4.3 Last mile communication

***Irina Stanciugelu**, Aurel Bilanici, Ian Cameron*

4.3.1 Introduction: disaster risk management and information and communications technology

Disaster risk management (DRM) is undergoing noteworthy changes, reflecting the emergence of a globalised system of DRM with technological, organisational, and institutional capacities enhancing DRM's ability as a unit in near real time across the globe (Jensen et al., 2015).

ICT is enabling better communications, remote sensing, monitoring networks, warning systems and modelling and geospatial technologies. Various ICT tools such as geographic information systems (GIS) and global positioning systems (GPS) can allow organisations to receive satellite information and produce accurate location information about the affected areas, which can be further linked with socioeconomic, demographic and needs assessment information (Hu and Kapucu, 2014). There are diverse emergency management information systems such as E-Team, Web EOC, SharePoint that make it easier to gather, process and disseminate information, which helps emergency managers make informed decisions (Carver and Turoff, 2007).

Incident management systems can inform disaster response teams with real-time information about the incident and available resources and can help emergency management organisations coordinate efforts (Iannella and Henricksen, 2007). Innovative means, such as citizen observatories enabled by ICTs (e.g. sensor technologies and social media), have the potential to provide new ways of participation (When et al., 2015) whilst at the same time generating relevant information and promoting demand-driven policy responses (Holden, 2006; Rojas-Caldenas and Corona Zambrano, 2008).

Despite the significant advantages of ICT, unequal ICT adoption within and between countries becomes a DRM limitation. As an example, the uneven distribution of warnings in the 2004 Indian Ocean tsunami resulted in many thousands of avoidable deaths.

Various ICTs are used in disaster risk management to help organisations process and share real-time information. Other functions of ICT are to establish different communication channels, to engage with stakeholders and to coordinate among a large number of agencies.

During Hurricane Katrina in 2005 the inadequate monitoring of infrastructure and failed warning systems led to hundreds of avoidable deaths. Also, the different level of adoption of ICT tends to affect the more vulnerable populations disproportionately. More generally referred to as the 'digital divide,' this tends to exacerbate economic differences (Jensen et al., 2015).

In this chapter, we focus on the main changes that ICT brings in DRM. The next chatper present what constitutes an effective early warning system (EWS) (Chapter 4.3.2 and 4.3.3) and investigate requirements for and recommendations on community linkages and community empowerment within the chain of an EWS (Chapter 4.3.4 and 4.3.5). Chapter 4.3.6 and 4.3.7 present the opportunities that ICT technologies and social media provide for engaging citizens in the emergency management and how the new digital technologies could be used to close the last mile communication gap. We conclude with some general remarks (Chapter 4.3.8).

4.3.2 'Last mile' communication and development of early warning systems (EWS)

The notion of the 'last mile' has been popularised in countries of the Indian Ocean in relation to tsunami EWS development (Thomalla and Larsen, 2010). Even so, 'last mile' has been understood differently: 'last mile' as a challenge for rural communities to access media and address this by supplementing traditional media channels for warning dissemination with additional technologies (LIRNE Asia, 2008); 'last mile' as the capacity of the community to take action in response to a received warning and that supports the development of the capacities of local institutions (Singh Bedi, 2006).

Early warning systems are designed to analyse the risks of vulnerable communities, carry out the task of monitoring environmental variables, issue warnings and ensure that appropriate response capabilities are in place.

The Hyogo Framework for Action 2005-2015, which was adopted at the 2005 World Conference on Disaster Risk Reduction, recognises early warning as an effective tool to reduce vulnerabilities, save lives and help protect livelihoods as well as to improve preparedness and response to natural hazards.

The Hyogo framework takes on the perspective of the 'last mile' in stressing that disaster risk reduction (DRR) must be 'underpinned by a more proactive approach to informing, motivating and involving people in all aspects of DRR in their own local communities' through multi-stakeholder and cross-sectoral partnerships (UN/ISDR, 2005). The diversity in interpretations of the notion of 'last mile' hints at the complexities associated with the links between DRM and ICT, the development of national and regional EWSs and the advent of social media in crisis management.

Early warning is defined as 'the provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response' (UNISDR, 2004). EWS defines a technological infrastructure that can assist in carrying out these tasks. However, the EWS needs to go beyond this infrastructure by taking account of how risks are understood and providing information for warning messages (Horita et al., 2016). EWS has four interlocking elements (Grasso, 2012):

- risk knowledge — to understand the risks (hazards and vulnerabilities) and priorities at a given level;
- monitoring — to stay up to date on how the risks and vulnerabilities change through time;
- response capability — so that each level (pre-season mitigation activities, evacuation or duck-and-cover reflexes) is able to reduce risk once trends are spotted and announced;
- warning communication — to prepare monitoring information into actionable messages understood by those that need them.
- In addition to the four elements, there are a number of cross-cutting issues that are critical to the development and sustainability of effective EWS; these include:
- effective governance and institutional arrangements;
- a multihazard approach to early warning;

- involvement of local communities;
- consideration of gender perspective, vulnerable populations and cultural diversity.

The most common view of EWS comprises a 'warning chain', a linear set of connections from observations through warning generation and transmitter to users. In the meteorological community, the term 'end-to-end' warning system is often used (Basher, 2005). The end-to-end concept aims to make forecasts and warnings more relevant and useable to end users. Such linear models are top-down and expert driven. They neglect the likely impact of the hazard and how warnings are communicated and responded to.

4.3.3 Effective early warning systems and warning communication

An effective EWS needs an effective communication system. Early warning communication systems are made up of the following two main components:

- The communication infrastructure hardware that must be reliable and robust, especially during natural disasters; many communication tools are currently available for warning dissemination such as cellular phone text messaging, email, radio, TV and web services. It is essential to assure the redundancy of communication systems, while emergency power supplies and back-up systems are critical in order to avoid the collapse of communication systems after disasters occur (Grasso, 2012). In addition, in order to ensure reliable and effective operations and to avoid network congestion, frequencies and channels must be reserved and dedicated to disaster relief operations.

- The warning messages: a critical element to influence the perception of risk and public behaviour is how the warning information is structured and what it contains. Generally, warning message content represents a source's assessment of the existence and seriousness of a threat as well as what the public should do to protect themselves (Lindell and Perry, 2004). A message delivered during a critical situation should contain:
  - hazard — short description of the physical characteristics of the hazard (nature and magnitude);
  - location — if possible, a certain position of the area affected by the hazard;
  - time (slow onset — occurring time, time estimated to reach the area; rapid onset — occurring time, rapid development);
  - guidance — the appropriate course of action necessary to prevent death or injury, providing protective action recommendations, including options for those unable to comply with recommended measures (e.g. evacuation orders);
  - pertinent details that should be included in messages; i.e. where to find shelter and the location of recovery supplies or aid stations that may not be obvious to the recipients of the warning.

Communication and dissemination systems should be tailored to the needs of individual communities (e.g. radio or television for those with access and sirens, remote disposals, warning flags or messenger runners for remote communities). Messages should incorporate the understanding of the values, concerns and interests of those who will need to take action.

Recent studies (Sellnow et al., 2015) have underlined the importance of using instructional messages (messages that take into account how people learn and the learning styles) during the response phase. The messages must include elements that not only explain the information, but also give its relevance (proximity, timeliness and personal impact) and motivate receivers to realise the value/utility of the message content and action (specific behavioural directions) that specify exactly what receivers are to do for self-protection.

A frequent problem is the weak link between the technical capacity to issue the warning and the local communities' capacity to respond effectively to the formal systems of warning (Basher, 2005). As such, it is important to recognise that these activities

cannot be undertaken or directed by a single organisation, but require the coordinated participation of many different types of organisations that are committed at community level. National platforms for disaster reduction, stakeholder roundtables or interdepartmental committees should be empowered or established to organise the required coordination. The core technical agencies can play a key role by demanding the establishment of such mechanisms and supporting them with specialised technical information.

4.3.4 People-centred approach to early warning

To respond to these needs, the EWS has grown from a 'techno-centric only' paradigm to a 'people-centric' one where the 'end-to-end' and 'multihazard' components and their procedural norms start to bind together (Adger, 2000; UN, 2015). This new global move is led by the World Meteorological Organisation (WMO) which adopts a service delivery approach that should be making early warning information available and ensure the information is timely, reliable, dependable, usable, expandable, sustainable, responsive, authentic and credible (Ahmed, 2015). The WMO argues (WMO, 2014) for service-oriented actions that start from:

- user engagement and developing partnerships;
- evaluation of user needs and decisions;
- linking service development and delivery to user needs;
- evaluation and monitoring of services, performance and outcomes;
- sustained improved service delivery;
- development of skills needed to sustain service delivery;
- sharing of best practices and knowledge with others.

People-centred early warnings need to be clearly understood by people, easily and readily accessible to people; and timely: tied to response actions to be taken by people before, during and after the event.

The people-centred approach to early warning is promoted by the Hyogo Framework for Action, and focuses on how communities must understand threats in order to deal with them. Communities must be active receivers of information and be engaged in monitoring and such to facilitate the adoption of protective actions (Grasso, 2012). The 'people-centred' characteristic requires many systematic approaches and diverse activities spanning the four elements of EWS described above, such as (Basher, 2005):

- identifying target populations (especially the vulnerable and disadvantaged);
- interacting with target populations to determine needs;
- involving communities in exploring and mapping their risks and planning their responses;
- fostering the development by communities of monitoring and warning systems for local risks;
- generating public information tailored to target groups and making innovative use of the media and education systems;
- establishing people-focused benchmarks and performance standards for technical warning services;
- developing formal mechanisms for public representatives to monitor and oversee warning system design;
- using surveys to measure public awareness and satisfaction;
- creating monuments, publications, annual events and other anchors of public memory and learning;
- providing training on social factors for technical experts, authorities and communicators who operate the warning system;
- conducting research on factors that enhance or impede human understanding of and response to warnings;
- providing exercises and simulations to enable people to experience and practice warning interpretation and responses.

4.3.5 Effective early warning systems: lessons learned at community practice level

The International Federation of Red Cross and Red Crescent Societies (2012) has published an overview of successful practices from the field for the disaster risk reduction/manage-

ment practitioners interested in EWS.

To be effective, warnings must have not only a sound scientific and technical basis, but also a strong focus on the people exposed to risk. Developing working relationships with partners, such as emergency managers and the media, and involving stakeholders in the development and review of the warning system is essential.

It presents guiding principles that could build a strong foundation for the design or strengthen EWS at any level. We present here the guiding principles per EWS component and for the cross-cutting themes.

The guiding principles per EWS component

- **Risk knowledge:**
  - K-1: Although risk knowledge exercises may not lead to early warning, all early warning must be founded on risk knowledge;
  - K-2: Accept that a community's priorities may not be your own.
- **Monitoring**:
  - M-1: Passive receivers of information do not save lives;
  - M-2: Some communities will need to drive their EWS;
  - M-3: Public displays of monitoring can motivate communities;
  - M-4: When hazards evolve, so must their monitoring.
- **Response capability**:
  - R-1: In EWS, we respond to warnings, not to disasters;
  - R-2: Strive to organise robust no-regrets response actions;
  - R-3: Embed response options by annually updating contingency plans with links to funding;
  - R-4: Practice makes perfect: test drive your response actions.
- **Warning communication**:
  - C-1: Clearly delegate responsibility to alert or mediate;
  - C-2: Do not fall into the sophistication trap for warning devices;
  - C-3: Use staged warnings (levels and colours) in dissemination.

Cross cutting themes – guiding principles

- CCT-1: Integrate within DRR — EWS is not a stand-alone;
- CCT-2: Aim for synergy across levels: community, national and regional/global;
- CCT-3: Insist on multihazard EWS;
- CCT-4: Systematically include vulnerability;
- CCT-5: Design EWS components with multiple functions;
- CCT-6: Accommodate multiple timescales;
- CCT-7: Embrace multiple knowledge systems;
- CCT-8: Account for evolving risk and rising uncertainty;
- CCT-9: EWS without borders: target the full vulnerability and hazard-scape;
- CCT-10: Demand appropriate technology;
- CCT-11: Require redundancy in indicators and communication channels;
- CCT-12: Target and reach disadvantaged and vulnerable groups;
- CCT-13: Build partnership and individual engagement.

In the changing landscape of EWS, stakeholders should continue to practice a combination of the approaches to build people-centric, multihazard, end-to-end and service-oriented EWS. The key for success would rely on:

- continued proactive governance;
- mobilisation of resources and capacity development for delivering the services (from all four streams) to the countries;
- making provisions for integrating EWS into the overall disaster risk reduction measures, which would be essential for keeping future harm away and moving ahead to build resilience at the centre of all activities (Ahmed, 2015).

4.3.6 Social media and communities in disaster: connecting the 'last mile'

ICT in general and social media in particular are an integral part of many people's lives today, including during times of crisis. As the examples illustrate in the previous chapter, crisis management authorities in many countries are using the new technologies to increase public awareness and preparedness for disasters, to alert and warn the public and to optimise situational awareness when crises strike.

While traditional radio and TV news remain important venues for sending emergency messages and updates to the general public (Collins and Kapucu, 2008), the widely accessible internet and wireless technologies allow for more flexible methods of communication (Cutter et al., 2007; Kapucu, 2006a; National Research Council, 2007).

For example, a great tool for both emergency managers and the public is Google Crisis Response, which organises emergency alerts and news updates relating to a crisis and publishes the information on dedicated landing pages. It also provides opportunities for donation in collaboration with international agencies such as Unicef, International Medical Corp and local relief organisations. Google also builds and provides tools to help crisis responders and affected people communicate and stay informed, such as Google Person Finder, Google Maps, Google Fusion Tables and Google Crisis Maps. Mobile apps have been developed with different demands and create a new approach for risk communication. The SMS alert system is useful in some cases for delivering alerts in an emergency, and GPS-related mobile apps (location sensoring and hazard maps) help to locate people in potential danger; some applications are developed as pre-disaster warning devices (educational apps). One example for such alert apps is the Katwarn system in Germany, which is currently used by disaster management agencies in more than 60 counties to inform the population about all types of disasters; it is available for Android, iOS and Windows phone platforms. Other examples for disaster alert apps are NINA, a general purpose disaster alert app. also from Germany, and SAIP, an app. provided by the French Ministry of the Interior to provide the population with alerts on major crises (with a special focus on terrorism alerts) (Klafft and Reinhard, 2016).

Social media use a decentralised, collaborative and network-based communication approach that allows citizens to generate data and share information about a hazard event irrespective of its geographic location and temporal extent, contributing to a resilient community.

Across various studies of emergencies and disaster events, numerous positive and negative aspects of social media have been identified (Reuter and Spielhofer, 2016):

- Social media promote cross-platform accessibility and a constant flow of information. During the Haiti earthquake in 2010, Ushahidi (an open-source multimedia mapping platform) allowed near-real-time mapping of the impacted population, which helped volunteers with rescue and response operations. Just-in-time information could be provided on how to cope with developing situations. During Super Storm Sandy in 2012, FourSquare (a location-based social network site) provided location information about visitors, which helped emergency responders with evacuation. The Louisiana Bucket Brigade, a local environmental justice organisation active along the Gulf Coast of the United States, created the Oil Spill Crisis Map after the 2010 Deepwater Horizon oil spill to provide information about community experience and risk perception to help with emergency management (Kar, 2016).
- Moreover, social media provide a framework for the work of journalists and for public discussion and debate. The United Nations Office for Outer Space Affairs established the Space-based Information for Disaster management and Emergency Response (UN-Spider) in 2006 to help with disaster risk reduction through stakeholder participation (UN, 2006).

Negative aspects of social media include the sometimes 'chaotic' or disorganised work of volunteers and the need for quality assessment, as well as the possible increase of task complexity and uncertainty for emergency services (Reuter and Spielhofer, 2016).

Social media can be understood as communication services that employ interactive online ICT (often referred to as Web 2.0 technologies) to enable the exchange of user-generated content. The term 'social media' embraces blogs, micro-blogs, social bookmarking, social networking, forums, collaborative creation of documents (via wikis) and the sharing of audio, photographic and video files (Balana, 2012). Social media are highly interac-

tive 'digital tools that feature content users may generate, manipulate, or influence' (Giroux et al., 2013). In other words, social media encourage interaction and dialogue between users, creating an information space that is decentralised and devoid of hierarchy.

By providing community members with tools to engage in crisis preparedness, response and recovery, social media may have a role to play in building community resilience — a measure of a community's ability to respond to, withstand and recover from adverse situations (Dufty, 2012).

Most studies regarding social media use for emergencies focus on understanding how emergency response organisations adopt tools like social media and bring attention to members of the public as contributors and receivers in the emergency information arena. The 'crisis informatics' is the study of the social and technical (socio-technical) behaviours in emergency response, with a focus on the flows of information between the people and organisations involved. The approach attempts to account descriptively and theoretically for social behaviour that is made possible through technology (Hughes et al., 2009):

- Citizen reporting: the ability for people to report from on the ground during and after an event is analogue to ideas of citizens as 'sensors' — members of the public who detect, measure and report local emergency information — and as 'journalists' — members of the public who collect, report, analyse and disseminate news and information.

- Community-oriented computing: social media have been described as facilitating online communities where members share and seek information during times of crisis (Wang, 2010).

- Collective intelligence and distributed problem solving: social media have been shown to facilitate collective intelligence — where large, distributed groups of people solve complex problems (Vivacqua and Borges, 2010). Citizens may also provide geographically tagged localised and distributed reports — known as volunteered geographic information — of crisis events through social media. This geographic information can then be collated and mapped by volunteers who call themselves 'crisis mappers', using open-source mapping software such as Google Maps, OpenStreetMap or Ushahidi (Heipke, 2010).

- Contributions to situational awareness: an important contribution that social media offer in times of crisis is their potential to enhance situational awareness (Ireson, 2009).

The behaviours described above show ways to use social media in order to build community disaster resilience. These include (Dufty, 2012):

- developing social capital (e.g. networks, leadership and support systems) for disaster resilience-learning communities;
- informing others of the disaster risks in their community and discussing and planning what is being done to manage the risks and what they can do;
- engaging with others to help them prepare for a disaster;
- providing intelligence through 'crowdsourcing' to others (including emergency managers) before, during and after a disaster;
- communicating warnings and other information to communities during a disaster;
- providing support to people during and after a disaster;
- coordinating community response and recovery.

4.3.7 High tech/low tech communication and ethical challenges of social media

The London power outage of 2003 highlighted the importance of not relying on one single type of medium for warning and for informing the public (UK Cabinet Office, 2005) and reveals the vulnerability of social media networks to power outages, which in turn can leave healthy, affluent individuals in their mid twenties feeling very vulnerable. The guidance provided by the United Kingdom Civil Contingencies Secretariat to accompany the Civil Contingencies Act advises emergency responders to promote the use of resilient communication systems such as battery-operated or wind-up radios during emergencies as well as embracing social media platforms such as Twitter and Facebook to communicate during a crisis.

A woman in her late eighties, living alone in a small apartment with a meagre income from a state pension might appear vulnerable, but during the large-scale power outage in the

UK capital in 2003 she was able to heat a can of baked beans on a gas cooker and make a meal with some pasta, as well as share her experience with thousands of people through interactive media by using a landline telephone to call a BBC London local radio phone-in programme which was discussing the power outage.

Although social media will not replace traditional media in the foreseeable future, today many young people already heavily rely on social media to gain information, making this population hard to reach through established communication channels such as radio or television. Therefore, it is about striking a balance; social media tools are one of many communication tools to use.

By contrast, many well-paid workers in their mid twenties, who were employed in the main financial square mile of the City of London, might have been considered to be less vulnerable than the old woman, but the power outage exposed their lack of resilience — they could not use credit or debit cards to pay for food or drink due to the outage, they could not get any cash from ATMs and those that had cash could not buy provisions from supermarkets which were forced to close as their tills did not work. There were also additional security as well as health and safety concerns caused by the power outage (Civil Contingencies Act DVD, 2005). Wi-Fi networks were not available, denying internet access to the workers who commonly used email to organise their social life.

Those workers in their mid twenties who had a supply of ready-oven meals at home could not cook them as their microwave and electric ovens were not working and they could not travel further afield to areas with power because the London underground train system had stopped running and taxis, which were in great demand, would only accept cash payments (Civil Contingencies Act DVD 2005). With mobile phones lasting just a few hours before their batteries died or the back-up batteries at mobile phone masts lasting little more than 2 hours, the City workers in their mid twenties were revealed to be highly vulnerable and displayed little resilience as the power outage affected their service- and technology-reliant lifestyle (Civil Contingencies Act DVD, 2005).

A study by the University of East London, carried out in 2010-2013, used gaming theory to predict social media use during a mass evacuation event in London and one of the main conclusions was that radio, especially BBC radio, was still regarded as one of the most trusted and reliable sources of information during an emergency (Preston, 2013).

Emergency managers normally have to walk a very thin line between actions that may be deemed excessive and any failure to respond adequately that could be considered as negligence (Alexander, 2014). Also, considering the vulnerable people, any system of disaster response or risk reduction that depends on social media for access to its services risks excluding those people who lack access to the technology. 'Computer illiteracy' is a form of disadvantage in a world that has become dependent on digital communication for many services. It is only partially compensated for by the fact that, by relaying information by word of mouth, other people will be able to help a disadvantaged individual cope.

Other ethical risks are associated with a largely unregulated internet-based system of public mass communication. The use of social media for malignant purposes could potentially include:

- attempts to persecute people or damage their reputations (Boggs and Edwards, 2010);
- attempts to spread malicious rumour;
- efforts to create violent protest;
- attempts to organise terrorist activities.

4.3.8 Conclusions and key messages

Partnership

In this changing landscape of ICT, EWS and advent of social media, the key for success in disaster risk management would rely on user engagement and developing partnerships for gradual evaluation and improvements. This process may comprise comprehensive provisioning of: (a) evaluation of user needs; (b) evaluation and

monitoring of actions, performance and outcomes; and (c) sharing of best practices and knowledge with others.

Knowledge

The opportunities and challenges that ICT and social media bring to development of disaster risk management foster a process that builds principles for action for communities of practice, creating a 'space of meaning' with theories for action, social change and instruments for implementation. Because each operational context is unique, stakeholders who aim to implement a policy or strategy have to learn their way into this implementation, often with a considerable need for innovation.

Innovation

This chapter presents some interesting and viable ways that disaster responders and people could rely on ICT and digital media to support their communities in times of disaster. In some cases, individual and community needs result in authority actions, moving toward the establishment of tangible resources that even endure over time. In other cases, ICT use might be ad hoc and temporary, resulting in the establishment of practices that prove useful to the community and can be used as tools for continuous adaptation and innovation.

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