Chapter 3

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

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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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