Building e-resilience: Enhancing the role of ICTs for Disaster Risk Management (DRM)

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Economic and Social Commission for Asia and the Pacific

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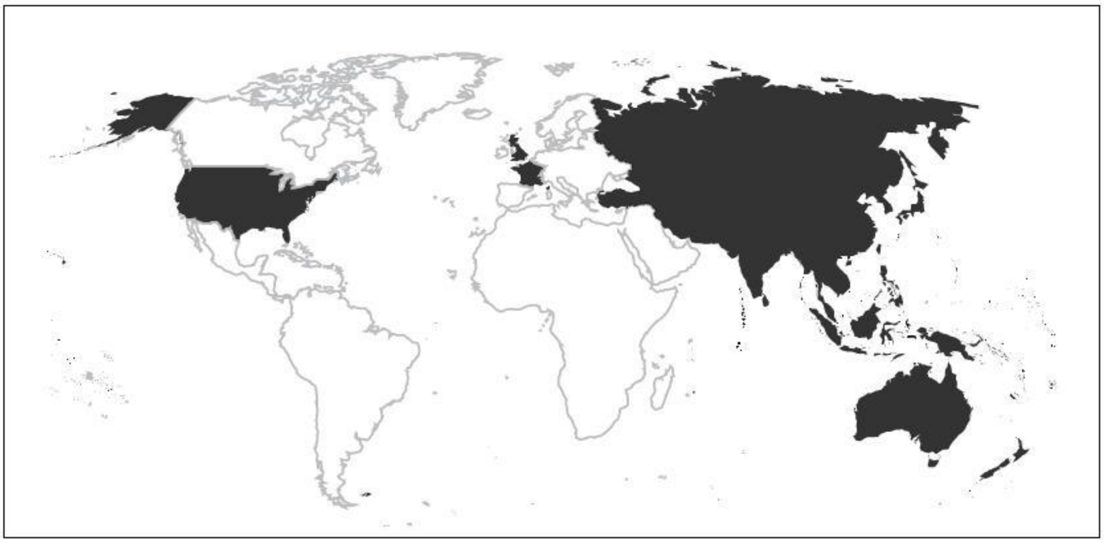

Disclaimer: This study has been prepared for ESCAP by LIRNEasia.

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Acknowledgement

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Table of Contents

List of Acronyms and Abbreviations

AADMER	ASEAN Agreement on Disaster Management and Emergency Response
ARRND	Agreement on Rapid Response for Natural Disasters
AVP	Audio–Visual Presentations
CAM	Communication Authority of Maldives
CDR	Call Detail Records
DINA	Disaster Information for National Awareness
DMC	Disaster Management Center
DOST	Department of Science and Technology
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EMS	Energy Management System
EMA	Energy Market Authority
FAiTH	Foreign Aid Transparency Hub
GIS	Geographic Information System
HFA	Hyogo Framework for Action
ICT	Information and Communication Technology
IES	Intelligent Energy System
IOC	Intelligent Operations Center
ISOC	Internet Society
ITU	International Telecommunication Union
KT	Korea Telecom
MNBD	Mobile Network Big Data
NCDM	National Council for Disaster Management
NDA	Non-Disclosure Agreements
NDRMC	National Disaster Risk Reduction and Monitoring Council
NOAH	Nationwide Operational Assessment of Hazards
NTU	Nanyang Technological University

PSC	Parliament Select Committee
SAARC	South Asian Association for Regional Cooperation
UAV	Unmanned Aerial Vehicles
UNDP	United Nations Development Program
UNISDR	United Nations International Strategy for Disaster Reduction
VLR	Visitor Location Registry

1. Introduction

Between 2004 and 2013, 41.2 per cent of all the reported natural disasters in the world were in the Asia-Pacific region.[1] While the frequency of natural disasters has stayed relatively constant, when compared with the previous ten years, the death toll increased three-fold during the same period, resulting in economic damage of over USD 560 billion.[2,3] Within the Asia-Pacific region, South-East Asia, in particular Indonesia and the Philippines were hardest hit. The underlying reasons appear to be unplanned urbanization, poor management of land use and climate change.[4]

Events that cause a state of emergency are, by definition, unexpected. From terrorist attacks to the rapid spread of communicable diseases to natural disasters, they cause disruption and distress. Dealing with the aftermath of any type of a disaster has many aspects. Each group of actors from government entities to the private sector, to community groups and the general public have roles to play. The lack of organized support services and access to infrastructure makes response and recovery a daunting task. For instance, when disasters occur in rural areas where access to transport and communication is poor it is harder to respond in a timely manner, and timely response is critical.

What governments can do is to reduce the risks posed by disasters to the lives and livelihoods of citizens. Generally, the focus is on having policies in place so that when a disaster strikes, the chain of command outlined by the policy is followed and first responders are deployed quickly. The emphasis is on saving lives and providing relief to those affected. With advances made in technology, the sophistication of systems

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[1] UN News Center (2014). *Asia-Pacific report: World's most disaster prone region experiences three-fold rise in deaths*. Retrieved 5 4, 2015, from United Nations Economic and Social Commission for the Asia Pacific: http://www.un.org/apps/news/story.asp?NewsID=49642

[2] The Indian Ocean Tsunami (2004), the earthquake in China's Sichuan province (2008), the earthquake in Chile (2010), earthquakes in New Zealand and Japan (2011) and Typhoon Haiyan in Philippines (2013) are among the major catastrophes in the region over the last decade

[3] UN News Center (2014). *Asia-Pacific report: World's most disaster prone region experiences three-fold rise in deaths.* Retrieved 5 4, 2015, from United Nations Economic and Social Commission for the Asia Pacific: http://www.un.org/apps/news/story.asp?NewsID=49642

[4]Economic and Social Commission for the Asia Pacific. (2014, 12 09). *Statistical Yearbook for Asia and the Pacific 2014*. Retrieved 3 2, 2015, from United Nations Economic and Social Commission for the Asia Pacific: http://www.unescap.org/sites/default/files/23-Natural-disaster-SYB2014.pdf

currently in place and the rapid pace at which new technologies and solutions emerge, Information and Communication Technology (ICT) is proving to be an increasingly important tool in Disaster Risk Management (DRM). Traditionally, access to food, clothing and shelter has been prioritized. Today, it is argued, that access to communication systems is as important, as it enables key personnel to be connected in order to provide the basic needs to victims.

The use of Mobile Network Big Data (MNBD) in the aftermath of the Haitian earthquake is a case in point that demonstrates the use of ICTs as an invaluable tool (this case and other example of MNBD for DRM is further explored in section 4.1). Further, Korean experts in Sri Lanka have presented the use of drones to assess the situation on the ground. It is a more efficient mechanism to assess the effects of a disaster. Such are examples of the use of more sophisticated technology for DRM purposes.

In its simplest form, ICTs are useful in all stages of the disaster lifecycle (Figure 1). Humans have an inherent need to be connected. In situations of emergency, ICTs provide the necessary platform to keep communication channels open, given the underlying infrastructure is available. ICTs have also proven to be a useful tool in more non-conventional forms of communication (e.g., Facebook status, Twitter etc.) to identify areas of pressing need.

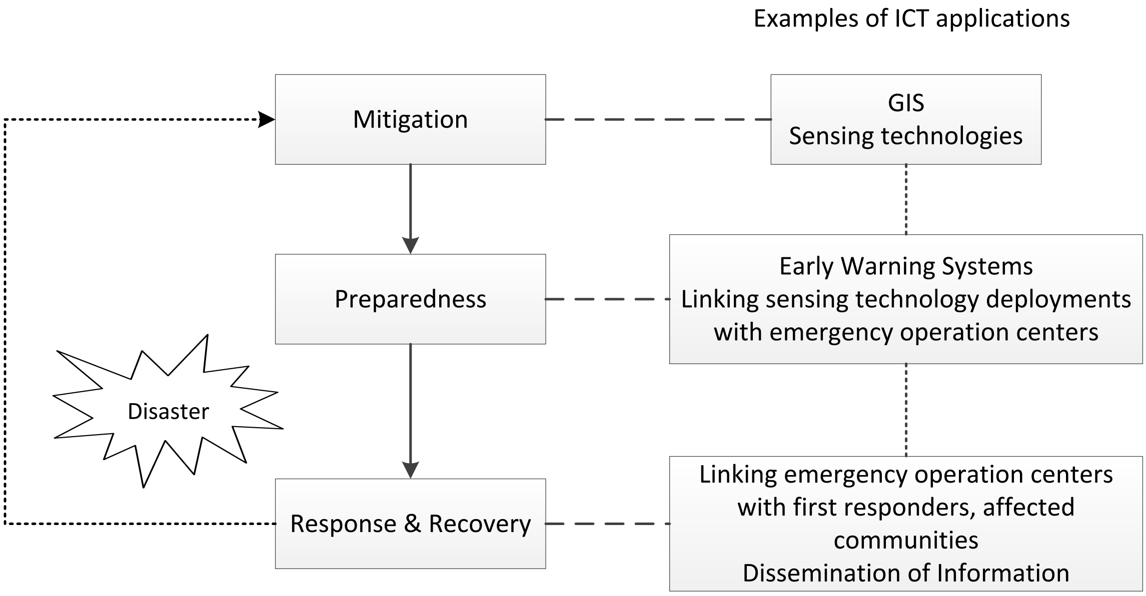

Figure 1: Examples of ICT applications at key stages of a disaster [5]

The objective of this study is to assess the use of ICTs in all aspects of the disaster lifecycle, particularly for disaster risk reduction (DRR) and DRM in the region. It also aims to look at good practices and emerging technologies that can be used for building e-resilience in the region.

2. The Sendai Framework for Disaster Reduction 2015 – 2030

With the impact of natural disasters affecting the global populace in manifold ways, establishing focused international efforts to successfully manage disaster risk and reduce impact on disadvantaged and vulnerable communities is imperative. The recognition of this led to the Yokohama Strategy for a Safer World in 1994, which was followed by the Hyogo Framework for Action adopted in 2005 for a 10-year time frame.

With the conclusion of the duration of the mandate fast approaching, the United Nations Office for Disaster Risk Reduction (UNISDR) launched a comprehensive consultation process.

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[5]Samarajiva, R., Zuhyle, S. Weerasooriya, R. (2014). *Building e-resilience: Enhancing the Role of ICTs for Disaster Risk Management (DRM)*. Retrieved 3 2, 2015, from: http://land-locked.org/wp-content/uploads/2015/10/Building-e-resilience-Enhancing-the-role-of-ICTs-for-Disaster-Risk-Management-DRM.pdf

The DRR framework that governs the timeframe from 2015 to 2030 was adopted in Sendai, Miyagi, Japan on the 18th of March 2015, and is therefore named the ‘Sendai Framework for Disaster Risk Reduction 2015-2030’.

In contrast to its predecessor the HFA, the Sendai framework has shifted its focus from the mere reduction of disaster losses, to encompassing the reduction of disaster risk as well, while proposing 7 tangible targets to assess the progress of the Sendai Framework. These national targets include meeting quantitative targets defined in terms of disaster mortality, affected persons and qualitative targets that govern the promotion of international cooperation.[6]

The Sendai Framework, while recognizing the good work performed by the HFA, attempts to recognize the gaps in its implementation, while reframing the ‘Priorities of Action’ around disaster risk as opposed to HFA’s priorities that included educating, putting in place institutional bases, and early warning systems as separate priorities.

The priorities of action of the Sendai framework were:

1. Understanding disaster risk;
2. Strengthening disaster risk governance to manage disaster risk;
3. Investing in disaster risk reduction for resilience;
4. Enhancing disaster preparedness for an effective response, and to “Build Back Better” in recovery, rehabilitation and reconstruction.

The description of each priority is outlined such that actions that are expected at national and local levels are laid out first, followed by ideal global or regional action for each priority.

The first priority, ‘Understanding disaster risk’ identifies that any action regarding disaster risk hinges upon the knowledgebase accumulated about the vulnerability and exposure of communities. It involves identifying disaster risk by frequently assessing it and making information about disaster losses or vulnerabilities freely available. It also includes the education of state and non-state stakeholders. Facilitating scientific exchange, leveraging indigenous and local knowledge to the process disaster risk

[6]Sendai Framework, pp. 7

management and investing in technology to better identify disaster risk are elements captured by the priority. The role of ICTs is also recognized in terms of using geospatial information technology to disseminate risk maps, as well as using GIS and ICTs for more accurate measurements.

Priority 2 delves deeper into the need for streamlined institutional arrangements in DRM. It encourages intra- and inter-sectoral participation to mitigate disaster risk. This priority outlines the need for national strategies, roadmaps and mechanisms to follow-up and assess progress, while also emphasizing the need to involve the community and delegate clear responsibilities to local authorities.

The 3rd priority deals with a multiplicity of measures, both structural and non-structural, that can introduce resiliency into the daily lives of communities. According to UNISDR, structural measures are physical constructions that may reduce exposure to disasters, such as retrofitting and rebuilding. Non-structural measures, in contrast, involve policy formulation, awareness, knowledge and other such initiatives. Priority 3 also deals at length with building-in resilience by means of insurance, risk sharing, safety-net mechanisms, as well as working towards financial instruments that consider disaster risk, ensuring business resiliency and other means that protect productive assets of the communities concerned. It also refers explicitly to building resiliency to healthcare systems and the tourism industry, recognizing that in some communities it could be the economic mainstay.

Priority 4 is the evidence of the Sendai framework's commitment to the tagline 'Build Back Better", which promotes building capacity to be disaster resilient during the recovery and rehabilitation phases. This priority deals with a multiplicity of phases of the DRM cycle and emphasizes preparedness to deal with post-disaster situations in the long and short terms. Provisions of this priority of action set out the need for policies that support the role of public service workers, provision of training and regular drills on disaster preparation. By far, it is this priority that best recognizes the importance of ICTs in DRR from forecasting and early warning to emergency communication systems, maintaining databases and case registries.

3. Legal and Policy Aspects of Dealing with Disasters

Disasters do not occur in isolation. National policies ought to take into account the need for regional collaboration in the event of a large-scale disaster. Although it is yet to be exercised, the Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations is an example of one such effort to have in place a regional agreement. Negotiated in 1998, the Tampere Convention came into force in 2005, shortly after the 2004 Indian Ocean tsunami. It simplifies the importing procedures allowing rapid deployment of telecommunication equipment in the event of an emergency. Forty-six countries have ratified the treaty to date.

There also exist many regional policies, plans and statements agreed upon by the leaders of the Asia Pacific region through various declarations (Figure 2). These agreements focus on all aspects of the disaster management cycle, such as preparedness, mitigation, response and recovery.

Agreement/ Policy/ Plan/ Statement	**Description**
ASEAN Agreement on Disaster Management and Emergency Response (AADMER)	This agreement facilitates emergency responses in 10 ASEAN member states. It enables mobilization of resources at a disaster situation and legally binds regional multi- hazard policy frameworks in all aspects of disaster management.[7]
South Asian Association for Regional Cooperation (SAARC) Agreement on Rapid Response for Natural Disasters (ARRND)	This regional agreement was signed by SAARC member states in 2011 to support and strengthens existing instruments for rapid response in the region. It facilitates assistance at a disaster situation, mobilizing resources, quality checks of relief items and regional standby agreements.[2]

[7]United Nations Office for the Coordination of Humanitarian Affairs (OCHA). (2015, 03 02). *Disaster response in Asia and Pacific*. Retrieved from ReliefWeb: http://reliefweb.int/sites/reliefweb.int/files/resources/Disaster%20Response%20in%20Asia%20Pacific_A%20Guide%20to%20Intl%20Tools%20Services.pdf

22nd annual meeting of the Asia-pacific parliamentary forum: Resolution APPF22/RES 15, Disaster Risk Reduction	This resolution facilitates urban planning based disaster risk management. It provides comprehensive measures for: disaster resilient infrastructure, establishing disaster resistant standards and disaster based education. The resolution strongly suggests that these measures have to be taken by the international community to reduce losses caused by disasters.[8]
Bangkok declaration on disaster risk reduction in Asia and the Pacific 2014	This declaration acknowledges disaster and climate risk management as an important component of development planning for sustainable development and poverty eradication. It recognizes the role of science and technology to promote risk reduction by strengthening capacities of different stakeholders of disaster management.[9]
6th Asian Ministerial Conference for Disaster Risk Reduction: Parliamentarians' statement	This statement ensures that the local and national governments in Asia allocate a percentage of their budgets for disaster risk reduction and climate risk management.[10]
Preparatory Committee (PrepCom 1) of the Third UN World Conference on Disaster Risk Reduction (2014): Joint statement on behalf of ASEAN	A challenge of HFA 1 for the ASEAN region is the use of science-based technologies for disaster risk reduction, identification of new risks and innovation.[11] The proposals for HFA 2 by the preparatory committee are science based disaster risk management for technical assistance, knowledge sharing and capacity building on disaster in the region.[12]
Aqaba declaration on disaster risk reduction in cities	This declaration calls for sustainable development policies to be linked with urban development planning. The objective is to increase disaster resilience, create strong disaster management

[8]Asia Pacific Parliamentary Forum. (2014). *22nd annual meeting of the Asia Pacific Parliamentary Forum: resolution APPF22/RES15 - disaster risk reduction*. Retrieved 02 18, 2015, from PreventionWeb.

[9]United Nations Office for Disaster Risk Reduction - Regional Office for Asia and Pacific (UNISDR AP). (2014, 06 26). *Bangkok declaration on disaster risk reduction in Asia and the Pacific 2014.* Retrieved 02 18, 2015, from PreventionWeb: http://www.preventionweb.net/english/policies/v.php?id=38038&rid=4

[10]United Nations Office for Disaster Risk Reduction - Regional Office for Asia and Pacific (UNISDR AP). (2014, 06 26). *6th Asian Ministerial Conference for Disaster Risk Reduction: Parliamentarians' statement*. Retrieved 02 21, 2015, from PreventionWeb: http://www.preventionweb.net/english/policies/v.php?id=38061&rid=4

[11]Samarajiva, R., Zuhyle, S., Weerasooriya. R. (2015). *Building e-resilience: Enhancing the Role of ICTs for Disaster Risk Management* (DRM)

[12]The Association of South East Asian Nations (ASEAN). (2014, 07 14). *Preparatory Committee (PrepCom 1) of the Third UN World Conference on Disaster Risk Reduction (2014): Joint statement on behalf of ASEAN*. Retrieved 02 21, 2014, from PreventionWeb: http://www.preventionweb.net/files/globalplatform/statementasean.pdf

	policies, increase investment on disaster risk reduction and community awareness by engaging civil society organizations.[13]
Sendai Charter for Asia's protected areas	The charter focuses on the need to manage Asia's protected areas. It addresses the integration of regional development planning and includes the conservation of protected areas.[14]
Sendai Framework for Disaster Reduction 2015 - 2030	Please refer to Section 2

Figure 2: Policies, plans and statements for disaster management and disaster risk reduction in Asia Pacific

3.1. National policies and plans

3.1.1. Japan

The National platform of DRR in Japan consists of four councils of important policies established under the Prime Minister in Japan. These four councils are council on economic and fiscal policy, council for science and technology policy, central disaster management council, and council for gender equality.[15] These councils assist the cabinet and prime minister as "fora of knowledge" on developing plans and policies for the country. These are formed under the basic act on disaster control measures in Japan. The central disaster management council ensures the comprehensiveness of DRM and discusses matters of importance with regard to disaster management in Japan.

[13]Aqaba Special Economic Zone Authority (ASEZA). (2013, 03 21). *Aqaba declaration on disaster risk reduction in cities*. Retrieved from PreventionWeb: http://www.preventionweb.net/files/32077_aqabadeclaration2014.pdf

[14]International Union for the Conservation of Nature (IUCN). (2013, November 17). *Sendai Charter for Asia's protected areas*. Retrieved March 2, 2015, from PreventionWeb: http://preventionweb.net/go/35610

[15]PreventionWeb. (2015). *Japan National Platform*. Retrieved from PreventionWeb: http://www.preventionweb.net/english/hyogo/national/list/v.php?id=87

The Disaster Countermeasures Basic Act (Act No. 223 of 15 November 1961; revised June 1997) provides for the institutional framework for disaster prevention and management in Japan. It regulates the elaboration of disaster prevention plans and the carrying out of emergency recovery measures. [16]

The initiative for disaster reduction through the Official Development Assistance (ODA) in Japan aims to strengthen the actions against tsunamis and other natural calamities.[17] This consists of policies on prioritizing disaster reduction. It formulates the co-operation corresponding to each phase of a disaster.

The Sendai city earthquake disaster reconstruction plan identifies systematic measures that the municipal government and citizens should jointly implement in an organized manner for the earliest possible restoration and recovery from the Great East Japan Earthquake.[18] The Sendai Cooperation Initiative for Disaster Risk Reduction[19] is a plan to build "a society that is resilient to disasters" along with the post-2015 framework for DRR. This plan consists of policies to invest in DRR strategies with the aim of better collaboration between the central government and other stakeholders.

3.1.2. Philippines

The National Disaster Risk Reduction and Monitoring Council (NDRMC) is the national platform for DRR in the Philippines and is mandated by the Philippine Disaster Act of 2010. The act ensures that various stakeholders participate in the development, updating and sharing of information on DRR. It also establishes a national early warning and emergency alert system in Philippines. The NDRM also

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[16]PreventionWeb .(2015). *Japan: Disaster countermeasures basic act (Act No. 223 of 15 November 1961; revised June 1997).* Retrieved from PreventionWeb http://www.preventionweb.net/english/policies/v.php?id=30940&cid=87

[17] Ministry of foreign affairs Japan. (2015). *Initiative for Disaster Reduction through ODA.* Retrieved from Ministry of foreign affairs: http://www.mofa.go.jp/policy/un/conf0501-2.pdf

[18] Sendai City. (2015). *Sendai City Earthquake Disaster Reconstruction Plan.* Retrieved from Sendai city: http://www.city.sendai.jp/shinsai/shinsaihukkokentou/pdf/keikakushiryou/plan%20English.pdf

[19] Ministry of foreign affairs Japan. (2015). *Sendai Cooperation Initiative for Disaster Risk Reduction*. Retrieved from Ministry of foreign affairs http://www.mofa.go.jp/files/000070664.pdf

runs initiatives to develop tools that assess existing and potential hazards caused by climate change to vulnerable communities.[20]

Policy	What it provides	The ICT angle
RA 10121 (Philippine Disaster Act of 2010)	• Multi-stakeholder participation in the developing and managing of Disaster Risk Reduction and Management Information System • Establishes a national early warning and emergency alert system to provide advice to all stakeholders of disaster management	• Database or information system • GIS-based national risk maps • Digital and analog broadcast, cable, satellite television and radio and wireless and landline communications
RA 9729 (Climate Change Act of 2009)	• The development of a database for information dissemination • Research, development, and the promotion of technology use	• Database • Risk assessment technology • Communication infrastructure
RA 10174 (People' Survival Fund Act)	• Funding and supporting early warning systems	• Early warning systems
RA 10344 (Risk Reduction and Preparedness Equipment Protection Act)	• Punishes the theft, and destruction of equipment used in risk reduction and prevention	• Equipment and technology used in disaster reduction and management (e.g. tsunami warning and monitoring system).

Figure 3: Summary of existing relevant DRM laws and the ICT involved in Philippines[21]

[20] Building e-resilience: Enhancing the role of ICTs for Disaster Risk Management in the Philippines: Philippines Case

[21] *Ibid*

3.1.3. Sri Lanka

The Disaster Management Act (2005) provides the legal and institutional framework for disaster management in Sri Lanka. The Ministry of Disaster Management, the Disaster Management Center (DMC) and the National Council for Disaster Management (NCDM) were created to implement the Act.[22]

- *National Policy for Disaster Management in Sri Lanka, 2013*: This policy was developed upon the recommendations of Parliament Select Committee (PSC) on Natural Disasters (2005). This was mandated by the Disaster Management Act.[23]
- *Disaster Management Act No. 13 of 2005*:[24] This Act provides for the coordination at the highest executive level. It establishes an institutional framework for disaster management. This includes the NCDM and the DMC. The Act elaborates powers and functions of this institution and recognizes the nature of disaster management.
- *Roadmap for Disaster Risk Management*:[25]A ten year comprehensive program of action for disaster risk management which has been developed by the Government of Sri Lanka with support from United Nations Development Program (UNDP). It proposes a strategy for a disaster management framework in Sri Lanka.
- *The Sri Lanka Comprehensive Disaster Management Program 2014 – 2018*:[26] A comprehensive plan, also developed with the assistance of the UNDP, builds on the roadmap of 2005 and proposes a disaster management approach, aligned with national priorities.[27] It recognizes, among others, that climate change impacts

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[22] The Sunday Times. (2014, December 28). Floods continue to displace thousands. Retrieved from: http://www.sundaytimes.lk/141228/news/floods-continue-to-displace-thousands-128964.html

[23] Ministry of Disaster Management. (2015). *Sri Lanka disaster management act, & policy.* Retrieved from Ministry of Disaster Management: http://www.disastermin.gov.lk/web/images/pdf/draft%20dm%20policy.pdfhttp://www.disastermin.gov.lk/web/index.php?option=com_content&view=article&id=90&Itemid=83&lang=en

[24] See more at http://www.dmc.gov.lk/attchments/DM%20Act%20English.pdf

[25]PreventionWeb. (2015). *Towards a safer Sri Lanka: road map for disaster risk management, project proposals (vol. 2).* Retrieved from PreventionWeb: http://www.preventionweb.net/files/17955_roadmapfordisasterriskmanagementvol.pdf

[26] NEWS.LK (2015*). Comprehensive Disaster Management Programme 2014-2018.* Retrieved from NEWS.LK http://news.lk/news/item/1808-comprehensive-disaster-management-programme-2014-2018

[27]Ministry for Disaster Management. (2014, September). *Sri Lanka Comprehensive Disaster Management Programme 2014-2018*. Retrieved from: http://www.disastermin.gov.lk/web/images/pdf/slcdmp%20english.pdf

DRR and therefore includes climate change adaptation practices when defining local disaster preparedness practices.[28]

3.1.4. India

The National Disaster Management Authority[29] was established by the National Disaster Management Act of 2005. It provides academic support and formulates a draft disaster management plan for the country. This is carried out by a High Powered Committee on Disaster Management. Currently, the primary responsibility of this authority is the coordination of disaster management actions of the government.

- *The Disaster Management Act, 2005 (Act no. 53 of 23 December 2005)*:[30] This Act facilitates the formulation of the national disaster management plan of India. It provides for the effective management of disasters by the Indian government bodies. It regulates the establishment, structure, organization, powers, functions and responsibilities of national, state and district disaster management authorities.[31]
- *National Policy on Disaster Management, 2009*:[32] This policy facilitates a paradigm shift from the relief-centric response that was available in India to a proactive prevention, mitigation and preparedness-driven approach for disaster management.

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[28] Samarajiva, R., Zuhyle, S., Weerasooriya. R. (2015). *Building e-resilience: Enhancing the Role of ICTs for Disaster Risk Management (DRM)*

[29] See more information at the official website of the National Disaster Management Authority: http://www.ndma.gov.in/en/ and Ministry of Home Affairs, India http://www.preventionweb.net/english/countries/asia/ind/?

[30] India.gov.in. (2015). *Acts/Rule.* Retrieved from National portal of India: http://india.gov.in/my-government/actsrules?acts_owner=All&acts_state=All&acts_central=All&keys=Disaster+management+act

[31] PreventionWeb. (2015). *India: Disaster management act, 2005 (Act no. 53 of 23 December 2005),* Retrieved from PreventionWeb: http://www.preventionweb.net/english/policies/v.php?id=30921&cid=79

[32] NDMA. (2009). *National Policy.* Retrieved from National Disaster Management Authority: http://ndma.gov.in/images/guidelines/national-dm-policy2009.pdf

4. Emerging uses of ICTs and Applications for DRM

There is no doubt that ICTs play an important role in all stages of a disaster (E.g., Box 1). This section focuses on emerging technologies that have the potential to enhance various aspects of the DRR / DRM functions.

The Great East Japan Earthquake

The Great East Japan earthquake was the worst to affect Japan in recent times and was the fourth strongest earthquake ever recorded. Its severe damage to the telecommunication sector was immense. In the case of NTT, it affected 1.5 million fixed line circuits, 29,000 dedicated line services and 4,900 mobile base stations. Ninety main transmission lines, 28,000 telephone poles and 2,700 km of cables were swept away. The intense destruction was attributed to the Tsunami that followed the earthquake, lengthy power outages and the disaster at the Fukushima nuclear power plant. Exchange buildings in Japan, a seismically volatile country, are built to withstand extreme conditions. In most instances, the exchange building stood strong post-earthquake but the severe flooding and high velocity-high intensity waves caused by the Tsunami halted operations. Of the 4,900 base stations that were affected approximately 4,500 were inoperable due to the lack of power supply.

Restoration

It required the relentless effort of 11,000 people over approximately 2 weeks to restore 90% of the affected exchange offices and mobile base station equipment. As an intermediate effort the NTT group installed temporary public phones, public Internet access points, lent mobile phones, satellite phones and tablets at no cost to government agencies and affected people. In addition, disaster emergency messages over all voice and data channels were provided in order to provide safety confirmation.

Base stations were affected in multiple ways and therefore the restoration efforts were customized based on the situation at hand:

- Cable cuts of optical fiber; base stations still operational: Transmission was established using microwave links via a vehicle with a microwave transceiver.
- Disabled cables; disabled base stations: Vehicles with microwave transceivers combined the function of a base station as well as a satellite ground station.
- Affected areas in vast areas with low population densities and low traffic: By adjusting the output power of the antenna, the base station was re-configured to cover more ground (approximately 4-6 cell sites).

In preparation for future disasters

The Ministry of Internal Affairs and Communications initiated a study on policies and made recommendations on enhancing the resilience of communication infrastructure. Essential measures outlined in the report are:

- Increased back-up power at the base stations and all other communication facilities to counter electricity outages. 1,700 base stations have been identified as critical and have received increased back-up power capacity. Access to continuous supply of fuel is also critical. For this purpose, a fuel storage facility in a Tokyo suburb has been established with adequate supply for major facilities in the Tokyo area for 3 days.

- Increased network redundancy and the use of techniques such as large-zone base stations (to widen existing coverage). Such base stations have been deployed in highly populated areas covering a radius of 7 Km on buildings that have high standards of earthquake resistance.
- Respecting the hazard maps created by local authorities and taking necessary safety precautions.
- Taking measures to mitigate traffic congestion on the network such as call restriction, prioritization and appropriate disclosure of network capacity.
- Satellite antennas have been made light-weight and deployed in normal vehicles so as to be able to reach affected areas quicker.
- Physical damage to buildings / communication facilities has been mitigated by relocating affected sites (or communication equipment) to higher elevations, moving building entrances to the 2nd floor, installing water gates to make the ground floor resistant to flooding. Transmission cables have been moved inland, those on bridges were moved under water and ring network topologies were adapted with by-pass routes added for redundancy.
- Post-disaster communication is vital but also causes network congestion. This is mitigated by converting voice messages to electronic files that can be sent over the packet network.

Box 1: The Great East Japan Earthquake - Restoration and Mitigation[33]

The Philippines is a case in point where ICTs have been incorporated in all stages of the disaster management lifecycle.

Disaster Prevention and Mitigation: The agency that facilitates and conducts disaster prevention and mitigation in Philippines are Department of Science and Technology (DOST). The major projects of this department are:

- *Project NOAH (Nationwide Operational Assessment of Hazards)*: This project initiates new efforts for disaster prevention and mitigation. Its goal is to provide high-resolution flood hazard maps of 18 major river basins in Philippines. These maps are used for emergency response and disaster preparedness.

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[33] Kobayashi, M. 2014. *Experience of Infrastructure Damage Caused by the Great East Japan Earthquake and Countermeasures against Future Disasters*. IEEE Communications Magazine.

- *Advanced Remote Data-Acquisition Unit (arQ):* This unit consists of low-power devices that can gather data from the field. These devices have enough memory to store one year's worth of collected data.

Disaster Preparedness

- The Office of Civil Defense' Disaster Information for National Awareness (Project DINA) informs the public of the measures (via audio–visual presentations (AVPs)) that have to be taken before, during and after a disaster.
- *DOST's PAGASA*: The agency that forecasts weather in Philippines is DOST's PAGASA. This agency has an upgraded FTP (File Transfer Protocol) server with high availability platform that links forecast and warning systems. Through this, it issues local forecasts/warnings through PAGASA's regional centers.
- *National Cell Broadcast System for the Public*: This is a part of the national early warning system in Philippines. It allows sending real-time location-specific information messages to a large number of telecom subscribers.

Disaster Response:

- *The National Disaster Risk Reduction and Management Council (NDRMC)'s Intelligent Operations Center (IOC)*: This is a communication facility that consists of an operational building and a vehicle with emergency communication equipment to respond to disasters.
- *Government Emergency Communication Program*: This program tracks, exchanges and uses critical information prior to, during and after a natural disaster.

Disaster Recovery:

- *The Foreign Aid Transparency Hub (FAiTH) and the Track Recovery System*: These two information systems are used by the government of Philippines to make communities aware on the expenditure of funds for disaster recovery.
- *iGovPhil*: This provides infrastructure and support services for e-Governance. The infrastructure of *iGovPhil* includes the government data centers and fiber optic networks to connect government offices. It provides high-speed communication to share tasks and data during a disaster recovery situation.

4.1. Mobile Network Big Data

At a basic level, 'Big Data' can be defined as extremely large volumes of data that cannot be processed using traditional data-processing applications and techniques. Advances in the ICT space have resulted in a quantum leap in the amount of data being generated from a multitude of sources – electronic transactions, sensors, online activities, social media, etc.[34] In recent times, such machine-readable data has been subject to extensive scrutiny by data scientists, who seek to utilize such data to gain insights beyond the original purpose of the data. While such analyses are being utilized by multiple sectors, such data also has relevance for disaster resilience. Numerous sources of data not just from specialized sensors, but also human activity data such as data from mobile phone operators, as well as online/social media activity such as Twitter, can provide timely information of relevance to disaster recovery as well as DRR. It can also provide timely information on human behavioral patterns such as migration, mobility, social network and so on. Dramatic changes in these patterns can incidentally signal anomalies such as emergency events.[35]

Developed economies have a host of potential Big Data sources that have applications for disaster and climate resilience. This is not the case in developing economies, with much lower levels of "datafication" (the act of turning aspects of everyday life into digitized data so that they can be quantified and analyzed) be it through sensor data, human activity, etc.. However, even in developing economies, mobile phone access and use is ubiquitous. Therefore, in developing economies, Mobile Network Big Data (MNBD) currently represents the single most important source of Big Data for development purposes, due to its almost comprehensive coverage of the population. This makes citizens the sensors, and the resultant data derived from using their mobile phones – a useful source of insights for development policy.

Mobile phone users generate a multitude of high frequency and temporally granular location data whenever they use their phones. All mobile networks at a minimum

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[34] Lokanathan, S. 2014. *Measuring the Information Society – Chapter 5*. International Telecommunication Union.

[35] Dobra A, Williams NE, Eagle N (2015) Spatiotemporal Detection of Unusual Human Population Behavior Using Mobile Phone Data. PLoS ONE 10(3): e0120449. doi:10.1371/journal.pone.0120449

generate two types of location data about a subscriber. The first is cell-handoff data such as Visitor Location Registry (VLR) data that is created to know what cell tower a phone is connected to at all times so that the operator can service a call to/from that phone. This gets updated almost every minute, but given the volumes in questions, most operators never store historical VLR data. The second type of positioning data available is from the passive logs of the operators created when phone events occur, e.g. outbound and inbound calls/SMS-es/MMS-es, mobile internet sessions (can be collectively called Call Detail Records or CDRs), airtime reloads, etc. Given that these are event based, they are not as ideal as VLRs. In either case, the location of a user is often resolvable only up to the geographic footprint of the cell tower, which can range from a few hundred square meters in urban areas to up to a few square kilometers in less dense rural areas. More accurate positioning data, such as triangulation or handset GPS, are currently not generated for the majority of mobile subscribers in developing economies.

Regular mobility patterns can be established relatively easily from CDRs, especially when one considers data covering even a month of activity. These can give insights not just on cross-regional travel volumes but also broader mobile patterns in inter- and intra-regional travel. Using such insights, it is possible to then establish mobility hubs, population sources and sinks, and the resultant population flows over varying temporal periods. Such data can be useful also to understand how people respond when there are external shocks (e.g. transportation strikes, road closures). Such insights are invaluable to model contingency plans when disasters may happen and therefore build greater overall resilience.

Mobility data from MNBD can show population displacements after a disaster. Such insights allow first responders and relief agencies to quickly locate affected populations, and improve their targeting of aid and scarce resources. In one retrospective study using CDR data from Haiti, the researchers showed the new locations of the former residents of Port-au-Prince who were displaced when the 2010 earthquake levelled their city (see Box 2). If such data can is made easily available, such insights can greatly improve post-disaster recovery efforts.[36]

MNBD has also been used in the health sector to understand phenomena such as the propagation of vector-borne diseases through the human migration. Human movement is a key behavioral factor in the propagation of many vector-borne diseases as it influences exposure to vectors and thus the transmission of pathogens. Research in Kenya combined passive mobile positioning data from CDRs with malaria prevalence data to identify the source and spread of infections.[37] Similar work in Haiti showed how mobile phone data was used to track the spread of cholera after the 2010 earthquake.[38]

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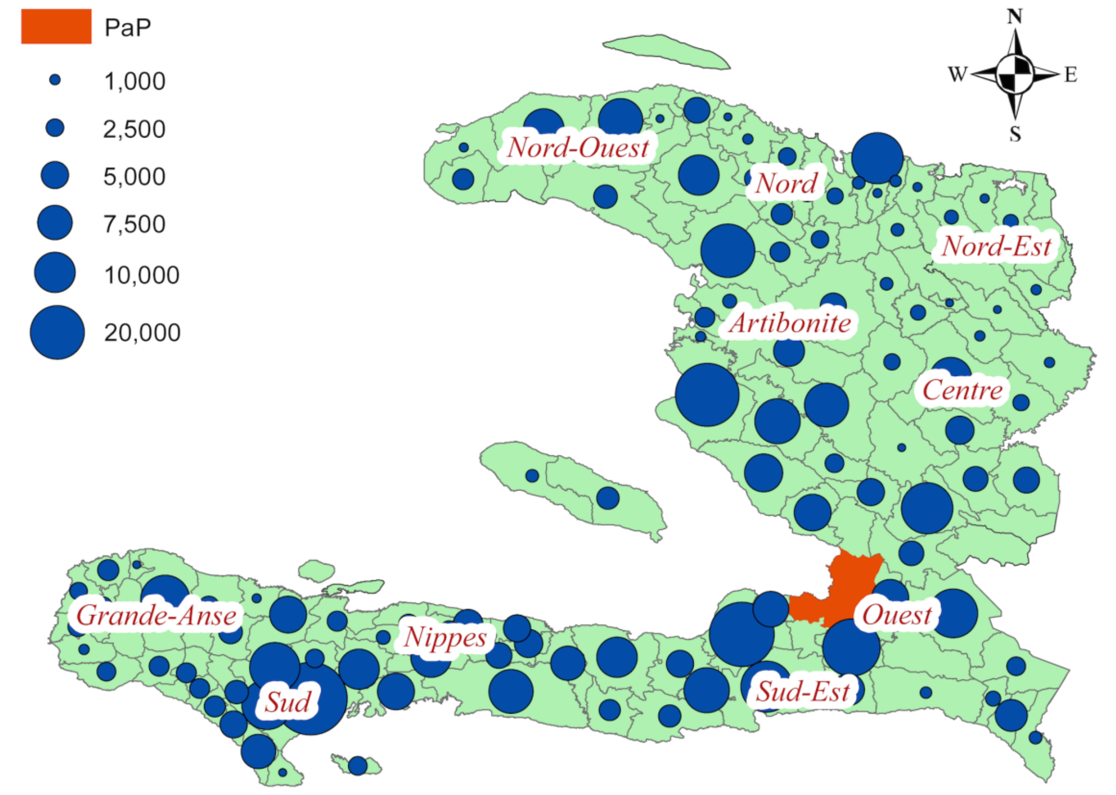
[36] Lu, X., Bengtsson, L., &Holme, P. (2012). *Predictability of population displacement after the 2010 Haiti earthquake.* Proceedings of the National Academy of Sciences of the United States of America, 109(29).

[37] Wesolowski, A., Eagle, N., Tatem, A. J., Smith, D. L., Noor, A. M., Snow, R. W., & Buckee, C. O. (2012). *Quantifying the impact of human mobility on malaria*. Science (New York, N.Y.), 338(6104), 267–70. doi:10.1126/science.1223467

[38] Bengtsson, L., Lu, X., Thorson, A., Garfield, R., & von Schreeb, J. (2011). *Improved response to disasters and outbreaks by tracking population movements with mobile phone network data: a post-earthquake geospatial study in Haiti*. PLoS Medicine, 8(8).



Post-earthquake distribution of Port au Prince (Haiti) population after the 2010 earthquake: The figure shows the number of people estimated to have been in Port-au-Prince (PaP) on the day of the 2010 Haiti earthquake, but outside the capital 19 days later. The circles represent the numbers of people who were displaced.

Box 2: Using MNBD to locate displaced persons in Haiti[39]

As the afore-mentioned examples show, MNBD has wide applicability for disaster resilience, recovery and epidemic/pandemic monitoring. With the recent outbreak of Ebola in Africa, MNBD has garnered greater interest. However, such data remains difficult to obtain. Accessing such data raises a host of concerns that have yet to be fully resolved: how to deal with privacy, technical challenges and transaction costs associated with extracting the data (in emergencies these need to be in real-time or at least near real-time to be of most use). Global agencies such as ITU, ISOC, UN Global Pulse, as well as regional organizations such as LIRNE*asia* are spearheading the emergent public discourse.

UN Global Pulse has also carried out research experiments for DRR (Box 3) using social media data.

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[39] ibid

UN Global Pulse uses Twitter data to predict a food crisis

Indonesia's enthusiastic mobile and social media users provide an ideal test bed with a rich data source. There are 200 million mobile phone subscribers and 9 million Tweets a day. It is also a country that is vulnerable to disasters.

UN Global Pulse has found certain correlations between social media events and livelihood fluctuations. For instance, increase in social media statuses about cancelled vacations occur a few months after a significant drop in household income (e.g. people losing their jobs). Likewise, UN Global Pulse also found a strong correlation between food-related sentiments (food words and mood states) and the consumer price index several weeks ahead. Unlike blogs that can be reflective of historical acts or crises, Twitter data is ephemeral – it is about what is going on now, in the present context.

Box 3: UN Global Pulse predicting a food crisis based on Twitter[40]

4.2. Unmanned Aerial Vehicles (UAV)

Also known as drones, UAVs have, in recent times, become more commonly used for DRM purposes, mainly in the response and recovery phase. Their aerial view imagery provides insights on the extent of the damage and, when outfitted with thermal imaging cameras, can help identify bodies trapped under debris. In areas of severe damage where transport links have been destroyed and are unreachable or are hazardous to first responders, drones provide a way of assessing the situation on the ground relatively fast – time to respond is a critical factor in the aftermath of a disaster.

Satellite imagery is costly and typically comes with data-sharing restrictions. UAVs however, are a more cost effective solution that can be launched by individuals or by affected communities. They can, therefore, be used as a tool for disaster preparedness and make communities more resilient. The grassroots approach is underway where groups such as SkyEye (in the Philippines) and CartONG (in Haiti) are actively

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[40] Byrne, C. (2013). *How The UN's New Data Lab In Indonesia Uses Twitter To Preempt Disaster*. Retrieved from: http://www.fastcolabs.com/3007178/open-company/how-uns-new-data-lab-indonesia-uses-twitter-preempt-disaster

training local communities on how to operate UAVs.[41] The use of UAVs to provide real-time videos of an aftermath can really benefit humanitarian aid organizations and governments, among others.

4.3. Smart Grids for Disaster Risk Reduction

Smart grid integrates ICTs into electricity generation, delivery and consumption to reduce the impact on the environment, improve the market system, quality of service provision and improve the efficiency of the system.[42]

4.3.1. Republic of Korea: Jeju Island

This is one of the first smart grid test beds in the world. The "National Smart Grid" project on Jeju Island is worth approximately 240 billion won (USD 208 million).[43] The goal of the Republic of Korea is to reduce CO_2 emissions by 30% from the predicted levels in 2020. This will contribute to minimize global warming and the disaster trends attached to it. This project is supported by the three major telecommunication service providers and home appliance manufacturers (KT, SKT, LG and Samsung) in Korea. These service providers are testing smart grid services, solutions for smart buildings/homes and smart transportation. The project covers 6,000 homes and aims to optimize energy usage. It introduces new and renewable energy sources and energy storage facilities to Jeju Island. By 2011, at the end of the first phase of the project, smart grid facilities and infrastructure were constructed on the island. By 2013, at the end of the second phase, the infrastructure was tested and demonstrated.

Mobile technology is used in Jeju Island to support smart grid solutions. It connects smart devices through mobile network infrastructure that is used for support services (billing, authentication, etc.). It provides ICT infrastructure to support demand response, building energy management and power retail. KT consortium is testing

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[41] Virgin Unite Business Innovation. (2014). *Humanitarian in the Sky: drones for disaster response.* Retrieved from: http://www.virgin.com/unite/business-innovation/humanitarian-in-the-sky-drones-for-disaster-response

[42] EPRI (2015). *Home.* Retrieved from http://smartgrid.epri.com/

[43] GSMA Intelligence (2012). *South Korea: Jeju Island Smart Grid Test-Bed*. Retrieved from http://www.gsma.com/connectedliving/wp-content/uploads/2012/09/cl_jeju_09_121.pdf

and analyzing present real time energy consumption data by collecting them from a range of connected devices, sensors and web-based cloud services on Jeju Island.

4.3.2. Tagonishi Eco Model Town, Sendai City

The United Nations Office for Disaster Risk Reduction recognized this city as a role model to make cities resilient and to promote community-based DRR by collaborating in private-public partnership.[44] This environmentally conscious urban development project was planned by local residents and private companies in 2009. It was modified after the Great East Japan Earthquake in 2011 as a disaster resilient community.[45] The previous commercial-oriented plan was modified as a residential area with apartment style housing and single-family residences. The concepts of this project are energy efficiency, resident comfort, safety, security, and oneness with nature and disaster resilient energy supply.

The Energy Management System (EMS) of this model town city was developed by Sendai Green Community Association. This is collaboration between NTT and Kokusai Kogyo (the lead contractor of the project). This organization provided the equipment for the disaster reconstruction public housing and detached homes to create a community that is energy efficient and resilient to disasters. The ICT devices in the houses in this city visualize electricity consumption by fitting to its solar power systems, storage battery units, gas cogeneration systems and other equipment. This system has a two-way communication between each device and the energy management system. It facilitates efficient management of energy consumption in its five power sources.[46]

The community in Tagonishi is a disaster-resilient community. In the event of a disaster, it can rely on its own power sources. It is energy self-sufficient and it consists of anti-liquefaction measures at an event of a disaster. The city buildings

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[44] UNISDR. (2013). *Sendai welcomes next World Conference on DRR*. Retrieved from http://www.unisdr.org/archive/33333

[45] Japan Asia Group Limited. (2012). *Tagonishi Eco-Town Selected as Model Project—Energy Management System Under Development*.Retrieved from http://www.kkc.co.jp/english/cms/pdf/555/2012-08-07.pdf

[46] NTT (2013). *Communication between people and the global environment*. Retrieved from http://www.ntt.co.jp/csr_e/2013report/pdf/en_35-36.pdf

have built-in disaster countermeasures such as smart grids, evacuation shelters, renewable energy sources, and emergency electricity supply systems.

4.3.3. Pulau Ubin- Singapore

The Energy Market Authority (EMA) launched the Intelligent Energy System (IES) pilot project in 2009. It tested the advanced metering and communications infrastructure, demand response management systems and management systems for distributed energy sources in Nanyang Technological University (NTU) and its surrounding residential and commercial areas. This project evaluated the communication methods of multi-dwelling buildings and landed buildings. The test bed of intelligent microgrids for renewable energy technologies, Pulau Ubin rural area, is the first of its kind in South East Asia.[47] During the first phase of the project (2010-2011) enabling infrastructure such as smart meters and the communication system were implemented and smart meter communication protocols and methods were established in the pilot area. The following phase (2012-2013) introduced smart grid applications and automation for residential and commercial customers.[48]

This system facilitates greater integration of electricity generation, such as renewable sources, integrates electric vehicle charging infrastructure, allows better energy management, outage management and improves grid reliability. The smart grid enables greenhouse gas emission reduction that in turn contributes to resilience against climate change.

5. Lessons Learned and Proposals for Strengthened Regional Responses

There is no doubt that ICTs have the potential to play a vital role in all stages of the disaster life cycle. However, they cannot be treated as stand-alone applications or services. An ecosystem needs to develop with policies and plans in place that provide a clear roadmap for all institutions, community groups and other governmental and

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[47] Seow. (2010). *Intelligent Micro Grid for Renewable Energy Technologies- Test Bedding*. Retrieved from http://www.globalislands.net/userfiles/Singapore_2.pdf

[48] National Climate Change secretariat, Singapore (2011). *Smart grid technology primer: a summary.* Retrieved from https://www.nccs.gov.sg/sites/nccs/files/Smart%20Grid%20Primer.pdf

non-governmental organizations on the plan for action in the event of a disaster. Mindsets need to change. This is perhaps one of the more challenging feats for those trying to develop and enhance the DRM practices and the preparedness of an economy.

As ICTs develop and become are integrated into practically every aspect of life, the dependency on such technologies soars. Otherwise distinct infrastructures become highly interdependent. Electricity, telecommunications and transport are examples. When, for instance, ICTs provide centralized control systems for electricity and transport networks, a failure at one choke point can have adverse effects on every component of the system. Therefore, embedding sustainability (as Goal 9 of the sustainable development goals suggests) and resilience into all new developments while addressing such interdependencies is key.

5.1. Lessons Learnt, Challenges Faced

The use of advanced ICTs usually also come with heavy investments. In most cases within the less developed economies of the region, access to other basic needs is given precedence. In an ideal world it should not be limited to "one or the other", however, when resources are inadequate, it is often the investments on ICTs that are deemed less important. Service providers mandate high levels of redundancy and resilience. For example, the use of mesh network topologies, increased battery backups and use of alternate energy sources for base stations, the network's ability to re-route traffic dynamically (both within and out of the country for in-country traffic) are some examples of measures taken by service providers to ensure quick turnaround times and least interrupted communications when dealing with network disruptions.

After 2011 in Japan, where communication links were severely damaged, a number of infrastructural changes have been made to deal with the challenges faced during and after the Great East Japan earthquake. These include the use of underground ducts to house the access networks, innovative telescopic joint and duct sleeve that can expand and contract to offset the tension along the axes of the conduits, the construction of gravel drains around manholes to equalize the effects of ground liquefaction (and therefore the potential surfacing of equipment),[49] the development of a service for smart phones which would enable voice messages to be converted to a data file, and carry it on the less congested packet network, [50] among others.

This report highlighted some emerging technologies such as the use of Big Data for DRM purposes. It is one that is still being explored but has so far demonstrated immense potential. However, along with it come significant challenges that have to be overcome in order to truly benefit from real-time use of MNBD. Utilizing new sources of data such as MNBD and even social media for assisting in predicting emerging trends and shocks as well as for building greater resilience is still an emergent field. However, prior to discussing the pathways to improving the state of the art in utilizing such datasets, the more immediate concern is how to make such data accessible to researchers, planners, and others for public purposes. As privately owned data, they are not very amenable to the open data initiatives that are currently popular in the public discourse.

There are also privacy concerns that emanate from such data sharing. Further, there are potential competitive implications for operators should their data be shared (even after anonymization). The result of these privacy and competitive concerns are that service providers are generally reluctant to share their data. When they have, it has often been (with some recent exceptions) with a few select researchers and institutions under lengthy Non-Disclosure Agreements (NDAs). Even after MNBD gathered renewed interest in the public discourse after the recent Ebola outbreak in West Africa, GSMA (the global lobbying group for most GSM operators in the world) came up with recommendations that suggested in-house analyses rather than data sharing.[51]

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[49] Tomioka, Hidoe. (2012). *Maintaining Communications Capabilities during Major Natural Disasters and other Emergency Situations*. Retrieved from: http://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/presentation/pdf/Telecommunications_Policy_Division_MIC.pdf

[50] GSMA. (2012). *Dealing with Disasters*, http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2012/06/Dealing-with-Disasters_Final.pdf

[51] The complete GSMA guidelines on the use of mobile data for responding to Ebola can be found at http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2014/11/GSMA-Guidelines-on-protecting-privacy-in-the-use-of-mobile-phone-data-for-responding-to-the-Ebola-outbreak-_October-2014.pdf

The question then is how to facilitate greater data sharing by service providers for public purposes, while accounting for concerns related to privacy and competition? As a regulated industry, MNOs operate under a license, which could theoretically be argued is a form of concessionary contract to deliver a public service, and as such, licenses could theoretically include provisions for data sharing. An alternate and less intrusive approach is to develop bottom-up, pragmatic, cooperative arrangements with government and private actors.

5.2. Strengthening Regional Ties

Disasters do not occur in isolation. The effects can cause distress within a local community or internationally, as they cut off communication and potentially economic activities that may have otherwise occurred. The destruction of the 2004 Tsunami spanned from the epicenter in Indonesia all the way across to the east coast of Africa. The Great East Japan earthquake and Tsunami of 2011 had severe negative effects on a nation that is otherwise well-prepared and well-experienced in dealing with natural disasters. Instead of only planning for and being prepared in the local context, having formal regional ties for such instances will perhaps alleviate the affliction faced by a country. Regional collaboration becomes increasingly important and economies and infrastructures become more connected across borders. For example, many developing economies in the region have infrastructure that was constructed by or belongs to other larger regional economies, thereby increasing interdependencies.

Given the potential and significant role ICTs play in the DRM space, the resilience of ICTs must be given due consideration. In most cases network providers inherently incorporate redundancy into their network roll-out plans. However, it is good practice to ensure necessary levels of resilience have been built into the networks both within the country and on links connecting the international gateways. Network topologies do matter: for instance, mesh networks theoretically provide multiple points of redundancy when compared to other network topologies. After the 2004 Tsunami, the Communication Authority of Maldives (CAM) mandated the use of ring or mesh networks. They also worked with the operators to have local mobile roaming as a service that is automatically enabled in the event of a disaster. Such strategies are easy to implement and need to be facilitated by the telecom regulators. In Sri Lanka, some mobile network operators have redundant links overseas through which traffic will be re-routed in the event of a network breakdown that affects the local switching nodes. After the Great East Japan earthquake, NTT has been collaborating with KT on the feasibility (taking in to account regulatory restrictions that may apply) of a satellite-sharing project for mutual coverage during emergencies. The satellite link would provide an alternative route to areas that have no network coverage.

At the national level, governments should engage in active participation of regional efforts in creating conducive environments for sustainable and resilient environments. All aspects of development planning, not just that of the ministry responsible for disaster management, but any developments in land-use, road networks, communications networks, electricity grids, the distribution networks of water for instance, ought to integrate DRR into the planning process. To facilitate this, an enabling environment for greater cooperation among different government entities needs to be created, keeping in mind the type of vertical and horizontal integration that is required, including local governments and community organizations. Taking into account technological innovations such as Big Data that can really enhance current DRM practices, governments should consider opening up data that can also benefit those responsible for disaster response.

At a regional level, it is recommended that international organizations assess and thereafter act upon concepts such as risk pooling that can benefit smaller economies in risk mitigation. Such organizations should also support the use of emerging technologies and the creation of knowledge centers which will also greatly benefit economies that currently do not have the technical expertise required to utilize available ICTs. International organizations can also facilitate better developmental planning to assist in governments' understanding and thereafter actions addressing critical interdependencies and the building in resilience in all vital infrastructures.