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Third Revolution Digital Technology in Disaster Early Warning

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Abstract: Networking societies with electronic based technologies can change social morphology, where key social structures and activities are organized around electronically processed information networks. The application of information and communications technologies (ICT) has been shown to have a positive impact across the emergency or disaster lifecycle. For example, utility of mobile, internet and social network technology, commercial and amateur radio networks, television and video networks and open access technologies for processing data and distributing information can be highlighted. Early warning is the key function during an emergency. Early warning system is an interrelated set of hazard warning, risk assessment, communication and preparedness activities that enable individuals, communities, businesses and others to take timely action to reduce their risks. Third revolution digital technology with semantic features such as standard protocols can facilitate standard data exchange therefore proactive decision making. As a result, people belong to any given hierarchy can access the information simultaneously and make decisions on their own challenging the traditional power relations. Within this context, this paper attempts to explore the use of third revolution digital technology for improving early warning.

Keywords: Disaster, Digital Technology, Early warning, Tsunami

1. Introduction

This paper attempts to explore disasters in the context of resilience giving more emphasis on preparedness and capacities for early warning. Therefore disaster context, Early Warning Systems (EWs), third revolution digital technology in disaster early warning, research aims and objectives, key findings from the literature on critical phases of EW and third revolution digital technology in disaster Early Warning (EW) as well as how findings of this paper can shape up future research work are sub topic covered under this paper.

1.1 Disaster Context

Disaster means a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources [1]. Improved social and organizational factors such as increased wealth, the widespread provision of disaster insurance, the improvement of social networks, increased community engagement and participation, local understanding of risk, improvements of resilience within natural systems can mitigate disasters [2]. In addition, improved resilience in the context of Capacity of a system, community or society potentially exposed to hazards to adopt by resisting or changing to reach and maintain an acceptable level of functioning and structure can mitigate disasters [3].

Social resilience captures the differential social capacity within and between communities. Demographic attributes to social capacity suggests that communities with higher levels of educational equality, and those with fewer elderly, disabled residents, and non-native English speaking residents likely exhibit greater resilience than places without these characteristics. Similarly, communities have high percentages of inhabitants with vehicle access, telephone access, and health insurance also may demonstrate higher levels of disaster resilience [2]. Therefore it can be argued that the resilience is affected by the capacity of communities to reduce risk, to engage local residents in mitigation, to create organizational linkages, and to enhance and protect the social systems within a community [4]. Capacity of the community is a measure of preparedness as the preparedness capacity is the ability to perform functions, solve problems by setting and achieving objectives at individual, organisations, institutions and societies levels [5].

Preparedness means the knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate respond to and recover from the impacts of likely, imminent or current hazard events or conditions [1]. Therefore it is important to address the question of how to improve what the public knows and to motivate them to take actions to prepare for future hazards [6,7]. Effective early warning thus become important as early waning means the provision of information on an emerging dangerous circumstance where that information can enable action in advance to reduce the risks involved specially the life loss. In this paper improving preparedness education with the access to right information on right time will be discussed in the context of early warning such as educating communities making them fully aware of the risk of hazard, the potential for disaster, evacuation routes and practicing evacuation drills for disciplined evacuation. Nevertheless, unless this complete process is monitored on a community-led, sustainable basis ensuring the community ownership as required community capacity will not be sustained [8]. As preparedness education can save lives with empowering individuals and communities, threatened by natural or similar hazards, by acting in sufficient time and an appropriate manner reducing the possibility of personal injury, loss of life and damage to property [9], it can be argued that early warning, preparedness and capacity as key components for resilience.

The effectiveness of preparedness education is increased when verbal and written information is frequently disseminated from multiple sources over multiple communication channels with consistent information regarding what recipients need to know and about actions that they should take [6]. This is very important for early warning saving lives making accurate decisions timely manner. As early warning system can be defined as the set of capacities need to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss [1], early warning system can be viewed as an information system designed to facilitate decision-making. Early warning systems exist for natural geophysical and biological hazards, complex socio-political emergencies, industrial hazards, personal health risks and many other related risks [10]. According to Mileti and Sorensen[11] a warning system means getting information about an impending emergency, communicating that information to those who need it, and facilitating good decisions and timely response by people in danger. Therefore generating and disseminating timely and meaningful warning information can enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss [1].

1.2 Early Warning Systems

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

The protection of people from external threats including those derive from natural hazards had been a key role of governments. During past decades many countries had developed and integrated early warning capabilities particularly for meteorological and hydrological events as an important tool for preventing disasters. The need for international coordination of these efforts is well recognized and mainly provided through specialized United Nations agencies responsible for geological hazards, food security, environmental protection and humanitarian response. As a result, The International Decade for Natural Disaster Reduction [9] promoted this concept and raised profile of EW resulted in acknowledgement of its crucial importance in the Yokohama Strategy for a Safer World endorsed at the World conference on Natural Disaster Reduction in 1994. The International Strategy for

Disaster Reduction, the successor to the IDNDR, has introduced a stronger focus on vulnerabilities and has emphasized the need to integrate disaster risk reduction into sustainable development. The World Conference on Disaster Reduction (WCDR) in Kobe, Hyogo, Japan, 18-22 January 2005 adopted the Hyogo Framework for Action 2005-2015: building the resilience of nations and communities to disasters in which risk assessment and early warning is one of the five themes of disaster reduction. Specific recommendations include the call for countries to develop people-centred early warning systems. In addition Agenda 21, the multilateral environmental agreements, the Barbodos Plan of Action for Small Island Developing States and the Johannesburg Plan of Implementation can be highlighted as other development frameworks called for actions to strengthen international, national and local initiatives to develop early warning in the context of disaster reduction for sustainable development and poverty reduction. Three international conferences on early warning such as International Conference on Early Warning Systems for the Reduction of Natural Disaster in 1998(EWC'98), Second International Conference on Early Warning- 'integrating natural disaster early warning into public policy' in 2003 (EWC-II) and the Third International Early Warning Programme entitled "effective Early Warning to Reduce Disasters: The Need for More Coherent International Action" was launched at the conference (EWS-III) 26-29 March, 2006 in Bonn, Germany produced a set of internationally agreed guiding principles for effective early warning systems as well as the outline of an international programme on early warning to reduce disasters. All three conferences addressed strengthening EWSs by incorporating EW into policy and development frameworks with a greater emphasis on social factors in EWs and mechanisms sustaining dialogue and collaborative action among key stakeholders [12].

At the third international EW conference held in Bonn, Germany in 2006, ISDR presented their global survey on Early Warning Systems (EWs) highlighting advances in the capacity of agencies in many countries to forecast potentially catastrophic events and implementation of EWSs for a broad range of hazards. In addition, the survey highlighted the variation of advances in EWS in countries and gaps specially in developing countries including Sri Lanka. For many developing countries lack of infrastructure, adequately trained staff and resources were the main gaps identified that to be prioritized. In order to fill such gaps it was recommended to have a globally comprehensive early warning system rooted in existing EW systems and capacities. As a result, in Intergovernmental Coordination Group for Tsunami Early Warning and Mitigation System for the North-Eastern Atlantic, Mediterranean and Connected Sea (ICG/NEAM TWS) meeting that was held in 2007 in Bonn , Germany developing a globally-standardized framework related to alert or warning levels. As a result, factors such as hazard dependent EWS frameworks and variations of EWS frameworks for the same hazard according to the country context were explored. This was further benefited with Kofi Annan' former Secretary –General of the United Nations(2005) demanding for a feasibility of implementing a global early warning system highlighting the devastating impact of Tsunami 2004 claimed more than 200,000 lives due to lack of a Tsunami Warning System in many of the countries affected including Sri Lanka. In addition, EWs has a major contribution to key priority area 2 of the Hyogo Framework for Action 2005-2015: building the resilience of nations and communities to disasters, which was conducted by negotiation among states and organizations at the World Conference on Disaster Reduction (WCDR) in Kobe, Hyogo, Japan, 18-22 January 2005.

As over the last 10 years time disasters have continued adversely impact on well-being and safety of persons, communities and countries claiming over 700 thousand lives, over 1.4 million injured and approximately 23 million homeless affecting more than 1.5 billion people by various ways, other International mechanisms for strategic advice, coordination and partnership development for Disaster Risk Reduction (DRR) had taken steps to improve resilience strengthening DRR frameworks. For example, the Global Platform for Disaster Risk Reduction and the Regional Platforms for Disaster Risk Reduction, the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030 that was adopted at the Third United Nations World Conference on Disaster Risk Reduction, held from 14 to 18 March 2015 in Sendai, Miyagi, Japan had been involved in the development of policies and strategies and the advancement of knowledge and mutual learning with special emphasis on preparedness for early warning and response in order to improve resilience [13].

Sendai framework is focused on four priority areas such as understanding disaster risk, strengthening disaster risk governance to manage disaster risk, investing in disaster risk reduction for resilience, enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction. This also highlights that, more dedicated action needs to be focused on tackling underlying disaster risk drivers, such as the consequences of poverty and inequality, climate change and variability, unplanned and rapid urbanization, poor land management and compounding factors such as demographic change, weak institutional arrangements, non-risk-informed policies, lack of regulation and incentives for private disaster risk reduction investment, complex supply chains, limited availability of technology, unsustainable uses of natural resources, declining ecosystems, pandemics and epidemics. Moreover, it is necessary to continue strengthening good governance in disaster risk reduction strategies at the national, regional and global levels and improving preparedness and national coordination for disaster response, rehabilitation and reconstruction and to use post-disaster recovery and reconstruction to "Build Back Better", supported by strengthened modalities of international cooperation. This calls for a broader and a more people-centred preventive approach for disaster risk reduction and improving resilience [13].

This aspect had been highlighted in the Global Assessment Report [14] as well due to following reasons.

- Most catastrophic events have not yet occurred
- Many infrequent but severe hazards simply might not have occurred
- events are never exactly the same, thus basing the risk assessment only on past event might hide unobserved, but yet possible, consequences
- Limitations of providing temporal and spatial information about the event and detailed records of consequences, specially linked with the local severity of the hazard and performance of the buildings.

Source: GAR, 2015

Given the explained background it is understood that, decision makers including people at immediate risk need to know which events and losses can possibly occur, their likelihood and frequencies in advance [14] . This is a critical consideration in early warning saving lives during disasters. Therefore, identifying critical phases/components of EW become crucial.

With reference to existing people centred early warning systems in the world, key components are risk knowledge, monitoring and warning service, dissemination and communication and response capability. Risk knowledge is mainly focus on systematically collecting data and undertaking risk assessments finding out whether hazards and vulnerabilities are well known, what are the patterns and trends in these factors, whether risk maps and data widely available. The second component, monitoring and warning service focuses on developing hazard monitoring and early warning services, finding out whether right parameters are monitored and scientific basis for forecasting and generating accurate and timely warning. Third component dissemination and communication that focus on communicating risk information and early warning, finding out whether warnings reach all those at risk, the risks and the warnings understood and warning information is clear and useable. Forth or the final component of early warning system is the response capacity that focus on building national and community response capabilities finding out whether response plans up to date and tested, local capacities and knowledge made use of and people prepared and ready to react to warnings. In terms of community response capabilities, utilization of exiting communication mechanisms for warning dissemination at grass root level becomes important. For example, use of mobiles for early warning with improved services such as access to internet. Introduction of internet accessible mobiles or SMART phone with the use of third revolution digital technology can be highlighted. Therefore, it is worth exploring application of third revolution digital technology in early warning.

1.3 Third Revolution Digital Technology in Early Warning

Information and Communication Technology can access millions of people within few seconds or even less, found to be a great strength during emergencies for warning communication. For example, geographic information systems that play a key role in alerting communities at immediate risk, the ongoing development of satellite-, wireless-, mobile-, radio- and internet based ICT are EW capacity to expand and grow improving preparedness and resilience. In looking forward with optimism, it is anticipated that, future research might examine the use of promising new ICT as part of the ECWS capacity in Australia, and more broadly around the world [15]

Third revolution digital technology has semantic features such as Standard Protocols that can facilitate standard data exchange. This enables sending the same alert to mobiles and all media stations while providing more intelligent, capable, relevant and responsive interaction than with information technology. Therefore people belong any given hierarchy can access the information simultaneously and make decisions on their own challenging the traditional power relations. Access to information enhances knowledge thereby ability of making the right decision. Access to the right information on risks on right time can save lives enhancing social interactions. Therefore, it is worth understanding how people's emergent roles and their inter-relatedness with one another help to build adaptive capacity and awareness making them better prepared for disasters. This is useful for proactive decision making responding to disasters saving lives and properties as well as reducing other social risks such as robberies [16]. However, this study will only focus on proactive decision making with third revolution digital technology saving lives during disasters.

According to Castells and Cardoso [17], networking societies with electronic based technologies can change social morphology, where key social structures and activities are organized around electronically processed information networks. As a result, operation and outcomes in processes of production, experience, power and culture can be modified. In this regard semantic features emerge from third revolution digital technology can play a vital role. In the environment of the Sematic Web an ontology is a partial conceptualization of a given knowledge domain, shared by a community of users, that has been identified in a formal machine- process able language for the explicit purpose of sharing semantic information across automated systems [18]. This is very useful for first respondents in a disaster situation to make accurate decisions. At present, first responses for an emergency happen via non-hierarchical, uncontrollable social media with instant global distribution of images. This information flow leads to create emergent roles of individuals subverting traditional power relationships in terms of challenging hierarchies and gaining control over decision making. However, critical knowledge and evidence of disaster managing agencies become important to engage with community networks and support people playing a vital catalytic role bridging or linking emergent roles, strengthening disaster preparedness [16]. Thus a closer examination of social relations and characteristics within communication networks is essential conceptualizing the knowledge flow enhancing resilience of the people making them proactive for EW saving lives.

2.0 Objectives

Objectives of this paper as follows,

- Identify critical phases of effective early warning to enhance community preparedness

- Explore the use of third revolution digital technology to improve early warning

3.0 Methodology

A literature review was conducted in view of examining critical phases of early waning for improving resilience with special emphasis on early warning preparedness and capacity. In addition, collecting information by visiting technical agencies related to tsunami warning in Sri Lanka such as Dept. of Meteorology (responsible agency for issuing Tsunami warning), Disaster Management Centre (DMC- for disseminating EW) Geological Survey and Mines Bureau (GSMB- earthquake and tsunami information), National Aquatic Resources Research and Development Agency (NARA- ocean monitoring) and discussions with the technical officers responsible for Tsunami warning were carried out. Accordingly, 5 interviews were conducted with tsunami EW focal points of the above agencies in Sri Lanka. In addition, related previous case reports were also reviewed. Analysis of the familiar social context and third revolution digital technology effects in early warning for improving preparedness capacities for disaster resilience, strategies for gaining risk knowledge and use of social support networks were taken into consideration. Analysis of related global, regional and national level assessments and reports was also carried out. Preliminary finding of this paper will support my future research work on developing strategies/roadmap for incorporating third revolution digital technology in early warning.

4.0 Findings

4.1 Key findings from the literature on critical phases of EW

There are four key components of a people centred EW system such as risk knowledge, monitoring and warning service, dissemination and communication and response capability. These are influence by effective governance, institutional arrangements and good communication practices. Therefore inter linkages of EW components and influencing factors can be interpreted as in below.

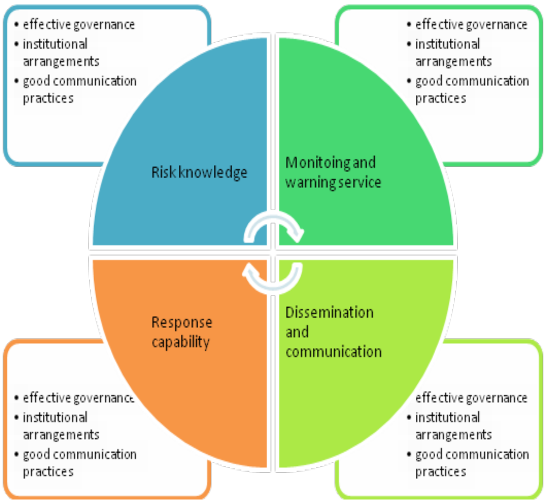

Fig 1.Interlinkages among components of people centred EW system and underpinning factors
Source: ISDR platform for the promotion of EW combined with Author's work, 2015

In order to ensure people and communities are warned in advance of impending natural hazard events and facilitate national and regional coordination and information exchange key actors such as International, national and local disaster management agencies, national meteorological and hydrological services, military and civil authorities, media organizations, businesses in vulnerable sectors, community based and grassroots organizations, international and UN agencies such as UNISDR, IFRC, UNDP, UNESCO, UNEP, WMO, OCHA become very important. Simultaneously institutionalization of the decision-making process by enforcing warning dissemination chain through government policy or legislation and empowering relevant authorities become importance. Functions, roles and responsibilities of each actor in the warning dissemination process should be specified in legislation or government policy. For example, meteorological authorities to provide weather messages, health authorities to provide health warnings. It is equally important to define roles and responsibilities of regional or cross border early warning centres including the dissemination of warnings to neighbouring countries. Nevertheless, in order to ensuring last mile EW volunteer network trained and empowered to receive and widely disseminate hazard warnings to remote households and communities become important. In building capacities of the vulnerable people for practicing responding to EW, installation of communication and dissemination equipments and systems tailored to the needs of communities become crucial. For example, radio, television, mobile for those with access; and sirens, warning flags or messengers, runners for remote communities). However, warning communication technology should reach the entire population at immediate risk without any discrimination including floating population. Therefore, use of multiple communication mediums for warning dissemination is essential. Also having two-way and interactive communication systems allowing verification of warnings can make EW system more effective (EWS; A checklist, Third International Conference on EW, 2006). For example having mobile devices with internet access belongs to third revolution digital technology for EW can help people receive risk information as well as ensure two way communications. Therefore, it is worth exploring use of third revolution digital technology within early warning systems.

4.2 Key findings from the literature on Third Revolution Digital Technology in Disaster resilience within the context of early warning system

Earthquake hazard monitoring can be highlight as the very inception of using digital technology for early warning. Computer systems in Phase 1 (Mainframe Era) were used for very dedicated Tsunami Warning System (TWS) functions in early times before 1980. A strong influence of digital technology on TWS architecture became visible in Phase II (Microcomputer Era) with the digitalization of sensor data and the availability of microcomputer systems. Phase III (Internet Era) created the concepts and foundation for the architecture of modern TWS and their basic components which include decision support components, sensor systems and warning components. The standardization processes of component interfaces and the encoding of data were fostered by the development and success of the Internet promoted by the work of standardization organizations such as World Wide Web Consortium (W3C), Organization for the Advancement of Structured Information Standards (OASIS), Open Geospatial Consortium (OGC) and International Organization for Standardization (ISO). The development of ocean-wide warning infrastructures in Phase IV (Ubiquitous Computing Era), as discussed in responsible UNESCO/ IOC bodies, will become technologically feasible to communities at immediate risk in near future. Given the explained background there is a clear shift from domain to ICT expects when looking at the domains driving the development of TWS (Wachter and Uslander, [19]).

The progress of TWS is mainly driven by development activities within specific scientific communities in Phase I and II, e.g. geodesists, physicists and geologists. Within Phase III these developments become more and more integrated in and depending on mainstream ICT evolution resulting from both the increasing system complexity and the progress in standardization. Exploring digital technology developments during the times of phase III and IV For example, cloud computing, integration of Earth Observation (EO) systems, ubiquitous sensing and volunteered geographic information become important to highlight third revolution digital technology as a supporting tool for EW [19].

Third revolution digital technology is a recognized EW aid that links technical agencies with or without agreements/mandates. All global, regional and national EW systems sustain with this digital aid due to its ability to use by millions of people by passing all hierarchies and power relations making effective decisions. Therefore, this can be easily applied linking up with all related stakeholders making EW mechanism effective. For example, Disaster Management Centre in Sri Lanka as the focal point responsible for coordinating and disseminating early warning in Sri Lanka with the relevant technical agencies and Technical Committees ensuring last mile dissemination, links up with the Department of Meteorology (DoM) and National Aquatic Resources Research and Development Agency (NARA), Geological Survey and Mines Bureau (GSMB) 24 x 7 basis with the use of third revolution digital technology such as internet, ubiquitous bandwidth and cloud storage. In addition use Inter Governmental Network (IGN) that connects technical agencies in Sri Lanka. However, even if the DoM is identified as the technical agency mandated for issuing Tsunami (seismic wave) Warning according to the Draft National Emergency Operations Plan Sri Lanka (2015), Ocean Observation Centre (OOC) of NARA with a Tsunami Warning Centre on 24 hr basis and monitoring ocean conditions around Sri Lanka in near real time provides Tsunami verifications to the Disaster Management Centre with the use internet based data exchange . This highlights third revolution digital technological features can connect stakeholders with or without mandate for early warning saving lives of the people at immediate risk.

Department of Meteorological Sri Lanka connects with Pacific Tsunami Warning Centre (PTWC), Japan Meteorological Agency (JMA) and Indian Ocean Tsunami Warning System (IOTWS) to receive tsunami warnings and earthquake bulletins through internet a feature of third revolution digital technology. IOTWS connects with Indian Ocean Regional Tsunami Service Providers such as Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG), Indian National Centre for Ocean Information Services (INCOIS) and Joint Australian Tsunami Warning Centre (JATWC) operated by the Australian Bureau of Meteorology and Geosciences Australia are able to provide tsunami warnings effectively to the relevant national authorities with the use of third revolution digital technology. This is due to the ability of third revolution digital technology accessing places any time with limited or no access for humans. For example, tsunami monitoring is done with the use of third revolution digital technology as initial capturing of tsunami signs using a recorder on seabed monitors changes in pressure and detect tsunamis. Subsequently, acoustic link transmits data to moored surface buoy and data relayed to satellite and satellite transmits data to ground stations linked with the global and regional tsunami warning networks mentioned before. In this regard, use of cloud computing, integration of Earth Observation (EO) systems, ubiquitous sensing and volunteered geographic information become important. Sensors with self-description capabilities and wireless communication connect with local level additional sensors to form ad-hoc sensor networks resulting higher resolution and lower uncertainty by synthesizing and exchanging their individually observed data for local monitoring.

With reference to ground level EW dissemination in Sri Lanka with the use of third revolution digital technology it is evident that the features such mobile applications have been developed called Disaster Early Warning Network II (DEWN II) for ensuring last mile EW. DEWN is one of the first mass alerting system used for EW in Sri Lanka. This is often deploys Global System for Mobile communication (GSM) technology with outbound messaging via SMS, cell broadcast, mobile app notifications etc. DEWN supports common alerting protocol (CAP) which is an XML based data format for exchanging public warning and emergencies between alerting technologies. DEWN can set priority groups for message broadcasts, regional groups based on requirement and also support media groups to integrate to the alerts via Application Programme Interface (API) [20]. However, it is important to conduct necessary training and awareness programmes as well as establish supporting infrastructure at agency as well as community levels for better familiarisation of such means of communication methods for proactive decision making during disasters saving lives.

In terms of agency capacity building for using third revolution digital technology for responding to disasters, interviewed experts mentioned that, use of General Packet Radio Service (GPRS) is better than Wi-Fi due to less interruption. Wi-Fi is potentially the best and cheapest delivery mode can access with the SMART phone. However, it can be really fast and slow depending on the connection and number of people using that Wi-Fi source. GPRS is one step up from no data signal at all cellular communication system's global system for mobile communication [21]. As most of the EW data exchange among relevant technical agencies happens via Internet in Sri Lanka, Sri Lanka Telecom (SLT) the main telecommunication provider for state sector technical agencies uses Fabre Optic technology providing internet connection to 24x7 operation units/centres for tsunami warning such as, Emergency operation Centre of DMC , National Tsunami Early Warning Centre of DoM, Ocean Observation Centre of NARA, and Seismic Data Analysis and Tsunami Alert Centre of GSMB. However, having necessary infrastructure such as dedicated communication lines with applicable communication protocols ensuring effective data exchange without interruptions had been highlighted by the interviewees for sharing risk knowledge and improving proactive responding. In addition, using satellite communication for EW dissemination and communication to ensure uninterrupted and fast exchange of data for data analysis and issuing warning were also highlighted. Using Google maps marked with vulnerable areas, evacuation routes, evacuation zones, and alternative routes for floating population during a disaster, places for vertical and horizontal evacuation that can be accessed visa SMART phones had been highlighted as useful applications of third revolution digital technology for communities at immediate risk.

5.0 Conclusions

Given the explained background it is clear that there are four key components of a people centred EW system such as risk knowledge, monitoring and warning service, dissemination and communication and response capability component three "dissemination and communication" using appropriate mechanism tailored to cater the needs of the people is critical for EW decision making saving lives. For example, DEWN II mobile application for SMART phone improve information access therefore decision making as a response capacity of the people at immediate risk. However, it is essential to conduct necessary awareness and trainings, practicing evacuation excises with such communication means and devices such as SMART phones facilitating two way communications. At agency level more preparedness is anticipated by having dedicated communication lines for 24 x 7 operated tsunami warning units of the technical agencies such as DoM, DMC, GSMB and NARA with applicable communication protocols required for sharing risk information for proactive responding. Preliminary finding of this paper such as identification of critical phases of early Warning and exploration of third revolution digital technology in early warning will support my future research work on developing strategies/roadmap for incorporating third revolution digital technology in early warning.

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