, analysis and storage of emergency-related data.

Mobile phones, tablets and the internet facilitate relief efforts, enable messaging and e-mail, and allow posting of digital photos on the internet, donation requests through websites, and electronic transfers in real-time information. Cloud computing services facilitate the sharing of information and documents among private and government organisations responding to catastrophic disasters; Since cloud applications are hosted at geographically dispersed locations, they are not at risk of going down if one of the facilities fails; hence they are more readily available and useful for catastrophic event response (Velev and Zlateva 2011). System architecture using cloud computing in DR has been explained by Pokharel et al. (2010). The researcher finds that the cloud offers high availability, high survivability, low unavailability and low downtime at little cost. Social media channels also allow for the transfer of information during a disaster; this ranges from individuals passing on warning information, to governments distributing real-time updates during an event Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2014). However, if the network is down this will not be possible.

Resilience systems are often viewed in terms of adaptive capacity (e.g., Beichler, S.A., Davidse, B.J., Deppisch, S. 2012). Resilient systems building is a process which must be framed as continual improvement (Maynard et al. 2011. ICTs cost money and will typically divert expenditure from other uses (e.g. Diga 2007). Countries must promptly mobilise finance to invest in dedicated climate-focused projects.

Between 2011 and 2014, the volume of concessional finance in support of climate and disaster resilience to SIDS nearly doubled, from USD 635 million in 2011 to USD 1.01 billion in 2014. While this shows that a considerable amount of financing has integrated climate- and disaster-risk considerations, it still accounts for a small fraction of overall concessional finance. Of the USD 5.7 billion in concessional finance committed to SIDS on average per year during this period, about 14 per cent explicitly supported efforts to enhance climate and disaster resilience (International Development Association, 2018).

By planning for a natural disaster, one can lessen the effects of the losses that inevitably occur. The World Bank allocates US$145 million per year to disaster risk management and climate adaptation – 22 per cent of its total funding to SIDS. In 2018, the World Bank provided US$20.5 billion in finance for climate action. Developed countries committed to jointly mobilise US$100 billion to climate finance per year by 2020, from public, private and alternative sources, to address the needs of developing countries. Thirty-five (35)SIDS are eligible for official development assistance (ODA) concessional finance used to support climate and disaster resilience (see International Development Association, 2018.

Concessional finance sources include bilateral donors, various multilateral organisations and global funds established specifically to finance climate and/or disaster resilience, such as the Least Developed Country Fund (LDCF), the Adaptation Fund (AF), the Climate Investment Funds (CIF) and the Green Climate Fund (GCF), among others. With concessional finance to SIDS as a whole shrinking and many SIDS at risk of losing access to it as they graduate to a higher-income status, enhancing the effectiveness of the provision and use of concessional finance from this multiplicity of sources becomes a priority. Countries can lower the cost of implementing disaster management systems through new technologies/ICT by utilising open data storage and open software solutions for disaster handling (Yap 2011).

The literature review highlights that ICT is any technology used to support information gathering, processing, distribution and use and is composed of hardware, software, data and communication technology (Beynon-Davies 2011). It also notes that diverse possibilities arise from the sharing of knowledge through ICT. More specifically, ICTs provide access to relevant data and information that facilitate communication and interaction between wide ranges of stakeholders, which can translate into actions being implemented. Access to information can promote flexibility through identification of alternative possibilities and knowledge sharing via web sites, social media and e-learning systems worldwide. ICTs and learning experiences from the field suggest the role of ICT-enabled skills and access to knowledge in enhancing the capacities of local actors and empowering marginalised groups (Labelle et al. 2008).

There are challenges with regards to the application of ICT to disaster risk management and reduction. Challenges revolving around the correct recipient of messages, congested networks (Jayakumari and Senthilkumar 2015).

The need for accurate databases for prediction of future disasters is critical to effective disaster risk reduction (Okada et al. 2012). To be successful, governments must plan and have access to the required resources prior to the occurrence of disasters, hence the integration of ICT in the mitigation state is essential.

3.4 Conceptual framework: An e-resilience approach for small island developing states

Floods are the most common natural hazard affecting small island developing state (SIDS) within the Caribbean region. They can exert substantial pressure and create disastrous situations in societies. In economic terms, floods account for approximately a third of all natural hazards in the world (Ahmad 2007). In the year 2018, floods affected the largest number of people, 35.4 million, including 23 million people in Kerala, India. They caused 2,859 deaths, including in India (504), Japan (220), Nigeria (199) and Korea DPR (151). In Asia and the Pacific, over the period 2000 to 2017, on average 5,424 deaths were recorded yearly as a consequence of flooding (UNISDR 2019).

Flooding is a natural and recurring event for a river or stream. It may result from heavy or continuous rainfall that exceeds the absorptive capacity of soil and the flow

capacity of rivers, streams and coastal areas. This may cause watercourses to overflow and channel onto adjacent lands. Human behaviour can influence flooding, but the most common causes of floods are climate related. Debris and land-use changes in particular have a direct impact on the magnitude and behaviour of floods. Therefore, ICT, more specifically, a social media type platform such as Twitter and Facebook, can be used to gather ideas, opinions and information from the community about potential human-made factors/issues and actions, such as fallen trees and landslides. Education through ICTs is a mechanism to raise awareness of climate-related risks. It also encourages and supports participation in developing policies.

Severe rains caused floods and landslides in Saint Vincent and the Grenadines, Saint Lucia, and Dominica from 23–25 December 2013. Nine deaths were recorded in Saint Vincent and the Grenadines and in excess of 500 people were affected; 237 were provided with emergency shelter (CDEMA 2014). Emergency funds of an estimated US$100,000 were made available to Saint Vincent and the Grenadines, Saint Lucia, and Dominica to provide for immediate needs, such as health and food supplies.

Floods cannot be prevented, but their devastating effects can be minimised. This conceptual framework, therefore, investigates the potential contribution of ICT as a disaster risk reduction strategy, primarily for minimising the impact of floods. The focus of the proposed framework is on e-resilience for floods during the mitigation stage of the disaster lifecycle. E-resilience can be seen as a system through which ICT interacts with a set of the resilience sub-properties, enabling the system to adapt to the effects of natural disasters/climate change.

The conceptual framework primarily discusses how ICT scan: enable swift access to information (collecting and sharing data) on floods; mobilise the required financial assets; strengthen social networks; and institute, facilitate and co-ordinate the actions needed for the system to withstand the occurrence – all through web-based applications. The framework views ICT as an adaptive process through its link with resources, institutions and structures. These serve as enhancements of the resilience sub-components: robustness, scale, redundancy, rapidity, flexibility, self-organisation and learning (Ospina and Heeks 2010b).The research presented in this chapter conceives ICT's contribution in terms of its effect on resilience sub-properties, flexibility, self-organisation and learning. These are exhibited in the proposed approach: the 'E-Flood Community System'.

3.5 Recommendation – the proposed approach

This research proposes the use of mobile technology to source and pool data through the E-Flood Community System. There are four (4) sub-components of the system: (i) Community-Tweet app; (ii) Adopt-A-Community; (iii) Flood-Tracker app; and (iv) Edu-Flood. Each sub-system solves a particular issue within the context of tapping into citizens to help deliver better services at a lower cost. Evidence-based decision-making creates real value, both financial and non-financial, for citizens. Done right, it allows government to assess policy and programme effectiveness, measure progress and engage in a more rational public debate. Mobile communication technology is

best suited to provide an integrated system solution for flood management at the mitigation stage. Mobile communication technology includes various types of technologies, such as GSM, GPRS, wireless LAN, satellite communications and devices such as cellular phones, global positioning systems (GPS) and Bluetooth-enabled devices.

3.5.1 Community-Tweet app

The basic concept of the Community-Tweet app is an electronic application/program that runs on mobile devices, such as smart phones or tablet computers, which allows users to post messages containing text, photos and/or video. The main aim is that the app will allow users to collect and share real-time information on examples of flood triggers, the location, size and type of debris such as plastic bags caught on banks, in trees and rivers, and other related suspicious activities.

Data can then be uploaded via the 'Community-Tweet app' and transferred automatically to various operation centres controlled by government, thus allowing policy-makers to track and control impending damage, identify trash sources, prioritise management areas and elect control measures. Mobile phones can provide cost-effective strategies. Data is an under-exploited asset. It is clear that the use of data has the potential to enhance productivity growth across SIDS, whether by fostering new processes or even enabling entirely new models. The idea is to solicit citizens input to improve public services. In this regard, community-based groups can be targeted as the main source point to collect and share data/information on noted flood triggers.

The system focuses on monitoring water level and speed remotely using wireless sensors such as ultrasound and pressure sensors. The ultrasound sensor measures the distance between itself and the surface of water. The sensor emits ultrasonic waves, which rebound in the water and provide the system with the distance between the node and the water. Pressure transducers are often the most effective level sensors, since debris can damage the sensor. Sensor devices and web server monitoring systems must be interconnected with wireless connection using Wi-Fi. Warning systems can be deployed with solar panel power and can use mobile cell networks or Wi-Fi to upload sensor information to the cloud. Level readings trigger alarms when flood water passes a designated threshold.

The system consists of three connected functions: water-level sensing; data interpretation, and communications. During a flood event, the rising water level is detected by a sensor placed at a predetermined level in the stream.

Moreover, the information collected from the tweets can be used to select locations to install 'blocked drains trackers'. These microchip sensors should be placed in strategic places. Microchips should also be installed in the homes of the most vulnerable communities to ensure utility service providers can immediately shut off electricity in flood crisis situations. A community armed with this kind of real-time data can move more quickly to prevent flash-flooding, which represents an increasing threat to property, infrastructure and the environment.

This proposal is assumed to be relevant, as implementing internet-based services and other technological service delivery applications may better enable governments to meet their service delivery goals (Alliance for Integrity 2018).In particular, encouraging community groups' participation creates greater engagement and empowerment of citizens and provides new opportunities. Enhanced service delivery and communication with citizens in turn helps to create speed and accuracy of information and reduces search costs, i.e. the costs government may have to incur to investigate activities in communities. Community-centred interest groups are influential as they voice their concerns in the media; they also lobby politicians and seek access to bureaucrats. In these pursuits, they may raise awareness about issues to motivate policy-makers and individuals to pay attention to societal concerns and issues. The Community-Tweet app proposal can improve knowledge concerning the extent and evolution of floods and water-related problems. If properly implemented and managed, it can be as successful as the New York City 311 system (see Case Study 1).

The Community-Tweet app (CTA) approach differs from the 311 non-emergency approach in various ways. First, 311 is a call-centre centric approach, whereas CTA is a web-centred approach. Second, CTA focuses on collating information specifically on mitigating against floods and landslides; third, CTA concentrates on activities within communities that can create hazards, debris, deforestation, blocked gullies, drains etc. Fourth, the proposed CTA is geared towards motivating community groups to participate and facilitate information exchange between community groups, the private sector and government, whereas 311 is geared towards individuals. The control centre should have a web portal and a social network with the group of people in the areas. Communities can be better informed more quickly through online social networking.

Case Study 1: New York City 311 application

New York City 311 is a centralised customer service centre for persons in New York to access non-emergency municipal services. The service is available 24 hours a day and seven days a week and allows callers to find information about services, make complaints or report problems, such as graffiti or road damage. On average, NYC 311 handles more than 20 million calls per year. New York City's 311 call centre was upgraded to integrate social media, mobile applications and texting access, to keep up with the evolving world of technology and increase efficiency. The New York City system allows the use of social networking sites, such as Facebook and Twitter, a micro-blogging service provider, allowing customers to send pictures of potholes or videos of vandalism and graffiti. Users can also see service requests marked on a map.

A mobile app is also available for download for Android or iOS operating systems that allows them to easily find government services or report service requests to 311. Three-one-one (311) systems were initially established to help alleviate the 911 congestion that resulted from high volumes of non-emergency calls, such as complaints about potholes, fallen trees, noise complaints and street or traffic signals

not working. Non-emergency calls to 911 can delay the delivery of emergency services, causing backlogs and inefficiencies for law enforcement.

In 2013, the City of New York through the Department of Information Technology and Telecommunications and the 311 Customer Service Centre lobbied for an integrated systems integrator to replace and re-architecture the incident-oriented Customer Service Management System. The aim was to create a more customer-centric, cost-effective and extensive system that offered all of the functions required to organise customer data and facilitate communications between city staff and customers. The system provides a cloud solution and an on premise solution. A critical success factor of NYC311 is the adoption of a new technologies app. Twitter is seen as a proactive tool: for example, sending out daily Tweets about alternative parking on side streets.

3.5.2 Adopt-A-Community

The Adopt-a-Community seeks to encourage companies/business/firms to sponsors communities to improve their access to the internet/ICT recourses.

While the government's responsibility is to collect, track and act on service requests from citizens. Its efforts are characterised by a digital divide, due to highly unequal access to and use of ICT, which manifests itself both at the international and domestic levels. An e-government approach can fail from the standpoint of gaining access to relevant information and service delivery (Department of Information Technology, 2015 and UN, 2010c) since, among others, segments of the population may not have access to internet-based applications simply because they do not have web access and web-related skills. E-government is a broad term that is generally understood to refer to 'the use of ICTs to more effectively and efficiently deliver government services to citizens and businesses' (UNDESA 2017).

The digital divide can be narrowed down to the effect and focus of utilising ICTs. Remote sensing and satellite systems and services remain costly and unaffordable for many countries. A number of collaborative initiatives, such as the Global Earth Observation System of Systems (GEOSS), support satellite access to environmental data at all stages of the DRM cycle. In recent years, commercial companies such as Google and Microsoft have started incorporating maps and satellite imagery into disaster-related applications, delivering compelling visualisation and providing tools that everyone can use.

The research presented in this chapter, therefore, proposes using private sector resources to implement measures to improve access to the internet and telecommunications infrastructure and increase ICT literacy, as well as development of local internet-based content. This also includes the cost of making the resources – for example, through internet access, training in web-based skills and training for vulnerable groups – available to communities. This can be done via an 'Adopt-A-Community' programme. The private sector will be encouraged to select a village. The criteria for selecting is voluntary, but can be based on community groups a business or organisation is already involved with, with respect to existing sponsorship, or where they would like to create greater awareness on environmental issues. This can

be seen as a cost-saving mechanism as well as a marketing strategy for businesses. The private sector is also responsible for providing the internet infrastructure, Wi-Fi access and web portal for collecting data.

Tax cuts and tax breaks may encourage the private sector to participate in such an Adopt-A Community' programme strategy. Tax abuse hinders governments' efforts to collect the taxes owed to them. Hence, tax breaks can also be seen as a strategy to address tax abuse and, in particular, tax evasion and tax avoidance by corporations. The Tax Justice Network estimates that all forms of tax evasion annually amount to around US$3.1 trillion, a little over 5 per cent of the world's GDP (Tax Justice Network 2011). Behavioural economics approaches such as 'Nudges' can also be used to reduce tax evasion (Neaţu 2015).

SIDS have limited resources and capacity for tax administration, which often means that violation of tax law remains unchecked. Increased mobility of capital and the rise of e-commerce creates new opportunities for taxpayers to violate tax laws. Combating tax evasion is especially critical for developing states. If the tax cuts are not financed by immediate spending cuts, they will likely also result in an increased budget deficit, which in the long-term will reduce national savings and raise interest rates. In this case, the financing provided by the private sector and the cost reduction saving to be realised by government through community involvement of can fill a specific budgetary fiscal gap. The concept of lobbying private sector firms to Adopt-A-Community is similar to existing 'Adopt-A-Highway' programmes seen across the world (see Case Study 2).

Case Study 2: Adopt-A-Highway

Adopt-A-Highway is an offshoot of the Adopt-A-Programme-type model utilised by counties to encourage volunteers to keep a section of the transportation infrastructure (e.g. highway, transit stop or rest area) free from litter. This is done in exchange for periodic litter removal. The sponsoring organisation is permitted to post a sign adjacent to the infrastructure they maintain. The models act as a cost-saving mechanism, as well as providing roadside litter reduction, public education, recognition and marketing. Specifically, the Adopt-A-Highway programme provides an avenue for individuals, organisations or businesses to help maintain sections of the roadside. Participation can include one or more of the following activities: removing litter on a stretch of roadside, planting and establishing acres of trees, shrubs and/or wildflowers, painting over graffiti as needed from one or more highway structures, and controlling weeds on the side of the highway. In addition to improving the aesthetic of the environment, this saves taxpayers millions of dollars every year.

The California Adopt-A-Highway programme (AHP) is one the state's successful government–public partnership agreements. From its inception in 1989, more than 15,000 shoulder-miles of roadside have been enhanced. The programme is solely administered by the California Department of Transportation (Caltrans 2018).

Virginia Adopt-A-Highway is a volunteer/organisational-based model in which civic or other organisations sponsor roadway segments, sign an agreement/contract for

two years with the Department of Transport (DOT) and agree to pick litter two to four times per year (on pre-prescribed dates). The volunteer group receives recognition via a sign. The group is required to follow safety requirements such as not clearing anything heavy, no animals, firearms, hazardous materials etc. The volunteer group receives limited safety training. No money is exchanged for the Adopt-A-Highway programmes.

Sponsor-A-Highway (SHP) is a contractor-based model. A sponsoring organisation pays a fee to an approved maintenance provider. The sponsoring organisation then receives recognition via a sign and the contractor picks litter 12 to 14 times per year. The maintenance provider usually provides and maintains the recognition sign. The Sponsor-A-Highway model is more commonly used on limited access, high-traffic volume, multi-lane highways where the safety of the workers picking the litter is of the greatest concern. A hybrid model combines elements of both AHP and SHP.

3.5.3 Flood-Tracker application

The Flood-Tracker application is a proposed web-based program. It should provide general public information on floods, bridge collapse, road closure, alternate route information, the production and use of flood hazard maps and flood alerts. The app should alert users of an impending flood hours before its occurrence. A key difference between existing flood trackers and the one being proposed in this chapter is that it includes an SOS feature that allows users to communicate directly with a control centre if they are in immediate/urgent danger.

During floods, the application should provide an evacuation points map, alternative roads and should display flood-prone areas during floods. Communities should be encouraged to record flood marks, as they may have the most direct experience of the event. Flood trackers already exist and are very useful as they provide instant information to persons who normally have to wait for radio and television to get information.

3.5.4 Edu-Flood

Edu-Flood is a public education outreach training programme provided via a computer or other digital device, allowing technology to facilitate learning anytime, anywhere. The programme should be designed educate individuals on floods, particularly those who may lack the physical or mental capacity to respond to warnings, for example, pregnant women, the elderly and differently-abled persons with missing limbs. They may find more value in having access to e-education to help build their resilience. For instance, governments can develop training programmes in virtual reality environments to show them how respond to floods.

Training for flood mitigation should seek to address both structural and non-structural strategies. Structural techniques seek to build structures in order to change or 'control' the physical environment; thus, common techniques include dams and floodwalls. Non-structural solutions encourage activities such as flood warning

systems, flood insurance, acquiring or elevating at-risk structures, flood proofing, and techniques for evacuating flooded areas and entering floodwaters. Games can be designed too, such as education tools. Various types of simulation exercises may be developed through interactive games to help raise awareness on the importance of flood safety.

Programmes for the vulnerable segments of society are critical, as the elderly and disabled are often left behind in Hurricanes (Stein 2018). ICT training for elderly people that matches young and elderly people can be a solution. Computers have the potential to aid older adults in enhancing creativity and promoting personal growth during leisure time (McGuire et al. 1999). They also have an impact on lifelong learning, access to information, rehabilitation (Ryan et al.1992) and improve their productivity (Lawhon et al. 1996). Older adults, persons ages 65 or older, are especially vulnerable during and after disasters (Bei et al. 2013; Malik et al. 2017).

Case Study 3: Behavioural insight

Society's support towards the government's e-resilience policy agenda and, more specifically, with respect to the proposal outlined above – Community-Tweets, Adopt-A-Community, Flood-Tracker and Edu-Flood – will be influenced by behavioural changes in the society, on an individual and corporate level. Governments generally solicit society's participation by enacting regulation (e.g. on buildings, automobiles and appliances) and providing subsidies. Collective action problems are undeniably difficult to solve, but can be addressed by behavioural interventions.

Behavioural measures can strengthen and complement conventional policy measures. Behavioural economics models of taxation – such as the non-expected utility theory and the social model – show how compliance can be affected by people's behaviour. The non-expected utility theory views taxpayers' compliance decision as a choice given the risk with known information. The other model incorporates social effects to account for the fact that taxpayers' decisions might be influenced by their specific social and cultural environments. They include factors like psychological costs, prestige, fairness, social norms and group effects. An alternative measure is to put 'nudges' in place. Subsidies or tax breaks/cuts can be used to incentivise (or nudge) specified behaviours public policy-makers believe are beneficial to society or to individuals. Bryan et al. (2017) provides a list of behavioural strategies to enhance the effectiveness of development programmes and policies. The central premise behind nudges is that individuals frequently behave in a way that economic theory finds difficult to predict (Thaler and Sunstein 2009, 7); hence, they can seek to change behaviour through a financial incentive (Thaler and Sunstein 2008).

There are two types of nudges. Type 1 is an intervention that seeks to assist individuals in making those choices that are in their own best interest. Type 2 nudges seek to steer individuals' behaviour to achieve a desired collective end – for example, reducing crime and encouraging environmentally-friendly practices. Government nudges include graphic warnings, large fonts, bold letters and bright colours, which can be effective in getting people's attention. When serious risks are involved, the best

nudge might be a private or public warning, such as informing people of the nature and consequences of their own past choices. That may provide behavioural solutions to problems. The World Bank's 2015 *World Development Report* presents examples of behavioural insights by analysing three principles of human decision-making: thinking 1) automatically, 2) socially and 3) with mental models (World Bank 2017).

Behavioural insights are relevant primarily to policy implementation, i.e. designing 'nudges' to ensure that a policy works smoothly (Halpern 2015). The 'Nudge Unit' has become shorthand for policy teams applying behavioural insights to government policy; for example, the Behavioural Insights Team in the UK and the Social and Behavioural Sciences Team in the USA (ibid). There are a variety of nudge-style tools that may inspire relevant interventions, including simplification.

3.5.5 Way forward

A comprehensive survey that analyses the potential effect of the 'E-Flood Community System' on both the community and business/firms is essential. Hence going forward such a survey will be conducted.

3.6 Conclusion

Countries need to benefit from rapid changes in modern technologies by incorporating technologies into their policies. As a tool, ICT must be used to create conditions in the domestic economy aimed at re-engineering disaster risk management strategies, and sharing and redistributing government resources with respect to the disaster lifecycle. To facilitate knowledge, transfer and information dissemination within the stages of the disaster lifecycle, countries and, in particular, communities, must be in a position to create their own knowledge and have access to adequate financing to facilitate the process.

Agencies which provide climate and disaster resilience financing in small island developing states should ensure countries have equitable access to funding that will allow them to facilitate ICT-enabled education and training (i.e. to promote e-learning and the use of e-learning materials. They should also foster mechanisms for enabling open data to support mitigation initiatives to lessen the impact of floods, build ICT capacity skills and promote stakeholder participation and partnerships. Mitigation measures tend to be potentially more efficient and provide more long-term sustainable solutions. To date, governments and private organisations have piloted various approaches channelling climate finance. These can provide important lessons for policy-makers.

Notes

1 E-resilience can be defined, as the ability of ICT systems to withstand and recover from disturbance such as a natural disaster. In addition, e-resilience is concerned with utilising ICT for societal resilience. See: http://drrgateway.net/e-resilience/about

2 http://www.un-spider.org/risks-and-disasters

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Chapter 4

ICT for Disaster Management and Emergency Telecoms – Preparation, Migration and Recovery for the Island of Mauritius

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Abstract

Effective crisis management relies on integration of emergency plans at all levels of government and non-government, both in Mauritius and Rodrigues. It is evident that by no means, can natural or human-made disasters be fully prevented. Information and communications technology (ICT) is used in almost all phases of the disaster management process. In the disaster mitigation and preparedness process, ICT is widely used to create early warning systems. An early warning system (EWS) may use more than one ICT medium in parallel and these can be either traditional (radio, television, telephone) or modern (SMS, cell broadcasting, satellite radio, internet and email, online media). In the immediate aftermath of a crisis, special software packages built for the purpose can be used for activities such as registering missing persons, administrating online requests and keeping track of relief organisations or camps of displaced persons. In addition, geographic information system (GIS) and remote sensing software/hardware are used effectively in all phases of disaster management. A spatial data infrastructure – a prototype web-based system that facilitates spatial data collection, access, dissemination and usage for proper disaster management – is a very handy tool. This chapter discusses in some detail considerations for the adoption of ICT for disaster management and emergency telecoms in the Republic of Mauritius.

4.1 Introduction

The creation of a regional information system, which is significant for assessing damage and needs of all kinds, is an action that is highly dependent on the use of ICT. Data banks also save time, since all of the information is gathered together and could be needed in co-ordination for immediate action. Furthermore, communication is the key element in all of the phases in the process. ICT is also significant for successful implementation of post-disaster management. The use of information technologies is increasing, yet there are some problems. Some of the major difficulties encountered include lack of data and weaknesses of IT systems that already exist, failure of

managers to consider the needs of users, lack of organisation, weakness of available software, deficient quality and the content of the information, especially given the chaotic nature of World Wide Web.

A number of key factors contribute to the successful introduction of ICT into the field. Among these are: mobility, ruggedness, flexibility, simplicity and sustainability. ICT that has been designed for crisis management only in a standalone mode is unaffordable and, therefore, partnerships with business is a precondition for secure, sustainable and updated ICT solutions for crisis management. The cost of developing individual ICT systems is enormous, and this forces organisations to look hard at what is commercially available right from the start. ICT solutions for crisis management should be based on open standards and open data or use of open source software where feasible. It is evident that disasters cannot be fully prevented by any means; only the loss caused by these events can be prevented or minimised. Disasters disrupt life, livelihoods, economies, political systems, belief systems – in short, everything that makes society work.

However, the first important steps towards reducing disaster impact are to correctly analyse the potential risk and identify measures that can prevent, mitigate or prepare for emergencies. While on some occasions the impact and severity of a disaster's outcome is unpredictable, ICT can play a significant role in highlighting risk areas, vulnerabilities and potentially affected populations by producing geographically referenced analysis through, for example, a geographic information system (GIS). The importance of timely disaster warning in mitigating negative impacts can never be underestimated. For example, although damage to property cannot be avoided, developed countries have been able to reduce loss of life due to disasters much more effectively than their counterparts in the developing world (Flanagan et al. 2011). A key reason for this is the implementation of effective disaster warning systems and evacuation procedures used by the developed countries, and the absence of such measures in the developing world. While saving everyone during a disaster is practically impossible, the use of ICT in warning people and helping them does without doubt save many lives.

4.2 Literature review

4.2.1 Disaster management

Disaster management (also known as disaster risk management) is the discipline that involves preparing, warning, supporting and rebuilding societies when natural or human-made disasters occur. Effective disaster management relies on thorough integration of emergency plans at all levels of government and non-government involvement. Multi-hazards include cyclones, torrential rains, floods, landslides, tsunamis, high waves, water spouts, tornadoes and droughts (Cutter et al. 2010). The importance of timely disaster warning in mitigating negative impacts can never be underestimated.

A warning can be defined as the communication of information about a hazard or threat to a population at risk, in order for them to take appropriate actions to mitigate

any potentially negative impacts on themselves, those in their care and their property. The occurrence of a hazard does not necessarily result in a disaster (Erdelj et al. 2017). While hazards cannot be avoided, their negative impacts can be mitigated. The goal of early public warning is to ensure to the greatest extent possible that the hazard does not become a disaster. Such warnings must be unambiguous, communicate the risks succinctly and provide necessary guidance. The success of a warning can be measured by the actions that it causes people to take, such as evacuation or avoiding at-risk areas. In a disaster situation, there is no doubt that timely warnings allow a person to take actions that saves lives, reduce damage to property and minimise human suffering. It has been observed in Mauritius that to facilitate an effective warning system, there is a major need for better co-ordination among the early warning providers, as well as those handling logistics and raising awareness about disaster preparedness and management. While disaster warnings are meant to be a public good, they are often most effectively delivered through privately-owned communication networks and devices.

4.2.2 Case of the Republic of Mauritius

Mauritius has vast experience in dealing comprehensively with natural disasters, like floods and cyclones in particular. Indeed, since the 1960s, the government's Central Cyclone and other Natural Disasters Committee (CCNDC) has been a national platform which has efficiently ensured cyclone risk reduction. In 2004, the Asian Tsunami Disaster impacted Rodrigues Island and reached the shores of mainland Mauritius. This prompted the Government of Mauritius to capitalise on the CCNDC's multisectoral and science-based experience to prepare a National Tsunami Early Warning and Response System and to capitalise on assistance offered through by the Indian Ocean Tsunami Warning and Mitigation System (IOTWS). In addition, the government also committed to the development of an integrated regional information network (IRIN), with the goals of creating of an early warning system for the islands in the Indian Ocean and ensuring adequate equipment to manage natural disasters, including tsunamis.

The government is leaving 'no stone unturned' in addressing the concern of disaster management. One major achievement has been the setting up and operation of a Natural Disaster and Operations Coordination Centre (NDOCC) at the Line Barracks. The centre is under the operational command of the commissioner of police. The NDOCC constitutes a national platform for co-ordinating the efforts of various agencies dealing with mitigation and relief, and is responsible for assisting agencies in initiating necessary actions to deal with national disasters (both natural and human-made) and to harmonise decisions of all stakeholders for a co-ordinated approach. For the NDOCC, the police department is the operational arm, whereas the Prime Minister's Office (PMO) is the administrative arm.

On 16 November 2009, the government decided to create a National Disaster Management Centre (NDMC) to take overall responsibility for the management of natural disasters in Mauritius; it was set up under the aegis of the Prime Minister's Office. The creation of this centre is in line with the recommendations of the Fact

Finding Committee on the Ex-Lola Flooding. Lola was a cyclone that affected Mauritius in 2008, resulting in torrential rain caused by a trail of torrential rain clouds. Other responsibilities of the NDMC comprise emergency operations management; long-term disaster mitigation; and management of post-disaster activities. However, the existing Central Cyclone and Other Natural Disasters Committee continues to constitute the central system to supervise, monitor and co-ordinate the activities of other authorities and take critical decisions, as appropriate. The Coordinating Committee is chaired by the Secretary for Home Affairs / Permanent Secretary of the Prime Minister's Office. It has members from different ministries, the Police Department, Meteorological Services, Government Fire Services, the Central Water Authority, Central Electricity Board, local authorities and the university. The Meteorological Services collect and disseminate most of the information related to natural calamities.

In April 2012, an earthquake which hit the coast of Indonesia triggered panic in the country, but also showed the shortcomings of ICT use in disaster management. While tsunami detection systems appear to have worked, the quake exposed flaws in the diffusion of warnings and effectiveness of evacuation plans. For instance, in Mauritius, a form of panic did prevail since different institutions were providing different information. While the Meteorological Services were on alert, no official tsunami warnings were issued. At the same time, flash information from the media worldwide and Mauritius as well were not providing adequate information, but instead created general apprehension. While the Indian Ocean was placed on alert, one major flaw from the media was to announce that tide waves would be sweeping the Indian Ocean and hitting the coastal region, while no such thing actually occurred. A surge in people seeking information created much more panic in the population. This shows that with better co-operation and sharing of proper information, such incidents would be avoided.

4.2.3 Support from the international community

Mauritius was also selected to receive capacity-building assistance from the UN International Strategy for Disaster Reduction (ISDR)-led international consortium of partners for an improvement of its tsunami preparedness and mitigation levels. Funded through the tsunami consortium framework of international donors, and implemented by UN Development Programme (UNDP) Mauritius and Seychelles, the project produced the following achievements: setting up of tsunami detection equipment, provision of equipment to an Emergency Operations Centre, delivery of public awareness activities, and training of key staff in tsunami preparedness and warnings.

A workshop on Disaster Preparation and Response in Mauritius was held at Le Labourdonnais Hotel in Port Louis from 24 to 26 August 2010. The workshop was conducted by the United States Africa Command (AFRICOM) Civil Military Emergency Preparedness Program (CMEP). The CMEP Program is designed to build capacity for partner nations to manage the consequences of all hazards (natural

and human–made). CMEP is part of a wider US Department of Defence programme. Three resource persons from CMEP were in Mauritius to conduct the workshop, which was attended by officers from government and parastatal institutions involved in disaster management. These included the Mauritius Police Force, the Government Fire Services and the Mauritius Meteorological Station, among others.

The workshop focused on several elements of disaster preparation and response over the three days. The CMEP team conducted presentations on 'Standard Operating Procedures for Response', 'Emergency Management Cycle', community and citizen preparedness and HAZMAT Response – that is, the response in cases of contamination that could threaten Mauritius and the measures in place to respond to this kind of situation. Mauritian participants had the opportunity to present and discuss elements from the local national plan for disasters.

4.2.4 NDMC risk management priorities

The National Disaster Risk Management Centre (NDMC) has earmarked the following as key priorities:

1. To develop a rational Disaster Risk Management Plan which will focus on mobilisation, deployment and co-ordination of national resources and requests for international assistance.
2. To prepare Disaster Risk Management Plans at the district level.
3. To develop and train community-level disaster response teams.
4. To target the initial efforts on the risk management of floods and droughts.
5. To focus on capacity building of government officers and personnel of associated agencies form the community level to the national level and on community mobilisation, i.e. motivating and supporting people to organise and take appropriate action to protect themselves, their property and their communities against hazards.
6. To improve disaster preparedness through:
    - a clear and comprehensive policy which addresses all elements of disaster risk management planning;
    - effective disaster planning and linkages at the district level and in the region, including Rodrigues Island and the regional islands as a basis for co-ordinated action with clear allocation of role and responsibilities;
    - operational planning for all concerned government and non-government agencies to ensure effective response actions in times of emergency;
    - effective implementation of specialist programmes;
    - early warning systems for floods and droughts; and
    - public awareness and training.

7. Support for the development of self-reliance and self-help at the community level to focus disaster prevention and mitigation on:
    - agricultural and sectoral programmes aimed at food, income and water security, and on reducing community vulnerability; and
    - Protection of key economic facilities.
8. To improve disaster response and recovery by improving emergency management systems such as command, control and co-ordination, damage and needs assessment, relief distribution and 'food for work' rehabilitation and reconstruction programmes.

4.2.5 Development of a National Disaster Management Plan

Beside the National Strategy, action plans on disaster management are formulated in accordance with various sector plans. The National Disaster Management Action Plan consists of various programmes, expressing the general vision to 2020.

The General Objectives of the Action Plan to 2020 are:

- Continuation of the programme on building institutional arrangements of disaster management (DM) within the Island of Mauritius at all levels.
- Establishment of a focal point and identification of a contact person in every institution, and developing an effective co-ordination and co-operation culture between agencies in DM.
- Organisation of effective early warning and information management systems. This guarantees timely and effective dissemination of early warning information to the community level.
- Building storage systems at the regional level in order to effectively dispatch material resources for relief and rehabilitation.
- Organisation of public awareness and education programmes that aim at educating all members of society on the causes of disasters, along with development of training programmes for all government departments and the public sector.
- Establishment of rescue and emergency response teams and establishment of an Information Centre for Disaster Management.
- Organisation of simulation exercises for disaster preparedness and linkage programmes between disaster management.
- Linkage programmes between disaster management and other sector programmes.

4.3 Methodology

4.3.1 Case study approach and expert reference group

This research used a case study approach and an expert reference group discussion approach, whereby all disaster management stakeholders in Mauritius were involved

and consulted. A national working group was mandated by the Information and Communication Telecommunication Technologies Authority (ICTA) of the Republic of Mauritius under the aegis of the Ministry of Information and Communication Technology. This project was compiled as part of other projects under Working Group 5. The stakeholders involved were the government, district councils, non-governmental organisations (NGOs), the private sector, the media, international bodies, and the scientific and academic community. Regular meetings were carried out and eventually a list of recommendations was produced to put in place so as to provide an effective framework for disaster management in Mauritius. The ownership of particular actions to be carried out was also established in order to prevent duplication and ensure the efficiency of the process.

Given this spectrum of players, and the important role of each, a fundamental need in developing an effective disaster information network is finding new ways to foster consensus and enhance co-ordination, co-operation and teamwork by involving representatives of all stakeholders in a meaningful way. Finally, what is proposed is a Disaster Information Network is to reduce losses from disasters by providing timely and accurate information to anyone who can use it to decide on appropriate actions to mitigate disasters, prepare for them, or improve response and recovery.

4.3.2 Objectives

The objectives of setting up such as system for disaster management and emergency telecoms is described below.

- *Reduce damage and deaths*

  Effective disaster management reduces or avoids morbidity, mortality, and economic and physical damage from a hazard. The methods used to achieve this include hazard and vulnerability analysis, preparedness, mitigation and prevention measures, and the use of predictive and warning systems.

- *Reduce personal suffering*

  Disaster management reduces personal suffering, such as morbidity and emotional stress following a hazard. The methods used to prevent suffering include hazard and vulnerability analysis, preparedness, and mitigation and prevention measures.

- *Speed recovery*

  The third objective is to speed recovery. The methods to accomplish this objective include effective response mechanisms and the institution of recovery programmes and assistance.

- *Protect victims*

  Disaster management provides protection to victims and/or displaced persons. Facilities utilise preparedness, response mechanisms, recovery programmes and assistance to address shelter needs and provide protective services.

4.3.3 Assumptions

The government recognises disaster risk management as a key development priority that will encompass hazard mitigation and vulnerability reduction through an effective preparedness strategy aimed at reducing the effects of natural and human-made disasters, particularly in rural areas. As such, the National Disaster and Operations Coordination Centre (NDOCC), under the aegis of the PMO and with the collaboration of a public–private partnership (PPP), will have to work in close co-operation to carry out the following responsibilities:

- Create a strategic plan.
- Stimulate and enhance private sector participation.
- Improve state and local utilisation of central capabilities.
- Act as a catalyst and co-ordinator for precipitating ideas and actions to improve disaster information systems.
- Carry out effective preparedness and capacity to provide an efficient emergency response when disaster strikes. This will have a real impact in combating poverty and promoting sustainable development in Mauritius and Rodrigues.
- Build consensus among public and private stakeholders at the central, state and local levels.
- Facilitate interaction among providers, disseminators and users through meetings, newsletters, journals, training sessions and exercises.
- Maintain a structure for providing advice from a broad constituency.
- The roles of the Ministry of Gender Equality, Child Development and Family Welfare and also the Ministry of Social Security, National Solidarity and Reform Institutions are paramount in the post-disaster management of the welfare of citizens. During the post-disaster period, these two ministries are the key players to protect, promote and provide assistance for the rebuilding of society.

4.4 Recommendations

The recommendations of the working group are summarised in Table 4.1 and are followed by relevant discussions for the creation of such a system for disaster management and emergency telecoms.

4.5 Discussions

4.5.1 Technical feasibility

'Technical feasibility' refers to the capability of current technology and methods of operation in meeting user requirements. The technical feasibility in the Republic of

Table 4.1 Recommendations

No.	Recommendation	Ownership	Remarks
1	Empowering the NDOCC under the aegis of Mauritius Police Force (MPF) to handle all issues related to ICT for disaster management.	MPF/PMO	PMO should empower MPF for NDOCC to be empowered as well.
2	Involvement of all key stakeholders from both public and private sector to work in close collaboration to implement this project.	NDOCC	Relevant ministries and telecom operators as well should be fully involved in the project.
3	Re-use of existing infrastructure and telecommunication facilities to ensure the operational feasibility of the project, including: i. communications equipment; and ii. amateur radio, also known HF, VHF, UHF radio spectrum frequencies between the different stake holders (e.g MPF, fire services) in worst case scenarios.	NDOC	For example, MPF has already procured communications equipment for police stations in phase one of the Crime Occurrence Tracking System (COTS) project. The network Infrastructure can be used for communication only in case of disasters, without affecting COTS data/servers.
4	Use of already existing IT systems such as **Sahana, Desinventar, Voxiva & Groove** (Microsoft), **Google Person Finder** so as to maximise all resources to help track families and co-ordinate work among all participating recovery organisations before, during and after a disaster. In addition, using existing software will help curb development costs.	**The private sector** (Microsoft, Google and other international IT companies)	Microsoft representative for Indian Ocean, Mr Paul Bunting, proposed to help in providing information with regards appropriate software. A half-day workshop could be organised with Microsoft's help to build up the concept of national responsibility.
5	Involvement of external bodies such as the Red Cross, UNDP, the European Union (EU), etc.	NDOCC, others	Help from the Red Cross, UNDP, the EU & other institutions will be needed.

(*Continued*)

Table 4.1 Recommendations (*Continued*)

No.	Recommendation	Ownership	Remarks
6	Education, training and public awareness.	NDOCC & PMO	Workshops would have to be organised by MPF and relevant ministries under the aegis of PMO would collaborate in building up public awareness.
7	Government should setup policies and legislation with respect to this project.	PMO & SLO	
8	A one-press button facility should be taken into consideration to facilitate co-ordination between the NDOCC, ministries, the Fire Service, the SAMU service, among others.	NDOCC	The one-press button would act as the main alert to link all relevant services in case of a disaster. This would speed up the response service and make it more effective. Furthermore, since most ministries are linked to the Government Online Centre (GOC), it is recommended that the Line Barracks be connected to the GOC for communication in case of emergency through a 'one-press button'.
9	The concept of a mobile camera service for real-time pictures/ photos should be taken into account.	**Relevant operators**	For instance, the co-ordination of the Maha Shivaratree festival was rendered easier with the help of Emtel, which helped with live coverage. More recently, a simulation operation was organised at Rose Belle and mobile cameras were used as well during the rescue operation. The same concept would be a 'plus' to the rescue team.
10	The concept of cell broadcasting **should** be implemented by all telecom operators, whereby messages are sent in the three main languages used (English, French and Creole) and would serve as a preventive measure in warning the public. This can be part of the CSR or NSR policy of the government.	**All telecom operators**	National corporate responsibility (NCR) and corporate social responsibility, or even the Universal Service Fund (USF), could be sources of financing for the cell broadcasting concept.

Table 4.1 Recommendations (*Continued*)

No.	Recommendation	Ownership	Remarks
11	The creation of a Disaster Management Database for the early warning system would enhance the efficiency and effectiveness of NDOCC.	NDOCC	The benchmark set for the Disaster Management Database would depend upon the type of disaster that occurs. For instance, the benchmark for a tsunami would not be the same as the benchmark for a terrorist attack.
12	• The involvement of hotels in this project will eventually ensure good warning systems for the security of coastal regions, mainly for tsunamis and cyclones. • Cases of oil spills will require the involvement of petroleum companies.	Ministry of Tourism and Leisure and petroleum companies	
13	The collaboration of the Mauritius Meteorological Services, Mauritius Police Force and Mauritius Oceanographic Institute is essential.	NDOCC	Involvement of foreign agencies. Existing protocol: Meteo France and Pacific Tsunami warning centres.
14	• A private network between stakeholders and NDOCC should be established. • Stakeholders such as the different ministries can be communicated with through the existing infrastructure of Government Online Centre (GOC), which is already linked to several ministries across the country.	NDOCC	A dedicated network could link stakeholders and NDOCC. As such, the rescue operation and dissemination of relevant information would be easier and much more effective.
15	Strategic positioning of sirens, for example at police stations in coastal regions and places where there is CCTV.	NDOCC	

Mauritius depends primarily on the key players in disaster warning (refer to operation feasibility) and the proper channels used for disaster warning, listed as follows:

- *Radio and television*

  Considered the most traditional electronic media used for disaster warning, radio and television have a valid use. The only possible drawback of these two media is that their effectiveness is significantly reduced at night, when they are normally switched off.

- *Telephone (fixed and mobile)*

  Telephones can play an important role in warning communities about the impending danger of a disaster. This arrangement not only ensures the timely delivery of the warning message, but also ensures the minimum duplication of effort. However, the drawback is the congestion of phone lines that usually occurs immediately before and during a disaster, resulting in many phone calls that cannot be completed in that vital period.

- *Short message service*

  Short message service (SMS) is a service available on most digital mobile phones that permits the sending of short messages (also known as 'text messages', 'SMSs', 'texts' or 'txts') between mobile phones, other handheld devices and even landline telephones. It may be that many residents of affected areas are unable to make contact with relatives and friends using traditional landline phones. However, they could communicate with each other via SMS more easily when the network is functional. This is because SMS works on a different band and can be sent or received even when phone lines are congested. SMS also has another advantage over voice calls in that one message can be sent to a group simultaneously.

- *Cell broadcasting*

  Most of today's wireless systems support a feature called 'cell broadcasting'. A public warning message in text can be sent to the screens of all mobile devices with such capability in any group of cells of any size, ranging from one single cell (about 8 kilometres across) to the whole country, if necessary. CDMA, D-AMPS, GSM and UMTS phones have this capability. There is no additional cost to implement cell broadcasting. It is already present in most network infrastructure and in the phones, so there is no need to build any towers, lay any cable, write any software or replace handsets. Nor is it affected by traffic load; therefore, it will be of use during a disaster, when load spikes tend to crash networks. In addition, cell broadcasting does not cause any significant load of its own, so it would not add to congestion. Cell broadcasting is geo-scalable, so a message can reach hundreds of millions of people across continents within a minute. It is also geo-specific, so that government disaster managers can avoid panic and road jamming by telling each neighbourhood specifically if they should evacuate or stay where they are. The only possible disadvantage to cell broadcasting is that not every user may be able to read a text message when they receive it.

- *Satellite radio*

  A satellite radio or subscription radio is a digital radio that receives signals broadcast by communications satellite, which covers a much wider geographical range than terrestrial radio signals. Satellite radio functions anywhere there is line of sight between the antenna and the satellite, given there are no major obstructions such as tunnels or buildings. Satellite radio audiences can follow a single channel regardless of location within a given range. Satellite radio can play a key role during both the disaster warning and disaster recovery phases. Its key advantage is the ability to work even outside of areas not covered by normal radio channels. Satellite radios can also be of help when the transmission towers of the normal radio station are damaged in a disaster.

- *Internet/email*

  The role the internet, email and instant messages can play in disaster warning entirely depends on their penetration within a region and usage by professionals such as first responders, co-ordinating bodies, etc. While these media can play a prominent role in a developed country, where nearly half of all homes and almost all offices have internet connections, this is not the case in the developing world. In many developing countries, less than 5 per cent of the population uses the internet and even those who are users do not use it on a regular basis. In such a situation, it is difficult to expect the internet and email to play any critical role. In spite of these drawbacks, many disaster-related activities are already underway within the internet community. For example, a new proposal for using the internet to quickly warn large numbers of people of impending emergencies is currently being drafted by the Internet Engineering Task Force.

- *Amateur radio*

  Amateur radio may be of use especially when traditional communications infrastructure breaks down. In such a situation, amateur radio operators transmit emergency messages on voice mode about the well-being of survivors and information on casualties to friends and relatives. As was evident during the Indian Ocean Tsunami that destroyed electricity and communications infrastructure in the Andaman and Nicobar Islands, amateur radio operators were the critical link between the islands and the Indian mainland and helped in the co-ordination of rescue and relief operations. Besides disseminating voice-based messages, some amateur radio operators can also transmit in digital modes that include technologies such as radio teletype, tele-printing over radio, packet radio transmission and the recent Phase Shift Keying, 31 Baud – a type of modulation. Amateur radio broadcasters are authorised to communicate on high frequency (HF), very high frequency (VHF), ultra-high frequency (UHF) or all three bands of the radio spectrum. They require a license from the licensing authority to ensure that only competent operators use their skills. However, depending on the country, obtaining a license can be a long process.

- *Sirens*

  Though not necessarily an ICT-based solution, sirens can be used in tandem with other ICT media for final, localised delivery.

- *Geographic information system (GIS) and remote sensing in disaster management*

  GIS can be loosely defined as a system of hardware and software used for storage, retrieval, mapping and analysis of geographic data. Spatial features are stored in a co-ordinate system (latitude, longitude, state, plane, etc.), that references a particular place on the earth. Descriptive attributes in tabular form are associated with spatial features. Spatial data and associated attributes in the same co-ordinate system can then be layered together for mapping and analysis. GIS can be used for scientific investigations, resource management and development planning.

  By utilising a GIS, agencies involved in the response can share information through databases on computer-generated maps in one location. Without this capability, disaster management workers have to access a number of department managers, their unique maps and their unique data. Most disasters do not allow time to gather these resources. GIS thus provides a mechanism to centralise and visually display critical information during an emergency. There is an obvious advantage to using a map with remote sensing or GIS inputs instead of a static geographical map. A static map is mostly analogous and is not interactive. By comparison, a vulnerability map with GIS input provides dynamic information showing cause and effect relationships.

- *The 999 Emergency Response Management System in Mauritius*

  The Police Information & Operation Room (PIOR) is working on a project to acquire an Emergency Response Management System shortly for 999 telephone calls received by the police. The new system will adopt modern technologies such as computer telephony integration (CTI), geographic information system (GIS) and integrated communications to improve the efficiency of actions to respond to public emergencies. One of the important features of the system will be to identify and locate the caller at the time of an emergency call, so as to be in a position to give prompt assistance by the nearest resource available.

  The police have already sought the co-operation of all telephone service operators (including mobile phone operators) for the new system to interact and have online information from them at the time a member of the public calls to report an emergency. Letters have been sent to the Data Protection Commissioner and the Solicitor-General for advice concerning exchange of data in such cases. The Data Protection Commissioner advised that data sharing for the purpose of protecting the vital interests of the data subjects involved was exempted from the application of Section 24 of the Data Protection Act.

4.5.2 Operational feasibility

'Operational feasibility' refers to the ability of the enhanced system to fit the operational pattern and resources of the organisation. The project is feasible, but it

would require the involvement and support of both local (public and private) and international institutions.

- *Government*

  Government should have considerable knowledge of the hazards to which the country is exposed. It must be actively involved in the design and maintenance of early warning systems, and understand information received to be able to advise, instruct or engage the local population in a manner that increases their safety and reduces the potential loss of resources on which the community depends.

  The government is responsible for policies and frameworks that facilitate early warning, in addition to the technical systems necessary for the preparation and insurance of timely and effective hazard warnings for the country. It should ensure that warnings and related responses are directed towards the vulnerable regions through the design of holistic disaster response and early warning frameworks that address the specific needs of the related micro- and macro-level actors. The provision of support to districts to develop operational capabilities is an essential function to translate early warnings knowledge into risk reduction practices.

- *Legislation*

  Government should put the appropriate legal framework in place in order to get the full co-operation and support of telecom operators. The law should bind telecom operators to provide, inter-alia, cell broadcasting facilities to the population at large – ideally free of charge in the event of a warning prior to a potential disaster – and also post-disaster communication, as deemed appropriate by the met office. Co-laterally, the law should also hold liable any stakeholders who have directly or indirectly failed in their duties and responsibilities in providing timely and effective assistance to the NDOCC in terms of infrastructure, logistics and utilities, communications and decision-making.

- *Districts councils*

  District councils, particularly those most vulnerable, are vital to people-centred early warning systems. Their input into system design and their ability to respond ultimately determine the extent of risk associated with natural hazards. District councils should be aware of hazards and the potential negative impacts to which they are exposed and be able to take specific actions to minimise the threat of loss or damage. As such, the geographic location of a district is an essential determinant in the selection of disasters upon which the system should focus its district education. For example, coastal districts need to be educated and prepared for the possibility of a tsunami, while a mountain community can be educated to respond to an early warning system for landslides.

- *Non-governmental organisations (NGOs)*

  NGOs play a critical role in raising awareness among individuals and organisations involved in early warning and in the implementation of early warning systems, particularly at the community level. In addition, they play an important advocacy

role to help ensure that early warning stays on the agenda of government policy-makers.

- *The private sector*

  The private sector has a diverse role to play in early warning, including developing early warning capabilities in their own organisations. The private sector is also essential, as businesses are usually better equipped to implement ICT-based solutions. The private sector has a large, untapped potential to help provide skilled services in the form of technical staff, know-how, or donations of goods or services (in-kind and cash), especially for the communication, dissemination and response elements of early warning.

- *The media*

  The media plays an important role in improving the disaster consciousness of the general population and in disseminating early warnings. The media can be the critical link between the agency providing the warning and the general public.

- *International bodies*

  International bodies should provide support for national early warning activities and foster the exchange of data and knowledge between individual countries. Support may include the provision of advisory information, technical assistance, and the policy and organisational support necessary to ensure the development and operational capabilities of national authorities or agencies responsible for early warning practice.

- *The scientific community*

  The scientific community has a critical role in providing specialised scientific and technical input to assist governments and communities in developing early warning systems. Its expertise is critical to analysing the risks communities face from natural hazards, supporting the design of scientific and systematic monitoring and warning services, fostering data exchange, translating scientific or technical information into comprehensible messages, and disseminating understandable warnings to those at risk.

4.5.3 Financial feasibility

Financial feasibility will depend on the involvement of all key players and channels used for developing and implementing the system for ICT disaster management. While the setting up of a fund should be provided in the national budget, and with ICT being the main pillar, licensed telecom operators could on their side contribute an 'x' percentage of their annual revenue to the fund. For this to be rendered possible, it would have to be added to the ICT Act 2001 by Ministry of Information and Communication Technology (MICT). The fund would be under the supervision of a ministerial committee comprising the different ministries and under the supervision of the Ministry of Finance and Economic Development (MOFED). The private sector (hotels, banks, etc…) as well, could contribute a 'y' percentage of their revenue in to the

fund under the form of a new terminology, CNR (corporate national responsibility), which would contribute in the flourishing of the fund.

4.5.4 Other considerations

The implementation of this project needs to be carried out in different phases. Below are some considerations that may be taken into account in the future, although initially the focus should be on the recommendations mentioned above. These considerations can be broadly classified in three categories, namely communication, simulation and identification.

Communication

1. There is the need for emergency agencies to interconnect on intervention sites, but currently the police, fire services and ambulance services rely on commercial networks to talk to each other, because they each have and maintain incompatible communication networks, often a mix of analogue / digital standards. Ultimately, moving towards a national digital network will offer centralised maintenance, easier levelling up to new standards, easier backups of critical components and will guarantee the same features for all. This national network should be able to encompass smaller intervention teams like those from social security. It is critical for emergency agencies and related teams not to rely on commercial networks in crisis situations, to completely free up commercial networks for civilian communication.
2. The technical implications for cellular operators to use each other's networks in case of destruction of their own capacity need to be considered. They already share the same mast in many cases.
3. The technical implications for international emergency agencies to interface with Mauritian telecommunication networks should also be taken into account, in case local operators are not able to maintain their services.
4. There is a need for a call prioritisation system to help rescue teams use commercial networks in crisis situations when these networks are saturated by civilians.

Simulation

1. There is the need for a software simulation of destruction, per disaster, which is able to predict the resilience of Mauritian communications, interventions, force positioning and movement of populations due to panic.
2. Fire services should be helped to digitalise their data on buildings and on other infrastructures (access, structures and contents) to ease up their interventions. This information should be shared with all emergency agencies.

Identification

1. Consideration should be given to a face recognition system embedded on handheld devices for field identification of victims.

2. A common database standard by all ministries concerned with identification of citizens needs to be used.
3. The technical implications and sharing of a location system of persons via their mobile phones should be considered.
4. A national DNA database associated with mobile DNA analysis systems needs to be designed.
5. There is a need for data recovery of these databases.

4.6 Conclusion

The primary responsibility for disaster management is at the local level and then at the regional level. Thus the need for co-ordination extends through all levels of government. Non-government entities complete the spectrum of players, with fundamental, critical roles in disaster management activities. Private industry, insurers and providers of lifeline services such as telecommunications, gas, electricity, etc., have heavy investments at risk in the event of disasters. They also expend significant resources for disaster mitigation, preparation, response and recovery. Non-government organisations (NGOs) created to support all phases of disaster management also provide critical resources and support to the emergency management process. Given this spectrum of players, and the important role of each, a fundamental need in developing an effective disaster information network is finding new ways to foster consensus and enhance co-ordination, co-operation and teamwork by involving representatives of all stakeholders in a meaningful way.

Effective design and implementation of such a system needs to be grounded in a detailed understanding of what information is available and how different users need to access that information. This involves much more than market research, because the basic issue is one of building consensus on needs and approaches in the provider, disseminator and user communities. Much of the implementation will need to be done in the much decentralised paradigm of the internet and World Wide Web by many different people and organisations. The problem is not one of organising a top-down business, but rather bottom-up teams and information exchanges that cut across many businesses, organisations, disciplines, etc.

Another purpose of a Disaster Information Network is to enhance communication among stakeholders through discussions over the network and exchange of ideas via newsletters, bulletin boards, and virtual or standard meetings. The problem is one of enhancing connectivity and encouraging teamwork. For this project to be successful, the participation of the government, especially Mauritius Police Force, Mauritius Meteorological Services, Mauritius Oceanographic Institute and other stakeholders – most importantly license operators, UNDP, the EU, the Red Cross and hotels in Mauritius – is essential. As such, the Natural Disaster and Operations Coordination Centre (NDOCC), which would take ownership of the project with support of the government, should develop the disaster management plan. The process needs to include participatory planning and stakeholder consultations to ensure that the plan reflects the needs and realities in disaster management.

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Chapter 5

A Critical Analysis on the Capacity of Blockchain-Based Parametric Insurance in Tackling the Financial Impact of Climatic Disasters

Christopher Sandland, Dale Schilling and Alastair Marke

Abstract

Disaster insurance – such as parametric and microinsurance – are emerging financial products to mitigate the socioeconomic impacts of climate disasters. Yet, there remain major hurdles to its extensive adoption. The main barriers include inefficient claim administration, as well as the lack of transparency of insurance products and the respective data. Therefore, insurance providers have been reluctant to invest in scaling these products and roughly 70 per cent of all losses today are uninsured.

This study by the Blockchain Climate Institute (BCI) has shown that implementing parametric insurance on the blockchain can overcome efficiency and transparency gaps, and hence can scale up insurance penetration, especially in developing countries. Blockchain-based parametric insurance achieves this through disintermediation: it removes inefficiencies by automating the entire insurance cycle; and it increases the transparency of insurance data with secure, immutable distributed ledgers that transfer and aggregate data, and make that data publicly available.

Insurance uptake can also be improved through the easing of access to policies and claim pay-outs via mobile phones and mobile banking wallets. Private and public keys can be used to provide proof of cover and authenticate the validity of the policy-holder, without the need for on-the-ground distribution of insurance products. Nevertheless, there are also barriers to the roll-out of blockchain-based parametric insurance (BBPI), including the lack of data, poor design, different regulatory approaches to insurance provider licensing and the potentially huge costs associated with the setting up of oracles. These can be resolved through continued research and development and collaborative approaches to regulation, such as the development of regulatory sandboxes.

5.1 Insurance for climate resilience

Climate disasters impact all countries and aspects of development: economic, social and environmental; with far-reaching effects, unprecedented in scope and scale. Evidence suggests that disasters like droughts, heat waves, floods, hurricanes

and wildfires have already increased or intensified over the last few decades due to climate change (V20 2015). Such phenomena translate into financial damages, equalling US$181 billion annually today, with developing countries bearing a disproportionate burden – approximately US$65 billion, or roughly 2.5 per cent of their gross domestic product (GDP) (Buhr et al. 2018). The Intergovernmental Panel on Climate Change (IPCC) has confirmed that a 1.0°C increase of warming has occurred, and it estimates a 1.5°C increase is likely *'between 2030 and 2052'* (IPCC 2018).

These societies are likely to become more vulnerable in a warming world. According to the Global Climate Risk Index (Kreft et al. 2015), the Vulnerable Twenty (V20) group of developing countries, such as small island developing states, least developed countries and African countries (Yamineva 2016), are most vulnerable and are most at risk to suffer weather and climate-related losses (UNISDR 2018). When considering V20 contributions to climate change being merely 2 per cent, by 2030, they will probably have absorbed more than half of the attributed economic cost (V20 2015; Tol 2018).

One such climate disaster was the 2011 monsoon season, which caused widespread damage across Thailand, Vietnam and Cambodia. More than 800 people died, 85 per cent of Thai provinces were declared flood disaster zones and over 20,000 square kilometres of farmland damaged (Holzheu and Turner 2017). Disruptions in business supply chains led to a shortage in components for electronics, vehicles and other goods. Total losses estimated by the World Bank amounted to US$47 billion, of which less than 8 per cent was insured (Holzheu and Turner 2017). These floods can be linked to the increasing frequency of El Niño events that continue to impact food production by torrential rainfall, leading to landslides and waterlogging that kills crops and inundates infrastructure (Thirumalai et al. 2017).

Disasters like these represent the physical risk of climate change: the socioeconomic damages linked to the increased frequency and severity of climate- and weather-related events (Dafermos et al. 2018). The United Nations International Strategy for Disaster Reduction shows that from the period 2005–10, *'over 700,000 people have lost their lives, over 1.4 million have been injured and approximately 23 million have been made homeless as a result of disasters'* (UNISDR 2015). Climate change will only exacerbate both the frequency and impact of disasters by 130 per cent at 1.5°C and 340 per cent at the 2.0°C warming levels (Kharin et al. 2018). This will be potentially devastating for V20 countries, which are the least-resourced to adapt to such increasing risk and to fund independent recovery efforts (Fernandez and Schäfer 2018).

5.2 The 'protection gap'

Insurance can play a major role in offsetting negative financial impacts when disasters strike. It reduces risk exposure; increases financial resilience for individuals; mitigates the socioeconomic effects of climate change across communities; and assists countries in recovering from natural disasters. While insurance can speed up post-disaster recovery, up to 70 per cent of catastrophic losses caused by extreme weather events

over the last decade were uninsured. This is known as the 'protection gap' (IAIS 2018), which ClimateWise, a global network of 28 insurance organisations (Actuary 2017), estimates to be US$1.7 trillion over the decade. For example, only a fifth of homeowners in the Greater Houston area had flood cover when Hurricane Harvey struck in August 2017, exacting US$70–90 billion in damages (Lloyds 2018). Insurance coverage is even lower in The V20 – approximately 4 per cent – with Vietnam and Bangladesh, with less than 1 per cent, ranked the lowest for insurance penetration (Holzheu and Turner 2017). This leaves them highly exposed to climate disasters. When 2009 Typhoon Mirinae hit Vietnam, catastrophic flooding followed, causing US$280 million in damages, of which only 3.6 per cent was insured (UNDP 2017).

When climate disasters strike countries with low insurance penetration, a decline in economic output and an increase in poverty follows. In Bangladesh, annual flood damage causes a 0.8 per cent reduction of the country's GDP (Holzheu and Turner 2017). In Peru, from 2003 to 2008, climate disasters increased poverty rates by 16 to 23 per cent (World Bank 2016).

The protection gap is expected to get worse over the coming years, as the frequency of severe weather events increases. As a result, the majority of insurance shortfall is so far covered by governments, civil society, or borne by the individuals or corporations affected. In recognition of the changing risk landscape and 'protection gap', InsuResilience was formed at Conference of the Parties (COP) 21, aiming to provide coverage for 400 million people across the V20 countries by 2020 (MCII 2015). As Maurice Tulloch, chair of ClimateWise puts it: *'The climate risk protection gap presents insurers with one of our industry's most profound challenges, but the cost of extending sustainable insurance cover is simply not affordable in many places'* (Actuary 2017).

The United Nations Sendai Framework for Disaster Risk Reduction cites financial protection as a key element of building resilience to disaster risk through 2030 (UNISDR 2015). Yet, there are significant challenges when it comes to addressing the protection gap across the V20. The cost of insurance is prohibitively high (Observer 2017). Nearly half of the citizens of V20 countries live in extreme forms of poverty, i.e. living on US$1.25 or less a day. On the demand side, many individuals neither have the ability to afford the 'high premiums' nor associated transactional costs of disaster-specific insurance (V20 2015). A lack of awareness in the value of insurance and trust in insurers are barriers to the widespread adoption of parametric insurance by households. On the supply side, the lack of reliable weather data, high rates of fraudulent claims and the reliance on government subsidies (Noy et al. 2017) widen further the 'transparency and efficiency gaps'. These factors create an unfavourable investment environment, discouraging insurers from offering products that could help reduce the protection gap in the V20 (Surminski et al. 2016; Cohen et al. 2017).

5.3 The attributes of blockchain-based parametric insurance

Novel insurance products like blockchain-based parametric insurance (BBPI) have the potential to amplify coverage among climate-vulnerable households. Parametric insurance (PI) does not require on-the-ground inspections, as settlements are based on pre-determined triggers that are linked to independent, objective measures that

are correlated with damages. Integrating PI on the blockchain via 'smart contracts' benefits the insurers and policy-holders by automating claims, enhancing trust, increasing transparency and ensuring immutability on securely distributed ledgers (Cohn et al. 2017). Smart contracts are virtual contracts written in computer code that governs a step-by-step transaction (Knezevic 2018). The terms of the agreement are pre-programmed with the ability to self-execute and self-enforce independently without intermediaries. Smart contracts can streamline the insurance process, reducing contracts to simple '*if-then*' statements, since the terms are easily converted to computer code and executed automatically (Cohn et al. 2017). Smart contracts have the potential to change the way we address climate and weather risks as well as how we respond to them. BBPI can, therefore, greatly reduce the cost of managing the claims process, hasten claims payments, enable payments to reach remote areas previously inaccessible (Greatrex et al. 2015), and improve access to the poor by allowing policies smaller than would otherwise be warranted under traditional disaster insurance (Noy et al. 2017).

BBPI can circumnavigate challenges that remain when insuring against climate change, such as a lack of reliable data, cost, high premiums for the poor, claims resolution disputes and delays in claim processing (UNDP 2017). Nonetheless, there are still a lot of unknowns relating to the development and uptake of BPPI. This chapter aims to:

1. assess the role of BBPI as a mechanism to address the efficiency and transparency gap concurrent in traditional insurance products;
2. highlight the emerging use-cases of BBPI in providing coverage for natural hazards with a feasibility assessment on effective coverage;
3. inform the community of insurers and reinsurers, policy-makers and the wider commercial sector of the potential of BBPI to address the ever-accelerating financial implications that climate change brings; and
4. recommend an action plan for mainstreaming BBPI into disaster insurance market.

5.4 The landscape of disaster response actions

Any feasibility assessment on BBPI to tackle the impact of climate-related disasters is necessarily an emerging topic. Highlighting the seminal contributions and use-cases in the related areas of disaster aid and catastrophe bonds, as well as parametric insurance, this section also describes the role of blockchain technology as it applies to parametric insurance. As this is a niche research subject which is complex in nature, a combination of semi-structured interviews and text-based surveys consisting of open-ended questions were utilised to enrich the knowledge base for stakeholders.

5.4.1 Disaster aid

Funding for disaster aid is disproportionately channelled to V20 countries. Experts forecast that this gap will widen as climate-related weather-events and shocks

compound. Disaster aid is leveraged through national contingency funds, social safety nets and charitable donations from domestic, regional and global humanitarian actors (OECD 2007). Disaster aid can take two forms: relief and reconstruction (UNISDR 2018). Relief emphasises the urgent but temporary nature of assistance, such as providing cash and materials, search and rescue, evacuation, food and water distribution, mostly as a humanitarian response by government, non-governmental organisations (NGOs) and the United Nations Central Emergency Response Fund (CERF). Reconstruction is typically managed by other development agencies and international financial institutions such as the World Bank for restoring infrastructure and the normal life of businesses with a long-term focus (Sawada and Takasaki 2017).

Reliance on disaster aid has drawbacks. First, it can 'crowd out' private coping mechanisms – such as insurance and reinsurance – supposed to minimise risk exposure and increase the resilience of communities to natural hazards. For example, a study on US homeowners impacted by flooding found that every dollar increase in aid granted decreased average insurance take-up by about US$6 (Kousky et al. 2013). Second, recipient countries and agencies often experience high transaction fees and delays in receiving aid and reimbursement (Brandon 2011). The UK Parliament's Select Committee on International Development notes that even when financial aid has been pooled and a robust pre-disaster action plan put in place, the fragmented landscape of agencies and poor co-ordination among them impedes disaster aid from reaching the areas that need it most in the aftermath of a disaster. These factors account for the 'efficiency gap'.

Most significant, however, is the relationship between disaster aid and the extent to which pledges are upheld. When Hurricane Katrina struck the low-lying areas of Louisiana and New Orleans in 2005 causing flooding and damage to more than a million housing units, significant portions of disaster aid were diverted and unaccounted (Paul 2018). Further studies blame the mismanagement of funds, inadequate monitoring of project spending, high management costs and competing priorities (Sawada and Takasaki 2017). This lack of transparency and consistency in the monitoring and reporting of disaster aid is referred to as the 'transparency gap'. The lack of accountability and valid data potentiate malpractice in post-disaster aid co-ordination (Connolly et al. 2018). The OECD recognises the importance of transparency, stating the need to *'enable transparency of aid flow; oversight, monitoring and evaluation; and effective anti-corruption enforcement to improve the efficiency, coordination and reduce disaster risk'* (OECD 2007; UNISDR 2015).

5.4.2 Catastrophe bonds

Catastrophe bonds (or CAT bonds) were first created and used in the mid-1990s in response to the devastation brought by Hurricane Andrew to Florida in August 1992. They emerged from the need of insurance companies to mitigate the risks they would face when a major catastrophe causing damages that could not be covered by invested premiums occurred. The insurance company issues bonds which are then sold to investors. If no catastrophe occurs, the insurance company pays a coupon to investors. Otherwise, the principal is forfeit and used to pay their claim-holders.

The notion of securitising catastrophic risks became prominent through the work of Richard Sandor (1992) and Kenneth Froot (1997), and a group of professors at the Wharton School who were seeking vehicles to bring more risk-bearing capacity to the catastrophe reinsurance market (Froot 1997). CAT bonds ultimately contributed more available and affordable insurance solutions to catastrophe-prone regions to the benefit of exposed individuals and business entities. They also mitigate systemic risks for insurers, reducing the burden on the government to 'pick up the slack'.

However, 75 per cent of the global catastrophe reinsurance capacity is allocated to North America and Western Europe and it virtually does not exist for vulnerable developing economies (Welt 2010). In response to this imbalance, the World Bank launched in 2009 the MultiCat Program – an issuance platform that arranges CAT bonds for developing countries. Since then, it has covered climate-related events such as hurricanes and drought risks worth US$2.5 billion, as well as other risks relating to earthquakes, tsunami and pandemics for countries such as Mexico, Malawi, the Philippines, Uruguay, the Pacific and the Caribbean regions (Levy 2017).

5.4.3 Parametric insurance

Parametric insurance is a form of insurance that does not indemnify losses after the fact (i.e., pay based on the damage suffered), but provides an alternative where insurers agree to make a payment based on pre-determined metrics such as the occurrence and severity of a triggering event. One of the key features of parametric insurance is prompt claim payments. Unlike traditional indemnity insurance, where payments are made upon financial quantification of the damage, parametric insurance pays out based on the occurrence only. It does not require an on-the-ground assessment. The threshold of pay-outs is designed beforehand to be approximately proportional to the losses expected to be incurred post-disaster (World Bank 2007).

One of the first examples of this form of insurance was the Caribbean Catastrophe Risk Insurance Facility (CCRIF), which has paid more than US$100 million since its inception in 2007 against hurricane, excess rainfall and earthquake perils (World Bank 2007; CCRIF 2017). Each pay-out was made within 14 days of a catastrophic event. According to the CCRIF CEO, Mr Isaac Anthony, *'the injection of short-term liquidity that CCRIF provides when a policy is triggered is not intended to cover all the losses on the ground following a disaster, but it is designed to allow governments to reduce their budget volatility and to provide much-needed capital for emergency relief such as clearing of debris and other clean-up activities, restoring critical infrastructure, and most importantly, providing humanitarian assistance to the affected population, thereby reducing post-disaster resource deficits'*.

Similarly, the World Bank's Sovereign Catastrophe Risk Insurance Programme provides the Philippines Federal Government with US$206 million worth of aggregate coverage from typhoons and earthquakes, as well as typhoon insurance for 25 provincial governments (Bretton Woods Project 2017). Pay-outs under this scheme are also based on parametric triggers. This approach leverages the capacities of private insurance and investor markets to increase 'pre-arranged' disaster risk

financing (ibid), with added advantages over traditional insurance such as lower premiums (3–6%), faster pay-outs and substantially lower transaction costs. PI also fills part of the protection gaps left by indemnity-based insurance (such as deductibles, excluded perils, adverse selection) (Sawada and Takasaki 2017); and avoids the moral hazard of recipients not installing enough protection measures – recipients receive the same payment regardless of the damage incurred and thus, have an incentive to avoid damages if possible (Linnerooth-Bayer et al. 2018).

PI is also being offered on a smaller scale to individuals and households. A trial by the Feed the Future Innovation Lab for Assets and Market Access, a collaboration between USAID and the University of California, Davis (UCD) to introduce index-based insurance to 50 villages in Mali in 2011, found that index-based insurance contracts tend to encourage farmers to invest more (UCD 2013). Cotton farming in West Africa is lucrative but risky for small-scale farmers, given the region's volatile weather patterns. Unprotected farmers in the region often choose to minimise their exposure by limiting their cotton cultivation, and planting 'safer' but less profitable crops. The risk of losing everything in a bad year has discouraged them from investing in better seeds, more lucrative crops or fertiliser, despite the potential gains. Compared to the uninsured control group, insured farming households produced 19 per cent more cotton, using 15 per cent more productive inputs and 28 per cent more seed (UCD 2013).

That said, PI is not without drawbacks. ActionAid International suggests that bureaucracy and corruption are systemic to the nature of the structuring of PI policies and can prevent timely claims pay-outs. This proved the case with the PI policy held by the Malawi government and underwritten by African Risk Capacity (ARC). Even though Malawi experienced one of its worst droughts on record, it took three months for policy-holders to receive any recompense, which placed thousands of lives at stake and deepened the humanitarian crisis (Bretton Woods Project 2017).

Another criticism of PI is 'basis risk'. Basis risk refers to the relationship between the pre-selected parameter and damages. This is estimated in advance and the claims payments may therefore not reflect the losses incurred. This is an issue with PI due to underused pooled risk and inadequate comprehensive and reliable long-term data that impacts claims estimation (Observer 2017). Moreover, poorly designed index insurance may pay at times where there is no loss incurred, yet fail to pay at all following a disaster.

For example, torrential rainfall in Jamaica in May 2017 caused widespread flooding, resulting in an estimated economic impact of US$385 million, but the excess rainfall parameters with CCRIF were not triggered (Artemis 2017). CCRIF does not offer flood cover, and the modelled damage of US$100m based on rainfall parameters alone was below the payment threshold of US$200m. This lack of payment has led to questions being raised about the benefit of policies that do not pay out despite significant damages. To cover flooding risk would require a redesign of the PI set-up: it would need to consider the relationship between excess rainfall and the resulting flooding effects on the built environment, land coverage, agricultural impacts and land use, among other factors, and estimate the damages from these.

Design failure is a major hurdle that PI providers are still addressing. As Michael Carter, a Professor of Agricultural and Resource Economics at UC Davis puts it, *'this kind of (poorly designed) contract is more likely to leave a farmer worse off for having bought it than it is to help them to achieve long-term stability and resilience'* (Russell 2018).

5.5 The role of blockchain technology in insurance

Blockchain is a distributed ledger technology in which transactions are recorded chronologically and publicly. It emerged to address the pitfalls of centralised databases, such as data manipulation, fraud, embezzlement and theft (Nakamoto 2008). Although the first major use-case was the cryptocurrency, Bitcoin, the blockchain technology that underpins it extends beyond currencies. Blockchain enables a near friction-free, inexpensive and transparent mechanism for peers to transact without an intermediary, and to monitor, report and verify on the validity of the transaction between members of complex networks. This facet ensures transparency and consistency in data channels, which is fundamental to providing transparent reporting of disaster aid and claims pay-outs.

Trust is established using a distributed consensus mechanism to check the validity of transactions, independent of intermediaries – for example, Proof of Work is used in the Ethereum blockchain. With blockchain technology, insurance data including policies, pay-outs, know-your-customer and anti-money laundering information can be recorded digitally on secure, incorruptible digital ledgers across a dispersed network of nodes. As the blockchain is open to writing and inspection, actors within the disaster aid landscape and insurance providers can be held accountable for their actions (Observer 2017). Further, the transfer of data is handled independently and automatically on-chain, removing manual routine and paper-based procedures.

Smart contracts can further streamline this process by codifying traditional insurance policies. Blockchain removes the need for a central authority, legal system or external enforcement mechanism by permitting a seamless and constant contract execution environment that renders transactions to be traceable, transparent and irreversible. Blockchain-enabled smart contracts, therefore, help build trust between policy-holders and the broader ecosystem of insurance providers, regulators and other players since the risk of data tampering (fraud, theft and hacking) is considerably mitigated (Clyde and Co LLP 2018). Research suggests that the automatic handling of data also removes 30 days of administration time from the insurance/reinsurance cycle (ibid), providing efficiency gains to the industry.

Unlike traditional database operations, with the blockchain, individual-level data can be attached and processed in real-time – at a significantly greater speed and volume than what is currently possible. This allows insurers to offer customised pricing to individuals, based on frequent risk assessments. This acts to tailor long-term risk reduction strategies for different groups and thus, enhances the effectiveness of distribution through building trusted relationships and transparent, timely post-disaster claim processing (OECD 2018). Decentralisation has the potential to disrupt

the traditional insurance model, enabling new peer-to-peer models of insurance. Friendsurance, an InsurTech start-up in Germany, for example, allows customers with the same type of insurance to connect and share premiums, assess risks and claims, with reduced costs (Clyde and Co LLP 2018).

Currently, insurers are experimenting and modelling policies through the use of different blockchains. Ethereum is the most diffuse blockchain offering smart contract solutions, while others exist such as NEO, NEM, EOS and Cardano. The most notable blockchain consortium in insurance is the Blockchain Industry Insurance Initiative (B3i), operating R3 Corda – a permissioned-private blockchain. AXA, on the other hand, is experimenting with the platform-agnostic Hyperledger Fabric, a permissionless open-source blockchain. The use of different blockchains highlights the fact that InsurTech is still maturing and the market consolidating. Thus, it is important to maintain interoperability and flexibility based on minimum standards to ensure a collaborative environment to build capacity, develop partnerships and share best practices as to optimising policies or driving a revolution in accessing and scaling such policies to address the 'protection gap' (ibid).

5.6 BBPI – a faster, fairer and cheaper approach

As aforementioned, there are several problems with traditional approaches to disaster aid and traditional indemnity-based and parametric-based insurance offerings for climate-related disasters. Disaster aid crowds out private coping mechanisms such as insurance, which increases risk exposure, reduces resilience to climate disasters and increases the burden on government budgets post-disaster. Traditional payment methods incur high transaction fees and delays in delivering aid to those who need it most. Mismanagement of funds, high management costs and the lack of transparency in when, where and how disaster aid is channelled are perennial problems. This is also the case with traditional indemnity-based insurance and securities such as CAT bonds covering climate-related damage.

Even PI, which circumvents many of the issues associated with indemnity-based insurance, still requires a trustworthy provider to pay when disaster strikes.

5.6.1 Technical workings of BBPI

Blockchain-based parametric insurance (BBPI) is arguably a faster, fairer and cheaper approach to post-disaster response. As with PI, claims payments are tied to pre-determined index triggers based on independent, objective measures. With BBPI, once the premium is paid, the contract details are entered onto immutable blockchain software via a 'smart contract', to ensure the payment is made when pre-specified weather parameters are met. If a weather event occurs according to a trusted data source (e.g., if wind speeds greater than 100mph are recorded at the nearest weather station), a payment is automatically triggered. As with PI, there is no need for the recipient to make a claim – but in the case of BBPI, the technology does that for them.

Unlike conventional PI, however, new policies are created as entries within the smart contracts ledger, and the computational steps taken to reach an approval or

denial of claim are made and published on the blockchain. In this setting, policies secured by blockchain technology are available in the public domain and for regulatory inspection (Davis 2018). This instils confidence in the data, overcomes data access issues, and provides a much-needed layer of transparency to improve inter-organisational co-operation between insurers and reinsurers. As transparency is central to establishing trust, individuals can be certain that insurance providers operate with integrity and legitimacy and will thus be more inclined to take out policies.

Blockchain technology has the potential to remove significant disputes, such as whether: policies were issued; premiums were paid; the identities of policy-holders had gone through know your customer (KYC) and anti-money laundering (AML) checks; and that the data of policies is in the risk pool. The instant verification of these parameters, coupled with the ability of the blockchain to consolidate data points from third-party providers, provides conditions to improve the affordability of premiums due to the reduction of risk (Davis 2018). In each transaction, the data is validated over time on an immutable chain that is more secure and difficult to hack than traditional database solutions. It also helps mitigate the risk of delivery, because blockchains are easier to code than traditional solutions.

5.6.2 The role of oracles

In BBPI, payments are triggered based on commonly-agreed third-party information from reliable sources, such as weather index databases and data based on high-resolution satellite imagery. As 'smart contracts' are deterministic in nature, they rely on oracles to bring this external data into the blockchain. 'Oracles' are third-party information sources that supply data to blockchains for the creation and execution of smart contracts (Lamberti et al. 2017). For BBPI, oracles are used to monitor weather index databases and high-resolution satellite imagery to confirm whether certain parameters are met. Oracles can improve the pay-out of PI by increasing the accuracy and objectivity in the data sets.

However, for oracles to be effective, a trusted source of data is required (Lamberti et al. 2017). This can be an issue where the data is not available – a common problem for many small nation states where the data is patchy or of low resolution – or where the data source is not considered independent and the data is potentially subject to tampering. In most small states, there is a shortage of devices to monitor the weather. Some countries have only a single weather station located at the main airport. The shortage of devices to monitor actual conditions on the ground is a major barrier. The lack of a functional internet in the aftermath of a disaster can also make ground-based technologies problematic.

To counter this, satellite-based earth observation data and unmanned aerial vehicles could be used to complement weather-index parameters and indemnity assessments by monitoring areas directly in the aftermath of a disaster and assessing the claim pay-out in near real-time. In addition, new low-cost meteorological technology is being developed that could address this issue over time. This will help bridge the 'data gap' between the exposure of disasters, which currently favour high-profile

emergencies at the expense of less visible suffering far from the media or the political spotlight (Davis 2018). In addition, a combination of consensus-based oracles could be utilised, which monitor various index databases concurrently to arrive at a commonly agreed outcome and thus, initiate the execution of the smart contract. This payment mechanism therefore removes the discretion out of the decision to pay out through disintermediation and automation.

That said, as oracles are still in their infancy, transmitting data to the blockchain and performing the verification is costly, a major impediment to scaling BBPI (Van Der Llaan 2018).

Despite the higher cost incurred in data transfer and management with oracles, as a whole BBPI is more cost effective than traditional disaster insurance. BBPI is also more closely aligned to the Sendai Framework, which permits the need for tools to *'promote the collection, analysis, management and use of relevant data and practical information and ensure its dissemination, taking into account the needs of different categories of users'* (UNISDR 2015).

5.6.3 BBPI in the agriculture sector

Drought means disaster for most farmers, particularly in the developing world and is likely to increase in propensity. Low rainfall reduces crop yields, reducing food, income and the capacity to buy the seed and fertiliser required for future seasons (Russell 2018). Conventional crop insurance is too expensive for most smallholder farmers. For insurers, the relatively high cost of administration compared to the small-scale premiums, on top of disputes and fraudulent claims, mean that it has not been economically viable to serve low-budget customers. This leads farmers to reduce investment in productive assets and select low-risk, low-return crops and livestock, restricting their ability to escape poverty and earn higher incomes (World Bank 2016).

Nowadays, fortunately, more than 20,000 farmers in Kenya, Uganda and Ghana have access to affordable crop insurance via their smartphones with WorldCover, a US-based InsurTech start-up (Bird 2018). Putting policies on blockchain-based smart contracts avoids the need for paperwork. Importantly, the insurance focuses on a single index parameter – rainfall – and does not rely on manual assessments or decision-making. The scheme uses satellite imagery to detect rainfall and interpolate plant growth. Payments are made using a mobile money transfer service. As Christopher Sheehan, founder and CEO of WorldCover explains:

> *'With machine learning and blockchain technology, we can process these data very cheaply to produce a really simple crop insurance product with premiums of $20 to $50 for a farmer who might only be earning $3,000 a year.'*

Similar systems are emerging in the agriculture sector across the world. Blocksure, a UK InsurTech start-up, is developing parametric microinsurance connected to a mobile banking platform in Indonesia. Etherisc, a platform for decentralised insurance, has formed a joint venture with Aon and Oxfam to develop a blockchain crop insurance programme in Sri Lanka. In parallel, Hillridge Technology is developing parametric

weather-index and yield-index financial products for crop and livestock farmers in Australia. Its products are tailored for where the farm is, what is being grown and the risk tolerance of the farmer.

5.7 Blockchain for wider impact on humanitarian assistance

Blockchain technology can also be leveraged to improve the delivery of humanitarian assistance, which frequently incurs weeks of delays to transfer funds (World Bank 2016). To tackle widely diffused problems of fraud, corruption and fund misappropriation, in 2017, the UN World Food Programme used the Ethereum blockchain to develop 'Building Blocks' – a pilot to provide food and cash relief to refugees of the Sindh province of Pakistan. By using smartphone authentication, combined with blockchain technology, payments from the UN agency to food vendors were validated, the recipients received food, the merchants got paid and the agency could trace payments. As a result, blockchain technology enabled aid to reach remote or disaster-struck areas faster, where ATMs may not exist or banks are not functioning normally, and with improved cost efficiency (from 3.5% to less than 1%).

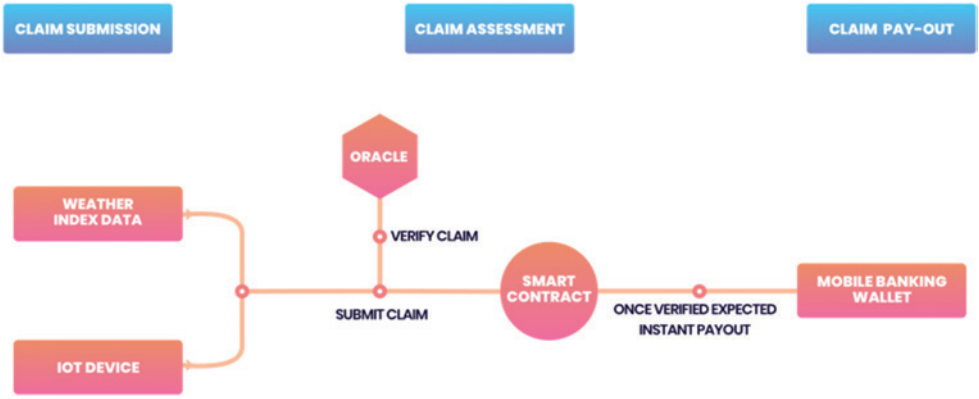
The trial in Pakistan also avoided the many security, theft and safety problems of handling cash in conflict-torn areas, demonstrating that in urgent situations, cryptocurrency can even take the place of scarce local cash, allowing aid organisations, residents and merchants to safely exchange money electronically (Observer 2017). *Smart Network*'s blockchain-based solution for international aid transfer is similar in this setting, as it can fully track the flow of funds through the chain from donor through to beneficiary.

5.8 Blockchain avoiding the pitfalls of traditional disaster insurance

BBPI also impacts the wider market structures, offering more diverse mechanisms for claim pay-out and insurance uptake. For example, by using the smart contract to handle claim payment, automation of claims handling can be realised in addition to improving the reliability and transparency of the pay-out mechanisms for the customer contract-specific rules enforcement. Automation by using smart contracts results in significant reduction of bureaucratic procedures and saves time for accountants, controllers and insurance companies as a whole. Building on this approach, Feed the Future has established in Kenya the world's first quality certification for agricultural index-based insurance to ensure that PI products across East Africa can truly promote long-term resilience for smallholder farmers (UCD 2013). The aim is to create incentives for insurance companies to create higher-quality contracts. For the USAID initiative, UC Davis and NASA will partner with the Regional Centre for Mapping of Resources for Development and a technical lab to measure and refine insurance quality.

By pairing smart contracts with established mobile banking services (e.g., M-Pesa with 30 million users) and Bit-Pesa (for cryptocurrencies), policy-holders can gain

Figure 5.1 How claims are assessed and paid using the BBPI contract for disasters (adapted from Clyde and Co. LLP 2018)



access to claims faster and more conveniently, see Figure 5.1. Moreover, as claims can be paid directly through these streams, it also '*becomes cheaper to service the claims, removing the investigative problem*'. This will not only improve efficiency in terms of the compensation process – which currently can take up to four weeks after a disaster, in some cases longer e.g., African Risk Capacity (Martin 2018) – but also reduce the probability of contract failure by providing a consistent contract execution environment. As Etherisc illustrates with its blockchain-based smart contract PI policy: *HurricaneGuard*, individuals affected by 2018 Hurricane Andrew received pay-outs within 24 to 72 hours in the wake of the disaster, without having to go through the long-winded claims process (Etherisc 2018). Therefore, blockchain offers the potential for insurers to efficiently serve emerging markets and exploit new opportunities by offering more inclusive insurance.

With BBPI, disintermediation (through the use of the smart contract) and direct claim servicing offer the advantage of removing the reconciliation processing of the entire insurance cycle, significantly reducing service and administrative costs. In addition, BBPI can overcome these issues relating to contract formation. BBPI can circumnavigate the need for insurers to provide proof of cover in paper format or for the insured to physically sign the policy document, since cryptographic primitives, i.e., private and public keys, could replace the need to physically sign policy documents. As a result, this can facilitate the access and distribution of PI.

Further, by using a public blockchain for PI such as Ethereum, the transfer and aggregation of data can be streamlined, and the risk of fraud rendered obsolete by using tamper-resistant distributed ledgers. This differs from the standards of today, such as traditional database solutions and processes where data is collected and stored privately in silos. Data collected on a public blockchain offers a higher degree of transparency, as data can be atomised on a standardised platform and open to the public domain, thereby allowing the network of insurance providers, ratings agencies, regulators and investors to have access to policies, claims and claims histories registered on the blockchain.

This data infrastructure builds capacity among agencies and provides the backdrop to improving the structuring of PI policies and, at the same time, auditability by publishing open and readily accessible data. IBM's blockchain solution, Open Insurance Data Link (OpenIDL), is one such initiative to automate regulatory reporting for the insurance sector. By leveraging the blockchain, OpenIDL improves both the operational efficiency and flexibility of reporting. Moreover, the community of regulators and reporting carriers gain access to more holistic and dynamic reporting, providing a more granular level of data coverage and hence, allowing risk to be better priced.

5.9 Coverage in developing countries

Given the increasing frequency and impact of natural disasters in developing countries, the need for inclusive insurance is clear. BBPI has the potential to lower barriers to growth and financial inclusion. The simplicity of BBPI enables it to utilise the existing and growing network of mobile network operators, retail stores, factories and agricultural co-operatives across V20 countries, to distribute products and increase penetration (Clyde and Co LLP 2018). Customers appear to prefer these digital and remote channels to pay for insurance policies. A study by EY, an accounting firm, confirmed that 80 per cent of customers are in favour of using these streams (EY 2018). Given the rapid proliferation of smart phones in developing economies and the shift with insurance providers to service claims via mobile payment channels, this provides an opportunity for individuals to uptake insurance products and therefore increase insurance penetration.

5.10 Challenges of BBPI roll-out

5.10.1 Poor data

Access to timely and reliable data is of particular importance for the insurance and reinsurance markets. Insurers need to accurately estimate the risks and appropriately price the premiums they charge their customers, and need to have confidence in the fidelity of payment triggers (Franzke 2017). One such initiative aiming to do so is INFORM, a global risk assessment database for humanitarian crises. INFORM supports decisions about prevention, preparedness and response by aggregating data to generate local disaster-risk knowledge. This enables local actors to access and exchange risk-related information and for insurers to understand hazard risk exposure (UNISDR 2018).

However, at present, adequate data is sometimes only available nationally, and occasionally not even at this level. This restricts co-ordination, planning and insurance pricing across borders (UNISDR 2015). It is well understood that data gaps are roadblocks to achieving optimal risk assessments and may detract from focusing provisions on the local level, especially in disaster-prone areas that are unaccounted for in the current system. Literature indicates that improving the architecture of insurance products and the underwriting procedure will be the cornerstone to increasing insurance penetration and meeting the agenda of the Sendai Framework (OECD 2007).

5.10.2 Regulation

How BBPI is regulated across jurisdictions can also impact its ability to scale in certain countries. Since insurance licences are currently granted per country, the effort and the cost to get worldwide insurance licenses are enormous. Different jurisdictions have different approaches to the regulation of blockchain technology. For example, an individual receiving a pay-out from a PI policy via cryptocurrencies may be taxed as such currencies are viewed as a security. The solution requires awareness and a lot of work from both business and politics. Regulatory uncertainty can also stifle growth and innovation. Even when regulation has been tough, investment is spurred in such places as New York where the Bit-license has been introduced, and Singapore and the UK where regulatory sandboxes developed recently. Other regulators are more open to blockchain, such as Malta and Estonia, with large companies operating in their jurisdictions and investments following.

5.10.3 Barriers to adoption

As a nascent technology, yet unresolved issues are keeping many insurers from adopting blockchain in insurance. These include slow transaction speeds, a lack of standards and interoperability between different blockchain platforms, connectivity with existing enterprise systems, and legal and regulatory concerns (Deloitte 2018). Progress is being made on increasing throughput and performance via new consensus mechanisms, on enhancing standards and interoperability, and reducing the complexity, cost and energy requirements. Over time, these developments will help lower the cost and risk of deploying blockchain, while expanding the applications of the technology.

For small states, there is the additional barrier of access to trusted oracles, the robustness of technology and communications infrastructure post-disaster – such as emergency cellular networks and a functioning internet – and the small market size for private insurers. The use of pilot programmes and studies – with the support of government and multilateral institutions – can help identify and address the unique challenges in applying BBPI to small states.

Finally, as with any new insurance product, uptake of BBPI, even if offered in market, is also a challenge. It requires a well-thought-out, go-to-market and distribution strategy, investment in product design, technology development and customer acquisition – including educating the consumer – before the product breaks even. It is critical to maintain the confidence of both policy-holders and underwriters, especially in the initial years before the product becomes financially self-sustaining.

5.11 A call to action

As climate change-related disasters increase in frequency and intensity over the coming decades, we cannot afford to ignore the potential for BBPI to provide faster, cheaper and fairer financial recourse for people affected by climate disasters. This is particularly important in rural and regional communities, especially in developing countries, who are least likely to have the capacity to adapt to climate change and have the most to lose in the event of climate-related disasters.

To address the challenge of implementing these novel solutions, governments, civil society and insurers should ask themselves these questions:

- What current disaster aid schemes or insurance products suffer from a lack of transparency, delays in payments after climate disasters strike or fail to reach intended recipients? Could a BBPI solution work instead?
- Is the BBPI solution structured in the right way so it pays out when needed, in a timely way, to the players who most need them? Can we invest in local resources to design the BBPI solution? Who has better insight to take into account local conditions? Has the BBPI structure passed a quality certification?
- Are there trusted data sources upon which risks can be assessed and payments can be triggered? Is there more to be done to make weather- and disaster-related data publicly available, free and easy to access? What investments need to be made in collecting, storing and providing data in a trusted, transparent and consistent way? Can novel technology such as drone and satellite data help?
- What role can government play to provide regulatory certainty to InsurTech providers? Can a well-structured regulatory sandbox be applied, particularly for micro-insurance? What can regulators do to foster a collaborative environment for innovative solutions and encourage the uptake of novel products?

BBPI not only offers a cost-effective, structured and fast approach to distributing funds to governments, organisations and individuals affected by climate-related disasters after the event. By providing a safety net to those vulnerable to the impacts of climate change, it allows them to invest in the future, rather than hoarding resources in preparation for disasters to come. Ultimately, BBPI can provide financial security and climate risk related resilience to individuals and frontier communities, in turn, promoting productivity equity across countries and regions.

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Chapter 6

Leveraging Blockchain Technology to Build Resilience and Disaster Risk Reduction in Small States

JP Fabri and Stephanie Fabri

Blockchain is a foundational emerging technology of the Fourth Industrial Revolution, much like the internet was for the previous (or third) industrial revolution. Its defining features are its distributed and immutable ledger and advanced cryptography, which enable the transfer of a range of assets among parties securely and inexpensively without third-party intermediaries. Blockchain is more than just a tool to enable digital currencies. At its most fundamental level, it is a new, decentralised and global computational infrastructure that could transform many existing processes in business, governance and society and also be an enabler to solve some of the world's challenges.

Countries today face numerous challenges. Economic globalisation, migration, demographic changes, environmental issues and climate change are placing all countries, no matter their size or wealth, under constant pressure. The recent economic and financial crisis has not only uncovered the high level of interconnectedness between economies and the volatility of the global economy, but has underscored the need for effective political capacity to steer policy. It has shown that all countries are vulnerable to global economic shocks in a globalised world. We also know that some countries, particularly small states, are inherently vulnerable to external shocks (Briguglio 1992, 1995, 1997, 2003). What matters in today's world is the strategy and capacity to respond to these adverse shocks. This ability to respond is described by Briguglio et al. (2006) as 'resilience'. Technology advances such as blockchain can be important enablers for building resilience in various areas, including disaster risk reduction.

If harnessed in the right way, blockchain has significant potential to enable a move to cleaner and more resource-preserving decentralised solutions, and unlock natural capital and empower communities with a view of building resilience to environmental and natural shocks, including disasters.

6.1 The nexus between small states, vulnerability and disasters

Many small island states are highly vulnerable to natural disasters and some face unique challenges due to the rising sea level. In fact, studies have shown that small states are proportionately more vulnerable to natural disasters. According to a study

conducted by the International Monetary Fund (IMF 2016), using the most widely used database on natural disasters (EM-DAT), the economic cost of the average natural disaster during 1950 to 2014 was equivalent to nearly 13 per cent of gross domestic product (GDP) for small states compared to less than 1 per cent of GDP for larger states. Similarly, the average natural disaster affects 10 per cent of the population in small states, compared to 1 per cent for other countries. This study (ibid) also found that this greater vulnerability of small states applies to almost all categories of natural disaster. Across a wide range of disasters (except extreme temperatures), an occurrence in a small state is proportionately more damaging than an equivalent event in a larger state, making the recovery in the aftermath of a disaster more challenging. For example, a disaster-level storm is 23 times more damaging than for large states, measured as a share of GDP. This partly reflects the large number of small developing states that are islands, so that when a storm makes landfall, it affects a larger proportion of the population. Greater damage may also reflect the more constrained fiscal space of small states, which can preclude adequate advance investments in risk reduction.

Disasters not only cost more in small states but are also more frequent. Ranked by frequency of disasters in relation to land area, IMF (2016) found that in its sample, 21 of 33 small states were in the global top-50. Small states, as a consolidated group, experienced 460 disasters between 1950 and 2014, an average of seven disasters within the group each year. By contrast, eight countries with a roughly similar overall land area to the combined small states experienced only 66 disasters over the same period, or roughly one each year. The higher frequency of disasters partly reflects the unfavourable geographical location of many small island states.

IMF (2016) concludes, reflecting frequency and impact, the cost of disasters over time is higher for small states. Over the last 25 years, the annual damage (including both disaster and non-disaster years) averaged 1.8 per cent of GDP for small states compared to 0.4 per cent of GDP for other countries. The cost, researchers say, is most probably underestimated.

In terms of economic vulnerability, these adverse weather events represent an extreme form of a supply shock and can have macroeconomic effects that are both large and long-lasting. Fabri (2014) found that natural disaster management was one of the most pressing challenges that small island states were facing, especially from a governance perspective. The literature describes the cycle of loss and recovery as a three-stage process. The first stage involves direct losses from the destruction of infrastructure and property. In the second stage, indirect losses accumulate from foregone output and incomes, and costs are incurred as individuals and business work around disruptions. Finally, as the recovery starts, rebuilding of infrastructures and replacement of damaged goods leads to a temporary boost in activity and employment in the affected areas. Nonetheless, various studies have classified the main economic impacts as follows:

- Natural disasters have a clear temporary impact on growth (Raddatz 2007; Noy 2009; Acevedo 2014; Cabezon et al. 2015).
- Evidence on the impact of natural disasters on underlying long-run growth is more mixed (Cavallo and Noy 2010).

- Fiscal balances tend to be adversely affected (Cabezon et al. 2015; Acevedo 2014).
- External trade balance also tends to worsen (Rasmussen 2004; Cabezon et al. 2015).

Differences in the cost of natural disasters have been attributed to institutions, as well as initial economic and financial conditions. Noy (2009) asserts that institutions directly affect the efficiency of the public intervention following a disaster or the indirect impact by shaping the private sector response. This response or the ability to respond is defined by resilience. Technology and leveraging latest technologies and the synergies between them can enable countries to build their resilience, improving their responsiveness to natural disasters.

6.2 The role of resilience

'Resilience' refers to a country's ability to recover quickly from a negative external shock (Briguglio et al. 2006). Unlike vulnerability, an inherent characteristic for small states – particularly island states – is that resilience is nurtured. Resilience takes on greater significance in countries that are inherently more exposed to external shocks, such as small island states.

In this context, resilience is indeed a pre-condition for economic growth and development. By building resilience, people, communities and governments will be equipped with the capacity to cope, act and rise to the challenges of the twenty-first century.

Building resilience is a transformative process that builds on the capacity of individuals, their communities and institutions to lessen the impacts of shocks, internal or external, natural or human-made, economic, health-related, political or social. Briguglio et al. (2006) argue that economic resilience depends upon appropriate policy interventions in four principal areas, namely: macroeconomic stability, microeconomic market efficiency, social development and governance. Although as a concept it was not included in the original index, good environmental management is also considered to be contributor to resilience.

The literature suggests that good governance has an important and central role in building resilience, especially in small island states (ibid). Building on these findings, Fabri (2007) found a significant development dividend of good governance, where any improvements in governance would lead to a multiplier effect on per capita incomes.

6.3 Blockchain and distributed ledger technology

Throughout the past couple of years, blockchain has been the source of much interest and excitement. This new technological revolution is promising to usher in a new era that will shake up a number of industries, including financial services, logistics, identity and government services. Fuelled by the hype and volatility of Bitcoin, blockchain has also been seen as a new vehicle through which to raise capital through the now infamous Initial Coin Offerings or Security Token Offerings (STOs). Prior to looking at how blockchain can also enhance disaster resilience, it is appropriate

to provide an overview of blockchain and the broader distributed ledger technology (DLT) it is part of.

DLT comes on the heels of several peer-to-peer (P2P) technologies enabled by the internet, such as email, sharing music or other media files, and internet telephony. However, internet-based transfers of asset ownership have long been elusive, as this requires ensuring that an asset is only transferred by its true owner and ensuring that the asset cannot be transferred more than once, i.e. that there is no double-spend. The asset in question could be anything of value.

In 2008, a landmark paper written by an as-yet unidentified person using the pseudonym Satoshi Nakamoto, 'Bitcoin: A Peer-to-Peer Electronic Cash System', proposed a novel approach of transferring 'funds' in the form of 'Bitcoin' in a P2P manner. The underlying technology for Bitcoin outlined in Nakamoto's paper was termed 'blockchain', which refers to a particular way of organising and storing information and transactions. Subsequently, other ways of organising information and transactions for asset transfers in a P2P manner were devised – leading to the term 'distributed ledger technology' (DLT) to refer to the broader category of technologies.

DLT refers to a novel and fast-evolving approach to recording and sharing data across multiple data stores (ledgers), which each have the exact same data records and are collectively maintained and controlled by a distributed network of computer servers, which are called 'nodes'. One way to think about DLT is that it is simply a distributed database with certain specific properties. Blockchain, a particular type of DLT, uses cryptographic and algorithmic methods to create and verify a continuously growing, append-only data structure that takes the form of a chain of so-called 'transaction blocks' – the blockchain – which serves the function of a ledger.

New additions to the database are initiated by one of the members (nodes), who creates a new 'block' of data, for example, containing several transaction records. Information about this new data block is then shared across the entire network, containing encrypted data so transaction details are not made public, and all network participants collectively determine the block's validity according to a pre-defined algorithmic validation method (the 'consensus mechanism'). Only after validation, all participants add the new block to their respective ledgers. Through this mechanism, each change to the ledger is replicated across the entire network and each network member has a full, identical copy of the entire ledger at any point in time. This approach can be used to record transactions on any asset which can be represented in a digital form. The transaction could be a change in the attribute of the asset or a transfer of ownership.

Two core and game-changing attributes of a DLT-based infrastructure are:

i. the ability to store, record and exchange 'information' in digital form across different, self-interested counterparties without the need for a central record-keeper (i.e. peer-to- peer) and without the need for trust among counterparties; and

ii. the ability to ensure there is no 'double-spend' (i.e. the same asset or token cannot be sent to multiple parties).

In the right context, distributed ledgers can potentially have a number of advantages over traditional centralised ledgers and other types of shared ledgers. The most important potential advantages of DLT are listed below, though generalisations are difficult because of the large variety of designs and specifications that permissioned and permission less blockchains can have:

- **Decentralisation and disintermediation**. DLT enables direct transfers of digital value or tokens between two counterparties and decentralised record-keeping, removing the need for an intermediary or central authority who controls the ledger. This can translate into lower costs, better scalability and faster time to market.
- **Greater transparency and easier auditability**. All network members have a full copy of the distributed ledger (which can be encrypted). Changes can only be made when consensus is established, and they are propagated across the entire network in real-time. This feature, combined with the lack of a central authority or limited involvement of a central authority, has the potential to reduce fraud and eliminate reconciliation costs.
- **Automation and programmability**. DLT enables programming pre-agreed conditions that are automatically executed once certain conditions hold. This is referred to as 'smart contracts': for example, invoices that pay themselves when a shipment arrives or share certificates which automatically send owners' dividends.
- **Immutability and verifiability**. DLT can provide an immutable and verifiable audit trail of transactions of any digital or physical asset. While in most cases, immutability is desirable, it can create problems related to recourse mechanisms if the system fails.
- **Gains in speed and efficiency**. DLT offers the potential of increasing speed and lowering inefficiencies by removing or reducing frictions in transactions or in clearing and settlement processes by removing intermediaries and automating processes.
- **Cost reductions**. DLT offers the potential for significant cost reductions due to removing the need for reconciliation, as DLT-based systems by definition contain the 'shared truth' and hence there is no need to reconcile one version of 'truth' with that of one's counterparties.
- **Enhanced cybersecurity resilience**. DLT has the potential to provide a more resilient system than traditional centralised databases and offer better protection against different types of cyber-attacks because of its distributed nature, which removes the single point of attack.

The technology is still evolving, and many regulatory and legal issues are yet to be resolved. For the time being, it is still unclear which DLT applications will actually deliver advantages over existing technological solutions and it is likely that overall gains will be incremental rather than sweeping in the medium term. The most commonly cited technological, legal and regulatory challenges related to DLT are listed below.

Technological challenges:

- **Lack of maturity.** DLT remains at an early stage of development and there are still serious concerns about the robustness and resilience of DLT, especially for large volume transactions, availability of standardised hardware and software applications, and also ample supply of skilled professionals.
- **Scalability and transaction speed.** Current iterations of permissionless distributed ledgers face issues related to scalability of blockchains, both in terms of transaction volume and speed of verifications.
- **Interoperability and integration.** Different DLT systems will need to be interoperable with other ledgers and integrated with existing systems if they are to be introduced at scale into the financial system.
- **Cybersecurity.** No software is immune from technical vulnerabilities.
- **Governance.** The absence of a centralised infrastructure and a central entity leads to concerns about ensuring effective governance of the overall infrastructure.

Legal and regulatory challenges:

- **Regulatory vetting and industry standards.** Regulatory vetting and development of industry standards are necessary, but are still in very early development phases. Malta, a small-island state, is taking a pioneering approach by offering technology certification through a new regulator.
- **Legal clarity over ownership and jurisdiction.** In payment and settlement systems, there are specific concerns related to how the 'point of finality' of a transaction would be defined in a DL environment. In addition, there are concerns about cross-border DL systems in terms of the jurisdiction of the underlying data and transactions. Regulating open, permissionless distributed ledger systems is particularly complicated, as no legal entity is in control of the distributed ledger. Regulation of private, permissioned ledgers is comparatively more straightforward, as there is usually an administrator or owner of the system that can be subject to regulation or existing regulatory frameworks for outsourcing arrangements could be used.
- **KYC and CDD.** For adoption in the financial system, DLT systems will need to comply with know-your-customer (KYC) and customer due diligence (CDD) requirements in anti-money laundering/combating the financing of terrorism (AML/CFT) regulations. Most permissionless DLT systems disguise the identity of network members by using public key encryption, which will make it difficult to comply with existing AML/CFT regulations and would allow transactions with un-vetted parties.
- **Recourse mechanisms.** As a defining characteristic of distributed ledgers is immutability, there are concerns about how transaction disputes will be resolved, in particular how erroneous transactions will be voided.

6.4 The role of blockchain in DRR

The Sendai Framework for Disaster Risk Reduction 2015–2030 was adopted at the Third UN World Conference in Sendai, Japan, on 18 March 2015. The Sendai Framework is the successor instrument to the *Hyogo Framework for Action (HFA) 2005–2015: Building the Resilience of Nations and Communities to Disasters*. The Sendai Framework is based around four main priorities of action, as shown in Table 6.1.

The document is also guided by a number of principles that are highly tuned to the principles and characteristics of blockchain technology. The principles adopted by the Sendai Framework include shared responsibility, increased accountability,

Table 6.1 Priority areas of the Sendai Framework

Priority	Description
Understanding disaster risk	Disaster risk management needs to be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment.
Strengthening disaster risk governance to manage disaster risk	Disaster risk governance at the national, regional and global levels is vital to the management of disaster risk reduction in all sectors and ensuring the coherence of national and local frameworks of laws, regulations and public policies that, by defining roles and responsibilities, guide, encourage and incentivise the public and private sectors to take action and address disaster risk.
Investing in disaster risk reduction for resilience	Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment. These can be drivers of innovation, growth and job creation. Such measures are cost-effective and instrumental to save lives, prevent and reduce losses, and ensure effective recovery and rehabilitation.
Enhancing disaster preparedness for effective response, and to «Build Back Better» in recovery, rehabilitation and reconstruction	Experience indicates that disaster preparedness needs to be strengthened for more effective response and to ensure capacities are in place for effective recovery. Disasters have also demonstrated that the recovery, rehabilitation and reconstruction phase, which needs to be prepared ahead of the disaster, is an opportunity to «Build Back Better» through integrating disaster risk reduction measures. Women and persons with disabilities should publicly lead and promote gender-equitable and universally accessible approaches during the response and reconstruction phases.

Source: United Nations (2015).

engagement and inclusivity. These are in themselves key principles behind blockchain technology and that is why it is believed that blockchain can also contribute to disaster risk reduction and resilience building.

In fact, blockchain – together with new technologies that constitute the advent of the Fourth Industrial Revolution such as the Internet of Things (IoT) – can bring various possibilities of enhancing disaster resilience, as Table 6.2 shows. It is believed that blockchain and the interplay of various other technologies can bring about tangible solutions in five key main areas, as outlined below.

As is evident, the interplay of various technologies brings tangible improvements in a number of areas.

IoT refers to a network of physical objects embedded with sensors and software that collect data and communicate with one another. As it relates to emergency management, IoT can be used to enhance data collection from the physical environment and quickly communicate this data to different city departments.

Weather-related disasters such as hurricanes or floods sometimes prevent emergency response teams from reaching certain locations. This obstruction reduces a team's ability to track damage, notify the public with up-to-date information and respond in a timely manner. However, if IoT devices were present in these areas, they would be able to more easily broadcast signals and communicate critical data such as temperature, water quality or smoke. With this data, the government can make more informed decision on how to deploy resources during a disaster situation. Today, the Rio de Janeiro City Hall Operations Centre uses sensors to collect real-time data about weather, traffic, police, and medical services in the city.[1] In the United States, the city of Houston worked with AT&T after Hurricane Harvey to deploy IoT technology for identifying damage and communicating information.[2]

Table 6.2 Possible applications of blockchain in disaster management

Key area	Initiatives
Prediction and forecasting of weather	• Extreme weather impact analysis • Ledger to identify and verify weather data
Early-warning systems	• Enhanced real-time monitoring of natural hazards • Decentralised weather sensors generating verified and automated alerts
Resilience planning	• Enhanced emergency disaster response
Resilient infrastructure	• With smart grids and decentralised electricity networks, there can be rerouting of power to prevent blackouts • Decentralised mini-grids to improve disaster resilience
Financial instruments	• Disaster recovery funding • Decentralised and automatic execution of disaster insurance platforms • Management and enhanced transparency in the disbursement of funding aid • Routes for infrastructure investment

From a more proactive standpoint, cities can place IoT devices on city infrastructure to monitor risk factors and surface data about potential emergencies. For example, the Lower Colorado River Authority (LCRA) uses 270 sensors to measure how fast water is moving across a stream and models what water may do at different touch points.[3] From this, LCRA can proactively manage floods and easily get ahead of water-related disasters in the area.

The benefit of blockchain in emergency management, meanwhile, is that it provides interoperability and transparency. Regarding interoperability, blockchain can be adopted as a universal system across organisations – similar to the internet – and allow multiple parties across that system to co-ordinate resources in an emergency. In a disaster relief scenario, multiple parties are often contributing resources to aid an affected area. If all parties involved in this scenario were to adopt a blockchain-based shared system of record, they could co-ordinate more efficient disaster responses, ensuring resources were allocated to the areas where they are needed most.

In terms of transparency in the disaster relief scenario, blockchain could provide an immutable record, accessible by everyone, to illustrate what resources have been dedicated to an area and by whom. This transparent record, to which anyone could submit an entry, would reduce the possibility of resource diversion and corruption in these types of scenarios.

Disaster relief and aid spending have increasingly come under scrutiny in recent years, as stories have emerged where aid payments were not received by the intended recipients and were instead 'lost along the way'. These incidents, of course, call for further layers of checks and balances to a system that is already burdened with a lot of bureaucracy and red tape. However, by building a disaster relief and aid spending system on top of blockchain technology, much of the bureaucracy and red tape can be reduced, while at the same time the level of transparency, speed and efficiency would increase substantially. Using the blockchain, all aid payments could be processed in a very fast and efficient manner and, above all, this allows the tracking of payments to the intended recipient in a transparent manner.

To test the use of the distributed ledger technology for humanitarian aid payments, the Start Fund, a UK-based rapid response operation run by 42 aid agencies within the Start Network, launched a pilot programme in 2016. The programme saw co-operation with the blockchain start-up ConsenSys to allow the network's non-governmental organisation (NGO) members to gain faster access to aid payments to respond to crises. Built on top of the Ethereum blockchain, the pilot enabled for transparent and efficient transfer of funds and also for the use of smart contract applications.

Since the launch of the Start Fund in 2014, it has been activated 90 times and has reached more than five million people in 49 countries. Through the use of blockchain and smart contracts, the organisation has managed to significantly reduce standard response times. For example, the UN's central emergency response funds currently take an average of 90 days to reach on-the-ground NGOs, while the Start Fund is able to disburse funds within 72 hours of being alerted – making it the fastest emergency

response fund in the world. The below case study illustrates the speed at which aid can be approved and granted. Given that everything is on the blockchain, there is an added layer of transparency and auditability in the disbursement of funds.

Case study: Response to flooding in Sri Lanka

During 13 to 15 November 2015, a depression system formed in the Northern and Eastern provinces of Sri Lanka, bringing heavy rainfall and triggering floods that affected more than 15,000 families in the Jaffna, Kilinochchi and Mulaitivu districts. This event was cause for concern, given that it took place prior to the start of the annual Northeast Monsoon season, which was forecasted by Sri Lanka's Department of Meteorology to receive 10 per cent higher-than-average rainfall. Additionally, major reservoirs had filled much earlier than in previous years, and trends were similar to the previous year, which had recorded one of the worst flood disasters in Sri Lanka.

On 18 November 2015, three agencies alerted the Start Fund, noting the limited funds and capabilities of the District Disaster Management Units, that vulnerable groups were left out of blanket distributions in evacuation centres, and that an anticipatory activation would ensure a more inclusive response. On 27 November, 8 days and 19.75 hours after the Start Fund alert, £105,915 was awarded to Handicap and Oxfam (a consortium project) and World Vision, which focused on addressing needs related to protection (awareness raising on disaster mitigation) and waster, sanitation and hygiene (pre-positioning and distribution of hygiene and shelter kits). This project reached 6,722 people with the total funding.

6.5 Opportunities for the Commonwealth

Blockchain and the emerging technologies that are powering the Fourth Industrial Revolution can usher in a new era of disaster resilience and recovery. Whereas a large proportion of Commonwealth member countries are in fact vulnerable to such disasters, some have been trail-blazers in building resilience in a number of areas and in their adoption of blockchain.

Blockchain is a transformational technology and has the ability to not only disrupt economic sectors and service lines but, more importantly, to usher in new economic systems and institutional design. It can also be seen as a disruptive force to improve government functions and public service administration.

Small island states face particular challenges in establishing an effective civil service. The literature on governance in small states focuses on the challenges that scale imposes on these states. Sutton (2006) identifies four characteristics relating to the performance of the public service:

1. **Exaggerated personalism**. Usually the public service is strongly influenced by ministers and senior public officials and may therefore be open to personal favours and patronage.

2. **Limited resources**. As a result of limited resources in small states, civil servants have to 'wear many hats', leading to inappropriate training and specialisation.

3. **Inadequate service delivery.** This occurs as a result of the cost indivisibilities that are associated with small size.
4. **Relatively high degree of dependence on foreign consultants**. A reliance on foreign management consultants often leads to these consultants promoting and applying 'scale-insensitive' management practices.

6.5.1 Blockchain in the public sector

Governments around the world are rapidly expanding their exploration and use of blockchains for a variety of uses. Just about every area of the public sector could benefit from blockchains in some way (ACT-IAC 2017). In future, centralised authorities could become less relevant in the context of blockchain technologies or their role could shift to providing a platform and governance for decentralised services, rather than being at the centre of every transaction. In reviewing global trends and research, a number of blockchain technology use-cases have emerged that governments are most actively exploring and, in some cases, actively implementing.

Identity

Blockchains could be used to establish digital identities for citizens, residents, businesses and other government affiliates. In addition to using blockchain technology to manage identity, multiple aspects of the identity could be managed using blockchain technology. For example, birth certificates, marriage licenses, passport and visa information, and death records could be managed via blockchains (ibid).

Personal records

Beyond those mentioned under identity, other personal records may be managed with blockchains. Health records, for example, could be made accessible and interoperable to all hospitals in a network or in a country. Governments will need to strongly consider patient privacy rights in such an application, such as ensuring patient authorisation is given in advance and that, ultimately, they own and control their own data. Within government, payroll systems could be built using blockchain technologies, where employees could input their time and be paid automatically through smart contracts (ibid). In Malta, educational certificates are published on the blockchain.

Financial services and banking

Blockchain technology can be used by governments to ease the overhead and burden associated with transferring funds among parties (e.g., facilitating inter-bank and international payments). In addition, some countries' central banks are experimenting with their own digital currencies built upon blockchain platforms. The Eastern Caribbean Central Bank (ECCB) is working on a blockchain-issued Central Bank Digital Currency (CBDC) pilot within the Eastern Caribbean Currency Union (ECCU). This ECCB CBDC pilot is the first of its kind and will involve a securely minted and issued digital version of the EC dollar (DXCD). The digital EC dollar will be distributed and used by licensed financial institutions and non-bank

financial institutions in the ECCU. The DXCD will be used for financial transactions between consumers and merchants, including peer-to-peer transactions, all using smart devices.

Land title registry

Land title registry is a natural fit for blockchain technology. Land titles and other records related to ownership could be chronologically recorded on a blockchain ledger, along with any details relevant to a sale of property. As blockchain transactions are immutable, a full historical record of a property or other asset could be reviewed through previous records in a blockchain. This could minimise the need for expensive and time-consuming third-party involvement for transactions (ibid).

Supply chain management, asset tracking and inventorying

Similar in principle to land title registry, having a comprehensive historical record of an asset is the essential purpose of supply chain management and asset tracking. Blockchain transactions can be used as a means of documenting every transfer of an asset from its origin. Governments could track an asset from its creation, through potentially multiple stages of transportation, and eventually through purchase and even managing asset inventory. This gives anyone with permission the ability to view the chain of custody (e.g., government officials, the public) and thus enables trust in the asset (Yaga et al. 2018) Potential examples include tracking food, medicines, natural resources such as diamonds, and many other assets from origin to distribution.

Benefits, entitlements and aid

The benefits, entitlements aid processes of today often involve a significant amount of overhead and checks for compliance. Government programmes such as social security and pension payments, medical care benefits, and domestic and international aid could benefit tremendously from blockchains. For example, as mentioned above, smart contracts could be used to automate processes for eligibility verification and disbursement of funds, such as distribution of funds for those affected by a major natural disaster.

Contract and vendor management

In permissioned ledgers, perfect transparency can be given to systems and transactions while only authorised users are able to record transactions. This enables the potential for blockchain technology to be leveraged as a tool for transparency and accountability in government spending, which is often executed through contracts. Things such as tracking and paying vendors, managing purchase commitments and transactions, and monitoring schedule performance could all be done in a way that is accessible to all relevant players, as well as the public, as appropriate. In addition to the transparency and accountability angle, blockchains can make government contracting more efficient by eliminating a significant amount of overhead and automating processes that lend themselves to the workflows of smart contracts.

Energy utilities

Public energy utilities may benefit from blockchain technologies for managing of smart energy grids. Blockchains allow for the 'recording of autonomous, machine-to-machine transactions regarding electricity use' (Yaga et al. 2018.). Blockchains could also be used to manage and track contributions from different power plants into a smart grid to ensure each power generator is credited appropriately for their contribution (ibid).

Voting

Blockchain technologies have the potential to enable new methods of voting by transforming what often remains a paper-based process in countries or an electronic process with limited validation and auditability capacities. This can enhance convenience and confidence on the part of citizens. By ensuring that individual votes are eligible and counted correctly, use of blockchains also has the potential to help prevent voting challenges such as ballot rigging, which still persist in many countries. These challenges, if not overcome, can result in a lack of trust in democratic processes and can enable election results that do not reflect the wishes of the public (Foroglou and Tsilidou 2015).

Mitigating and identifying fraud

Through verifications of things such as land ownership, other assets and identities, blockchain technologies can assist governments in mitigating the risk of fraud, as well as identifying fraudulent transactions that do manage to get through. One major example of this would be for assessing and collecting tax payments.

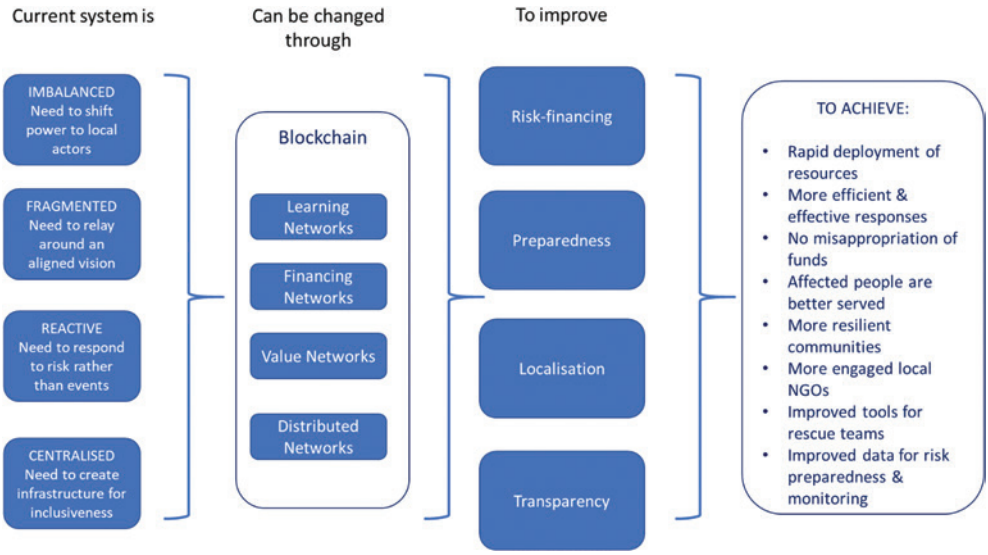
Small islands present some unique challenges in this regard, especially those linked to scale and resources. Therefore, a central and independent organisation like the Commonwealth Secretariat can play a pivotal role in supporting blockchain technology adoption by small island states. There can be collaboration between small island states which are in the process of adopting blockchain, like Malta. This can serve as a launchpad for broader adoption by other small states.

6.5.2 Blockchain for disaster risk reduction: An opportunity

In the previous section, the author presented some use-cases of blockchain in the public sector. One area which was mentioned was aid; however, this can be extended within the whole lifecycle of natural disaster management. The Commonwealth Secretariat can play a key global role in mitigating these risks and bringing about a new approach to dealing with vulnerability and building resilience. The world needs a humanitarian system that is more inclusive, diverse and dispersed. Rather than concentrating resources and decision-making – creating bottlenecks and inhibiting reform – we need to create an ecosystem of interconnections and interactions that is devolved, flexible and resilient.

The author of this chapter believes that blockchain has the power of being an inclusive network which will bring about revolutionary changes, no less in resilience

Figure 6.1 The use of blockchain in building disaster risk reduction resilience



and specifically in disaster management. Whereas blockchain is an enabler, it requires strong leadership and the Commonwealth Secretariat is well placed for this at this current juncture. In order to bring about key changes in the sector and enable countries to embrace blockchain technology, it is being proposed here that the Secretariat should be a catalyst for small states to build resilience in this area – as shown in Figure 6.1.

No single agency can bring about this change, but by collaborating on a global scale and through its values of engagement and inclusiveness, the Commonwealth Secretariat can act as a true catalyst. The author believes that the following key principles should be high on the Secretariat's agenda for disaster risk reduction.

Distributed networks

Right now, the humanitarian system is highly centralised, inflexible and resistant to change. Power and decision-making are concentrated and humanitarian responses are not defined by those closest to crises. We need to move away from this model, to one that generates solutions that are locally appropriate, independently governed and globally connected in a way that fosters efficiency, innovation and shared learning.

The Commonwealth Secretariat, together with member governments and civil society, should create a global network of national and regional hubs which are all connected on the blockchain. The network would enable power, resources and innovation to be centred closer to crisis-affected communities. This is expected to lead to the provision of better, faster and more predictable responses. All hubs would be interconnected to ensure resources and value can be shared. The Secretariat should prioritise establishing hubs in countries which are more vulnerable to disasters. The network would also serve as a means to transfer of knowledge on how to respond to such crises.

Financing networks

Despite improvements in our ability to predict disasters, the humanitarian system continues to react as though they are unexpected surprises, responding only after they occur and then often slowly. Despite research suggesting that early intervention is more effective than allowing a situation to escalate, organisations remain constrained by entrenched historical funding mechanisms.

We need new funding instruments that will enable humanitarians to mobilise more collaboratively, more predictably and in anticipation of, rather than response to, crises. New financing models should be based on three main criteria:

1. using science and data to model and quantify risks in the areas in which funds operate;
2. encouraging the pre-planning and costing of different crisis response activities; and
3. pre-positioning funds according to pre-agreed triggers, so that when the conditions are met, funding is rapidly released.

Crisis modelling and prediction would enable a more structured, rules-based approach and build certainty into financing.

Value networks

The network would be facilitated by a global platform. The platform's value will lie not in delivering programmes, but in its ability to introduce network-wide solutions, to reduce duplication and to enable all parts of the network to share and learn from one another. Participants will benefit from a 'network effect', as the platform fosters exchanges between its members. Participating in the network means reaching a greater range of users; this will help in reducing duplication and concurrently disseminating knowledge and best practice more widely.

Inclusive networks

To bring a greater diversity into the humanitarian system, for finances to flow efficiently through the network, and smaller organisations to access funds directly, we need to find ways to break down the barriers created by the current system of due diligence. Due diligence – the vetting of organisations due to receive funding – is vital for donors: it gives them reassurance that the organisations they fund have the governance and financial systems necessary to minimise the risk of misuse of funds. However, the cost of vetting, and the stringent requirements demanded by funders, result in the exclusion of many smaller organisations as potential fund recipients.

Organisations often need to be quite large to have the systems and financial accountability necessary to underwrite financial risks. This creates significant barriers to entry and reduces the possibility of inclusiveness in financing as a result of the need for due diligence requirements. In addition, donors and NGOs all have their own vetting systems, creating unnecessary duplication and administrative cost

for every actor and donor in the aid system. We need to address both the inefficiency and the stifling of smaller-scale organisations that are inherent in current due diligence practices.

The blockchain and the use of artificial intelligence allows the use of global due diligence databases to provide:

- a standardised due diligence process that is tiered (not simply pass or fail) and can be tailored to context;
- online verification and validation of organisations; and
- opt-in capacity building and training to enable actors to move up the due diligence tiers.

At the heart of this initiative is to find a faster, cheaper and more effective due diligence solution which could take many forms.

Learning networks

Feedback and learning would take centre stage at every level of the proposed global network – within each programme and each hub. Learning will be decentralised: learning loops will be embedded across the global network – in each hub and every project – and all parts of the network will be equipped to develop their understanding and performance based on the feedback they receive. The network will ensure that the people delivering the programmes are those best positioned to understand the context and complexity of the work. Instead of top-down control, these teams will be guided using learning loops. The network will need an enabling framework to keep teams aligned while allowing them independence. We believe that three main thrusts of learning will be critical to the success of the project and to building resilience:

1. Demonstrating accountability – communicating outputs and outcomes to illustrate the performance of programmes
2. Building knowledge – accumulating evidence and insights over time so that future work can be stronger
3. Adapting to change – staying alert and flexible, pivoting and correcting course as changing circumstances demand

From the above, it is evident that blockchain technology has the potential of being a key enabler of change in the area of disaster management. This chapter has only looked at one potential use with multiple benefits; however, as Table 6.2 shows, there are many more areas in which blockchain can really make a difference. We believe that at the national level, countries need to implement blockchain to revolutionise public service delivery and build country resilience. However, we also believe that the Commonwealth Secretariat should take a leadership role and, by utilising the experience of its member states such as Malta, it should build a 'Commonwealth of Blockchain Islands'. The use-case for disaster risk reduction can be one of the first projects of such a network whereby small-states will learn and share best-practices in the adoption of blockchain.

6.6 Conclusion

Polities and the policy-making agenda are becoming ever more complex. The interconnectedness brought about by globalisation has amplified common challenges. However, there remains wide disparities between the coping ability of countries and resilience-building strategies become central.

Small countries remain inherently vulnerable and exposed to external shocks, yet most have not yet managed to build up their resilience. Their exposure and vulnerability to natural shocks and disasters has cost thousands of lives and decades of lost economic growth and resilience building.

The opportunity for blockchain-enabled innovation to benefit humankind and our environment is substantial, but the technology itself is still at a relatively early stage, with many hurdles to overcome. Far from being an obstacle, this presents an important opportunity for stakeholders to collectively ensure the future development of blockchain technology and its application. As argued in this chapter, blockchain can be expected to play an important role in enabling new technological solutions to pressing environmental challenges, including disaster management, but can also be extended to climate change, biodiversity, ocean health, water management, air pollution, resilience and waste reduction.

Harnessing blockchain technologies to drive sustainable and resilient growth and a new wave of value creation will require decisive action. The opportunities that blockchain offers need to be developed and governed wisely and that is why the chapter has argued that the Commonwealth Secretariat should take global leadership in harnessing blockchain between its member states and as a use-case to implement this revolutionary technology to achieve the Sendai goals.

Given the vulnerabilities and the need for resilience in this area, this chapter has argued for the creation of a Commonwealth of Blockchain Islands to use blockchain technology as an enabler for resilience.

Notes

1 See: https://10innovations.alumniportal.com/internet-of-things/iot-in-disaster-management-saving-lives-with-early-warning.html
2 See: https://www.iotforall.com/iot-natural-disaster/
3 See: https://gcn.com/articles/2017/09/20/iot-flood-sensors.aspx

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Chapter 7

A Knowledge Management Initiative in Support of the Caribbean Comprehensive Disaster Management Framework and DRM Capacity Building

Barbara Carby

Abstract

Despite global advances in risk assessment and production of data and information on risk, there is little evidence that risk assessments are informing disaster risk reduction. There is need for translation of data and information into knowledge which is understandable and usable. This chapter presents a knowledge management project that was developed in support of the Comprehensive Disaster Management Strategy and Framework, the regional framework which guides disaster risk management in the countries of the Caribbean Community (CARICOM). The project is compared to elements of the UN International Strategy for Disaster Reduction (UNISDR) IKM4DRR Scorecard and suggestions are made for sustaining project outcomes. Creation of a virtual space for co-production of knowledge for the CARICOM disaster risk management community is proposed to support continued development of disaster risk management (DRM) capacity in the region.

7.1 Introduction

The Global Assessment Report on Disaster Reduction (GAR) 2015 reports that global economic losses from disasters have reached an annual average of 250 to 300 billion United States dollars (USD). Mortality and economic losses from extensive risk in low- and middle-income countries are trending upwards, while small island developing states (SIDS) will be hard hit as their future losses are projected to be 20 times more than in Europe and Central Asia (UNISDR 2015). Since introduction of the Hyogo Framework for Action (HFA), investment in risk assessment, risk identification and production of risk information has increased considerably; this is accompanied by growth in the risk modelling community of practice, increased risk data availability, and the scientific and technical capacity to transform data into risk information (UNISDR 2015). However, there is little evidence that risk information is informing development or disaster risk reduction (DRR) programmes and policies (UNISDR 2015). In order for risk information to inform development and DRR,

the GAR's authors conclude that risk information needs to be translated into risk knowledge, i.e. information which is understandable and usable by different users.

The Sendai Framework for Disaster Risk Reduction 2015–2030 states that knowledge management is the basis of understanding risk and lists several activities that would support this process. These include:

a. collection, analysis and use of data and practical information;

b. dissemination of information, taking into account needs of different categories of users;

c. making non-sensitive information freely available;

d. sharing of experiences;

e. facilitating the science–policy interface for effective decision-making; and

f. promoting incorporation of disaster risk knowledge in formal and non-formal education, as well as civic and professional education and training.

Definitions of knowledge management are varied. Wang et al. (2001) define it in terms of an organisation's ability to capture, create, deliver and use knowledge in order to achieve organisational learning. Groff and Jones (2003) state that it is a combination of tools, techniques and strategies to retain, organise, analyse and share business expertise. Rowley (1999) asserts that management entails processes associated with the identification, sharing and creation of knowledge.

The differences between data, information, knowledge and wisdom were considered by Ackoff (1999), who proposed the data, information, knowledge, wisdom (DIKW) hierarchy:

- data represents the characteristics of objects and events;
- data is processed into information in order for it to be more useful;
- information, he states, answers questions such as who, what, where, why;
- whereas knowledge answers 'how to' questions;
- wisdom, he concludes, deals with values and involves the exercise of judgement.

Arven (2013) linked the DIKW hierarchy to risk. He interprets data as input to the risk assessment; information as the risk description; knowledge for the decision-maker is understanding the risk description; knowledge for the analyst is understanding how to do the risk assessment and understanding the risk description; wisdom for the decision-maker is being able to use the risk analysis in the right way; and wisdom for the analyst is the ability to present the results of the analysis in the right way.

The gap between the availability of data and information on risk, translation into knowledge and their application to DRR and development has been considered by various authors. Gaillard and Mercer (2012) believe that knowledge must be translated to action by adoption of an integrated and inclusive approach involving

all DRR actors across scales and including all types of knowledge. In considering the problem, Weichselgartner and Pigeon (2015) state that policy-makers often do not use available research in their decision-making and that researchers do not consider the needs of policy and practice when doing research and do not produce findings in a usable form. They suggest that there needs to be a shift from production of risk information to co-production of risk knowledge that is understandable and usable by multiple users.

UNISDR (2013) considers that knowledge management brings together people, resources, processes and information in order to achieve a strategic objective and includes knowledge translation, knowledge brokering and innovation brokering.

One can conclude therefore that to be effective, the production of knowledge entails collaboration among users and producers of knowledge and that the knowledge produced should meet the needs of the user, must be understood by the user and be applied by the user.

Questions surround whether 'knowledge' can be 'managed', e.g. Wilson (2002). However, the idea of knowledge management and its importance to disaster risk management is accepted by various authors (e.g. Spiekerman et al. 2015; Pathirage et al. 2012; Weichselgartner and Kasperson 2010).

Management of DRM knowledge should have the aim of reducing the impact of hazards and, thus ultimately, reducing loss of lives, property and economic impact. However as has been stated above, losses continue to increase, despite increases in available data and information. The challenges would seem to include communication between policy-/ decision-makers and researchers (Weichselgartner and Pigeon 2015), how to move from knowledge to action (Gaillard and Mercer 2012), inadequate inclusion of all actors in society (McEntire 2005), and difficulties in integrating research findings into policy and practice (Manandhar and McEntire 2014). Any attempts at applying knowledge management for disaster risk management should seek to address these challenges.

This chapter presents a knowledge management project that is underway in the participating states of the Caribbean Disaster Emergency Management Agency (CDEMA), which is the umbrella organisation for disaster risk management of the Caribbean Community (CARICOM). The project is compared to the UNISDR Information and Knowledge Management for Disaster Risk Reduction Framework and Scorecard to assess integration of knowledge management principles in project implementation. Suggestions for sustaining project outputs following the project closure are made and a pathway for future co-production of knowledge among researchers, policy-makers, practitioners and the private sector is presented.

7.2 Caribbean countries' exposure to hazards

Caribbean countries are exposed to multiple hazards of natural and anthropogenic origin. Each year, several countries are impacted by hydro-meteorological hazards.

Table 7.1 Impact of selected disasters on Caribbean countries

Country: type of disaster, year	Economic impact (US$ millions)	Impact as a % of GDP/GNP
Grenada: hurricane (Ivan), 2004	889	212
Cayman Islands: hurricane (Ivan), 2004	3,432	183
Jamaica: hurricane (Ivan), 2004	595	8
Guyana: drought, 1997	29	n/a
Jamaica: drought, 2000	6	n/a
Montserrat: volcanic eruption, started 1995	n/a	44% decline in real GDP between 1994 and 1997
Cuba: drought, 2004	3.1	n/a
Haiti: earthquake, 2010	8,000	121% 2009 GNP
Dominica: hurricane (Maria), 2017	164,000	167

Source: Various including ECLAC 2004; National Hurricane Centre 2016; FAO 2016; DFID 1999; Aon Benfield 2018.

Tropical cyclone systems can impact multiple countries, causing loss of life and damage, as was the case with Hurricane Ivan which affected multiple countries including Grenada, Jamaica and Cayman Islands (Table 7.1). Volcanic eruptions and earthquakes occur less frequently, but can be devastating. The eruption of Soufriere in Montserrat, which started in 1995, resulted in 20 deaths and necessitated relocation of the capital to the north of the island after the original site was covered by pyroclastic flows. The most recent major earthquake in the region, in Haiti in 2010, resulted in more than 200,000 deaths (ECLAC 2010).

In Caribbean countries, a high percentage of gross domestic product (GDP) is often generated in areas at risk from hazards. Dilley (2005) lists the following percentages of GDP exposed in at-risk areas from two or more hazards for some Caribbean SIDS: Jamaica 96.3 per cent, Dominican Republic 95.6 per cent, Trinidad and Tobago 83.1 per cent, Barbados 79.9 per cent and Dominica 68.3 per cent (McDonald 1985). In addition, for Caribbean SIDS, climate change will contribute an additional US$1.4 billion to future losses from wind damage only by 2050 (UNISDR 2015).

The interlinkages between disasters and development have been recognised for some time (Cuny 1983; Anderson 1985; Wisner et al. 2004). Wisner et al. (2004) argue that environmental issues and disasters must be discussed in the context of development policy. Anderson (1985) argues that development should decrease vulnerability by addressing those factors – material, organisational or sociopsychological – which cause vulnerability in the short and long term. She characterises disasters as a failure of development (1985). This development–disaster nexus has underpinned global DRM frameworks since the 1990s and is the platform for priority action in the Sendai Framework for DRR. Appropriate, i.e. risk-sensitive, development is important in preventing or reducing the impact of disasters and in ensuring that development is resilient and sustainable (Wilkinson et al. 2016).

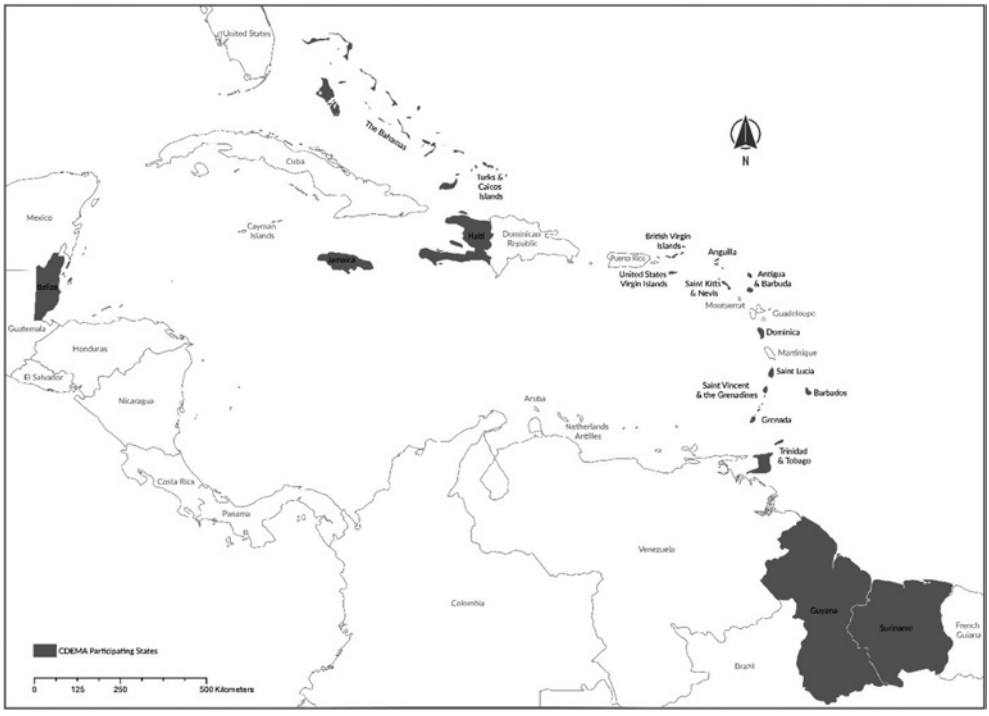
7.3 Risk management approaches in CARICOM states

The Caribbean Community (CARICOM) comprises 15 full and 5 associate member states, extending from The Bahamas in the north to Guyana and Suriname on the northern coast of South America, the Lesser Antilles to the east and Belize in the west. In 1991, the governments of CARICOM established the CARICOM Caribbean Disaster Emergency Response Agency (CDERA), now the Caribbean Disaster Emergency Management Agency (CDEMA). CDEMA participating states as at 2017 are shown in Figure 7.1. CDERA led and co-ordinated the regional effort in disaster management, seeking to focus attention on the disaster development nexus and the need to include disaster risk reduction in regional programming (Collymore 2011). In 2001, CDERA through a consultative process developed the Comprehensive Disaster Management Strategy and Framework (CDM), which voiced a concept of including all segments of society in the management of all hazards through all phases of the disaster continuum (ibid). The 2001 version was updated for 2007–2012 with a stated goal of 'Regional Sustainable Development enhanced through Comprehensive Disaster Management'. CDM 2007–2012 had as Priority Outcome 2:

> *An effective mechanism and programme for management of comprehensive disaster management knowledge has been established*

Priority Outcome 2 acknowledged the importance of knowledge management to the success of CDM. CDM 2014–2024 continued this trend, with Outcome 2 of the new

Figure 7.1 CDEMA participating states (dark shading)



Strategy being 'Increased and sustained knowledge management and learning for Comprehensive Disaster Management' (CDEMA 2014).

The current global framework, the Sendai Framework for Disaster Risk Reduction 2015–2030, emphasises the importance of collaboration and knowledge management to disaster risk management and states the need for the public and private sectors, civil society organisations, academia, and scientific and research organisations to work closely together and to create opportunities for collaboration and for businesses to integrate disaster risk reduction into business practices (UNISDR 2014).

7.4 Background to the Enhancing Knowledge Application for Comprehensive Disaster Management (EKACDM) project

In 2004, CDEMA undertook a study on Disaster Management Teaching and Research in Caribbean Tertiary Level Institutions. It revealed that:

a. There were elements relevant to disaster management in the curricula of different tertiary institutions, particularly at the University of the West Indies (UWI). However, the programmes and course offerings were diffuse and insufficient.

b. CDEMA participating states had been treated to a rich menu of learning opportunities in several aspects of CDM. However, in most instances, these were 'one-off' seminars, workshops and courses of short duration, which, while beneficial to the participants, were not integrated into a structured programme that could be regionally institutionalised.

c. A diverse set of tertiary institutions were already offering lectures, courses and modules in a few relevant subject areas, but there were gaps in both teaching and research of disaster risk management that required adequate coverage.

The study concluded that CDEMA should emphasise the region's need to develop multidisciplinary training and research programmes on disaster risk management and discuss with the University of the West Indies whether it could be the focal point to ensure such programmes were implemented.

The University of the West Indies (UWI) is a regional education institution serving 16 Commonwealth Caribbean countries through four campuses – Mona Jamaica, Cave Hill Barbados, Saint Augustine Trinidad and an Open Campus offering distance education. The UWI Strategic Plan 2012–2017 states that UWI is charged with assisting with the resolution of development issues facing the region and supporting the inclusive development of the Caribbean region. In this context, UWI provides technical support to a range of CARICOM institutions, including CDEMA.

Based on these discussions and taking into account the recommendation of the 2006 CDEMA report and a stakeholder consultation process, UWI established the Disaster Risk Reduction Centre (DRRC) to, inter alia, contribute to sustainable development in the region and to advance UWI's DRM programme. At about this time, in discussions with CDEMA and UWI, the idea was mooted that a knowledge management project would be developed which would address some issues raised

by the reports, as well as supporting CDEMA's CDM Strategy and Framework. Thus, the idea of the Enhancing Knowledge Application for Comprehensive Disaster Management (EKACDM) project was born.

In 2013, UWI received funding support from the Government of Canada for the project. The purpose of the project is to establish an effective mechanism for managing and sharing comprehensive disaster management (CDM) knowledge that is used for decision-making by governments, local communities, the voluntary sector and the private sector. The ultimate outcome of the project is: 'reduced impact of natural and technological hazards and the effect of climate change on men, women and children in the Caribbean region'. The project is led by the Disaster Risk Reduction Centre of UWI's Institute for Sustainable Development. Although not conceived as a 'capacity building' project, aspects of the EKACDM initiative – such as increasing research in DRR, training private sector interests, development of academic courses and ensuring access to knowledge outputs – will contribute to the development of DRM capacity in the region.

The EKACDM project was developed specifically to support the regional CDM Strategy and Framework Priority Area 2 which, through two versions between 2007 and 2024, speaks to knowledge management in support of CDM. The project supports fact-based policies and programmes in CDM, underpinned by sound data on hazards, vulnerability and risk, in order to reduce vulnerability and disaster risk. The reasoning is that development of fact-based policies and implementation of effective programmes requires improved data, including gendered data, access to high-quality information on hazards, exposure and impacts, and a cadre of trained men and women who can translate data and information into realistic and effective policy.

Examination of the project's logical framework shows three intermediate outcomes:

1. enhanced *regional network* that generates, manages and disseminates knowledge for CDM and that includes gender issues;
2. increased use of *standardised gende- sensitive education and training materials* for CDM by professionals and students in the Caribbean; and
3. enhanced mainstreaming of gender-sensitive decision-making for CDM in the public and private sectors, in particular small and medium enterprises (SMEs).

Immediate outcomes are:

> 1.1 Improved knowledge generation in CDM. This will be achieved by three outputs: research facilitated by scholarship and exchange programmes for students and staff of tertiary institutions, as well as staff of national disaster management offices; improved gender-sensitive methodologies in risk mapping, hazard impact mapping and risk assessment; and comprehensive assessment of disaster risk reduction experiences in order to develop good practices and recommendations for risk reduction.
>
> 1.2 Improved knowledge management and dissemination in CDM. This to be achieved by electronic dissemination of knowledge products through regional

databases and documentation centres, thus allowing public access to regional CDM data. Publication of technical materials on DRR on websites and through mailing lists, the CDEMA mechanism and journals.

2.1 Improved access to quality multidisciplinary gender-sensitive educational and training materials for CDM. This to be achieved through development of multidisciplinary courses for the public and private sectors and civil society and a training and certification programme.

3.1 Improved awareness of CDM research outputs for policy and practice, to be achieved through development of policy guidelines and frameworks.

3.2 Increased availability of tools for gender-sensitive CDM in two key economic sectors, SMEs and other components of the private sector, to be achieved through development of manuals, modules and online courses for mainstreaming CDM into sectors.

Successful implementation of the project is expected to ultimately result in the reduced impact of natural and technological hazards and the effects of climate change on men, women and children in the Caribbean region. This ultimate outcome is in harmony with the CDM ultimate outcome of safer and more resilient CDEMA participating states.

7.5 Methodology

In an effort to ensure relevance and to engage stakeholders in co-production of knowledge, consultants engaged to produce project outputs were asked to follow a sequence of steps, while having the flexibility of making adjustments as required. These steps followed a mixed methods approach in which data were gathered by survey instruments developed for the specific output required. This was supplemented by key informant interviews and focus group discussions.

Informants were selected from the target stakeholder groups named in the project document from the public and private sectors and non-governmental organisations (NGOs). The informants were then able to recommend other players within sectors – a form of snowball sampling. Data from surveys, information from the focus groups and a review of relevant literature informed development of draft outputs.

Draft documents were circulated for review or, in some cases, were reviewed during face-to-face workshops. A multidisciplinary peer review network of persons from academia, business and civil society also carried out reviews. The final knowledge products reflected all these inputs.

7.6 EKACDM as a knowledge management project

Perusal of knowledge management literature reveals elements common to knowledge management frameworks and processes across authors. Alavi and Leidner (2001) recognise four processes for knowledge management – creating, storing/retrieving, transferring and applying knowledge. Wiig (1997) lists knowledge creation,

development, organisation and leveraging as important aspects. Alazmi and Zairi (2003) list the following factors as being critical to successful knowledge management implementation: creating, sharing, training, transferring and technical infrastructure. Ruggles and Holtshouse (1999), cited in Dalkir and Liebowitz (2011), give as key attributes of knowledge management: generating new knowledge, accessing valuable knowledge, using knowledge in decision-making, embedding knowledge in processes and transferring knowledge to other parts of the organisation.

The UN International Strategy for Disaster Reduction (UNISDR) publication, *Information and Knowledge Management for Disaster Risk Reduction Framework* (IKM4DRR), sets out some key principles for information and knowledge management. A scorecard is included which allows assessment of the implementation of IKM4DRR principles in programme design and implementation (UNISDR 2013). The framework and scorecard post-date project design and are more suitable for programmes designed for national-level implementation; however, this provides a useful framework within which to assess whether project design and implementation have captured the knowledge management principles enunciated in the framework. The full scorecard is too long to be applied in its entirety here. The sections chosen are those that are more relevant to project design and implementation, viz Principles and Key Concepts, Elements of a Successful System, and Design and Planning. Other aspects of the scorecard, such as Monitoring and Evaluation, Communicating Impact, and Learning from Failures and Good Practices can be incorporated into the project Sustainability Plan. Tables 7.2a, 7.2b and 7.2c show the status of the project with respect to elements of the scorecard.

Table 7.2a Status of EKACDM project with respect to IKM4DRR Scorecard: Principles and Key Concepts

IKM4DRR principle	Yes	No	Partially – EKACDM status
Demand driven	Y		The project was developed as a result of expressed need of stakeholders. Surveys and other data and information gathering activities are integrated into project to inform outputs.
Standards based			Information and data standards have not yet been developed. The project calls for standardisation of training materials.
Collaborative	Y		The information system as planned will be developed in collaboration with regional partners and will allow sharing of data and information at the national and regional levels.
Sustainable			A sustainability plan will be developed and integration with the regional risk information system is planned. Education and training outputs will be integrated into ongoing programmes.
Transparent			Risk information will be available to the public. There is as yet no plan for ongoing evaluation of the risk information system.

Table 7.2b Status of EKACDM project with respect to IKM4DRR Scorecard: Elements of a Successful System

Element	Yes	No	Partially – EKACDM status
Stakeholder engagement and awareness	Y		A stakeholder engagement plan has been developed. Project outputs target various audiences. Collaboration among researchers, practitioners, policy-makers and the private sector is included in project design. Gender is included as a cross-cutting theme.
Identification of stakeholder groups			Stakeholders from the four groups have been identified.
Management, producers, users, communicators of information			
Inclusion of special groups in stakeholder groups		N	Except for women, special groups are not included in project design.

Table 7.2c Status of EKACDM project with respect to IKM4DRR Scorecard: Design and Planning

Element	Yes	No	Partially – EKACDM status
Analyse IKM4DRR system demand			User needs were taken into account, professionals were engaged at the start of the project. Level of readiness was not assessed.
Assess technology			Open source technology is being used. Social media will be incorporated. User technology constraints have not been identified. Integration of communications systems is not one of the aims of the project.
Plan for sustainability			A sustainability plan will be developed. Integration into the regional risk information system is planned.

Source: Adapted from UNISDR 2013.

Key: 'Yes' shows a high level of good practice; 'No' shows potential obstacles to good practices implementation; 'Partially' shows progress towards IKM4DRR good practice and describes the current state of EKACDM implementation.

The EKACDM project reflects several elements identified as being key principles and good practice in the IKM4DRR Framework. It is demand-driven, collaborative and transparent, with provision being made for establishing a path for sustainability at the end of the project. Other elements of the scorecard have been partially achieved and there are some omissions. For example, special groups as identified in the framework – persons with impairments, the elderly, children and indigenous

communities – are not included in the project, which focuses on gender. Other omissions are outside the scope and remit of the project. For example, integration of communication systems would be the responsibility of CDEMA at the regional level and national disaster risk management offices at the national level. Opportunities to include some elements in project implementation, particularly through an information portal, exist; assessment of technology readiness, for example, will be included in design of the portal and databases; others, such as identification of funding sources and institutional support, can be included in the sustainability plan which is to be developed.

In addition, the project encourages production of knowledge through research by providing scholarships for pursuit of postgraduate degrees, as well as exchange fellowships for short attachments to universities. DRM professionals from national disaster risk management offices are also eligible for these exchanges. This approach not only encourages the creation of new knowledge, but also contributes to building research skills, improving professional development and exchange of knowledge among the DRM community. There are also provisions for dissemination and sharing of knowledge, which include:

a. technical publications in scholarly journals and/or on websites;

b. presentations at conferences, including the signature regional CDM conference;

c. workshops and training events with a variety of stakeholders;

d. websites and social media platforms; and

e. development of courses for online delivery.

All project documentation and report outputs will be stored electronically in a database, which will link with databases managed by regional organisations, NGOs, tertiary institutions and development partners, as well as sites housing hazard and risk maps for the region. The database will also contain data and information on historical disaster events, as well as research outputs, and will be accessible to the public.

Knowledge sharing and dissemination are important for the capacity building aspects of the project. Additional capacity building will be achieved by training of small and medium sized enterprises from multiple islands in integrating disaster risk management into business practices.

Stakeholder engagement includes decision- and policy-makers who are engaged throughout the project in different roles. They are members of the project Technical Committee and a Peer Review Network, which is engaged for quality assurance. Policy-makers also act as key informants in interviews and as participants in surveys, which are used to inform the development of project outputs. These outputs will be reviewed by policy-makers at the stage of final drafts and comments will be used to finalise outputs. This engagement should result in products that are relevant to the needs of policy- and decision-makers.

7.7 Discussion

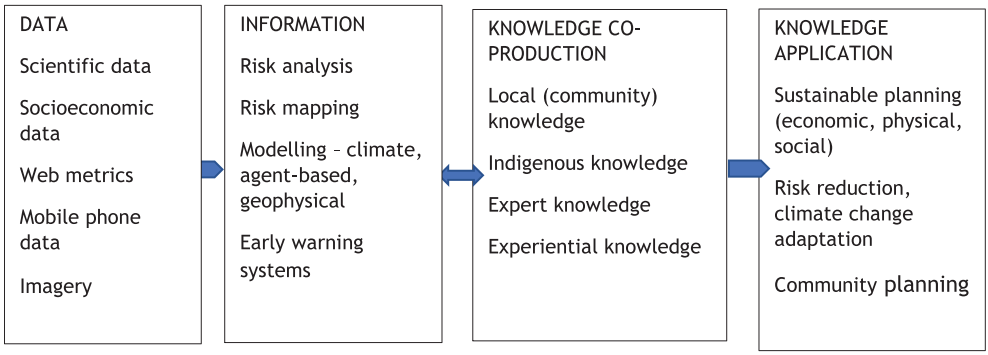
The CDM Framework 2014–2024, in an analysis of results from the previous framework (2007–2012), notes that information on disaster management and preparedness has been available, but there continues to be an impact of hazards on the population, and infers that the problem may be that 'available information is not translated into life-saving knowledge for the communities at risk' (CDEMA 2014, 27). Life-saving knowledge must be available in appropriate formats for all communities at risk. It is therefore appropriate to ask whether and how this project will influence the knowledge landscape of CDEMA participating states.

Weichselgartner and Kasperson (2010) emphasise the need for knowledge production that makes connections across disciplinary boundaries, as well as among scholarly enquiry, policy and practice, which integrates a variety of types of knowledge and which engages in collaborative production of knowledge. This, they conclude, will enhance the quality of decision-making. Manandhar and McEntire (2014) seek to link theory to practice, stating that practitioners should seek to incorporate research findings into their work; and calling upon practitioners and policy-makers to include DRR in the early stages of development. The EKACDM project seeks in its design and implementation to provide an enabling environment for interaction among researchers, policy-makers, practitioners and the private sector. Risk assessment methodologies developed or improved by researchers under the project are to be presented to CDEMA for endorsement.

Weichselgartner and Pigeon (2015) note that DRR-informed decision-making and policy require knowledge. However, policy- and decision-making require the right types of knowledge delivered to the right persons at the right time (Pathirage et al. 2012). In an effort to provide the right type of information, the project seeks to address needs identified by stakeholders as expressed in the regional CDM Framework and in consultations carried out during the project. Weichselgartner and Pigeon (2015) suggest that there is a need for integration across scales, multiple actors and knowledge sources to provide relevant knowledge. Gaillard and Mercer (2012) suggest that filling the knowledge-to-action gap requires an integrated and inclusive approach which blends top-down and bottom-up methods, integrates local and scientific knowledge, and includes actors working across all scales. The project includes owners and operators of small and medium enterprises, DRM professionals working at institutional level, as well as national level policy-makers and practitioners. Further, there is an effort to capture the knowledge gained through the experiences of DRM actors at the local through national levels by application of the case study method in which approaches and programmes are studied, analysed and lessons derived. Derived lessons are then distilled into good practices for DRR and documented.

The regional nature of the project means that upon the project conclusion, each CDEMA participating state will decide whether and how it uses the outputs. Knowledge requirements of individual countries vary, as does the ability to dedicate human resources to appropriate and apply knowledge. Figure 7.2 shows possible ways of sustaining project gains. Beyond this, it would be desirable that there be changes in

Figure 7.2 Proposed CDEMA knowledge management system



data, information and knowledge management across CDEMA participating states. The changes proposed here are described below:

a. endorsement and application of the earthquake impact assessment method as a standard method and continued encouragement of public participation in the build-out of the database;

b. integration of education and training materials into institutional programmes for online or mixed mode delivery;

c. continued capture of tacit knowledge through lessons learned and distillation into good practices; and

d. co-production and sharing of knowledge among all DRM actors and the academic community.

The earthquake impact assessment method is to be endorsed by CDEMA as a standard method, following which it can be used for earthquake response and recovery planning by participating states. The method should be included in tertiary academic programmes. In this way, students could provide support for improvement in the software and method, as well as updating of data. In addition to the training that will be carried out under the project, continued regular training of professionals should be undertaken with the aim of building a cadre of persons skilled in application of the method.

It is important that the EKACDM knowledge products be available to all stakeholders. This will be achieved through project knowledge products being linked to the regional risk information system, allowing access to project outputs, education and training products for the DRM community as well as the private sector, and academic literature and research outputs. Beyond this, many of the courses developed under the project should be integrated into ongoing tertiary-level programmes throughout the region, thus ensuring future capacity building, sustainability and access. A partnership between UWI and CDEMA will see courses being offered to DRM actors as opportunities for professional development.

Capture and sharing of tacit knowledge, which includes information as well as experience, is one of the most difficult aspects of knowledge management

(Spiekermann et al. 2015; Gillingham and Roberts 2006). The EKACDM project can be seen as starting the process of capturing tacit knowledge through the development of case studies and the distillation of lessons learned into good practices. Continuation of the capture of tacit knowledge and its dissemination could be achieved through operational debriefs and evaluation reports, which capture the views and experiences of DRM actors at all levels. Documentation of debriefs and dissemination as a knowledge management product through the regional risk information system would ensure region-wide access. The lessons and good practices derived from case studies can be adopted or adapted by countries. Good practices should be applied, monitored, evaluated and improved upon. Results of application and improvements can be documented and archived. Although debriefs are usually country specific, lessons identified during debriefs could be of wider benefit to other Caribbean countries, as well as to other SIDS. Mercer et al. (2012) mention 'inter-island' networks as a method of fostering knowledge building in SIDS.

There is currently no central co-ordinating mechanism for knowledge management and no established forum for co-production of knowledge in the CARICOM states. The database being established through the project is conceived as a system for archiving, disseminating and sharing data and information. However, there is the potential for it to be more than a database. It is suggested here that it could be designed as a regional knowledge management system. The design could include a virtual space for co-production of knowledge with interaction across scales – community, national, regional; across disciplinary boundaries; and across sectors – policy, research and practice. Scientific data, socioeconomic data and other data, such as data harvested from web metrics, mobile phones, satellites or crowd sourcing, are input to the database. The data are processed and transformed into information such as risk maps, risk analyses, geo-hazard models, climate models and agent-based models.

For the next step, a radical shift from current approaches is suggested – co-production of knowledge. In order to develop the required knowledge products, a multi-stakeholder group would add experiential knowledge, local knowledge and context knowledge to the scientific outputs. These types of knowledge would be obtained through expert opinion, outputs from focus group discussions, and deliberate capture of local and indigenous knowledge. The purpose of this interaction would be to produce knowledge that has the users' input and ownership, is multifaceted, is contextualised and is understandable and applicable for the user, thus improving the capacity of users to apply knowledge to DRR efforts. Documentation of the process and product(s) of the effort and archiving within the database would permit accessibility for all stakeholders. Learning from one country or project would be available for application elsewhere.

The concept is represented in Figure 7.2.

This approach could also be relevant for non- Caribbean SIDS. Mackay et al. (2019) reporting on work done in Pacific SIDS, note the importance of knowledge management meeting the needs of users in order to widen ownership and participation, with the aim of building resilience.

7.8 Lessons learnt

Some of the learning from this initiative may be useful for other small island states implementing similar initiatives. Harnessing the inputs of a wide cross-section of the DRR community and policy-makers not only provided rich input for manuals and policy documents, but also ensured that these outputs were relevant to needs. This approach was also seen as very positive by stakeholders, as stated in evaluations.

All available research opportunities were taken up. The project was important to growing the cadre of young researchers in DRR in the region, as well as supporting ongoing research by faculty. This support for capacity building and generation of new knowledge is a desirable feature of the project which could be duplicated.

One of the gaps identified by stakeholders was inadequate levels of communication by the project. Given its length (five years), complexity and reach, a dedicated communications specialist taken on board at an early stage would have improved project communications.

Over the life of the project, there were two regional conferences at which outputs from the project were shared. These provided the opportunity to reach the wider DRM community which was not directly served by the project. In particular, the DRM community was appraised of ongoing research of relevance to the community and of tools that would support practice. The conferences also provided the opportunity for training selected participants in the seismic impact assessment methodology to be used in the region. Participation was possible as support for the regional conference was specifically included in the project budget.

7.9 Conclusion

The EKACDM project's emphasis on knowledge and its application to CDM reflects the imperative that to understand and manage the drivers of risk, so as to reduce the impact of hazards and disasters, requires appropriate application of knowledge to DRR. The project's design allowed for building regional capacity in DRM by providing scholarships and professional exchanges, increasing access to knowledge products, training and developing graduate-level courses.

The impact of the EKACDM project will not be evident during the lifetime of the project, and there is no provision made for medium- to long-term evaluation of impact. There is an opportunity for scholarship, however, as the academic community could (and should) research the relevance and utility of knowledge created, its uptake and its influence on policy and practice. Practitioners, policy- and decision-makers, and researchers could participate in a longitudinal study on a) whether policy- and decision-makers use the outputs; b) how the outputs are applied; and c) the short- to medium-term impact of including CDM in sectoral policies.

Such research provides the opportunity for collaboration among scientists, practitioners, policy-makers and the private sector, all of whom were involved in the project, and all of whom could contribute to the co-production of knowledge on project impact.

The paradox of knowing better while losing more (White et al. 2001) has been previously mentioned. For more knowledge to be effective in DRR, it must be more appropriately applied by policy- and decision-makers. There is here another opportunity for co-production of knowledge, as scientific outputs could be combined with experiential and local knowledge to produce relevant, applicable and contextualised knowledge for DRR application.

The EKACDM project has a defined lifespan. Gillingham and Roberts (2006) point out that knowledge management is not a 'quick fix' and that its benefits are realised over a period of time. They posit that if knowledge management is to thrive, then capturing, distributing and sharing knowledge must continue. Several opportunities are suggested here to ensure that the benefits of knowledge management started under the EKACDM project are maintained and built on over time.

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Chapter 8

Capacity Building at the Community Level in the Face of Disaster Risk Reduction in Mauritius

Nirmal Kumar Betchoo

Summary

Over the past decade, more than 1.5 billion people have been affected by disasters that have cost at least US$1.3 trillion. Climate change, weak governance, and an increasing concentration of people and assets in areas exposed to natural hazards are driving disaster risk upwards, especially in poor and fragile countries (UNDP 2018).

This poses a critical threat to achieving the Sustainable Development Goals (SDGs). There have been the UN Development Programme's (UNDP) disaster risk reduction efforts, which aim to risk-inform development in line with the goals and targets of the SDGS, and the Sendai Framework for Disaster Risk Reduction. UNDP works with country partners to strengthen national and subnational policy, legal and institutional systems; foster greater coherence of disaster risk reduction and climate adaptation efforts; provide access to risk information and early warning systems; and strengthen preparedness and response measures. Together, these efforts strengthen the resilience of countries and urban and rural communities.

Disasters are common in small island developing states (SIDS) and Mauritius, an island in the Indian Ocean, is no exception to such problems. During the summer season, there are cyclones and floods affecting the country that cause casualties – namely refugees leaving their destroyed homes looking for security in shelters. There is already a committee working on disaster risk at the national level and monitoring activities related to disaster risk reduction. This is a centralised task, where central government monitors the risk. Given that risks are impending during the summer season; it would be useful to develop capacity at the community level.

The islands of Mauritius and Rodrigues are generally prone to a wide range of natural hazards including cyclones, flash floods, torrential rains, landslides, drought, pests, epidemics, tsunamis and tidal waves. Light earth tremors have been felt in Rodrigues, while coastal erosion arising from climate change can also be added to this list. The underlying challenge is that of building capacities, bridges and networks, in promoting problem-solving actions that mobilise key actors and constituencies, that generate effective momentum and impact, and that are culturally sensitive and scientifically sound (UNESCO 2017).

Local communities comprise citizens who face disasters but might not have the ability to tackle the problems effectively on their own. This chapter highlights that there must be a means for developing capacity in selected communities that are more vulnerable to risks than others. Such capacity can be built from members of society who have the desire to serve the nation voluntarily in times of risk and who might co-ordinate during such difficult times to assist local authorities in bringing about improvements; these aspects are of utmost importance in such demanding times.

Disaster risk reduction is a major consideration for all small island developing states (SIDS) that have become vulnerable because of climate change. This is in part because there are more calamities and natural disasters taking place and at a higher magnitude in different parts of the world and these do affect small nations. The island of Mauritius, situated in the South-West of the Indian Ocean, is no exception. As such, a Disaster Risk Reduction (DRR) Management Committee was set up in 2016 with a view to better anticipate and manage risks. At the time of writing, the outcomes from the committee had been positive, with few casualties following its setting up. Those events that did result in casualties were closely linked with flooding disasters in places like Fond du Sac and the northern part of the island in 2018 and 2019.

The threats to the coastline and tourist industry are just some of the risks Mauritius faces as a result of rising temperatures. According to the latest World Risk Report (World Risk Report, 2017) Mauritius is classified as the country with the thirteenth highest disaster risk in the world and is the seventh most exposed to natural hazards.

The island is situated in the Indian Ocean's tropical cyclone belt and may suffer more intense cyclones as temperatures rise (Republic of Mauritius 2016). Mauritius is also braced for more frequent and severe flash flooding. Flash floods in 2013 in Port Louis, the capital, resulted in 11 people losing their lives. However, problems might arise from the fact that the DRR Committee is centralised with a top-down approach and information is channelled to the public via radio or television. There appears to be no direct public involvement when citizens are faced with calamities. Cyclone refugees just rush to the community health centres to benefit from first-hand assistance. During their stay in such centres, it is also difficult to manage the situation due to a lack of qualified personnel.

8.1 Introduction

This chapter considers the need for capacity building at the community level, namely in villages and localities affected by calamities. Some places are affected by flooding while others can be struck by cyclones and related hazards. If capacity is built in the form of resource persons who can be involved in DRR during such times, there might be better co-ordination within the community and problems could be more effectively addressed.

To build up capacity requires first, a top-down involvement whereby the government can call for people from the communities to act as volunteers in the process. There are already *'forces vives'* ('life blood') in such communities, comprising people willing to give help in times of disaster. It is important here to build capacity from citizens

coming from a wide sphere of social life. For instance, teachers from primary schools could be effective as educators for children in times of disasters; social workers might be helpful in the cleaning and rehabilitation process; while women from various fields could be suited to nursing and counselling and psychologists could help deal with people affected by traumatic events. Added to these possibilities, there could be graduates who are either employed or unemployed, who might become involved by participating in DRR in communities. For example, developing countries such as India, Mozambique and Guatemala have adopted such a bottom-up approach to disaster risk reduction by engaging communities, particularly youth, in such endeavours and the results have proved to be conclusive through a higher level of awareness and commitment from local communities and a desire to better address natural calamities (UN Volunteers 2017).

There are already volunteers in Mauritius, helping out in challenging situations. The development of such capacity entails a focus on people who have the correct profile or background. Citizens participating in DRR should be people who have shown a keen social interest and who wish to volunteer. They must be to some extent already engaged in such activities or show a desire to be involved in them. This also builds a sense of patriotism among the community while enhancing active participation in DRR. Such capacity building must involve individuals who are able to network with the public in times of calamities, liaise with the Disaster Risk Reduction Committee in Mauritius, volunteers and local teams to provide assistance and moral support to refugees in times of the disaster.

This proposal could be of particular importance in refugee centres during cyclones or bad weather conditions, where refugees experience various hardships. The development of capacity at the local level can partly address such problems. During flooding, centralised organisations might take time to tackle immediate issues, but if capacity has been developed locally through volunteers, first-hand solutions might be found.

However, there are some immediate constraints that must be considered. First, volunteers linked with capacity building need to have the time available to participate in DRR. Second, having recognised the competence and devotion of such people, there might be a mechanism to reward them financially and ensure their availability at other times of disaster. Next, there might be the need to recognise the contribution of all members involved to ensure that there will be more opportunities to develop and sustain such capacity in the future.

Ultimately, capacity building at the community level in selected vulnerable locations in Mauritius could be useful. When problems crop up and the authorities are affected by insurmountable calls and demands for relief from the population, capacity built at the community level can address immediate problems quickly and also assist central government in reducing risks effectively.

8.2 Methodology

This chapter describes past events to explain the need to develop capacity within communities. It analyses selected situations that resulted in casualties in Mauritius and

looks at how the problem was tackled. Based on observations and findings reported in the media, it develops a concept of capacity building in relation to disaster events.

Developing capacity must involve people from different spheres of life. Educators will be helpful in supporting vulnerable people and children; psychologists or mentors could be useful in the same endeavour, while the police can ensure security; and women could be effective in counselling other women in such difficult times. At the reconstruction level, capacity might be built from volunteers coming from non-governmental organisations (NGOs) who have shown evidence of good social involvement.

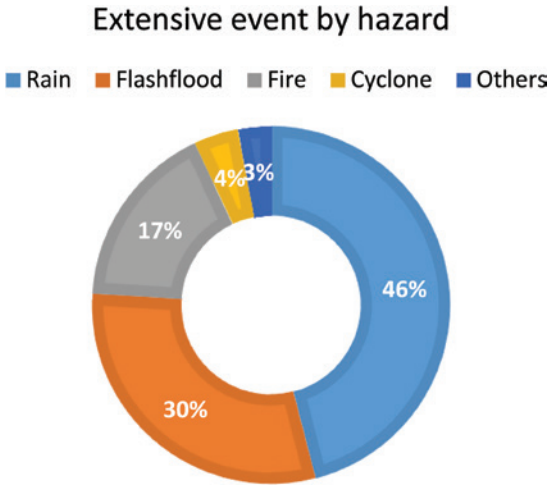
8.3 Disasters in Mauritius today

It is essential at this point to highlight the different disasters that have occurred in Mauritius in a recent past and how these featured in terms of their relative impact. Out of 1,104 extensive disasters between 2015 and 2018, rain was the most prevalent (46%), followed by flash floods (30%), fire (17%) and cyclones (4%) (see Figure 8.1). Being a tropical country, rain affects the country during the summer season – with high volumes of rainfall and torrential downpours having impacts on work, people and health. Flash floods have been recurrent recently, while fire hazards affecting sugar plantations, agriculture and residential areas also account for extensive hazard events (*Financial Times* 2017).

8.3.1 Economic loss due to extensive events (physical and agriculture)

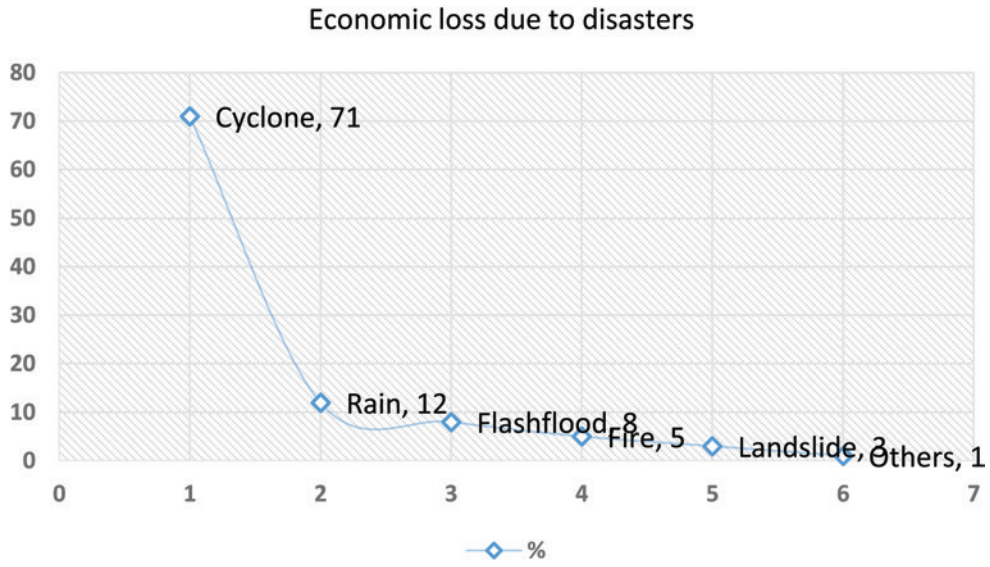
It is important to assess the economic losses that have affected the nation in a recent past as a result of hazard events/calamities. Cyclones have caused an immense economic burden to the country, due to damage caused to agriculture in physical

Figure 8.1 Extensive hazard events



Source: UNISDR (2015).

Figure 8.2 Economic loss due to disasters



Source: UNISDR (2015).

terms. Rain and flash floods have also contributed to heavy economic losses, with these commonly affecting economic growth and making the nation economically vulnerable to disasters over the years (UNISDR 2015).

Figure 8.2 shows the percentage of economic loss due to disasters on the y-axis with indexed values stating the loss magnitude and the ordered classification of disasters on the x-axis.

8.3.2 Illustrations of recent disasters in Mauritius

To illustrate the disasters affecting the country, two case studies are included here, these being the most important ones in recent years. They show how the country became suddenly vulnerable to such events and how these disasters impacted Mauritius, both economically and socially. The first case depicts Black Saturday, 30 March 2013, a flash flood that killed 11 people. The second one relates to the passage of an intense tropical cyclone, Berguitta, on 17 January 2018 and its aftermath.

Black Saturday

The images of this fateful day are still present in people's memories. On 30 March 2013, Mauritius lived one of the worst days of its history. In the early afternoon, Port-Louis was prey of heavy showers causing large accumulations of water and flash floods in the capital and surrounding areas. The streets were completely submerged, and people panicked. Port Louis was flooded: shops, homes and vehicles all took on water, creating great fear among Mauritians. Human chains were formed to withstand the strength of the water. Many cars were trapped and some of them started to float (5-Plus Dimanche 2013).

In the afternoon, tragic news was spread announcing the deaths of several people. At the end of the day, it was found that 11 people had lost their lives in the floods. Six people died in the underground passage of Caudan, which was completely submerged. The images of this catastrophe spread through social networks, internet sites and TV, which portrayed members of the Groupe d'Intervention Police Mauricienne (GIPM) and the Special Mobile Force(SMF) and professional divers looking for bodies. Mauritius was traumatised by this unprecedented event. At Canal Dayot, the water infiltrated dozens of houses causing significant damage. Trapped, many people were forced to flee to take refuge elsewhere. One person died in the rising waters, while several families in this region lost everything. In the following days, as the island mourned its dead. In a spirit of solidarity, Mauritians from all over the country offered food and other material assistance to the victims. For months, Mauritius had to struggle to get back on his feet.

Cyclone Berguitta

Although Berguitta was not yet close to Mauritius at 5 o'clock on Thursday 18 January 2018, there had already been one death and someone was seriously injured. The refuge centres were already crowded. At 5pm on the day before, there were 2,187 people in the country's 38 shelters, having had to leave their flooded and damaged homes (Accuweather 2018).

The authorities were unable to manage the refuge centres; there was a lack of beds, food and staff. The Minister of National Solidarity called on non-governmental organisations (NGOs) to provide hot meals to the people affected. In the face of the disaster, there was a groundswell of solidarity to help the victims, illustrating how the Mauritian people can be generous and compassionate.

Once again, this country, which aspires to become a high-income country aiming at developing 'Smart Cities', seemed incapable of supporting a small percentage of its inhabitants in a moment of distress. It was feared that the government, though aware of the arrival of Cyclone Berguitta, had made no provision or arrangements to support the people affected. Yet it was known that not everyone had concrete houses equipped with generators and provisions for weeks to withstand the cyclone.

The scene was already catastrophic even before the cyclone passed. As usual, when there is a cyclone approaching, Mauritians make provisions, buy candles, torches, bottles of water etc. And it is always the same scenario: some shopkeepers increase their prices while some products run out.

The risks of the sea flooding inland are great in some locations. In Port-Louis, it was believed that the esplanade of the Caudan as well as the tunnels would be overwhelmed by the sea rising. Some people did not follow official instructions and went to the already stormy sea on 17 January. At Poste Lafayette, the water had already covered the beach. Some 3,011 people were forced to leave their homes to take refuge in the shelters, while the effects of Berguitta were felt throughout the country. The largest number of refugees was in Port Louis, in this case 1,621 (L'Express 2018). There were little or no casualties but refugees remained in shelters for at least two weeks.

8.4 Developing a National Disaster Risk Reduction Policy in Mauritius

The Minister of Civil Service and Administrative Reforms and Minister of Environment and Sustainable Development stated that Mauritius was committed to develop a National Disaster Risk Reduction and Management Policy, strategic framework and action plan in the near future. According to Minister Alain Wong, the first step to implementing the Sendai Framework was to understand the risks faced; the government had already identified some of the risks via the commissioning of the Disaster Risk Reduction Strategic Framework and Action Plan ('the DRR Report') in 2013 based on the Hyogo Framework for Action 2005–2015, the predecessor of Sendai Framework (Government of Mauritius 2013).

The main aim of the DRR project, he said, was the development of an inundation, flooding and landslide national risk profile for the Republic of Mauritius, along with the development of a strategic framework for the integration of disaster risk management into urban planning and development. The National Disaster Risk Reduction and Management Centre (NDRRMC) was working on the recommendations proposed by the DRR Report.

The implementation of the Sendai Framework would require participatory, multi-agency and multistakeholder engagement, the minister highlighted, adding that the NDRRMC was collaborating with all stakeholders concerned to align Mauritius to the targets and priority actions of the Sendai Framework. 'We are working together on disaster risk reduction and management activities to ensure the sustainability of development efforts and reduce loss of life', he said.

The various actions taken and being implemented in order to mitigate the effects of disasters and save life and property include:

a. setting up a national multi-hazards early warning and emergency alert system; this was completed by the end of 2018;

b. training community-based disaster response teams;

c. launching a website and using social media for communication with the public during disasters;

d. setting up a state-of-the-art national emergency operations command to manage disasters at the national level; Rodrigues will have its own emergency operations command, as will all 12 local authorities;

e. the setting up of a Disaster Response Unit within the Mauritius Police Force to be a specialised high-level trained disaster response agency;

f. procurement of a Mobile Command Vehicle equipped with a robust communication and co-ordination system to co-ordinate disaster response on ground; and

g. including disaster management in the education curriculum for primary and secondary schools, with a school safety plan component.

8.4.1 Capacity building through the implementation of the Sendai Framework

The 'Implementation of the Sendai Framework: Development of Risk Reduction Strategies and Plans' workshop was aimed at supporting the capacity development and pilot testing of draft Sendai Framework indicators at the national level by the Mauritius National Disaster Risk Reduction Management Centre (NDRRMC). Furthermore, this workshop was delivered as a 'training of trainers' (ToT) that aimed to support the sustainable advancement of capacity development initiatives within Mauritius, as well as contribute to the development of an international cadre of disaster risk reduction professionals (Government Information Service 2015).

The Sendai Framework for Disaster Risk Reduction 2015–2030 was adopted by UN member states on 18 March 2015 at the Third UN World Conference on Disaster Risk Reduction (WCDRR) in Sendai City, Japan. The Sendai Framework is built on elements which ensure continuity with the work done by states and other stakeholders under its predecessor, the Hyogo Framework for Action, and introduces a number of innovations as called for during the consultations and negotiations. Many commentators have identified the most significant shifts as: a strong emphasis on disaster risk management as opposed to disaster management; the definition of seven global targets which are: the reduction of disaster risk as an expected outcome; a goal focused on preventing new risk, reducing existing risk and strengthening resilience; as well as a set of guiding principles, including the primary responsibility of states being to prevent and reduce disaster risk, and engage all-of-society and all-of-state institutions.

In Mauritius, certain actions were initiated, namely: the promulgation of the National Disaster Risk Reduction and Management Act 2016; the setting up of the National Disaster Risk Reduction and Management Council; and the implementation of a national multi-hazard early warning and emergency alert system.

8.4.2 Mauritius investment in resilience on disasters

Mauritius adopted used the Africa Regional Platform for Disaster Risk Reduction to identify the challenges facing small island developing states (SIDS) in the face of a rise in climate-related disasters which constitute a real threat to many of them. Mauritius has shown a keen interest in the Sendai Framework for Disaster Risk Reduction, investing 2 per cent of its gross domestic product (GDP), approximately US$230 million annually, in reducing disaster risk for the Indian Ocean nation's population of 1.3 million (McClean 2016). This has compelled the nation to use the Sendai Framework as and when calamities arise and set up a disaster risk committee monitoring potential hazards in the island.

Climate change includes higher temperatures, changing precipitation and runoff patterns, and extreme weather conditions, leading to reported increasing incidences of weather-induced disasters including floods, droughts, wild fires, strong winds, heatwaves and cold waves. Such climate change agents contribute to an increase in disaster risks, thus making disaster management a vital and urgent component of any

climate change adaptation programme. As a small island developing state, Mauritius has been ranked as the thirteenth country with the highest disaster risk and seventh on the list of countries most exposed to natural hazards (Prevention Web 2016). It is highly vulnerable to the effects of climate change and its adverse impacts on socioeconomic development.

The country has seen clearly the overlap between climate change adaptation and disaster risk reduction.

Speaking at the opening ceremony on Disaster Risk Reduction, Mr Alain Wong Yen Cheong, Minister of Environment, Sustainable Development, Disaster and Beach Management, said: 'Past events call for the need to integrate climate change adaptation, disaster risk reduction and management strategies…. Mauritius is investing in climate-resilient infrastructure such as improved drainage systems, elevated roads and larger reservoirs' (Preventionweb, 2016).

The focus on larger reservoirs and water storage capacity is an important issue as drought sweeps across the member states of the Southern African Development Community (SADC), affecting 41 million of the region's 257 million people, including 23 million who are in immediate need of food assistance (Preventionweb, 2016).

The national budget of Mauritius in 2016 provided for a series of measures in the areas of renewable energy, sustainable transport, smart agriculture, the ocean economy and water. 'We expect these measures to have twin contributions in addressing climate change impacts as well as reducing disaster risks', the minister said.

Since the mid-1940s, overcoming cyclone impacts has been a top priority and after past tragedies, 90 per cent of the Mauritian housing stock now comprises cyclone-proof concrete buildings. Cyclone and drought-resistant sugar cane varieties have also been developed to secure the future of the country's lucrative sugar industry.

'Building back better', a core priority of the Sendai Framework, is a feature of the country's disaster risk management strategy, with a focus on ensuring that essential utility services suffer minimum disruption from events such as the cyclones which hit the Indian Ocean archipelago once every five years.

According to the Meteorological Services, Mauritius is hit 3 to 5 times every year by storms, which often means heavy rains which can trigger landslides. Some 37 sites have been identified across the country as being susceptible to landslides.

Minister Cheong focused his debate during the presentation on mainstreaming the four priorities for action of the Sendai Framework into Mauritius's national programmes for disaster risk reduction. He stressed it was crucial to understand all dimensions of disaster risks, strengthen disaster risk governance at all levels and across all sectors, invest in resilient infrastructure, and reinforce disaster preparedness for more effective response and recovery. Accordingly, Following the establishment of the National Disaster Risk Reduction and Management Centre in 2013, there were 12 local DRR committees operating across the country and they had conducted 50 disaster simulation exercises during 2016. (Mc Lean, 2016). over the last year.

As part of his argument for investing in resilience, Minister Cheong cited the UN International Strategy for Disaster Reduction (UNISDR) Global Assessment Report on Disaster Risk Reduction (GAR; UNISDR 2015), which found that governments need to be setting aside US$314 billion every year globally to meet annual average losses from earthquakes, tsunamis, tropical cyclones and river flooding.

'For small island developing states like Mauritius, escalating disaster losses pose an existential threat. It is forecast that SIDS may lose on average 20 times more of their capital stock annually due to disasters', he said.

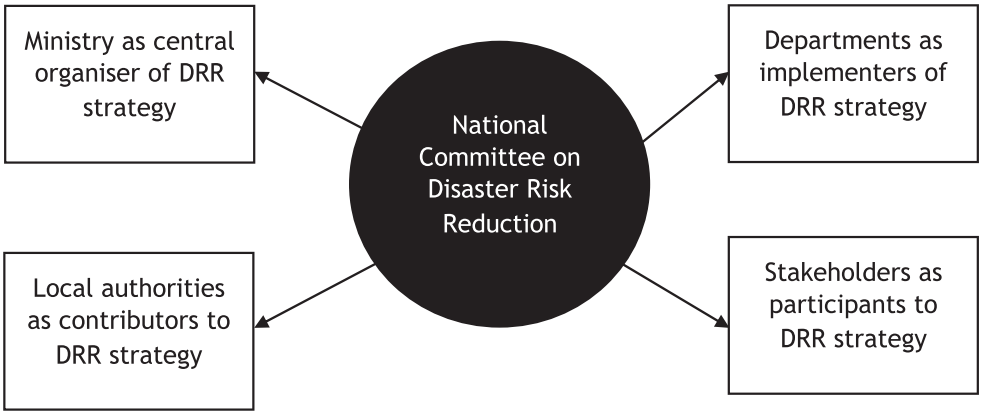
8.4.3 Initiating action for a National Disaster Risk Reduction Plan

It was acknowledged there was a national need to develop a National Disaster Risk Reduction and Management Plan for disaster risk reduction and management by the Government of Mauritius in 2015. This would be reviewed and updated as and when necessary, providing for measures to be taken for the prevention of disasters or the reduction of their impacts. The integration of disaster risk reduction down to the local level was also envisaged, along with implementation of measures to ensure preparedness and capacity building to respond effectively to disasters. This could include the allocation of roles and responsibilities of every ministry, department, local authorities and other stakeholders, along with operational arrangements for in disaster risk reduction and management activities (see Figure 3).

The National Crisis Committee on Disaster Risk Reduction should take decisive and timely actions through the National Emergency operations Centre (NEOC) to: ensure that general preparedness plans are activated at all levels; safeguard the life of persons in danger, including evacuating persons at risk; supervise the organisation of disaster response operations; provide relief assistance; take appropriate measures during the initial recovery phase; and other measures as may be appropriate in the circumstance.

Building a disaster resilient nation is a high priority for the Mauritius government. Yet, to be realistic, there exist several constraints, namely: lack of financial resources;

Figure 8.3 Institutions involved in disaster risk reduction in Mauritius



as an island state there is limited available space in the event of relocation; continuous capacity building of personnel; and renewing existing equipment with new technology. Strengthening the network of monitoring stations is costly and upgrading equipment to new technologies is also expensive. New regulations and policies are being put in place to develop resilience of the nation.

8.4.4 Setting up of a National Disaster Risk Reduction Centre in Mauritius

Created in 2016, the National Disaster Risk Reduction and Management Centre (NDRRMC) is the body that acts as the main institution for the State of Mauritius for planning, organising, co-ordinating and monitoring disaster risk reduction and management activities at all levels. The NDRRMC co-ordinates with all stakeholders (World Risk Report 2017).

The National Centre, inter alia:

a. acts as the main institution in Mauritius for co-ordinating and monitoring the implementation of disaster risk reduction and management activities as per the National Strategic Framework and National Plan;

b. ensures the implementation of the National Strategic Framework and National Plan;

c. co-ordinates and monitors all disaster risk reduction and management activities;

d. co-ordinates and monitors the implementation of the disaster risk reduction and management programmes through community participation and public awareness campaigns;

e. works in close collaboration with the Mauritius Meteorological Services, which shall develop and improve warnings and advisories systems for all natural hazards affecting Mauritius;

f. implements a national multi-hazard emergency alert system to provide accurate and timely advice to the public and key stakeholders;

g. supports ministries, government departments, local authorities and communities in building capacity for disaster risk reduction and management;

h. facilitates and co-ordinates the conduct of regular trainings, drills and simulation exercises to test the adequacy of disaster response plans;

i. undertakes and participates in post-disaster reviews, including lessons drawn from previous disasters in disaster preparedness and response plans;

j. assists relevant stakeholders to develop an appropriate risk transfer mechanism for post-disaster recovery and rehabilitation purposes;

k. collaborates with all relevant stakeholders so that disaster risk reduction and management become an integral objective of environment-related policies and plans, sound land-use planning, natural resources management, education

and social development plans, economic and sectoral policies, as well as infrastructure through enforcement of building codes;

l. fosters regional and international co-operation in disaster risk reduction management issues, including best practices and sharing of expertise;

m. promotes research and development and commissions studies on disaster risk reduction and management matters; and

n. publishes and disseminates information concerning disaster risk reduction and management.

8.5 Capacity-building at the community level

The citizens of Mauritius are well aware and well educated regarding most hydro-meteorological hazards, namely tropical cyclones, heavy rainfall, large waves and strong winds. Some knowledge and understanding exists regarding landslides and tsunami. Public awareness campaigns include audio, video and clips on television and radio, brochures, posters in public places and government buildings, and talks in educational institutions, in communities, focusing on women, youth centres and the elderly.

Apart from centralised decision-making, local authorities, municipal and district councils have legal responsibility to manage risks and DRR at the local level (Dunputh 2012). All municipal and district councils meet individually before the beginning of the cyclone season, to review their strategic plans, take note of gaps and inadequacies experienced during the previous cyclone season, and to ensure a status of preparedness of all partners concerned. The challenge here again is the enforcement of regulations and the absence of a legal framework. The overall mind-set of the people is that local authorities or the central government will carry out DRR; there is little individual commitment and therefore inadequate community participation. Further education and public awareness need to be undertaken by local authorities to engage the whole community at the local level.

Some work has already been done in Mauritius to adopt the Sendai Framework since Mauritius is a participating member in many of the initiatives and conferences held on the subject. However, according to Desai (2015), the country's approach has tended to involve a particular authority/department representing the country and developing some strategy to the best of their ability, without a thorough or 'holistic' approach. This approach is not going to provide the necessary capacity for 'building resilience to natural disasters'. A recent study conducted by a consortium of both international and local consultants for Mauritius identified the following nine key recommendations after an assessment revealed that substantial areas of the country were exposed to elevated levels of flood, coastal flooding and landslide hazards (Desai 2015). The recommendations were, namely, to:

1. strengthen the co-ordination of risk prevention;

2. transpose the results of the study into the National Development Strategy;

3. cease any further degradation of coastal riverine and marine ecosystems;
4. accept a culture of risk and make sure that all hazards and their potential impacts on every aspect of society were fully understood and considered;
5. create a sound spatial data infrastructure;
6. improve emergency response capacity to ensure seamless co-ordination of all activities before, during and after a disaster strikes;
7. extend the existing early warning systems for tsunami and cyclones to cover other hazards, such as flood and drought; and
8. create an emergency fund to facilitate recovery from a disaster.
9. engage the communities in potential disaster risks.

8.5.1 The functions of local committees

Every local committee shall, in respect of the area under its jurisdiction and under the supervision of the National Disaster Risk Reduction and Management Centre 2016 ('the National Centre'):

a. work closely with its local community in disaster risk analysis and vulnerability assessment;
b. prepare and implement, in accordance with any guidelines laid down by the National Council, the local plan to be approved by the National Centre;
c. promote and implement disaster risk reduction and management education and public awareness programmes;
d. build capacity, acquire resources and co-ordinate disaster risk reduction and management activities; and
e. conduct trainings, drills and simulation exercises.

8.5.2 Capacity-building-through local committees

Setting up local committees with clear objectives, as mentioned above, demonstrates that there is an intention to develop competencies at the local level. So far, this chapter has highlighted views first, from the strategic or governmental perspective and then from a tactical or national perspective through the existence of the Disaster Risk Reduction Committee. Currently, to be able to develop capacity, there must be people coming from communities and different spheres of life. These could include educators, force and volunteers. These are in fact key resources that might be addressed in capacity building developed in this paper.

Capacity building will first be assessed in terms of resources to be used, followed by how people and organisations might be effectively prepared to face the impending challenge of natural disasters in Mauritius and also to better respond to this major concern.

8.5.3 Building capacity through competencies

To build capacity, one needs to consider the importance of competencies. Capacity building is defined as the process through which individuals and organisations obtain, improve and retain the skills, knowledge and other resources necessary to do their jobs competently or to a greater capacity (SPRC 2018). Community capacity building is a conceptual approach to social, behavioural change and leads to infrastructure development. It simultaneously focuses on understanding the obstacles that inhibit people, governments, international organisations and NGOs from realising their development goals and enhancing the abilities that will allow them to achieve measurable and sustainable results.

The term 'community capacity building' emerged in the lexicon of international development during the 1990s. Today, community capacity-building is included in the programmes of most international organisations that work in development, such as the United Nations, World Bank and non-governmental organisations like Médecins Sans Frontières (MSF 2011). Community capacity building often refers to strengthening the skills, competencies and abilities of people, communities and local grassroots movements so they can achieve their goals and potentially overcome the causes of their exclusion and suffering. Organisational capacity building is used by NGOs and governments to guide their internal development and activities.

Below, an illustrative example of capacity building is provided showing potential people that could be involved at the community level and their capabilities.

8.5.4 Actions to be initiated

Figure 8.4 provides a mind map of how a local team – as a result of capacity building – carries out the different actions that will be needed from them. Though the actions are not exhaustive, they clearly depict how effective capacity building can play a positive role in managing disasters at the community level in Mauritius[1].

From the profiles presented, it is important to see that there is proper definition, monitoring and screening of the capacity built around, including the importance of synergy.

Defining capacity

Capacity-building at the community level must be well defined. This requires finding the right people with the right profile to deal with the problems resulting from disasters in Mauritius. Such capacity has also the ability of providing a bottom-up approach to dealing effectively with disasters. Two key concepts in such development are monitoring and screening capacity and synergy.

Monitoring and screening capacity

It is necessary to see how each selected member fits in the group and how the role is effectively carried out. Each role should be well defined to avoid duplication and redundancy. Each contributor must know what is expected of him or her.

Figure 8.4 Potential citizens involved in disaster management at the community level

Local community	Illustration	Capabilities
Educator		The educator is an influential person in providing pedagogical awareness of disasters and their risks to the population. Being widely educated, the educator can act as a mentor to refugees and vulnerable people. Precaution regarding health and safety can be passed onto refugees. Educators also provide effective mentoring to school children, who in turn influence the family.
Police force		The police force ensures security in times of disaster. It plays an important role in communicating information linked with disasters and providing help to people in difficulty. Precautionary measures against disasters can be implemented by the police force. Even monitoring security can be quite well handled by the police force.
Student		Students can become volunteers in helping people in times of disaster. This could be an experience that they can gain vocationally and that can add to their competencies which can make them accountable as potential community leaders. Volunteering could be also a part of the function that students undertake during free times away from studies.
Social worker		Social workers are invaluable in times of natural disasters. They can address both problems of a physical or psychological nature. Being close to the community, social workers can be a first-hand resource to people in difficulty and may be quite effective in handling immediate problems. They can help in welcoming refugees in centres/ shelters in times of crisis.
Psychologist		A psychologist or nurse can be an important resource in times of disaster. People who are displaced are psychologically affected by material or physical loss. Displacement and adjustment might be difficult for refugees. Psychologists can help addressing problems affecting vulnerable people and providing the necessary support and comfort in times of distress.
Volunteer		Volunteers might constitute the most important aspect in the capacity building exercise. They can come either from social workers or any citizen willing to provide a helping hand. They could be first-aiders, helpers or any opinion leader in the community who is willing to immediately respond and address the needs of the vulnerable people.

Synergy

Synergy is expected because all members forming the capacity must collaborate fully and play a useful role in bringing the desired outcomes in times of disasters. Quite often it is feared that a lack of collaboration and group cohesiveness can be detrimental to capacity building.

Figure 8.5 outlines how the local team is expected to work under capacity building. The main tasks are highlighted.

- Working closely with its local community in disaster risk analysis and vulnerability assessment

  Once capacity is built among members of the local community, there will be the need to work closely with the community in disaster risk and vulnerability assessment. Disaster risk assessment comes from an assessment of potential risks in areas that are the most likely to be affected. In Mauritius, coastal areas are places at risk, namely Poste de Flacq or Baie du Tombeau (see Figure 8.6). These have been identified as tsunami risk areas. Similarly, localities close to rivers and terraces in Mauritius are also important in the assessment. The possibility of landslides exists in inhabited urban areas like La Butte (Davies 2015). In such circumstances, the local community must be informed of the risk. Some simulation/drill exercises are carried out at regular intervals and these are bound to have a positive effect on the community, provided that effective collaboration is obtained.

- Preparing and implementing, in accordance with any guidelines laid down by the National Council, the local plan to be approved by the National Centre

  It is essential to have the plan implemented at the national level. Capacity built with the local community will be empowered to work out and implement

Figure 8.5 Local team working under capacity-building

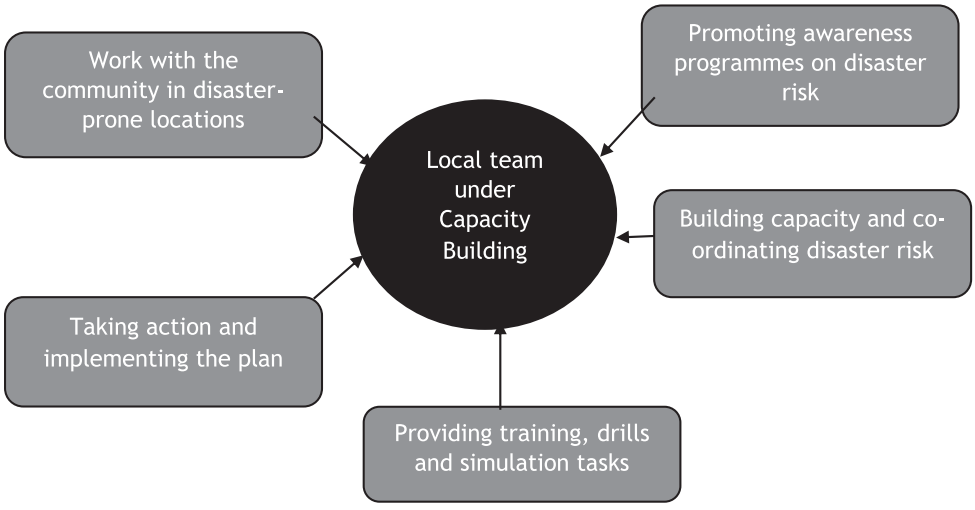
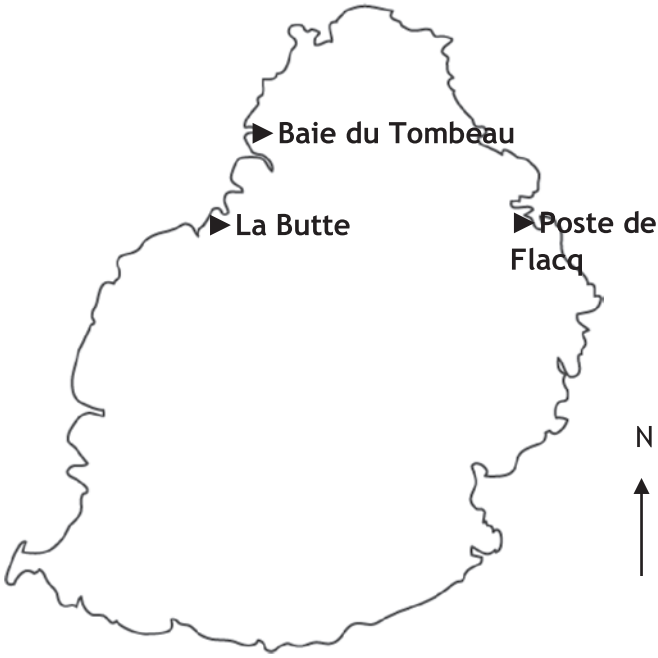


Figure 8.6 Vulnerable locations in Mauritius



the guidelines. For instance, there could be actions initiated like awareness campaigns and risk alerts through communiqués, welcoming the refugees and displaced persons in shelters and properly accommodated places. There could also be lifesaving activities and similar precautionary measures likely to be taken by actors involved in the national team. Further, the recording of data, communications with different parties involved, as well as interactions with higher authorities like the central committee, the police force and the national security forces could well be initiated by the team at the community level.

- Promoting and implementing disaster risk reduction and management education and public awareness programmes

  The local community team has to be effective in promoting disaster risk reduction, management education and public awareness programmes. Campaigns through local radio and posters, ones that are fairly cheap and within budget parameters, could be effective in building public awareness of disasters. The Mauritian community is well aware of precautions to take during the cyclonic season, and the low incidence of accidents and deaths evidence this. Little has been so far said of other disasters, where the public is informed through traditional media, because their impact has not been felt that strongly. A simulation exercise based on a possible landslide or tsunami might look simple, yet its importance must be emphasised to the public. Traditional media involves television, radio, posters and announcements made by authorities, while non-traditional means are mainly social media such as Facebook, podcasts and websites that provide online information on the imminence and threat of disasters. In times of crisis

in Mauritius, traditional media have an advantage over the non-traditional ones. People have been accustomed to using radio and television in times of cyclones and calamities as such experience is easier and more accessible to them.

- Building capacity, acquiring resources and co-ordinating disaster risk reduction and management activities

  The co-ordination of disaster risk and management is important. Too often problems crop up suddenly in such situations and it becomes difficult to co-ordinate effectively – as with Ebola disease management or the Haiti earthquake in 2010. In easily cut-off areas, it is imperative to build local capacity to respond. Local residents can be empowered with early warning systems, evacuation plans, and training to identify and mitigate hazards before the emergency strikes (CARE Emergencies 2015). Co-ordination by the local team should be done with the community, the National Council for Disaster and including international groups like the Red Cross or external NGOs willing to assist a community. For example, access to a location affected by a disaster might be quite difficult. The local team could be of great help by quickly liaising with partners, offering facilities to third parties, as well as managing activities locally like providing supplies of medicine, food and amenities required. Transparency and accountability should also be enforced in such critical times.

- Conducting trainings, drills and simulation exercises

  For the local team to be effective, it is important to implement a training programme. This comprises short but tailor-made training programmes that particularly address a disaster situation. Through tailor-made training programmes for humanitarian actors, in-country technical support and a global network of practitioners, effective capacity building can integrate environmental considerations within humanitarian and early recovery operations (UNEP 2018). First-aid training is essential in such situations. Similarly, team building and team management programmes could be helpful where the local team needs to be well managed. From the practical side, drills and simulation exercises are helpful in that they train local community members to be familiar with the real needs in a crisis situation.

8.6 Conclusion

This chapter discusses the relevance of capacity-building at the community level in Mauritius. Examples of nations involved in disaster risk reduction are numerous. Just a few examples – like a stakeholders' evaluation of the Metro Manila prototype experience where the community took part in the launching the Community-Based Disaster Risk Reduction Training Learning Circle to enhance learning through knowledge and solution exchanges, by focusing on addressing systemic gaps and topics in risk reduction. Such a situation indicates a keen interest and involvement from the community, creating a positive dynamic to engage stakeholders and commit institutions to the goal of changing practices and influencing policy (Earthquakes and Megacities Initiative 2007). In Fiji, the provincial government incorporated

disaster risk reduction and development priorities identified by communities into its provincial development plan (UN Secretariat of ISDR 2010). In Bangladesh, as the result of a community risk assessment, local authorities got practical experience in assessing their risk environment, determining the vulnerabilities of their local communities and taking the appropriate actions to mitigate them (ibid).

The National Disaster Risk Reduction Committee in Mauritius has set up committees at the local level, but their functions and roles have not been explicitly defined. Taking into consideration that hazards have increased in the country recently, creating more disasters and risks, it is necessary that the capacity for risk reduction and response be developed at the local level. By identifying actors likely to help in creating capacity within communities, it is likely that there will be better actions initiated at the local level, depending upon the implementation of the desired policies.

It is expected that a high level of co-operation will be provided to local teams and this must be encouraged through training, motivation and management. Being close to the community in question, capacity building at the community level provides first-hand assistance to the local population, develops quick and effective relationships with vulnerable groups, while addressing directly the immediate needs and concerns of people in distress. At the same time, this small picture sensibly contributes to the bigger picture of capacity building that impacts people under distress during disasters.

Note

1 Illustrations used: clipart-library.com; istockphoto,com.

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Chapter 9

Fresh Lessons on Preparedness for Disasters

John L Roberts and Gina Bonne

9.1 Best buys in disaster risk reduction?

Until now, the smart money in disaster risk reduction (DRR) has been assiduously built on the evidence of studious cost-benefit studies and other research (Hugenbusch and Neumann 2016; Mechler 2016; Adhikari et al. 2018; Eckhardt et al. 2018; Dudley et al. 2015). This has given rise to the best present and robust practices of early warning systems, community education, evacuation, emergency shelter, high technology-assisted search and rescue, retrofitting, 'building back safer', and family, business and sovereign insurance.

Notwithstanding this solid basis for current policy, after the impact of Hurricane Maria in Puerto Rico in 2017 and the political contretemps that emerged from the publication of the epidemiological studies of the huge burden of secondary mortality in the aftermath of Maria (Kishore et al. 2018), DRR strategy is clearly due for substantial reassessment. Current investments in DRR are important and necessary, but after Maria, no longer sufficient.

The unravelling of the true impact of Hurricane Maria provides a key to open the door for more research and review of the operational and policy implications of the hitherto somewhat neglected long tail of the aftermath of disasters. This applies to hurricanes in particular and to natural disasters in general. Much of the true social, economic and environmental damage of the aftermath of disasters has been undocumented and more needs to be explored on the vulnerability of small and island states, where retreat from the threat is not an option and where those most at risk to the impact of the aftermath may be left unattended and at critical risk.

This review cites evidence from a range of documented disasters, where the fatalities in the aftermath have been recorded. This can amount to over 70 per cent of the total death toll. Some of this arises from the destruction of basic service infrastructure and the disruption of services, when staff, if they can get about, discover vital elements of services which may be damaged or destroyed beyond effective operational use and cannot be fixed. Such breakdown of medical, pharmaceutical and other social services can result in death and serious harm to those whose survival depends on them. The size of this vulnerable group may depend on the stage of development of the country and the extent to which the survival of elderly and people with a disability is dependent on the seamless provision of certain critical services.

While the traditional DRR strategy has been on prevention, search and rescue, and 'building back better', it is clear that more attention needs to be given to focus research and resources on the impact of the aftermath of disasters. This chapter examines the nature of disaster risk (Roberts J L, 2010), and offers fresh analysis and recommendations for action with special reference to small and island states, to avert and mitigate the wide-ranging service implications of the aftershocks of disasters.

9.2 The long tail of the aftermath of disasters

Recent environmental disasters from hurricanes have evidently tested, beyond their limits, existing prevention and preparedness systems. Hurricane Irma in Puerto Rico in 2017 resulted in 52 direct deaths plus 82 indirect deaths, with an estimated US$64.76 billion in damage. Hurricane Maria, a category 5 hurricane, which followed on closely in September 2017, resulted in 64 direct deaths, but an estimated over 4,000 indirect deaths[1] from secondary and tertiary impacts (Kishore et al. 2018) and variously estimated US$68–102 billion in damage (Pasch et al. 2018; Wallemacq and House 2018), (UNISDR, 2018).

There was an early warning system alerting people to the approach of Maria, 35 hours before its impact. Then, on the small island of Puerto Rico and in neighbouring sites on the storm path, there was wide-scale destruction of homes and business premises; extensive flooding from heavy rain and sea surges up to three metres above ground; mudslides; severe damage to roads and fallen trees inhibiting transport; severe damage to harbours and marinas; and crops destroyed. Around 80 per cent of poles carrying utility services were blown down, with power and communications blackout fatally affecting people dependent on medical care and other vital services for survival; water supplies were cut for long periods in many places. The subsequent slow re-establishment of basic services still left thousands of homes and businesses without power, affecting 3.4 million people nine months after the initial impact. Hurricane Maria was the third costliest hurricane in US history (Pasch et al. 2018).

Pasch and his colleagues found after Hurricane Maria in Puerto Rico in 2017, vulnerable groups were the main victims of this long tail in the timeline of mortality after the initial impact of the disaster. The vulnerable groups included those on low incomes, older adults, people with chronic medical conditions, and patients with ongoing specialist treatment requiring prescription medicines.

Similarly, Ho and colleagues studying adult mortality after the major earthquake and tsunami affecting the Indian Ocean 2004/5, found that factors associated with death after the immediate impact of the event included age, gender and isolated people without available help (Ho et al. 2017).

Carroll, a professor from the Indiana School of Medicine, reporting on the long-term health consequences of the urricane Harvey in the USA impact of Hurricane Harvey in the USA, cited the importance of the subsequent impact of waterborne and communicable diseases, including respiratory and gastrointestinal conditions arising from pollution and industrial and hazardous waste, and the high density of homeless people surviving for long periods in emergency shelters. Specifically, Carroll cited

the lack of necessary medical services for people with chronic conditions such as asthma, heart disease and those with kidney failure on dialysis and worse pregnancy outcomes. Carroll stated that after the Hurricane Katrina in 2005, the mortality rate reached 47 per cent above normal in New Orleans, ten months after the storm, suicide rates peaked and post traumatic stress disease (PTSD) appeared among police officers and rescue volunteers, (Carrol A E and Frankt, 2017) (West C et al. 2008).

The detailed study of the aftermath of Hurricane Maria called for improvements in the training of physicians in the certification of deaths associated with the disaster, emphasising the long-term impact, which had been initially masked (Pasch et al. 2018).[2]

Saulnier and colleagues in their paper, 'No Calm after the Storm', a systematic review of human health following natural disasters, called for further research into the long-term effects on mortality (Saulnier D D et al. 2017). It is also clear that in the light of this pattern of cascading fatal impact on vulnerable people, more attention is needed to devise preventive measures and improved preparedness that could reduce these longer-term risks to human health, often overlooked in the long mortality tail of the aftermath of disasters.

While the focus here is on storms, the indirect impact of other types of disaster may well follow a similar pattern in affecting the survival of vulnerable people.

9.3 Adapting DRR strategy from the lessons from Hurricane Maria 2017

Such reports on recent disasters provide vital lessons for reviewing the emphasis on the range of elements encompassed in the Sendai Framework for strengthening resilience, especially in small island states. The detailed epidemiological study on the impact of Maria highlighted the inadequacy of an organised command structure for disaster response and emergency communication; serious flaws in the links between central and local government; out-dated emergency planning, not designed for greater than category 1 hurricanes; and weaknesses in the mortality reporting systems – all revealing a picture of an island, 'not prepared for multiple cascading failures of critical infrastructure and key resources sector' (Santos-Burgoa C et al. 2018).

In particular, recent disasters have highlighted the intensity and extensive penetration of such natural phenomena, the cumulative impact of their destructive forces, and the limited protection that early warnings and infrastructure protection can provide. Moreover, following the political controversy over the assessment of their human impact[3] in which the long-term impact of Hurricane Maria was revealed, fresh attention should now be given to the cascading impact of destruction in leaving vulnerable people without vital facilities and services on which their continued post-disaster survival depends, including safe water and sanitation, power, shelter, nutrition and medical services.

These lessons need to be incorporated into global DRR strategy and at the local level in the Indian Ocean Commission (IOC) countries. This will require improving systems of data collection on the secondary and tertiary effects of disasters, developing ways

of identifying those most at risk and providing standby emergency support suited to their needs.

9.4 Three phases of preparedness

Patterns of death, injury, disease and disablement follow a general course of impacts after a storm. These embrace three stages into which differing forms of preventive action and response have been classified (Keim 2018); these are, broadly, the primary, secondary and tertiary stages/effects.

Primary effects involve the immediate potential impact of the hazard, for which preventive measures include the design of cyclone-proof buildings and their maintenance, early warning systems, safe emergency shelter, and the setting back of infrastructure from the coast and rivers that might flood.

Secondary effects are those that follow on from the immediate impact of the disaster, for which response and prevention measures include efficient, well-co-ordinated search and rescue operations, rapid first aid and trauma care, clearing of debris, and the proper identification and disposal of those with fatal injuries. Secondary response also involves the emergency re-establishment of important basic services, such as power, lighting, ventilation, information, security and communication services. Secondary action includes maintenance of emergency shelter and transfer to more suitable accommodation, with the provision of social care, child care and education services, and the rapid and accurate diagnosis and appropriate management of non-fatal injury or disease, after the initial impact of the disaster. This may require emergency nutrition and shelter adapted to the needs of differing groups of people, with access to specialist care by traumatic orthopaedic and ophthalmic services, burns and heart care and lung emergency care for those suffering from the effects of toxic smoke, for example.

Tertiary effects can require longer-term support measures for the permanent rebuilding of infrastructure, re-establishing businesses and jobs destroyed by the disaster, rehousing homeless people and ensuring special social care, and education and medical care for those in need who have been deprived of vital support systems, including power and medical supplies. This requires advance identification of the most vulnerable and personal support and care for them, especially disabled and elderly people whose survival may be dependent on specific care regimes that have been disrupted or cut-off. In this phase of response, there may be disease epidemics arising from the destruction of crucial infrastructure. The mitigation of tertiary impact has yet to be widely accepted as an important gap in preparedness.

9.5 Current emphasis on capacity building for DRR

Before Hurricane Maria in 2017 and the research showing the long tail of mortality from secondary and tertiary effects (Pasch et al. 2018), the focus of DRR has properly been on post-disaster rescue, recovery and rehabilitation as the strategy for strengthening resilience and risk reduction. Moreover, the weight of research has focused investment on DRR to avert the immediate impact of the disaster, through

heroic efforts in salvaging lives from the debris and tending them in shelters, where primary prevention has been inadequate; then comes much physical reconstruction, retro-fitting and incorporating in new design of infrastructure protection against storms, flooding and the other hazards that overwhelmed communities. A probabilistic cost-benefit analysis approach has become common to yield the best results in policy formation from DRR research (Ye et al. 2106).

Such assessments tend to put disaster insurance premium relief above investment in retrofitting, but encourage public–private partnerships to cover the risks. The results, however, mask the importance of fatalities. Physical capacity building, early warning systems, and training for search and rescue are all important and necessary elements in a DRR strategy; however, they are not sufficient in the light of the lessons learned from Hurricane Maria.

Using the US Department of Transport value of a statistical life (Moran and Monje 2016), the human cost in fatalities of Hurricane Maria rises from the cost of US$614 million for directly attributed deaths to US$29 billion for indirectly attributed deaths. That takes the human cost from additional 0.7 per cent of the total of that hurricane in terms of cost of loss and damage, to a hugely increased 34 per cent.[4]

Such new lessons from Hurricane Maria must shake up much research assessments of where to place the critical investment for DRR and what technologies to apply. Saving the lives of those who are continually dependent on life-support services, requires quite a different pattern of operational response compared to the standard evacuate, search and rescue, rehabilitate and rebuild stronger. It requires being alert to the needs of those people who may not be vulnerable to the direct impact of a hurricane, and who may not need to be rescued from the debris, but who then become vulnerable and exposed to its aftermath.

9.6 Planning, investment and action after the storm: protecting the most vulnerable

It is well over a decade since James Shultz and his colleagues published their iconic paper on tropical cyclones (Shultz et al. 2005). In that review, they drew attention to the weaknesses in the process of existing studies, especially in monitoring a post-cyclone population through their long secondary and tertiary impact and extended periods of recovery. It is evident from recent events that more attention should be given to these aspects in the strategy of prevention and response, to anticipate and obviate the long-term health impact, the psychological consequences, behavioural patterns and the effects on elderly people, recent immigrants, single parent families, poor people and those with special medical needs. The Schultz review called for longitudinal investigations of high-risk zones, especially those people living in coastal areas. It also called for multidiscipline studies, including studies of the impact on health of the methods of disaster management. Their call for a more integrative approach to assessment of the lessons learned from cyclones remains a continual challenge.

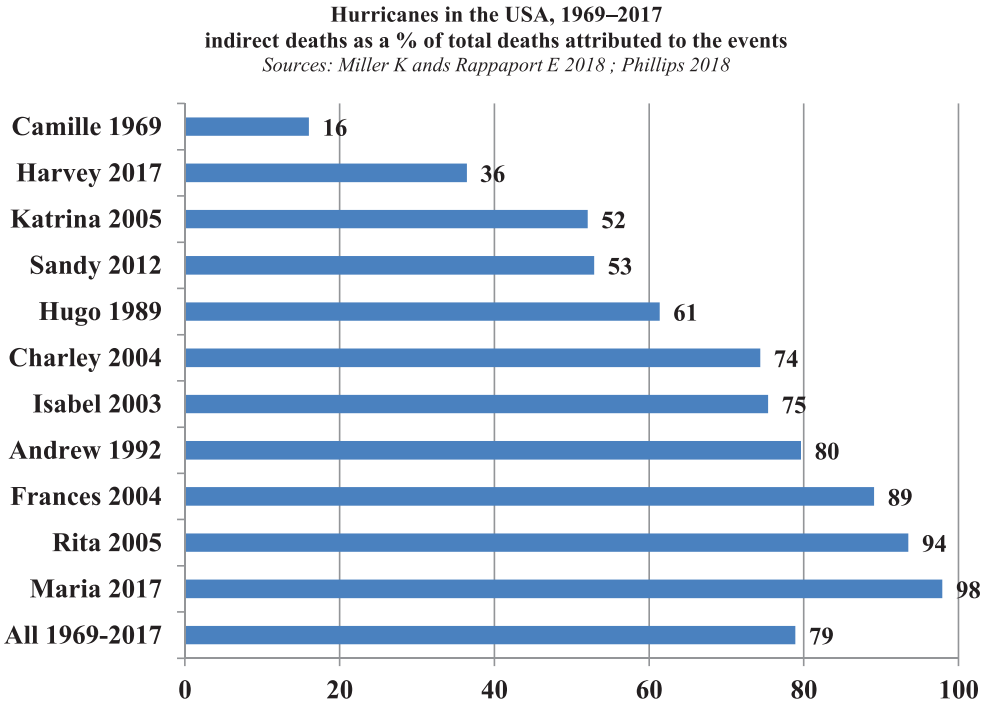
In their review of the outcome of 59 tropical storms in the USA in the last 50 years, Rappaport and his colleagues found that indirect fatalities associated with these

storms, though often under-recorded, were nearly as great as direct fatalities. Common factors included: loss of electricity leading to falls in darkness; hypothermia and hyperthermia due to loss of heating and air-conditioning; failure of life- sustaining medical equipment; carbon monoxide poisoning through misuse of generators; and deaths from cardiovascular failure in people with heart disease, resulting from overexertion in clearing damage, bailing out flood water, repairing buildings and heat stress (Rappaport and Blanchard 2016).

From Hurricane Harvey in Houston USA 2017, which was a category 4 storm, there were 107 reported deaths, of which 39 were classified as indirect, though this may be a conservative figure as the aftermath of the storm was considerable. Harvey caused severe chemical pollution of the air from damage to chemical plants, and sewage flowed on the streets causing substantial risks to health. Extensive gaseous benzene release put people with asthma and chronic obstructive lung disease at risk, increasing the frequency of cardiovascular events (Phillips 2018).

Figure 9.1 shows the indirect deaths from selected hurricanes in the USA 1969–2017 as a percentage of the total deaths from these events. Overall, 79 per cent of the deaths were indirect. With Maria, in 2017, 98 per cent of deaths were indirect; with Rita in 2005, 94 per cent of deaths were indirect and with Katrina, in the same year, 52 per cent of deaths were indirect. In this list, it is only Camille in 1969 and Harvey in 2017 that had fewer than 50 per cent deaths from indirect factors.

Figure 9.1 Hurricanes in the USA, 1969–2017



9.6.1 Planning, investment and action for a category 5 wind storm

The impact of Hurricane Maria in 2017 in Puerto Rico involved high levels of mortality, mass evacuation, extensive damage to housing and to key infrastructure, flooding and a breakdown of communications. A vast majority of people, their homes and businesses were without power for nine months after the initial impact.

The detailed follow-up epidemiological study showed that the full death toll of Hurricane Maria in Puerto Rico, of possibly more than 4,000, was well over 50 times higher than the initial estimate. The greatest number of the additional deaths was among the most vulnerable people, whose survival depended on continuous supply of medical and social care services the provision of which was critically affected by the disruption of facilities in the aftermath of the disaster (Pasch et al. 2018).

This raises a number of serious questions about whether small island states are well prepared for the impact of a category 5 hurricane on their most vulnerable people. Using the impact of the disaster in Puerto Rico as a model of the worst-case scenario, for other small islands, let us ask:

1. Have the emergency response teams and the relevant ministries of health and social care, identified the relevant classes of critically vulnerable people in advance, such as those on life support systems, on renal dialysis, those patients in intensive care, high-risk pregnant women and others, whose survival depends on certain medications and care regimes being continually available?
2. Do the relevant ministries and local operational bodies have effective plans for the support of these most vulnerable people in the face of disruption of the vital services on which their lives depend?

Further questions are raised about the procedures for the certification of cause of death and the use of International Classification of Diseases (ICD) 11 (WHO 2018) to ensure that both direct death from a storm and the cascading effect of indirect deaths are properly recorded. The follow-up study of Hurricane Maria found serious deficiencies in the mortality classification in use in Puerto Rico. This greatly understated the long tail of death in the aftermath of the storm. Moreover, it failed to draw attention to the issue of those vulnerable people whose untimely deaths were due not to the violence of the storm itself and the effectiveness of search and rescue teams, but were affected by the long-term impact of the disaster on the seamless provision of vital life-saving services to them. So, we must also ask:

1. Does the system of certification of death and the coding of the certificates in the mortality reports adequately capture the longer-term impact of external cause of death on the most vulnerable people in the longer-term aftermath of natural disasters?
2. Are the medical and statistics staff trained in the correct procedures and do they have access to appropriate manuals of guidance?
3. Is there an audit system in place to check the validity of cause of death certification and misuse of 'garbage' codes?

9.7 How well are the South-West Indian Ocean islands protected against the impact and aftermath of disasters?

It is timely therefore to review the existing provision for disaster risk reduction policies and plans in the South-West Indian Ocean islands, and to examine how far they take into account the range of impacts now apparent from the most recent evidence in island states, which are in general economically and environmentally vulnerable.

A series of exemplary expert studies on the South-West Indian Ocean islands, published in 2015 and carried out by the UN International Strategy for Disaster Reduction (UNISDR) with support from the European Union (Leste de Peridoe and Ishigaki 2015) as part of the extensive Islands Project of the Indian Ocean Commission, justify re-examination. The studies covered the local history of disasters, comparing the experience of Comoros, Madagascar, the two Commonwealth states of Mauritius and Seychelles, and the island of Zanzibar, examining their relative vulnerability, their populations at most risk, and their capacity for resilience within the context of their relative stages of economic and social development.

The assessments showed the relative intensity, frequency and impact of common hazards from tropical cyclones, sea-level rise and climate change. The studies showed evidence of investment in protective measures, including a heavy emphasis on protective infrastructure, early warning systems and training. We must now ask:

1. How far did these studies adequately look into the potential secondary and tertiary impacts of disasters, in the light of the cases now emerging from recent disaster events elsewhere?
2. How far are the IOC countries preparing for a greater emphasis on the continued provision of critical life-dependent special services for the most vulnerable people?

The detailed studies of the five islands of Madagascar, Comoros, Mauritius, Seychelles and Zanzibar were reported in 2015 as part of a joint exercise by UNISDR and the Indian Ocean Commission through the Islands Project. These studies provided a wide-ranging assessment of disaster risk, public investment planning and financing strategy. They showed that 96 per cent of the disaster loss in the period 1980–2013 was due to cyclones, amounting to a loss of US$17.2 billion at 2012 prices. There were 1,635 deaths in that 34-year period attributed to the disasters, principally to extensive events (that is, ones of high frequency but low impact), of which there were 1,204 in the period, and only one event classified as intensive (that is, low frequency and high impact). The hardest hit island in the period was Madagascar with a loss of 1,309 lives, but the fatality rate per million population in the period was higher in Mauritius and Seychelles than in Madagascar (see Table 9.1). The highest economic loss and loss per capita was in Madagascar, but Seychelles had the second highest economic loss per capita, principally due to flooding.

The assessment of the health impact was in terms of the immediate impact on mortality, without review of the longer-term effects on health. In the assessment of

Table 9.1 Loss due to disasters in the South-West Indian Ocean islands, 1980–2013

Islands	Population *(millions)*	Total economic loss from disasters *(million US$)*	Total economic loss per capita *(US$)*	Deaths from disasters	Deaths per million population
Madagascar	22.3	8,839	396	1,399	62.7
Mauritius	1.26	59.6	47	127	100.8
Seychelles	0.08	15	187	7	87.5
Comoros	0.73	10	14	34	46.6
Zanzibar	1.3	1	1	1	0.8
Total	25.7	8,924	347	1,568	122

Source: Leste de Peridoe and Ishigaki 2015.

economic loss and physical damage, the study considered the impact on assets in terms of loss of income, and destruction of property and infrastructure for up to five years after each event. The economic loss did not include any monetary value for loss of life.

The UNISDR studies of these islands found that at that time there was:

- no coherent disaster risk reduction policy, strategy or action plan for the region;
- no investment policy;
- critical infrastructure insufficiently protected;
- contingency planning underdeveloped;
- a lack of coherent planning and investment between ministries; and
- a need for more capacity building on risk assessment.

The recommendations from the UNISDR studies in the South-West Indian Ocean (Leste de Peridoge and Ishigaki 2015) included:

- further investment in DRR through national budgets, especially in Madagascar and Comoros which were behind the other islands studied in their financial commitments in this field;
- improvement in the capture of the real value of economic losses;
- increase in training in risk management, with capacity building in the analysis of DRR, increasing technical support for probabilistic risk assessment;
- rise in the regional awareness of the need for DRR;
- filling the data gaps in risk assessment;
- provision for further assessment of the indirect effects of disasters; and
- integration of climate change into risk assessment process.

9.7.1 *World Risk Report* 2018 – high disaster risk in island states

More recently, in 2018, the *World Risk Report* presented an assessment of the relative risk of disasters in 172 countries and their capacity for resilience (Heintze et al. 2018) This report found that 13 of the 15 countries with the highest risk were in Africa and that 9 of these 15 were island states. Table 9.2 shows the position of each of the South-West Indian Ocean countries covered in the review, indicating that Mauritius was the most at risk and Seychelles the least at risk. The review was based upon a composite assessment using existing internationally published indicators.

The report calculated the risk index from a composite of available indicators rather than by a specific detailed review of the nature of the hazards and the action taken for resilience. So, for example, the measure of susceptibility was a composite of indicators of safe water and sanitation, slum housing, undernourished people, poverty, age dependency, gross domestic product (GDP) per capita and the Gini Index. Coping capacity was a composite of the corruption perception index, good governance, disaster preparedness and availability of medical services. The measure of lack of adaptive capacity was derived from the extent of education, of research, gender equity, forest management, expenditure on health services and life expectancy.

These *World Risk Report* assessments mirror those made by the UNISDR studies of 2015, showing the relatively high risk of disasters in Mauritius and Madagascar, the high level of resilience in Mauritius and the high lack of adaptive capacity in Seychelles, which is not prone to cyclones but has a high level of risk from flooding seriously affecting its coastal development areas. These measures of risk are illuminating, but provide a rather broad brush approach to risk assessment and they do not focus on what is promoted in the Sendai Framework as the crucial tests of resilience, which are the capacity for effective response and 'building back better', reducing mortality of affected people, and reducing economic loss, damage to infrastructure and disruption of basic services. The *World Risk Report* shows that both Madagascar and Comoros are highly vulnerable and susceptible to disasters and seriously lacking in coping and adaptive capacities.

9.8 Follow up of the 2015 UNISDR and IOC studies

Since 2015 when the joint UNISDR and IOC studies were undertaken, action has been taken in all the islands.

9.8.1 Action in the South-West India Ocean islands since 2015

Set out below for each of the South-West Indian Ocean countries, is a summary based upon recent reports and key person contacts, of the latest position.

The IOC Islands Project 2011–2017 (Bonne 2017) included a major section on DRR. This resulted in all the countries involved in the project[5] setting up disaster risk management units or centres, which continue to be operational, working on DRR policy development, DRR strategy and action plans. These are being linked to preparedness for climate change and adaptation.

Table 9.2 World Risk Index 2018

Country	Ranking 1=most at risk	WB Index	Exposure	Vulnerability	Susceptibility	Lacking coping capacity	Lacking adaptive capacity
Mauritius	16	14.27 Very high risk	37.22 Very high	38.35 Low	17.69 Low	59.26 Low	38.09 Medium
Madagascar	32	10.89 Very high risk	15.63 High	69.68 Very high	66.53 Very high	84.72 Very high	57.80 Very high
Comoros	51	8.36 Very high risk	13.13 High	63.67 Very high	47.48 Very high	84.06 High	59.46 High
Seychelles	115	4.59 Low risk	11.64 Low	39.44 Low	18.22 Low	60.88 Low	39.22 high

Source: Heintze H-Jet al. 2018.

9.8.2 Disaster insurance

One component of the Islands Project was to explore, through collaboration with the UNISDR and the World Bank, the case for disaster risk insurance, through a probabilistic assessment based on the record of the last 30 years or more of disaster experience across the participating countries.

The Islands Financial Protection Programme (IFPP) against 'catastrophic risk' was undertaken with UNISDR and the World Bank, starting in 2013. It aimed to strengthen capacities for unified climate change adaptation (CCA) and disaster risk reduction (DRR).

The design allowed the IOC to undertake a detailed implementation programme, for the introduction of risk financing activities in the IOC region, covering: (a) disaster response; (b) post-disaster reconstruction; (c) disaster reduction investments; (d) climate change adaptation; and (e) insurance and reinsurance schemes.

The overall initiative was designed to identify the proportion of development investments in schools, health facilities, infrastructure and roads etc., which included disaster risk considerations.

The review used tools such as the World Bank Disaster Aid Tracking instrument to identify flows of overseas development assistance (ODA) towards disaster risk reduction. A second step assessed current mechanisms that include DRR in public investment, examining whether there are existing mechanisms in national, sector and public investment planning or project formulation to ensure that DRR and CCA considerations are factored into public investment.

The scheme was ambitious, but advice from the World Bank, which considered the overall insurance scheme, was that it was not appropriate for the islands concerned. So, the idea of the insurance approach was not pursued in the IOC Islands Project countries. This is rather at odds with the development of disaster insurance for Pacific islands and for Caribbean islands (UNDP 2017).

Catastrophic insurance can be entered into by individuals and corporate bodies to cover loss due to disasters such as storms, flooding and earthquakes, with premiums related to risks and potential loss to be covered. The cover can exclude certain types or amount of loss, and may include conditions to be met in terms of precautions taken against loss. It may also include certain conditions that limit the minimum and maximum compensation.

Loss of life and injury may be excluded, or compensation limited to set lump sums and the specific registered details in the certification of cause of death.

While the uneven pattern and level of risk across the IOC islands may not be favourable to collective disaster insurance, there could be a case for exploring partial cover insurance for the emerging issue of the increasing recognition of the long tail of indirect impact, with lower premiums linked to specific criteria for adjudicating on the long tail of the aftermath in loss.

9.8.3 Enhanced preparedness

In the IOC countries, instead of insurance, emphasis has been placed on enhanced disaster preparedness and response, not least in the development of more resilient infrastructure and immediate action concerning the practical aspects of integration of disaster risk reduction and adaptation to climate change.

The DRR management process has progressed in the region, in the face of the disaster risk profiles for the countries, (UNISDR Prevention Web, 2018a) especially in Mauritius through its National DRR Management Centre. Similar management and security centres have been set up in the other countries involved. In the Comores the French-based Platforme d'Intervention Regional de l'Océan Indien (PIROI) is working closely with the disaster response activities of the Red Cross and Red Crescent. PIROI is developing plans and technical capacities to respond in the region through accords agreed with the countries themselves.

A Regional Disaster Risk Reduction and Climate Change Adaptation Plan was tabled at the Council of Ministers of the IOC in 2018.

DRR is now being tackled in tandem with fresh perspectives on adaptation to climate change across the IOC countries, including la Réunion (France) in partnership with Tanzania, Mozambique and South Africa (IOC 2018). This is now being taken forward by the IOC, with the Agence Francaise de Developpement (AFD) as an accredited partner.

This planning, investment and action is important, necessary and all very well, yet, more careful further thought needs to be given to support for the most vulnerable people whose lives are at risk in the aftermath of storms for lack of services. For them, the first task in enhanced preparedness is to identify these people in advance. Most will already be known to the health and other support services, and could be targets for special surveillance and relief following the disruptive effects on the very services on which they rely. As all supply chains are increasingly on short or immediate delivery cycles, so it is with such people. There is a growing practice in the USA for centres of renal dialysis to have disaster preparedness plans to avoid disruption of services to their highly vulnerable patents, which can include advanced evacuation, training, and back-up supply and delivery systems (Kleinpeter 2011).

9.8.4 Planning for more preparedness for the aftermath of disasters

It was found, after Hurricane Maria in Puerto Rico, that households on average were without electricity for 84 days; without water for 68 days; and without cellular phone connections for 41 days, while 9 per cent were unable to reach emergency services by telephone. The resulting interruption of medical care was found to be the principal cause of sustained high mortality rates in the aftermath of Hurricane Maria (Kishore et al. 2018).

This presents a potential risk of preventable death for all island states in the aftermath of disasters. More planning and investment is needed to reduce the risks inherent in

the aftermath of a storm. It is those vulnerable people who may be hidden from view and unable to communicate their needs, who need help, before they are in crisis and die from want of simple, vital support.

9.8.5 Drone technology to the rescue?

Hope, however, could be coming from recent innovations in the peaceful use of drone technology (UN Peacekeeping 2018). Such aerial technology has potentially large post-disaster advantages. It is now being used for:

- leapfrogging over broken infrastructure for detailed surveillance of isolated people;
- locating missing people in need;
- extending Wifi connectivity where links have been cut; and
- targeting the delivery of vital medical and other supplies.

Such innovative services need to be reviewed as a standard part of enhanced preparedness, especially in island states whose normal logistical systems have been dislocated by a disaster and may take weeks or months to restore to normality. The first step, however, is to identify those who are currently dependent on vital continuing medical care/support and to devise plans with them for their emergency support in case of disasters.

9.9 The indirect impact of disasters

Different countries are prone to different types of disaster; but all are at risk from both the direct and indirect effects. In the IOC countries, Mauritius and Madagascar are at risk from cyclones, though these are more frequent and severe in Madagascar than Mauritius, with the latter having built greater resilience. Seychelles and the Comores are not subject to cyclones, but respectively are affected by flooding and desertification. Seychelles was hit by the 2004/5 Indian Ocean Tsunami, while La Réunion experiences regular impacts from its active volcano, from which the population is well protected. All the IOC countries are starting to experience the effects of climate change, including changes in rainfall, sea-level rise and variations in the seasonal weather patterns affecting agriculture, fisheries and livelihoods.

Previous research has tended to focus on the indirect impact of disasters in terms of their economic and, particularly, the commercial impact. While data are scarce and strong calls have been made to improve data collection and models of assessment, the field is perhaps richer in theory than concrete measurement (Jacobs 1999; Benson 2012).

In the UK, through the Government Office of Science, Benson (2012) has reviewed the issue of the indirect economic impact from disasters and examined the twin hypotheses that disasters are an economic disaster for countries, but contrasted with the Schrumpeter notion of the 'gale of creative destruction' giving rise to regeneration, higher productivity and greater competitiveness. Her conclusions call for more

research, but tend to support the view that in poor countries, disasters can overwhelm an economy which has little resilience for renewal and 'building back better' (ibid).

Hurricane Maria, however, has opened the door to the need for more study of the indirect impacts of disasters on vulnerable people and the management of risk reduction for them.

This issue is of general significance for all disasters whose indirect fatal impacts are as poorly documented as the medium- to long-term indirect impacts of disasters on the economy in general and their distributional effects.

9.10 SDGs and the Sendai Indicators: a heavy burden for small states

In light of this review, the present authors have revisited the development of international systems of goals, targets and indicators incorporated in the UN Sustainable Development Goals (SDGs) and in the Sendai Framework, to re-examine how far these data systems are worthwhile as tools for policy-making. They are clearly becoming a burden for small states where missing data is a growing problem (Roberts 2018).

9.10.1 Reported position of IOC countries

Despite the wide-scale problems of lack of reporting on the Millennium Development Goals (MDGs) and SDGs (Roberts and Ibitoye 2012; Roberts 2018), the latest versions of UN SDG database,[6] shows that all the IOC Islands Project countries, except Tanzania, have reported values for SDG 1.5.1 and 1.5.2 showing the human and economic impact of cyclones in the period 2005 to 2014.[7] All these, including Tanzania, have reported under SDG 1.5.3 that they have DRR strategies, except Comoros, which has set up a National Platform for DRR. However, none has reported to the SDG database that they have local strategies under SDG 1.5.4, although Seychelles has had local strategic plans since 2008.

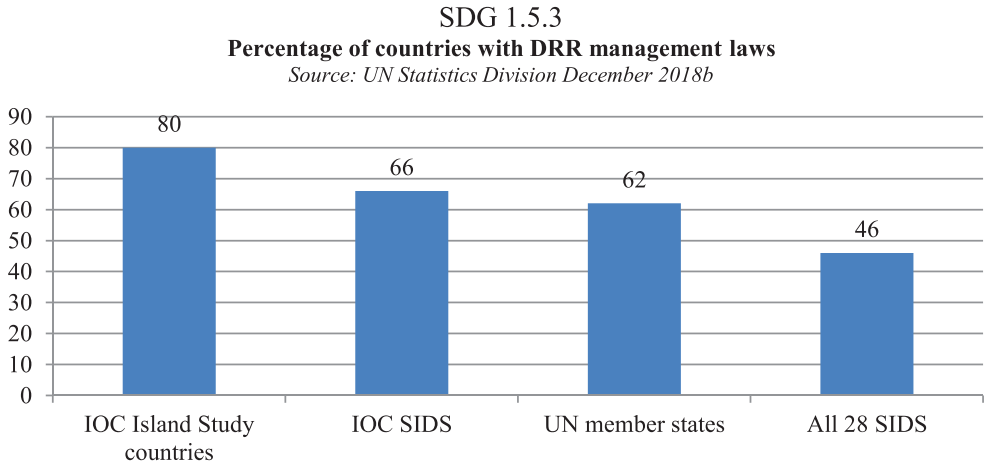
Yet as the cyclone season approaches in Mauritius, the District Council of Pamplemouses, in the north of the main island, has set up a local DRR management committee, with emergency services, local business interests and civil society represented.

The response of the countries included in the UNISDR and IOC Islands Project, to establish at least national legislation or regulations for DRR management arrangements, compares well with the response among SIDS in general and with that of UN member states overall (see Figure 9.2). This in itself is a significant benefit of the investment in the studies themselves.

Comoros

Comoros is at great risk from cyclones, sea surges, tsunamis and the active volcano, Karthala. It has established a National Platform for DRR, with a financial contingency plan to respond to such hazards.

Figure 9.2 Percentage of countries with DRR management laws, SDG 1.5.3



Mauritius

In Mauritius, a strategy is being developed to respond to the risks of natural disasters, particularly cyclones. There has been in place for many years a well-developed and effective cyclone warning system (Roberts 2004). In 2015, the government set up a National Disaster Risk Reduction Management Centre in the Ministry of Environment and announced in 2016 that a DRR policy, a strategic framework and an action plan were being developed. This is expected to cover flooding, landslides and natural risk profiling. The plan is expected to include a multi-hazard early warning system, training for community-based response teams, a website and communications system. A national emergency operations command has been set up, with the disaster response command under the national police force, equipped with a mobile command vehicle. Mauritius has been affected by a series of category 5 cyclones since 1960.[8]

In 2016, Mauritius made a commitment to the Sendai Framework and its implementation (UNISDR 2016b). The 2015 UNISDR IOC study had found that in Mauritius, the central infrastructure was not sufficiently protected against disaster risk and contingency financing methods were also underdeveloped.

With certain of its parastatal bodies, Mauritius has compensation funds covering loss and damage to assets in disasters. For example, the Central Electricity Board and the Central Water Authority have funds, as well as Mauritius Ports and Airport Mauritius. The sugar planters have a Sugar Insurance Fund to protect the harvests of planters and estates and to guarantee against loss.

Madagascar

In Madagascar, there is a strong commitment and programme for DRR, which has been strengthened following Cyclone Enawo in 2017 (UNISDR 2017b). This category 4 cyclone had the following impacts:

- 81 recorded deaths;
- 250 people injured;
- 500,000 people affected;
- 200,000 people displaced;
- 40,000 houses destroyed;
- 3,900 school classrooms damaged;
- 1,300 waterpoints polluted; and
- 100 health centres damaged.

In addition, many roads and electricity supplies were destroyed, there was extensive flooding and the port of Antalaha was left inaccessible (UNISDR 2017b).

Madagascar's Disaster and Risk Management Act was amended in February 2016 to include an updated strategy on disasters and risk management; this was validated by the government in September 2016. The two documents are based on the Sendai Framework for Disaster Risk Reduction, a global agreement adopted in 2015, and on good practices documented over time.

Co-ordination of disasters and disaster risk management in Madagascar is handled by a National Committee for Disaster and Risk Management, which includes the government and relevant stakeholders. Through this committee, members share experiences and are able to advise the Bureau National de Gestion des Risquese et des Catastrophes (BNGRC) to help improve the implementation plan of the national strategy on disaster and risk management.

A key step taken by the Government of Madagascar is to include disaster risk reduction in its national development policy and consideration of disaster risk reduction in all national poverty reduction programmes. One of the strategic areas of the country's 2015–2019 National Development Plan is the valuation of natural capital and the strengthening of resilience to risks of disasters.

To inform this process, UNISDR provides technical support to the government, including through risk profiling and has published a report on disaster risk reduction to facilitate planning and implementation of risk-informed development (UNISDR 2017b).

Seychelles

Since 2008, Seychelles, under the Disaster Risk Management Act (updated in 2104), has had a national disaster response plan and complementary plans in every district. While Seychelles does not suffer from cyclones, except in its southern-most islands,[9] it does have heavy flooding along the coastal areas where most of the people live and businesses are located. The small island of la Digue is, for example, receiving US$1.5 million from the Global Climate Adaptation Alliance for restoration work on land drains following continual flooding of coastal areas from heavy rainfall (Seychelles

New Agency 2016). Seychelles was badly affected by the Indian Ocean Tsunami of 2004/5, which cut off its main airport for some days, disrupting domestic and international travel.

Tanzania

Tanzania has a website dedicated to the SDGs (Tanzania, 2018). Its strategy on DRR is integrated within the national Vision 2025 and mainstreamed with the national development planning and implementation framework, with a parliamentary group established for the implementation of the SDGs (UNA 2018).

9.10.2 Flaws in the SDGs and the Sendai Framework data set for small states

The SDGs (UN Statistics Division 2018b) were intended as a more refined extension of the former Millennium Development Goals (MDGs) (UN Statistics Division 2018a). The MDG system had 8 goals, 17 targets and some 48 indicators. The system proved too elaborate for many small countries to collect and report the data required, with a resulting heavy level of missing data. One study on progress with the MDGs found 44 per cent missing data for small island developing states (SIDS) and other small states and 27 per cent missing for benchmark states (Roberts and Ibitoye 2012).

Notwithstanding, while attempting to fill certain gaps on the scope of the MDGs, the SDG system increased the size of the burden of data by more than doubling the number of goals, making a nearly tenfold increase in targets and a fivefold increase in indicators. Missing data remains a major issue, and the latest 2018 UN report on the SDG system revealed that 80 per cent of the data was missing (UNDESA 2018). The increasing burden is felt heavily by small states and has been cited as a curse rather than a cure for the monitoring of sustainable development (Roberts 2018). William Easterly in *Foreign Policy* magazine has suggested that 'SDG' should stand for 'senseless, dreamy and garbled'.[10]

To add to the already overburdened lot of the statistics bureaux in small states, the UNISDR is calling for implementation of a further elaboration of data for monitoring disasters, linked to the Sendai Framework, involving another set of 38 indicators covering 7 targets and 4 priorities. While some of these indicators duplicate what is already defined in the SDG system, the overall burden for small states is increasing, with little apparent gain for policy-making.

An official report (UNISDR 2017) on recent disasters in 87 countries, including 11 SIDS, determined to try to implement the Sendai Framework data system, provides sorry reading. Many countries provided only partial data across the 38 indicators. The reports were especially weak on the assessment of economic loss, loss of livelihoods, and impact on agriculture and forestry assets. Asked if they needed help in gathering data for the system, less than half the countries in the survey responded. Of those that did, the majority wanted financial assistance, capacity building and technical transfer to comply with the requirements of the Sendai Framework data system.

A minority of countries responded to questions on damaged and destroyed health systems, disruption to education, the status of implementation of a DRR strategy, clear timeframes for action and the existence of a follow-up procedure. Less than a quarter of the countries surveyed had data on the extent of the population exposed to disaster risk that were covered by an early warning system and pre-emptive evacuation process. The report concluded that considerable work would need to be done to enable countries to provide the agreed indicators in the Sendai Framework data system.

The Sendai Framework data system has been painstakingly documented, with an 80-page manual on data definitions and collection methods (UNISDR 2016a, 2017b, 2017c). This, however, is unlikely to engage the fullest support of many SIDS and other small states, whose capacities for the collection and reporting of obligatory data are already overwhelmed, with many calling for help(UNISDR Prevention Web, 2018b) .

For monitoring macroeconomic development, international analysts commonly confine themselves to the economic fundamentals, embraced by less than ten indicators: it is an extravagance to call for data on 242 SDG indicators and 38 on disaster management alone, devoid of evidence of the practicality of the exercise, nor showing concern for the cost effectiveness of the elements for illuminating differences in performance and aiding policy- and decision-making. The need to cut the data requirements down to size, at least for SIDS and other small states, needs further consideration (Roberts 2018). To some extent, this will emerge automatically, as small states, for lack of resources, restrict their reporting to key indicators. Yet some attention needs to be given to the practice of the UN Statistics Division? The insertion of estimated values to substitute for gaps in reporting by the countries themselves, which can be misleading.

It has been found, not surprisingly, that countries with higher levels of income invest more in greater levels of risk reduction and security and those with lower levels of income suffer more. Wealthier countries develop better protection and may have more transparent systems for accounting for national expenditure and great clarity in attributing disbursement to specific ends (Kelenberg and Mobarak 2011). But what is more critical is how far the expenditure on risk reduction actually reduces risk and what are the 'best buys' for a given level of investment in the face of the strength and frequency of known hazards. For this, a clear evidence base is required and the 2015 UNISDR and IOC studies of the South-West Indian Ocean islands lay out clear priorities for future strategy and action. Some progress has been made, but consolidation of this broad policy is now required. This is all the more necessary in the light of the findings of the review of Hurricane Maria (Andrade et al. 2018).

The UN *Post Disaster Needs Assessment* (PDNA) report on lessons learned from a decade of experiences (Jeggle and Boggero 2018), was compiled before the full results of Hurricane Maria appeared. As a result, it did not have the benefit of the findings of post-Maria epidemiological study, which brought into such sharp focus the massive impact on people with special needs and the probability that other such disasters had failed to spot this crucial issue for the future of DRR management. However, that

otherwise model PDNA report did draw oblique attention to the issue by noting that disaster needs assessment as a method should ensure greater inclusion of the most vulnerable socially marginalised groups with special needs (ibid, pages VII and 37). The study included Marshall Islands, Vanuatu, Fiji, Haiti and Seychelles in its review.

Nor is there much cause for greater hope that the Sendai Framework indicators will capture the true impact on the most vulnerable, whose unheroic long tail of deaths in the aftermath can contribute massively to the overall long-term mortality of disasters. For the guidance manual on the Sendai Framework data system addresses the issue rather obliquely, without providing a technical methodology that has emerged from the meticulous post-Hurricane Maria study (UNISDR 2017c).

The guidance manual gives greater emphasis to the direct, immediate deaths in a disaster, i.e. the 'direct causes of death that are more feasible to attribute'. Maybe this guidance will now be changed in the light of figures emerging of the overwhelming impact on the mortality from a category 5 wind storm – where the most vulnerable people linger for a while, but die in its aftermath. Maria also demands not just that methods of attributing death to the disaster are refined[11] and use is made of the correct ICD classification of death,[12] but that the strategy for saving life is reoriented accordingly.

Despite the enhanced performance of the IOC countries in responding to a key part of the Sendai Framework, which is duplicated in the SDGs, there must be serious doubts both of the capacity of small states to complete these data sets and of the usefulness of these indicators to them for policy-making. Moreover, these official international data systems have yet to take into account the lessons learned from Hurricane Maria in terms of data collection and disaster preparedness.

The Sendai Framework priorities begin with the understanding of disaster risks and end with 'building back better' (Wahlistrom 2015). After Hurricane Maria, the interpretation of these priorities needs to be re-evaluated.

9.11 Essential DRR issues for small island states

As a checklist for policy-makers in small island states, the six key questions to ask are:

1. What action has been taken to establish a policy, strategy and action plan on DRR?
2. How far have the conclusions and recommendations of previous post-disaster reviews been followed through?
3. Has the core of the Sendai Framework been implemented, and the key data required for monitoring progress towards the Sendai targets been collected and reported?
4. Is the island protected against the risk of a category 5 cyclone or other severe disasters (early warning systems, critical infrastructure, housing, power, water and sanitation, evacuation measures and emergency shelter, emergency food, medical supplies, communication systems)?

5. What steps have been taken to reduce the risk of flooding?
6. What steps have been taken to identify the most vulnerable groups of people dependent on vital medical and social care and to provide emergency support system for them in the aftermath of a disaster?

For a sharper focus on DRR, the international data systems in the SDGs and the Sendai Framework dataset need to be revisited, to reduce the burden of data collection on small states and to provide a plan to reduce the evident mortality from the aftermath of disasters.

9.12 Conclusions and recommendations

The recent history of natural disasters has shown the long-term human impact has an extended tail of deaths following on after initial disaster events. This furthermore contributes to the demise of a much larger number of the most vulnerable people than was hitherto suspected. In Hurricane Maria in the USA, such late indirect deaths were 98 per cent of the total deaths; in Rita they made up 94 per cent and in Katrina 52 per cent. The number of these deaths can thus, far outweigh those whose lives are lost by buildings falling on them or by drowning in subsequent floods and mudslides.

This long-run fatal aftermath, which is a probable feature of many types of disaster, must cause us seriously to revaluate the potential for preparedness. For quite different action is required to reduce the risk of this much larger death toll, which may be commonly understated in disaster reports. A correct assessment of this tail depends on the correct use of methods for the classification and coding of the cause of death and, above all, a different type of technical intervention.

Review of the preparedness for DRR in the South-West Indian Ocean Islands confirms this concern, even after exemplary studies had been conducted in the Islands Project, with support from UNISDR, the IOC and the EU. More needs to be done to address the post-disaster risks to survival of vulnerable people – for example, those on dialysis, those with asthma and chronic obstructive lung disease, and others whose lives depend on power, water and sanitation, and continual medical care services.

Registers of those at risk after a storm, and alternative support mechanisms for them, are being developed in other countries. The use of drone technology now operated by the UN for peaceful use, should be reviewed as a potential to provide urgent support to the most vulnerable people in the aftermath of disasters, whose lives are at risk from disruption of vital, timely services.

9.12.1 The lessons learned from the Island studies and action since 2015

This chapter gives rise to recommendations for action in preparedness and in further study, as follows.

DRR systems should:

1. consolidate the implementation of the recommendations of the 2015 UNISDR and IOC studies in all the countries covered;

2. provide a sharper focus on the risk factors affecting the long tail of indirect fatalities in the aftermath of disasters;
3. identify the most vulnerable people and ensure emergency back-up services are available for them;
4. provide education programmes to alert people and services to the risk factors which affect the survival prospects of the most vulnerable, especially those with chronic disease and who are dependent on life-saving medical services;
5. identify those life-support systems that are at risk from disruption of power and other technical support and provide alternative back-up for emergencies, such as the use of drone technology; and
6. improve reporting systems on cause of death certification and coding to capture the full extent of indirect fatalities and injury from disasters.

After Hurricane Maria, there is much to be done to re-orientate global and local DRR strategy to avert further loss of life from the aftermath of disasters, which may tragically continue to account for a large and neglected loss of human life, especially in small and island states where there is little room for evacuation to the hinterland.

Notes

1 'Deaths occurring as a direct result of the forces of the tropical cyclone are referred to as "direct" deaths. These would include those persons who drowned in storm surge, rough seas, rip currents, and freshwater floods. Direct deaths also include casualties resulting from lightning and wind-related events (e.g., collapsing structures). Deaths occurring from such factors as heart attacks, house fires, electrocutions from downed power lines, vehicle accidents on wet roads, etc., are considered "indirect deaths"." (Pasch et al. 2018)

2 Classification and certification of cause of death is the responsibility of qualified physicians and is governed by international convention for the completion of death certificates using the *International Classification of Diseases (ICD),* now into its 11th edition (WHO 2018). The appropriate cause of death resulting from natural hazards is found in Chapter 23 of the ICD: 'External Causes of Morbidity and Mortality', and the sub-section: 'Exposure to Extreme Forces of Nature'. There are special guidelines for completing the death certificates, which are then passed to official medical statistics offices for coding and compilation into national statistical returns, which are then annually reported to the WHO for international comparative purposes. Pasch and colleagues found that there was a clear raised mortality rate following Hurricane Maria in Puerto Rico; the causes of death specified in the statistical reports were replete with the use of what are termed 'garbage' codes, such as heart failure. These are resorted to by physicians who do not know which classification to use or who want to conceal the real cause of death or the underlying factors. Pasch found in a series of local key-person interviews that many physicians in Puerto Rico had not been trained in appropriate classification methods related to hurricanes, the special manuals for classification had not been distributed and there were certain disincentives arising for hazard insurance that dissuaded physicians from citing the hurricane as a factor in many late deaths (Pasch et al. 2018).

3 See: Anderson, JL (2018), 'Daily Comment', *New Yorker*:, available at: https://www.newyorker.com/news/daily-comment/what-donald-trump-fails-to-recognize-about-hurricanesand-leadership (accessed 20 November 2018).

4 Using US$85 billion as a mid-point of reported estimates of damage due to Hurricane Maria in Puerto Rico.

5 Comoros, La Réunion (France), Madagascar, Seychelles and Zanzibar (Tanzania).

6 Accessed 17 December 2018.
7 For Madagascar from 2005 to 2015.
8 Cyclone Carol (1960), with winds of up to 256km/h and barometric pressure of 943; Jenny (1962), with winds up to 235km/h and barometric pressure of 995; Gervaise (1975), with winds up to 280km/h and barometric pressure of 951; Hollanda (1994), with winds up to 216km/h and barometric pressure of 984; Dina, (2002) with winds up to 228km/h and barometric pressure of 988.
9 The islands of Farquar is receiving World Bank support to build back better following cyclone Fantala in 2016, with the loss of tourist infrastructure and where the recovery needs are estimated to be US$8 million (Seychelles News Agency 2016).
10 Easterly, W (2015), *Foreign Policy,* 28 September, available at: http://foreignpolicy.com/2015/09/28/the-sdgs-are-utopian-and-worthless-mdgs-development-rise-of-the-rest/
11 The guideline does draw attention to the need for more correct attribution of immediate disaster deaths, but does not go into detaild of the correct use of the International Classification of Diseases (WHO 2018). Nor does it identify the need for retraining of registration and coding staff certifying cause of death, using Chapter 23 of the classification for external causes and the sub-code for exposure to extreme forces of nature as an underlying cause of death, as recommended in the Maria report recommendations (Pasch et al. 2018).
12 The ICD 2018 reference guide (WHO 2018) prescribes the use of the following terms on death certificates and morbidity classification to allow the use of the external causes code to link a main cause of death to the external cause of extreme force of nature, by using terms such as 'due to'; 'caused by'; 'attributed to'; 'secondary'; and 'associated with'.

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Chapter 10

Strengthening Resilience Through Disaster Risk Reduction: A Gender-centred Perspective for Malta

Roberta Lepre and Isotta Rossoni

10.1 Introduction

In 2016, Resolution 60/23 by the Commission on the Status of Women (CSW) called upon states to:

> *promote a gender-responsive approach, the integration of a gender perspective and the empowerment of women and girls in environmental, climate change and disaster risk reduction strategies, financing, policies and processes, towards achieving the meaningful and equal participation of women in decision-making at all levels on environmental issues and towards building the resilience of women and girls to the adverse of climate change* (UN 2016).

Increasingly, international organisations, non-governmental organisations (NGOs) and policy-makers have come to acknowledge the immense benefits of integrating gender analyses and gender-responsive approaches in DRR work (UNISDR, UNDP and IUCN 2009; FAO 2016; Oxfam 2010). The core notion underlying this approach is that 'nothing in disaster work is gender-neutral' (Gender and Disaster Network 2005). In other words, recognising the differential and gendered impact of natural disasters, as well as capitalising on women's skills and know-how is considered essential to design and implement DRR policies that are not only inclusive, but also effective. Introducing gender mainstreaming in DRR work holds implications for prevention of gender-based violence, a common occurrence during/in the aftermath of natural disasters (Enarson and Pearse 2018). Gender equality and climate action should thus go hand in hand, as they have the potential to be mutually reinforcing. This view comes forth strongly in the 2030 Sustainable Development Goals, where gender equality features alongside a range of objectives focusing on environmental protection and sustainability (UN 2018). All countries, particularly those that are vulnerable to natural disasters, such as many small states, should take into consideration gender issues when devising their responses to prospective environmental threats and ensure that the whole population is represented by those vested with decision-making.

The island of Malta, at the crossroads between Europe and Africa, is one of the EU Member States that is likely to be most affected by climate change

(Guerreiro et al. 2018; Deutsche Bank 2008). Malta is prone to floods, erosion and fresh-water shortage (European Commission n.d.). Initiatives such as the National Flood Relief Project – which involved the construction of a network of underground tunnels, canals and bridges for better storm-water drainage by 2015 (Ministry for European Affairs and Equality n.d.) – hold promise and show an inclination towards better preparedness for small- or large-scale disruptions or potential disasters. However, flash storms and flooding remain a relatively frequent occurrence in the country (*Times of Malta* 2018; *The Malta Independent* 2018), and are often responsible for damage to infrastructure, increased traffic and, on occasion, harm to or death of residents.[1]

More recently, published research suggests that in the future, Malta will be plagued by more frequent and more severe droughts (Guerreiro et al. 2018). Valletta will be one of the European cities worst hit by drought and heatwaves as a result of climate change, potentially pushing the country beyond breaking point. Guerreiro et al. (2018) analysed changes in flooding, droughts and heatwaves for 571 European cities for the years 2050 to 2100 using all available climate models. The research team showed results for three possible futures, which they called the low-, medium- and high-impact scenarios. Even in the most optimistic scenario, Malta will experience 38 per cent more heatwave days each year and maximum temperatures around four degrees Celsius higher. On this view, drought will become 1.29 times more severe. Scientists estimate that the world's temperature is set to rise to 3°C above what was normal before the industrial age began. Sea-level rise will drastically alter the shape of the Maltese coastline, with the Northern and Harbour areas being hit especially hard. These bad omens should not only act as catalysts for enhanced DRR efforts, but also give impetus for gender mainstreaming and gender-responsive research and policies.

This chapter will discuss the numerous opportunities available in the Maltese context to marry DRR with the battle for gender equality. Rather than viewing gender equality as 'given-for-granted' or 'inherently desirable', the authors will strive to justify the significance of gender equality in the context of DRR in the Maltese scenario. Moreover, they will discuss and advocate an intersectional approach to gender equality, which recognises that gender interacts with other power structures and categories in meaningful ways, thus allowing for a more nuanced understanding of the situations of vulnerability faced by individuals (Swedish Secretariat for Gender Research 2015). Drawing on existing data and research, this chapter will explore gender-centred approaches to DRR, discussing their applicability in the Maltese context. To do so, it will identify the most salient gender issues in Malta, as well as shed light on the vulnerabilities generated by the complex interactions of gender with age, disability and migration status. In addition, it will stress the importance of including women and women's rights activists in DRR initiatives and decision-making, identifying gaps and opportunities within existing political and social structures and presenting suggestions for gender mainstreaming in DRR in Malta. This analysis hopes to inspire DRR research and prevention work that is attuned to gender issues and at the same time, embraces an intersectional perspective, acknowledging that there cannot be resilience without gender equality.

10.2 Gender-centred approaches to DRR

In 2012, on the International Day for Disaster Reduction, UN Special Representative of the Secretary-General for Disaster Risk Reduction, Margareta Wahlström, stated that more than 200 million people who were affected by disasters every year are female, adding that the best recovery programmes are those that engage female survivors. True resilience, in Wahlström's view, is only possible if women are proactively involved in DRR (UNISDR 2012).

Wahlström's outlook resonates with a wide majority of gender-centred DRR research and policy work (FAO 2016; UNDP 2017; UN Women n.d.). Literature focusing on disaster and disaster preparedness in developing countries generally explores the gendered embodied experiences of disasters (Luft 2016). An example of this is Röhr's (2005) analysis of the 1991 cyclone in Bangladesh, which saw the death of five times the number of Bengali women compared to local men. Röhr pointed out that the root cause of this imbalance lay with the use of public spaces to issue warnings, in a context where women cannot leave the house unchaperoned. In the lead-up to the 1991 cyclone, warnings were issued to men in public spaces, whereas women, confined to the domestic sphere, remained unaware of the impending danger and perished at home while waiting for the return of their male relatives. Women's inability to swim also contributed to their victimisation. Similarly, research conducted by Oxfam (2005) found that the tsunami that hit India in 2004 struck down many more Indian women than men. While men were out at sea fishing, women were on the shore, waiting for them to bring in their catch to process, and thus perished while fulfilling their daily duties prescribed by traditional gender roles.[2] In other disaster scenarios, due to gendered processes of marginalisation, women and girls have lost their lives because they could not swim or climb trees, or because they stayed behind to look after children and the elderly Ear (n.d.).

Beyond death, direct harm or damage to property, women are also susceptible to the indirect effects of disasters. This includes an increase in reproductive work (care giving, domestic roles) in the aftermath of a natural disaster (United Nations/Economic Commission for Latin America and the Caribbean 2003), often coupled with loss of productive employment. Many women worldwide are engaged in the informal sector, which is commonly hit the hardest in the event of a disaster (Demetriades and Esplen 2008). In addition, systemic sexism and discrimination can also act as barriers to women and girls accessing healthcare and other services, with severe impacts on their health and well-being (ibid). Another worrisome indirect effect of natural disasters concerns violence and victimisation. After a disaster and in particular in situations of displacement, women and girls often become the targets of domestic violence, sexual violence and harassment (Demetriades and Esplen 2008; Enarson, Fothergill and Peek 2006). In many cases, violence stems from men's loss of control in the face of loss and deprivation, and is further fuelled by society's unrealistic expectations towards men in post-disaster reconstruction (Zara and Parkinson 2013). Thus, disaster scenarios can transform and aggravate gender inequality, as well as engender novel situations of vulnerability.

Within scholarship examining gender issues in DRR, there is also growing acknowledgement that men and women hold different sets of skills and expertise that

are not only complementary, but also pivotal to effective DRR. Regrettably, women are often excluded from decision-making and prevention initiatives. Le Masson's (2013) research in the Indian context reveals that men and women often perceive existing resources and challenges differently; hence opening up space for women's voices in DRR can contribute to building better informed and more holistic preparedness. Similarly, at the 2015 UN World Conference on Disaster Risk Reduction in Sendai, Japan, Kairangi (2015) referred to Fiji to illustrate the differences between men and women's reactions to disasters; while men in danger situations will attempt to make the house safer, women will often stock up on food and other essentials. She further discussed the vital role played by nurses in the course and aftermath of natural disasters. The support offered to disaster victims by nurses, who are predominantly female, was acknowledged by Cook Islands following the cyclone of 2011. Given the paucity of nurses on its territory, the government brought in foreign nurses to support and work with victims of the cyclone (ibid).

The recognition of differential impacts and skills across genders has given rise to advocacy work and research supporting the notion that DRR initiatives can and must act as a platform for gender empowerment. *Gender Responsive Disaster Risk Reduction* (2014), a publication drafted by the United Nations in the lead-up to the Third UN World Conference on Disaster Risk Reduction held in Japan, makes an appeal to ensure that DRR policies are sensitive to gender differentiation and promote the inclusion of both men and women in DRR efforts across sectors. This should be done to ensure that DRR initiatives serve to combat gender inequalities rather than strengthen them, and contribute to furthering human rights and development (UN 2014). International research would seem to indicate that DRR has the potential to help tackle existing forms of gender inequality. Nielsen and Reenberg's (2010) research in Burkina Faso found that adaptation projects aided women in negotiating their gender roles in the domestic sphere. Other researchers working in Mali argue that environmental changes engendering male outward migration allowed for the creation of new paid jobs for women, particularly those from disadvantaged backgrounds (Djoudi and Brockhaus 2011). Making gender equality and empowerment integral elements of DRR is one of the key objectives of the UN Post-2015 Framework for DRR, which seeks to ensure that women's rights and the strengthened resilience of communities, and of women and girls, are at the core of disaster risk reduction efforts.

10.3 What's missing?

Gender analyses represent an important contribution to research on disasters and disaster preparedness; nevertheless, they occasionally fall prey to generalisations and over-simplifications (Demetriades and Esplen 2008). More specifically, analyses that fail to identify the complex interactions between gender and other forms of domination such as race, class, age, migration status or others, fall short of accounting for the multitude of human experiences of suffering. An intersectional approach can help conceptualise multiple and intersecting subjugations, challenging the assumption that patriarchy, racism and class privilege operate in isolation and with distinct outcomes. Intersectionality is a tool to grasp the multidimensional dynamics

of power and inequality (Dhamoon 2011) before, during and after a disaster. Such intersectional analyses should span the micro, meso and macro levels (Luft 2016) and be contextual, namely grounded in a well-rounded understanding of the specific circumstances and the particular location in time and space of women and girls. In fact, research conducted internationally provides invaluable insights; yet findings from one country or locality cannot be extrapolated and applied indiscriminately to other contexts (Demetriades and Esplen 2008). The battles and challenges of women in Malta will differ substantially from those of women in India; as will those of Maltese women from migrant women living in Malta; or those of young migrant women and the older generation. Moreover, within the very same group of 'migrant women' in any country, narratives may vary based on the type of migration status (or lack thereof), religious belief, age or other factors. Intersectionality therefore implies heightened awareness of intragroup differences.

Finally, gender analyses shouldn't focus exclusively on 'women'; although women are often the target of discrimination, the challenges faced by men – and for that matter, migrant men, gay men, young men, older men – vis-à-vis natural disasters should also be taken into account. Furthermore, including men as a focus of research can not only aid in identifying the vulnerabilities confronted by men, but also provide insight into how these vulnerabilities interact with and generate new vulnerabilities for women. An example of a gender-centred analysis exploring the issue of domestic violence on women, which encompasses men, is research undertaken in Australia following the Black Saturday bushfires of 2009. To make sense of the increased rates of intimate partner violence, researchers explored the colossal expectations placed on men who survived the fires and the ensuing feelings of hopelessness and inadequacy. Frustrated masculinity, often combined with alcohol and drug use, are pinpointed as chief causes of domestic violence (Zara and Parkinson 2013). The next sections of this chapter discuss gender inequality issues in Malta and articulate an intersectional gender analysis in DRR for Malta.

10.4 Gender inequality in Malta – gender and its intersections

The European Institute for Gender Equality (EIGE) regularly assesses the state of gender equality across Europe, ranking member states in a Gender Equality Index. The Index measures equality in the areas of employment, finances, knowledge, time, power and wealth, assigning to each country the score of 1 for full inequality and 100 for full equality. In 2015, Malta scored 46.8 out of 100, ranking 16th out of 28 in Europe. While Malta scored high with regards to access to health for both men and women, it gained low scores in the domains of power and time. EIGE's assessment noted the paucity of women in economic and political decision-making; and highlighted the disproportionate amount of time spent by women on care and domestic tasks (EIGE 2016).

According to a recent article published by the Malta Chamber of Commerce, although women in Malta pursue and complete post-secondary and tertiary education, they tend to work fewer hours than their men, with employed women working an average

of 35 hours per week, six hours less than their male counterparts. In addition, the unemployment rate for women is higher by almost one percentage point than for men (Malta Chamber of Commerce 2018). Although Malta's gender pay gap in 2017 stood at 12.2 per cent, lower than the European average of 16 per cent (Eurostat 2019), Eurostat data shows a widening gap from 2011 onwards, when the pay gap was 7.7 per cent (Eurostat 2018). In practice, this means that nowadays women doing the same job as men in Malta were getting paid 11 times less (Malta Chamber of Commerce 2018). The gap grows bigger within the 65+ age group, a finding symptomatic of the increased challenges faced by older women in Malta (ibid).

Migrant women from outside the EU, and in particular asylum-seeking women, are confronted with additional barriers vis-à-vis employment. A large majority of female asylum seekers living in Malta are out of employment, in spite of their high qualifications and work experience. The main obstacle to accessing and securing employment is discrimination on the basis of age, religion or nationality, colour and the hijab (Camilleri-Cassar 2011; Chana Merino 2017).

Women living with a disability in Malta grapple with specific difficulties vis-à-vis both education and employment. Although rates of education and employment for people with a disability are generally lower than those of the general population, disabled women tend to be more at a disadvantage than their male counterparts. Women with a disability generally do not further their studies past primary education; are 34 times more likely than men to take care of the household; and 3 times less likely to gain employment. Women with a disability are also twice more likely than men to live in an institution or in private accommodation that is old and/or in need of renovation (Spiteri Gingell 2011).

National Statistics Office (NSO) data for 2014–2016 shows that women remain at greater risk of poverty than men (NSO 2018). Single parent families – which have registered an increase in Malta in recent years and are generally headed by women (Cutajar 2006) – are at particular risk of experiencing poverty. Data show that the rates of single mothers' access to full-time employment are considerably lower than those of single fathers, and they often engage in part-time work or low-paid employment (Deguara n.d.; Government of Malta and European Commission 2003; Cutajar 2006). Teenage mothers wishing to access employment are likely to experience increased complications. Many teenage mothers would have interrupted their studies due to pregnancy; their lack of qualifications combined with their mothering role render securing a well-paid job problematic (Cutajar 2006).

There is also a covert dimension to women's poverty, which might not be captured by statistics measuring income by household. In Malta, it is often men who control the finances, even if women are commonly in charge of family expenses. Women belonging to low-income families may thus sacrifice food and clothing for themselves, in order to attend to their children's needs (Deguara n.d.). Moreover, in situations of domestic violence, perpetrators often restrict access to finances as a tactic to control their victims. Qualitative research conducted in Malta shows that financial dependence is an important dimension of gender-based violence on the island (Naudi et al. 2018).

Malta has registered an increase in reported domestic violence offences in recent years (Formosa 2017). This is in part due to changes in legislation, which allowed for specific data on domestic violence to become available from 2007 onwards (ibid) and, arguably, on increased awareness as a result of civil society activism (see: Dimitrijevic 2018). Regrettably, due to fear, shame, disillusionment and lack of trust in the authorities, many domestic violence crimes remain unreported (Gerada 2017 quoted in Saliba 2017; Micallef Straface 2013 quoted in Calleja 2013).

Women are the main targets of domestic violence with the European Union Agency for Fundamental Rights (FRA) research showing that women in Europe grapple with discrimination in the workplace, harassment and sexual harassment, (cyber) hate speech and violence of a physical, psychological and sexual nature (FRA 2014); based on a 2014 FRA Survey, 15 per cent of women in Malta had experienced physical or sexual violence by a current or former partner since the age of 15. Vakili Zad (2013) points to a direct link between discrimination, low socioeconomic and political status, and women's higher rates of victimisation in Malta. Due to discrimination and hampered access to employment, women become increasingly dependent on their male partners and, consequently, more vulnerable to violence. Women from disadvantaged backgrounds may become homeless after fleeing the domestic home. Violence is often present throughout the life span: it generally begins between the 20s and the 30s and continues for 30 to 40 years. Forms of abuse include emotional and financial abuse, and neglect by male spouses, children or partners (NCPE 2015).

Migration status and cultural beliefs problematise reporting – many migrant women who are victims of domestic violence and may experience other forms of gender-based violence – such as female genital mutilation (FGM), rape and harassment – during their migration journey do not report crimes to the authorities for fear of deportation, cultural and language barriers (Rossoni et al. 2018). Due to traditional beliefs, older women may also be reluctant to seek help (NCPE 2015; Naudi et al. 2018); women with a disability experiencing violence face the additional challenge that professionals supporting victims of violence do not fully grasp the problematics inherent to their target group (Naudi et al. 2018). Although violence in same-sex couples has gained increased scrutiny abroad (see, for instance, Jolly 2014), there is still limited awareness in Malta about violence in the context of gay and bisexual male couples or in the queer, transgender and bisexual communities.[3]

10.5 Gender and DRR

As previously argued, there is a direct relationship between gender equality, women's empowerment and climate change. First, women appear to be disproportionately vulnerable to the effects of climate change, which could, in turn, exacerbate existing gender disparities. Second, women have unique knowledge and skills that can help make the response to climate change more effective and sustainable. Third, climate change policies that take account of gender-based vulnerability and the unique contribution that women can make, could help advance gender equality and women's empowerment while fighting climate change.

10.6 Differential impacts

Given the dearth of gender-centred analyses in DRR in the Maltese context, assessing the differential impacts of climate change and natural disasters on the island is problematic. Research focusing on floods and landslides between 1965 and 2014, conducted in the Italian context, would seem to indicate that in Italy, higher numbers of men – particularly older men – perish in natural disasters, compared to lower percentages of women. While victims of floods generally perish outdoors (e.g. while driving), being indoors is more dangerous in the event of a landslide. The researchers justify the higher rates of male victims, by pointing to the prevalence of risk-taking attitudes among men and the differential exposure of the genders to geo-hydrological hazards in Italy (Salvati et al. 2018). Nevertheless, they also note that women over 70 are more vulnerable to floods than men in the same age group, thus highlighting the importance of considering additional variables besides gender (ibid). Referring to the similar findings stemming from international research (see Jonkman and Kelman 2005; Coates 2010), the authors conclude that: 'In developed countries, flood mortality is larger for males, and particularly drivers of motor-vehicles, whereas in low-income countries flood mortality is higher for females' (Salvati et al. 2018, 868, 869).

While one could hypothesise that similar consequences would apply to Malta, this research does not take into account other forms of direct impact, such as damage to property, which may also concern women. Moreover, the researchers fail to discuss the indirect damages documented by international research, most notably the increase in women's reproductive work following a natural disaster (Unites Nations/Economic Commission for Latin America and the Caribbean 2003). In light of evidence pointing to the large discrepancies between time dedicated to household chores and care by women and men in Malta (EIGE 2016), one could argue that climate change and natural disasters would likely broaden the gap. Furthermore, one should also consider the indirect impacts of disasters in terms of access to employment and other services, such as health. While it is possible that disaster scenarios open up new opportunities for employment (see Kairangi 2015), arguably, women's already hampered access to employment is likely to worsen as a result of such events. This is particularly true of women who are doubly or triply marginalised due to migration status, religion, age, disability or other factors, as previously argued.

When it comes to access to health and mental health support, this may prove particularly problematic for migrant women due to language and cultural barriers (Kopin and Integra Foundation 2016), but also for men, both local and foreign. Mental illnesses are still surrounded by stigma in Malta (Agius et al. 2016) and, very often, men are reluctant to seek help (Calleja 2018; Times of Malta 2018), a finding validated by international research (Demetriades and Esplen 2008). Moreover, mental health issues and expectations towards men in a post-disaster scenario may also result in an increase in domestic violence and violence against women (Enarson and Pearse 2018), exacerbating existing issues and inequalities.

10.7 Improving today for a better tomorrow: resilience through gender-responsive approaches to DRR

In the aftermath of Hurricane Andrew, which hit Miami in 1992, women's knowledge and their role as primary actors in both the local community and the care economy aided them in responding more effectively to the effects of the disaster. Their community-based links ensured that even the more marginalised, such as victims of crime, single mothers and youths, received adequate support (Blomstrom et al. 2014). Women are essential to true resilience and should be proactively involved in DRR efforts. A quick glance at activism in the area of women's rights in Malta in recent years,[4]. proves that there are numerous organisations whose members are talented, invested and passionate about their cause. Additionally, and more importantly, they foster links with the most marginalised within the Maltese community, namely with those who are likely to be most affected by climate change and natural disasters. Civil society actors working in the areas of disability, mental health and LGBTIQ (lesbian, gay, bisexual, transgender, intersex and queer) rights should also be involved in prevention efforts.

Engaging civil society actors that work with marginalised communities can help identify existing signs of resilience; it would be a mistake to assume that resilience should be built from scratch. Many individuals, including individuals in situations of vulnerability, have already faced a range of life-changing challenges. A woman who has managed to cope with violence, recover and look to the future is a resilient woman, and can likely provide valuable input to those working on gender-responsive DRR. The next section will present the authors' suggestions for gender-responsive policies in DRR.

10.8 Suggestions for gender-responsive policies

Malta has developed a national climate change adaptation strategy, which was approved in May 2012, following the review of the work submitted to it by the Climate Change Committee appointed in August 2009, which committee consisted of nine men and one woman (Climate Committee for Adaption Change, Malta 2010).

In 2016, following the setting up of a new risk assessment process and the finalisation of the first national risk assessment (NRA), Malta also participated in a thematic peer review on risk assessment (European Commission 2016). One of the main recommendations emanating from this peer review outlined the need for Malta to 'institutionalise the involvement and co-operation of the government and other stakeholders in a national platform for disaster risk reduction that includes all sectors of society (governmental, private, civil society, experts, academics, industry etc.)', with another recommendation to 'consider having the NRA address more in-depth the risks related to, inter alia, rises in sea level and climate change'. It was pointed out that 'Malta, as an island and a small country, is more vulnerable to climate change than inland and bigger countries' (European Commission 2016, 28).

The Sustainable Development Goals, developed with the aim of having a set of universal goals to guide leaders across the globe in addressing the world's urgent

environmental and economic challenges, are built on the success of the Millennium Development Goals, albeit including new areas of priority, including climate change, economic inequality and innovation. Goal 11, which deals with 'Sustainable Cities and Communities', requires that by 2020, governments should 'substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels'(UNDP n.d.).

The Sendai Framework provides that:

> *Disaster risk reduction requires an all-of-society engagement and partnership. It also requires empowerment and inclusive, accessible and non-discriminatory participation, paying special attention to people disproportionately affected by disasters, especially the poorest. A gender, age, disability and cultural perspective should be integrated in all policies and practices, and women and youth leadership should be promoted. In this context, special attention should be paid to the improvement of organised voluntary work of citizens.*

Gender mainstreaming entails integrating a gender perspective into every stage of the policy process, assessing the impact of policies on men and women and redressing inequalities.

'This is the way to make gender equality a concrete reality in the lives of women and men, creating space for everyone within the organisations as well as in communities – to contribute to the process of articulating a shared vision of sustainable human development and translating it into reality' (European Commission n.d.).

As such, gender mainstreaming is a tool through which to contribute towards effective and inclusive policy-making and programme implementation, while contributing to sustainable development. 'In practice, this requires a proactive approach, the need to identify those areas where a degree of inequality could potentially arise, assess the underlying causes for such inequalities, and take the necessary steps to bring about change' (ibid).

Malta has recently launched its 'Sustainable Development Vision for 2050' – a document which sets out a long-term framework for 'advancing sustainable development in Malta while taking into consideration past shortcomings and achievements'.

The document aims to identify 'existing gaps where further development is required and setting out realistic goals to address these challenges. It also takes into account developments at international and EU level' (Ministry for the Environment, Sustainable Development and Climate Change 2018). The document is intended to pave the way for a new Sustainable Development Strategy for the Maltese Islands for 2050, described in the document as 'one of the priorities of the Maltese Government' and which is set to guide all future policies and policy implementation, with the aim of addressing the current national and global challenges.

It is argued that:

> *Gender mainstreaming should form the integral basis of policy formulation from the initial stage of policy development. Planners cannot assume that women and men, girls and boys will automatically benefit equally from a policy. This will ensure that the development of the policy takes account of and is responsive to gender requirements and that any inequalities are anticipated and addressed. Effective policies, programmes and projects that meet the needs of all citizens and benefit them equally can only be achieved if attention to gender issues is taken systematically at all stages in the planning process* (National Commission for the Promotion of Equality 2013, 10).

The adoption of a gender mainstreaming approach into the new Sustainable Development Strategy for the Maltese islands therefore presents a unique opportunity which would, on the one hand, ensure that the said strategy itself is effective in the widest and most inclusive manner possible, in that it takes due consideration of its potential impact on men and women, and removing the assumption that people will be impacted in the same way despite criteria that differentiate them; while on the other, serve as a platform for the promotion of gender equality and the empowerment of women in Malta – a country which, despite its relative economic success, still ranks a miserable 91st place in the World Economic Forum's *Global Gender Gap Report* (World Economic Forum 2018).

The development of the new Sustainable Development Strategy for the Maltese Islands for 2050 will require inclusive foresight. Foresight methodology is 'an operational framework within which…data are placed so that their meaning may be seen more clearly' (Leedy 1997, 204). 'Foresight methodologies then, may be viewed as frameworks for making sense of data generated by structured processes to think about the future. In organisations, foresight methodologies have a particular role in the strategy development process. Foresight informs the thinking that occurs before strategic decisions are made by expanding the perceptions of the strategic options or choices available…' (Conway n.d)

The *Global Gender Gap Report* states that:

> *the equal contribution of women and men in this process of deep economic and societal transformation is critical. More than ever, societies cannot afford to lose out on the skills, ideas and perspectives of half of humanity to realise the promise of a more prosperous and human-centric future that well-governed innovation and technology can bring* (World Economic Forum 2018).

Understood as 'the (re)organisation, improvement, development and evaluation of policy processes, so that a gender equality perspective is incorporated in all policies at all levels at all stages, by the actors normally involved in policy making' (Council of Europe 2004) gender mainstreaming is therefore a tool which can make policies and programmes more efficient and, in turn, a nation more resilient.

When it comes to the implementation of gender mainstreaming, various methods and approaches have been developed. One of such notable approach is the '4R'

method, described as 'an effective instrument for analysing and implementing a gender equality perspective in policies, programmes and activities' as 'it provides a gender analysis on how the operation is run and financed' (National Commission for the Promotion of Equality 2013, 16).

The first 'R' stands for 'representation' and seeks to determine who the decision-makers of a particular initiative are, and who implements such decisions, with the aim of having a healthy gender balance in decision-making structures. Looking back at the Climate Change Committee which presented the recommendations for the 2012 Climate Change Adaptation Strategy, for instance, one sees that that committee consisted on nine men and one woman. It is imperative that the same mistake is not repeated in the development of new Sustainable Development Strategy for the Maltese Islands for 2050, by ensuring, among other things, that both male and female genders are equal participants in the foresight methodology process that should inform the development of the strategy.

The Organization for Security and Co-operation in Europe (OSCE 2009) Ministerial Council's Decision 7/09 on Women's Participation in Political and Public Life underlines that participating states need to take effective measures to ensure women's equal participation and representation at all levels of life. This is because the OSCE believes that the promotion of equality between men and women and the protection of human rights 'are essential to peace, sustainable democracy, economic development and therefore to security and stability in the OSCE region' (OSCE 14/04, 1). Furthermore, research indicates that adequate diversity paves the way for generating more comprehensive solutions, leading to higher-quality decisions (Wiersema and Bantel 1992).

When it comes to women and leadership, however, the situation in Malta is rather bleak. Malta's percentage of women parliamentarians has only risen by five percentage points in more than 60 years (Dalli 2018 cited in the *Times of Malta* 2018). This figure is not surprising, in the context of a country in which 45.7 per cent of the electorate perceive men to be more suitable than women for parliamentary representation (National Statistics Office Malta 2007).

Article 12 of the Istanbul Convention requires state parties to 'take the necessary measures to promote changes in the social and cultural patterns of behaviour of women and men with a view to eradicating prejudices, customs, traditions and all other practices which are based on the idea of the inferiority of women or on stereotyped roles for women and men' (Council of Europe 2011). Despite various efforts to change perceptions,[5] progress remains slow for a variety of reasons, including the lack of family-friendly measures and lack of spousal support (Cutajar 2014). This notwithstanding, the fact that a salient feature of the new proposed Sustainable Development Vision 2050 is to mainly focus on prevention, rather than mitigation (Ministry for Foreign Affairs and Trade Promotion 2018), presents a further timely opportunity.

The second 'R' in the 4R method mentioned above stands for 'resources'. Being 'the most comprehensive statement of a government's social and economic plans and

priorities' (United Women National Committee Australia n.d.), a budget is one of the main resources that should be addressed in the assessment.

> *Gender responsive budgeting (GRB) is about ensuring that Government budgets and the policies and programs that underlie them address the needs and interests of individuals that belong to different social groups. Thus, GRB looks at biases that can arise because a person is male or female, but at the same time considers disadvantage suffered as a result of ethnicity, caste, class or poverty status, location and age. GRB is not about separate budgets for women or men nor about budgets divided equally. It is about determining where the needs of men and women are the same, and where they differ. Where the needs are different, allocations should be different* (Budlender 2006, cited in National Commission for the Promotion of Equality 2009).

It is worthy to mention, for instance, that without adequate gender representation and gender sensitive budgets, the social costs which result from a natural disaster can be overlooked or remain insufficiently resourced. The social costs of a natural disaster can far outweigh the direct financial costs. Such social costs can arise from, *inter alia*, mental health issues arising as a consequence of the disaster, higher rates of alcohol abuse, the spreading of chronic diseases and family violence (Australian Business Roundtable for Disaster Resilience and Safer Communities 2016). With regards to family violence, the Istanbul Convention obliges Malta, as a signatory to the convention, to 'take the necessary legislative and other measures to prevent all forms of violence covered by the scope of this Convention by any natural or legal person' (Council of Europe 2011), and hence this perspective needs to be integrated into the development of Malta's new Sustainable Development Strategy for the Maltese Islands for 2050.

> *Emergency situations can be an incredibly stressful, disruptive and traumatic time for those affected. Whole communities can be uprooted, friends and family divided, homes, livelihoods and, of course, lives can be lost. In the aftermath of such a disaster, people may experience a range of physical, psychological, emotional or behavioural reactions that, while perfectly natural, can significantly impact their ability to cope with the situation* (Australian Red Cross 2015, cited in Tehan 2016).

The third and fourth 'R's in the 4R method stand for 'realia' (analysing conditions) and 'realisation' (formulating new objectives and measures). These are the steps which, when applied to the development of the Sustainable Development Strategy for the Maltese Islands for 2050, would require analysis of current data to be projected onto a future scenario, and developing measures and initiatives aimed at, on the one hand, preventing the escalation of the negative consequences brought about by climate change; while on the other hand, developing measures aimed at mitigating such consequences – in other words, building resilience.

10.9 Final considerations for Malta and other small states

- Like Malta, many small states are in a privileged position to devise and implement DRR policies that are gender sensitive and gender responsive. Small size is

synonymous with increased opportunities for networking and establishing strategic partnerships among different professionals, thereby creating truly multidisciplinary task forces, jointly working towards the achievement of various SDGs.

- In a scenario where citizens are increasingly disillusioned with politics and prime ministers, presidents and policy-makers are often perceived to be detached from the people, small states can really 'turn the tide' by involving members of the polity in DRR efforts. This involvement should not serve to impose the desires of the majority over those of minorities, but rather provide a platform for empowerment for all individuals within society, including the most marginalised.
- As highlighted in the discussion of the Miami hurricane (see Section 6), social society is crucial to DRR efforts. Multisectoral collaboration on DRR and gender issues can help bolster the know-how of the non-profit sector in small states, promoting social innovation and capacity building. Although various forms of multisectoral collaboration may already be in place, the objective should be that of broadening the scope through more harmonious practices and concerted efforts.
- The collection of gender-disaggregated data goes hand in hand with the need to gather 'intersectional data', namely data that is disaggregated by age, race, religion, sex, gender, gender identity/expression, migration status, sexual orientation, religious affiliation, disability and any other factor that is of relevance. Gathering and analysing this kind of data can help small states orchestrate more effective DRR policies, setting an example for many countries worldwide.

10.10 Conclusions

Given Malta's status as one of the fastest-growing economies in the EU, enjoying a general government surplus (Ministry for Foreign Affairs and Trade Promotion 2018), the country is in a privileged position to be able to invest resources and efforts into developing a strategic plan which would benefit generations to come. Malta's renewed commitment to mainstream the principle of gender equality in all spheres of life (Dalli 2018 cited in the *Times of Malta* 2018), coupled with the new Sustainable Development Vision 2050 which is intended to inform all policy development going forward, presents a unique opportunity to enhance resilience through gender mainstreaming, while creating a platform through which to improve the country's performance vis-à-vis gender equality.

The Maltese government's commitment to extend its efforts in relation to gender mainstreaming, *inter alia*, through the introduction of an 'equality duty' on government, and an obligation to have a minimum of 40 per cent of the under-represented sex on its boards (Dalli 2018 cited in the *Times of Malta* 2018), implies that there is the necessary political will to take this agenda forward. Specific gender equality policy, expressed through recently introduced legal amendments and the adoption of a national strategy (ibid), strengthen this position. Current relevant data is also available and, in this regard, it is imperative to ensure that all such data is compiled in a gender-disaggregated manner in order to enable the required analysis, and that this data is made public to inform adequate consultation with a wide range of stakeholders, including academia,

civil society organisations and the business community. Further research might be required to inform the development of future policies and programmes. The relevant administrative systems, such as the Focal Point Network falling under the organisation of the Ministry for the Environment, Sustainable Development and Climate Change (MESDC), which is tasked with the exchange of information on matters pertaining to sustainable development in Malta, appears to be a system which could be pivotal in spearheading this approach – assuming that there is sufficient awareness concerning the value of introducing a gender mainstreaming approach and expertise in the manner in which this should be carried out. The Malta Critical Infrastructure Protection Unit, whose function is to co-ordinate all critical infrastructure protection and emergency and disaster management issues at the national level, is another system which could be pivotal in adopting this approach.

However, it is important to ensure that for this and other administrative systems to function properly and effectively, and to meet the ambitious goals set in relation to sustainable development and gender parity, adequate financial and human resources are made available. Last but not least, a drive to empower more women to enter political and public life and to be active participants in decision-making processes needs to be aggressively sustained. This will require a systemic shift to transform systems and structures and make them more gender inclusive, on the one hand, while on the other hand actively working to change prevalent cultural and social attitudes towards the perceived roles of men and women.

This is an ambitious task which will require the highest political commitment, as well as co-operation and coherence among various policy dimensions. Positively, there is already acknowledgement of the need to raise further awareness of the need to break silos and harmonise efforts towards long-term sustainable development (Ministry for Foreign Affairs and Trade Promotion 2018). If Malta chooses to adequately implement the legal and policy frameworks which it has already committed itself to, it can truly become a global pioneer in leveraging gender mainstreaming to bring about positive, sustainable transformation.

Definitions

Disaster: 'A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts' (UNISDR 2017).

Gender mainstreaming: 'Gender mainstreaming has been embraced internationally as a strategy towards realising gender equality. It involves the integration of a gender perspective into the preparation, design, implementation, monitoring and evaluation of policies, regulatory measures and spending programmes, with a view to promoting equality between women and men, and combating discrimination' (EIGE 2016)

Resilience: This paper draws on the definition of resilience articulated by Le Masson et al. (2011), namely as 'the ability of individuals, their homes and their communities to anticipate, avoid, confront, recover from and adapt to natural hazards and

environmental changes so that impacts are the least destructive possible' (Le Masson et al. 2011, 13). The notion of resilience is not only crucial to research and policy work in the field of climate change and DRR, but also to work in the area of gender-based violence and mental health. Numerous studies – see, for instance, Anderson et al. (2012); Shanthakumari et al. (2013); and Lopez-Fuentes and Calvete (2015) – focusing on female victims/survivors of domestic violence, have identified elements promoting resilience, which include individuals' personal traits, their surrounds (e.g. social networks) and societal factors. Future research should strive to integrate these two bodies of research to further develop the notion of resilience within gender-sensitive approaches to disaster risk reduction (DRR).

DRR and CCA: There are ongoing debates on the differences between DRR and climate change adaptation (CCA), which concern the identification of hazards (mostly hydro-meteorological in the case of CCA; hydro- meteorological, human and technological for DRR), the time scale and the measures envisaged (Tearfund 2008). This chapter will refrain from delving into the synergies and areas of conflict between the two fields, referring exclusively to DRR. This choice is motivated by DRR's tendency to focus on vulnerabilities which extend beyond an exclusive focus on disaster preparedness (ibid). This approach is better suited to the discussion on gender-based vulnerabilities presented in this chapter.

Notes

1 A case in point was the death of a Romanian man residing in Malta, who passed away as a result of a tree falling on his car during a storm. See: https://af.reuters.com/article/worldNews/idAFKBN1FU0GM

2 If a boat is far from the shore, it is likely to be limitedly affected from the destructive power of a tsunami; this, on the other hand, will hit the shallow waters by the shore the hardest. See: https://earthobservatory.sg/faq-on-earth-sciences/why-does-boat-sea-experience-tsunami-differently-boat-near-shore

3 For this reason, these issues were highlighted in a joint document by the Commission on Domestic Violence and the University of Malta as relevant research topics, requiring investigation. See: https://www.um.edu.mt/data/assets/pdf_file/0008/347642/ResearchBookletonDomesticViolenceprovidedbytheCommisiononDomesticViolence.pdf

4 See, for instance: https://lovinmalta.com/news/local/maltese-women-to-rally-in-valletta-this-weekend-after-domestic-abuse-murder-that-shocked-nation; https://www.maltatoday.com.mt/news/national/72919/2016_was_the_year_the_maltese_stood_up_for_womens_rights_and_gender_equality#.XCis4BNKjrk; and http://www.independent.com.mt/articles/2018-03-08/local-news/Watch-Yes-means-yes-no-means-no-The-Women-s-Day-March-6736185948. There are a range of organisations involved in the area of women's rights, gender and gender-based violence including The Women's Rights Foundation, Victim Support Malta, the Migrant Women Association, GEM, Soar and many more.

5 See for instance the project: 'Gender Balance in Decision Making' (National Commission for the Promotion of Equality 2013).

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Chapter 11

Gender and Environmental Governance for Disaster Risk Reduction in Jamaica

Siddier Chambers

Abstract

In 2019, the mid-term evaluation was due for the Comprehensive Disaster Management (CDM) Strategy and Programming Framework 2014–2024 in the Caribbean. This environmental governance framework is an agreed consensus to achieve disaster risk reduction (DRR) in the Caribbean region and it aligns with Jamaica's Vision 2030 National Development Plan. The Office of Disaster Preparedness and Emergency Management (ODPEM) and the Disaster Risk Reduction Centre (DRRC) are two of the leading organisations in Jamaica implementing DRR projects at the national level within the CDM Framework. However, the gender components of the various projects are almost invisible, although the framework indicates gender mainstreaming is a priority. The framework recommends a gender analysis of all projects implemented as a strategy to disaster risk reduction. Based on this recommendation, gender analysis was conducted on available projects of the ODPEM and DRRC.

This chapter is guided by the gender equality principles of social justice, commitment, partnership and citizens' participation. Two methods of research were employed, namely, a desk review of the literature, government and organisations' official documents and interviews with DRR specialists. Qualitative data were collected and analysed using content analysis and pattern matching.

The findings include best practices for an inclusive disaster preparedness, response, recovery and mitigation based on gender considerations. Gender-specific gaps were identified between the framework and actual implementation. Recommendations were put forward for a more effective gender mainstreaming in the governance and implementation of DRR in Jamaica, which may also be applicable to other small island developing states (SIDS). These findings could contribute to the Monitoring and Evaluation Reporting Framework, which is an integral component of the CDM Strategy and Programming Framework 2014–2024.

11.1 Jamaica's vulnerability to disasters

Due to its geography and location, Jamaica is exposed to a wide variety of hydro-meteorological and geological hazards. Hurricanes, floods (riverine and coastal),

earthquakes, landslides and drought have exacted a heavy toll on physical infrastructure, economic sectors, the environment and livelihoods. Jamaica is the third most exposed country in the world to multiple hazards, with more than 96 per cent of the country's gross domestic product (GDP) and population at risk from two or more hazards annually (World Bank 2019). Between 1998 and 2018, nine (9) named tropical cyclones affected Jamaica, which caused significant financial and physical damage and losses. For this period, the economic cost of disasters related primarily to extreme weather events is estimated at 1.81 billion US dollars (127.3 billion Jamaican dollars [JMD]) (World Bank 2019; Planning Institute of Jamaica [PIOJ] 2012). The severe impact of disasters on the Jamaican economy is a debilitating trend that always results in critical revenue being diverted away from social and economic development to disaster recovery.

Loss of lives, relocation, dislocation and homelessness add to the traumatic experience that comes with disasters such as a hurricane. During the 1998–2018 period, more than two (2) million of the country's population were affected, including 60 casualties (ibid). Exposure to disaster is considered high, as approximately 70 per cent of Jamaica's population resides in coastal areas and over 50 per cent of economic assets – including airport and seaport facilities, tourism infrastructure and industrial activity – are concentrated in coastal zones (Statistical Institute of Jamaica [STATIN] 2017). The 2014 Inter-American Development Bank (IDB) Risk Profile for Jamaica calculated exposure of physical assets at approximately US$19 billion (IDB 2015). This mostly accounts for transportation and communications infrastructure (such as bridges and road networks), public utilities, and residential and commercial buildings.

The most recent significant natural disaster losses are attributed to a trough-generated, excess rainfall event occurring over the period 14 to 18 May 2017. This event resulted in landslides and flooding across 11 of the 14 parishes, with more than 66 communities reporting inundation. Over a month's average rainfall was experienced at some locations during this five-day period. The total cost of loss and damage was reported at 31.5 million US dollars (JMD 4 billion) or 0.2 per cent of 2016 GDP (PIOJ 2017). The bulk of this loss was concentrated in the transport infrastructure sectors.

In 2005, Hurricanes Dennis and Emily disrupted the social and economic livelihoods of 331,590 women, men and their families (PIOJ 2005). Approximately 8,000 farm families and over 1,000 fisher folk from 11 parishes suffered major losses due to the direct impact of these disasters. Dislocation and relocation of families were some of the added social and psychological trauma experienced by affected residents. The worst affected areas were 'some 121 communities island-wide, many of which are located in St. Thomas, St. Catherine, Clarendon, Kingston and St. Andrew, [which] were affected by flooding and landslides due to Hurricane Dennis. Initial estimates indicated direct damage to dwellings and household effects amounting to approximately $100.0 million in these areas. Approximately 6,000 households were reportedly in need of housing assistance' (ibid). These disasters also resulted in major infrastructural damages, as reported by PIOJ (2005):

> *Total damage was estimated at $5,976.91 million or US$96.87 million. This is equivalent to 1.2 per cent of the previous year's GDP. Infrastructure was the most affected area with damage and losses of $4,826.05 million, followed by the Productive sectors ($796.25 million); and the Social sectors ($260.14 million). Transport/ Roads and Bridges was the most affected sub-sector with total damage and losses of $4,271.89 million, or 71.5 per cent of the total impact. This was followed by Water Supply and Sanitation, $400.00 million, and Agriculture and Livestock, $379.90 million. Considering indirect losses only, Transport/Roads and Bridges was the most affected sub-sector ($514.00 million), followed by Waste Management ($55.40 million), Electricity ($50.00 million) and Manufacturing ($30.4 million).*

The vulnerabilities of the country are further underscored by the fact that approximately 20 per cent of its total population live in informal settlements (ibid) and the prevalence of poverty is estimated to be 19.9 per cent (Government of Jamaica 2016). Poverty and inequalities exacerbate the impact of disasters on the rural population (STATIN 2017). However, the consensus in the disaster risk management field is that mounting economic costs and humanitarian losses from disasters can be curtailed given the numerous policies and programmes for risk reduction, and especially because all those losses diminish development opportunities for the current and future generations (Food and Agriculture Organization of the United Nations [FAO] 2017).

Jamaica is also vulnerable to the adverse impacts of climate change. Jamaica's observed changing climate is evidenced by long-term trends and variations on timescales ranging from seasonal through decadal and even longer (Climate Studies Group, Mona 2017). Future climate for Jamaica is forecasted to be characterised by increasing temperatures and declining annual average levels of precipitation (Government of Jamaica 2011), combined with an increase in the number of days with heavy rains and sea-level rise (SLR). Climate modelling by the Climate Studies Group, Mona, projects mean annual temperatures to increase by 1.3°C by the 2020s and 1.6°C by the 2030s, with a pronounced drying (mean annual rainfall decrease) trend to occur by the latter half of the 2030s (Climate Studies Group, Mona 2014). Environmental governance becomes an imperative in a context such as Jamaica, where there is high debt, a long trend of disasters, limited revenue, where approximately 2 per cent of that revenue is diverted to disaster recovery, and heavy reliance on external support for social programmes and disaster risk reduction.

11.2 Enabling policy framework: International, regional & national

International, regional and national plans and agreements have contributed to an enabling platform for environmental governance for the implementation of initiatives to reduce risks associated with disasters and climate hazards. At the international level, the Sendai Framework for Disaster Risk Reduction 2015–2030, Hyogo Framework for Action, Rio+20, United Nations Framework Convention on Climate Change (UNFCCC) and its gender action plan, along with the Sustainable

Development Goals (SDGs) for 2030 (UN 2019) aim to fast-track programmes of action for disaster risk reduction (DRR) and gender vulnerability. The SDGs with direct influence on these two development priorities are:

- Goal 5: Gender Equality
- Goal 6: Clean Water and Sanitation
- Goal 10: Reduced Inequality
- Goal 11: Sustainable Cities and Communities
- Goal 13: Climate Action
- Goal 14: Life Below Water
- Goal 15: Life on Land

11.3 Regional Comprehensive Disaster Management (CDM) Strategy and Programming Framework 2014–2024

The Regional Comprehensive Disaster Management (CDM) Strategy and Programming Framework 2014–2024 provides a platform to implement and monitor DRR at the regional level. The Caribbean Disaster Emergency Management Agency (CDEMA) has oversight for the CDM Framework, which seeks to harmonise resources and measure actions aimed at reducing risks related to disasters at the community and sectoral levels in the Caribbean. Agriculture, tourism, health, civil society, education, finance/economic development, and physical and environmental planning are the priority sectors of the CDM. It focuses on integrating disaster risk reduction and climate change considerations and their impact on vulnerable groups, because such an approach validates the principle of inclusivity that underlines this regional framework. Implementation of the CDM Strategy going forward will see the maintenance of cross-cutting themes, namely, gender, climate change, information and communications technology, and environmental sustainability. The goal is to realise 'safer, more resilient and sustainable CDEMA Participating States through Comprehensive Disaster Management'. The realisation of this goal depends on seven pillars:

1. National, regional and sectoral institutions with adequate/minimum standards of capacity to deliver the CDM programme
2. Knowledge management which is applied for fact-based decision-making
3. Disaster resilience which is enhanced within key sectors of the economy
4. Operational readiness at the regional, national, sectoral and local levels
5. A clearly established and understood nexus between climate change adaptation (CCA) and DRR, with programming and governance harmonised
6. Community resilience which has been enhanced for the most vulnerable, with gender concerns addressed at all stages and levels
7. Resource allocation which underpins the ability to deliver the strategy

The framework is strongly centred on actions that enhance public–private partnerships and which must be treated within all the sector groupings. Climate change initiatives are strategically aligned as vehicles for the implementation of DRR priorities. This regional plan seeks to harmonise resources that will help to save lives, livelihoods and properties from the ravages of disasters and hazardous events, which impact the Caribbean almost annually and do not discriminate in their effects whether by gender, political affiliation, socioeconomic status or age.

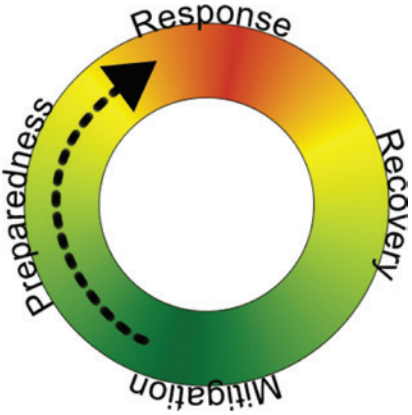
At the national level, the Disaster Risk Management Act and Vision 2030 Jamaica National Development Plan affirm the government's commitment to protect lives and properties before, during and after a disaster. Vision 2030 Goal 4 (Jamaica has a healthy natural environment) recognises that healthy, productive and protective environments, social systems and economies are fundamental to Jamaica becoming the place of choice to live, work, raise families and do business.

A disaster is any event, natural or human-caused, which creates an intense negative impact on people, goods and services, and/or the environment, and exceeds the affected community's internal capability to respond, prompting the need to seek outside assistance (UN 2009). One such example is Hurricane Gilbert, which affected Jamaica on 12 September 1988.

The comprehensive disaster management (CDM) cycle

Jamaica, through the Office of Disaster Preparedness and Emergency Management (ODPEM), has embarked on a comprehensive disaster management (CDM) programme that illustrates the cyclic process by which we plan for and reduce the impact of disasters, and take steps to recover after a disaster has occurred. Appropriate actions at all points in the CDM cycle will lead to greater preparedness, better warnings, and reduced vulnerability or the prevention of disasters during the next repetition of the cycle. Figure 11.1 illustrates the four phases of the CDM cycle: mitigation, preparedness, response and recovery.

Figure 11.1 Comprehensive disaster management (CDM) cycle



Source: Government of Jamaica 2008.

Phases of the CDM cycle

There are four phases in the CDM cycle:

1. Mitigation

   During the mitigation phase, structural and non-structural measures are undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards. According the United Nations International Strategy for Disaster Reduction (UNISDR), the adverse impacts of hazards often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Management activities in the mitigation phase encompass engineering techniques and hazard-resistant construction, as well as improved environmental policies and public awareness, along with hazard vulnerability and risk assessment. Measures taken during the mitigation phase also address preventing natural or human-caused events from giving rise to disasters or any emergency situations, e.g. not allowing your child to have access to matches, gasoline or kerosene oil.

2. Preparedness

   During the preparedness phase of the CDM cycle, measures are taken to reduce to the minimum level possible loss in human life and other damage, through the organisation of prompt and efficient actions of response and rehabilitation, such as practising earthquake and fire drills. Preparedness activities are geared towards minimising disaster damage, enhancing disaster response operations, and preparing organisations and individuals to respond. They also involve planning, organising, training, interaction with other organisations and related agencies, resource inventory, allocation and placement, and plan testing.

3. Response

   The response phase involves actions carried out in a disaster situation with the objective to save life, alleviate suffering and reduce economic losses. The main tool in response is the implementation of plans which were prepared prior to the event. Response activities are post activities geared towards:

   - providing emergency assistance;
   - reducing probability of additional injuries or damage;
   - speeding recovery operations; and
   - returning systems to normal level.

4. Recovery

   In the recovery phase, also referred to as the recovery and rehabilitation phase, activities are geared towards the restoration of basic services and the beginning of the repair of physical, social and economic damage, e.g. lifelines, health and communication facilities, as well as utility systems. The recovery phase also includes efforts to reduce disaster risk factors.

11.4 Gender mainstreaming in disaster risk reduction

Gender mainstreaming is one approach to strengthening the governance of public services and development initiatives. Gender mainstreaming in CDM encompasses the identification of differences in vulnerabilities between women, men, boys and girls and then addressing those vulnerabilities in the formulation, implementation and evaluation of policies, programmes and projects (CDEMA 2014). Vulnerability implies that some people are less or more susceptible than others, at different times and places, to a specific hazard or range of hazards, and vulnerability exists at different scales (Crivello and Espinoza-Revollo 2018; Herslund et al. 2016). Vulnerabilities of women and men can be assessed based on four factors, namely, economic, social, physical and environmental (UN 2009), as well as during the phases of the CDM cycle (mitigation, preparedness, response and recovery). For the purposes of this chapter, the vulnerabilities will be reviewed within the CDM cycle. Ultimately, an improved and resilient quality of life for women, men and their families is the desired outcome of gender-responsive disaster risk reduction initiatives. The integration of gender considerations is therefore integral to the effective implementation of the CDM Framework in addressing the current and future needs of the Caribbean people.

Several studies identify the differences between women and men at various phases in the CDM cycle. Senior and Dunn (2008) provide a list of differential gender needs during three hurricanes in Jamaica, revealing that during the recovery phase, physical and mental health challenges were more pronounced for males, while females encountered more threats of gender-based violence and inadequate sanitary facilities – as highlighted in Table 11.1.

Table 11.1 Differential gender needs during three hurricanes in Jamaica

Hurricane	Male	Female
Gilbert (1988)	Managing prostate cancer in a shelter	• Lack of water and other basic needs • Poor facilities to accommodate pregnant women • Lack of private areas for mothers in shelters to breastfeed their babies • Lack of facilities to cater to the basic needs of women with breast and cervical cancers • Threat of sexual harassment of females by males in shelters
Ivan (2004)	Poor sanitary facilities in shelters	• Poor/inadequate sanitation facilities to meet the needs of menstruating women, resulting in females disposing of their used sanitary pads publicly
Dean (2007)	• Psychological scars • Lack of coping skills • Not easy to adjust to the centre or after the disaster	• Increased risk of rape and incest • Lack of condoms in shelters to reduce the risk of unplanned/ unwanted pregnancies and sexually transmitted infections, including HIV

Dunn (2018) further argues that Jamaican women and men with pre-existing vulnerabilities such as poverty, unemployment and disabilities, rural residents and especially homosexual men are exposed to greater risks, mainly during the response and recovery phases of disasters (Dunn 2018). An earlier study by Jonkman and Kelman (2005) on 13 flood cases in Europe and the United States, which resulted in 247 flood disaster fatalities, revealed that 'males are highly vulnerable to dying in floods and unnecessary risk-taking behaviour contributes significantly to flood disaster deaths'. Evidence in the Caribbean indicates that women are often at a disadvantage during a disaster, mainly because of their triple roles as caregiver, breadwinner and community leader (Senior and Dunn 2008). During the preparedness phase, some women are often absent from the decision-making process and often times receive warning information late or it is not adequately disseminated to them (UN 2009). However, Begum (1993) found that during the 1991 cyclone in Bangladesh, even though women received the early warning, many did not relocate to safety, mainly because of their obligation to fulfil their gender roles and responsibilities to care for their children and property. Their non-compliance to the early warning was influenced by their gendered reality and resulted in mass causalities, where approximately 100,000 persons died, the majority being women (Begum 1993).

Additionally, it was noted that elderly men are more vulnerable to homelessness after a disaster, while men in general are more exposed to danger during the disaster due to gendered expectations of their being protectors (ibid). Both women and men have unique vulnerabilities that must be taken into consideration before, during and after the passage of a disaster (Garcia-Ortega et al. 2012). In 2010, Tropical Storm Nicole claimed the lives of 16 persons (2 females and 14 males) and injured another 42 persons (11 females and 31 males) in Jamaica (University of the West Indies 2018). Therefore, Nicole had a greater impact on males – 75 per cent mortality and 74 per cent injuries – than females. Drowning, crush injury, vehicle accidents, trauma and lack of medical treatment accounted for most of the casualties. Furthermore, the economic devastation was estimated to be greater for males, with the majority of the approximately 17,000 domestic crop farmers and 1,700 livestock farmers whose property, crops and livestock were damaged (ibid).

These data indicate the gender dynamics of disasters and the strong influence that gender roles, responsibilities and identity can have in exacerbating disaster risks. However, more targeted interventions during the preparedness and response phases might contribute to a reduction in the gender-related risky behaviour of women and men. Effective adaptation and mitigation efforts require sector-specific plans with sex-disaggregated data and nuanced evidence from impact assessment (CDEMA 2014).

11.5 Methodology, limitations and areas for future research

The methodology used for this research included a desk review of available project reports and key events held on gender and disaster issues since 2014; and interviews with specialists active in disaster risk reduction, climate change and environmental

governance in Jamaica and at CDEMA. Purposive sampling was used to select the participants. A total of four (4) specialists and four (4) DRR initiatives contributed to this study. The chapter also benefited from discussions with specialists at an international conference on disaster risk reduction held in London on 25–26 February 2019.[1]

In conducting this research, several important areas for further research were identified, which are not only suggested by the findings but also address two limitations inherent in the study. The first significant limitation was the limited sample size of DRR initiatives and specialists due to lack of access to requested data and low response to survey. This resulted in selection bias. Therefore, the findings and conclusions do not reflect the perspective of the general population of DRR specialists nor the general outcomes of DRR initiatives in Jamaica since 2014. Secondly, lack of consultation with female and male beneficiaries of DRR initiatives has limited the ability of the researcher to conduct a thorough gender analysis of the differences in vulnerabilities during the various phases of the CDM cycle. Future research could benefit from access to a larger sample of DRR projects and specialists that incorporate the views of beneficiaries of DRR initiatives; and thereby produce findings that are more representative of the population and applicable to other SIDS.

11.6 Key projects and initiatives implemented under CDM Framework 2014–2024 by the Office of Disaster Preparedness and Emergency Management (ODPEM) and the Disaster Risk Reduction Centre (DRRC)

The projects and initiatives that were available for review by the Office of Disaster Preparedness and Emergency Management (ODPEM) were the following:

1. Disaster Risk Management Gender Symposium (2019)
2. The National Disaster Risk Management Volunteers Programme (2018)
3. Resettlement Action Plan for Harbour Heights, Kingston, Jamaica (2015)

The Disaster Risk Reduction Centre at the University of the West Indies (UWI-DRRC) made the following project available for review:

1. Enhancing Knowledge Application for Comprehensive Disaster Management (EKACDM) Project (2013–2019)

11.7 Discussion on gender and DRR projects of the ODPEM and DRRC

The data outlined in Table 11.2 indicate that the first initiative disseminated pertinent information on gender and disaster to professional women and men. The effectiveness of this initiative could be enhanced through an evaluation of how the information provided was being translated into actions within the

Table 11.2 ODPEM and DRRC DRR projects with gender considerations

Initiative	Beneficiaries	Main impact/outcome/output
Disaster Risk Management Gender Symposium **Implementing agency: ODPEM, 2019**	• Women • Men	Gender and development specialists disseminated data and information to academia and professionals in the public, private and civil society sectors and the general public via presentation and radio interviews on the role of gender in enhancing disaster management: • Pillars of Community Resilience in the Face of Disaster Risk Reduction (DRR) – (Delivered by the Bureau of Gender Affairs – BGA); and • Gender Vulnerability for Disaster Risk Reduction – delivered by the Institute for Gender and Development Studies (IGDS).
The National Disaster Risk Management Volunteers Programme – NDRMVP **Implementing agency: ODPEM, 2017–2018**	• Women • Men	• Trained a total of 117 volunteers (72:28 female to male ratio) at a seven-day residential camp. The training included: - basic disaster management; - basic radio telecommunication; - basic light search and rescue; - basic fire safety and prevention; - basic community hazard mapping; - basic initial damage assessment; - basic shelters and shelter management; - basic emergency operation centre; and - basic first aid. • Developed knowledge products, including brochures and flyers. • Developed media disaster risk reduction programmes and campaign. • Hosted two (2) information fairs and participated in various events to disseminate materials and increase public awareness on DRR at the community, parish and national levels. • Designed a volunteer management database system that allows for the online registration and monitoring of applicants and the collection of sex disaggregated data.
Resettlement Action Plan for Harbour Heights, Kingston, Jamaica **Implementing agency: ODPEM, 2015**	• Women • Men	• Two female-headed households affected; living situation disrupted for one household who lost their house. • Three male-headed households affected; living situation for two households disrupted for those who lost their homes. • Income and livelihood were uninterrupted. • Monetary resettlement compensation was provided by the Government of Jamaica to all the heads of households.

(*Continued*)

Table 11.2 ODPEM and DRRC DRR projects with gender considerations (*Continued*)

Initiative	Beneficiaries	Main impact/outcome/output
Enhancing Knowledge Application for Comprehensive Disaster Management (EKACDM) Project **Implementing agency: DRRC, 2013–2019**	• Women • Men • Children	Three key outcomes of the Initiative: 1. an enhanced regional network that generates, manages and shares knowledge on CDM and that includes gender issues; 2. increased use of standardised gender-sensitive educational and training materials for CDM by professionals and students in the Caribbean; and 3. an enhanced mainstreaming of gender-sensitive decision-making for CDM in the public and private sectors, in particular for small and medium sized enterprises (SMEs).

various participating organisations. Collection of the diverse gender needs and perspectives of the participating women and men was another important step in mainstreaming gender that was absent from this initiative. In the second initiative, sex-disaggregated and demographic data were collected, which provided adequate knowledge of the persons affected by the disaster. Although the women, men and their children were impacted psychosocially, they only received rebuilding and monetary compensation.

Finally, the EKACDM Project, which is a repository for CDM information, tools and strategies, had a strong emphasis on integrating gender at the national and regional levels. The repository hosts valuable data on the gendered dynamics of disasters for 17 countries in the Caribbean, including Jamaica. The text format of the information might exclude access for some women and men, especially those with low literacy and limited technology, and women and men living in remote and rural communities. The use of local language and audio-visual formats provides effective communication tools for the dissemination of new information and public education initiatives.

11.8 Best practices in DRR project implementation that contributed to gender mainstreaming

Some of the project activities for DRR in Jamaica included the dissemination of data and information, resettlement, monetary compensation, establishment of regional networks, and development of standardised educational and training tools. In the implementation of these activities, deliberate efforts were made in integrating the needs of women and men; differential vulnerabilities of women and men in disasters were recorded and gender was considered in the decision-making processes, as well as during information collection and dissemination. Table 11.3 outlines the strategies employed by the two organisations at different phases in the disaster risk management cycle in making DRR initiatives gender-responsive.

Table 11.3 Jamaica's best practices in gender and disaster risk management

Preparedness & response	Recovery & mitigation
• **Dissemination of pertinent information on gender and disaster to women and men working in key areas and the general public** • **Collection of sex-disaggregated and demographic data** • **Integration of gendered needs and priorities within CDM information, tools and strategies at the national and regional levels** • **Having a central location to host data on the gendered dynamics of disasters** • **Received gender technical expertise through partnership with international development partners (IDPs), consultancies and technical working group** • **Development of knowledge products to prepare women and men to respond in the event of a disaster**	• Dissemination of pertinent information on gender and disaster to women and men working in relevant areas and the general public • Collection of sex-disaggregated and demographic data • Infrastructure rebuilding and road repairs • Monetary compensation for female-headed and male-headed households • Damage assessment and needs assessment tools integrated gender considerations • Development of knowledge products to support women and men to better recover and mitigate disaster challenges

11.9 Gaps in gender mainstreaming in DRR in Jamaica

The ODPEM and DRRC have taken important steps to reduce the risks and vulnerabilities of women, men and their families during the various phases of the DRM cycle. It is anticipated that those strategies have enhanced the governance and the impact of the various initiatives on the lives of the beneficiaries. However, to better demonstrate the organisations' commitment to gender mainstreaming, inclusive, and comprehensive disaster risk reduction and reducing social and economic losses from hazard impacts, the following gaps should be addressed in future initiatives:

- absence of psychosocial interventions that address the needs of the affected population (women, men and children), especially during the recovery phase of the DRM cycle;
- lack of internal gender specialists both at national and regional CDM organisations, which contributed to gender mainstreaming being a 'piecemeal' effort that is unsystematic, unsustainable and lack accountability;
- limited ability of DRM specialists to grasp gender considerations of policies, projects, programmes and related international commitments, such as the gender targets of the Sustainable Development Goals (SDGs);
- skewed perception of gender being related only to women's issues; and
- although evidence is noted of men's vulnerabilities, there is limited acceptance and not enough deliberate efforts to address their gendered challenges during and after a disaster.

11.10 Conclusions, recommendations and policy implications

At the national level, Jamaica has made significant strides in integrating gender into disaster risk reduction and the comprehensive disaster management cycle. Several initiatives of the ODPEM and DRRC have contributed to the implementation of the Caribbean's Comprehensive Disaster Management Strategy (CDMS) and Programming Framework 2014–2024.

However, based on assessment of several projects, the gender components are almost invisible and often reduced to the number of female and male beneficiaries, although the framework indicates gender mainstreaming is a priority. The framework recommends that the different vulnerabilities of women and men be taken into consideration in the various stages of the comprehensive disaster management cycle to contribute to more targeted response, greater reduction of risk and more innovative approaches to resilience building. When women and men are better aware of how their lives are impacted differently and similarly by disasters, the conscious and unconscious ways in which their gender roles and identity influence their decisions and actions before, during and after a disaster, generally, there is greater ownership in reducing risks and building resilience. How information is disseminated and collected from citizens, the resources made available to the responsible organisations, and their operations as well as their levels of engagement with the public have a direct impact on the risk reduction and resilience building of women, men, their families and communities. Governance of environmental resources that is gender-responsive is more effective in strengthening resilience and reducing disaster risks. As noted by the World Bank Institute (2009):

> *Gender shapes the disaster experience and the ability to recover. It explains why certain groups of people are at greater risk or why some others recover at a slower pace. Since gender plays an important role in assigning roles and responsibilities within groups and in determining the access to and control of resources among groups, gender sensitivity and gender aspect become a valid and important policy domain during disasters and throughout the rehabilitation, recovery and reconstruction process* (World Bank Institute 2009).

Improvement in the quality of life of every Jamaican can be more targeted, measured and systematic, especially before, during and after a disaster. As the country continues to work towards the achievement of Vision 2030 and the fulfilment of its international commitments to disaster risk reduction and gender equality, application of the following strategies can contribute to more inclusive sustainable human development. These recommendations to improve environmental governance, enhance gender mainstreaming and strengthen resilience in DRR in Jamaica may also be relevant to other small island developing states (SIDS) because they encompass some of the priorities of the Sendai Framework for Disaster Risk Reduction 2015–2030 and were influenced by global cases in disaster risk reduction:

1. Monitor and evaluate how knowledge of gender needs is being translated into actions within key CDM organisations.
2. Collect gender needs and experiences from diverse groups of women and men, including those with differentiated abilities.

3. Include psychosocial interventions for women, men and children during the recovery and mitigation phases.
4. Use local language and audio-visual formats for information dissemination throughout all stages of CDM cycle to enhance communication of DRR to diverse populations.
5. Invest more in strengthening internal capacity of CDM organisations, especially the employment of full-time gender specialists, locally and regionally.
6. Review the CDM governance mechanism at the national level and ensure greater participation of national gender bureaus in the planning and implementation phases of related policies and programmes.
7. Synthesise key national and regional priorities on gender, climate change and CDM.
8. Develop relevant and clear gender-specific indicators for national and regional implementation plans and policies, such as the Caribbean's CDM Framework 2014–2024.
9. Co-ordinate gender mainstreaming recommendations and integrate them into national and regional work programmes and the implementation plan of the CDM Framework (2014–2024), along with required human and financial resources, and seek additional funding to support their full implementation.
10. Engage the active participation of the private sector and educational institutions to contribute to the collection and dissemination of data and information on gender, climate change and DRR.

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- The Commonwealth Secretariat
- Office of Disaster Preparedness & Emergency Management (ODPEM)
- Disaster Risk Reduction Centre (DRRC)
- Caribbean Disaster Emergency Management Agency (CDEMA)

Note

1 The conference entitled 'Strengthening Resilience Through Disaster Risk Reduction' was the Annual Research Conference on Small States hosted by The Commonwealth on 25–26 February 2019 at Marlborough House, London. See: http://thecommonwealth.org/media/news/commonwealth-pioneer-small-state-disaster-solutions

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