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Sustainable Early Warning Systems: HazInfo Sri Lanka

Gordon A. Gow and Nuwan Waidyanatha

Early in the morning on December 26, 2004, seismic equipment reporting to the Pacific Warning Tsunami Center (PTWC) in Hawaii detected a massive earthquake off the coast of northern Sumatra. Scientists working at the Center soon determined that a tsunami threat existed for the Indian Ocean and concern began grow about the need to inform people living in the region. While outside the immediate jurisdiction of the PTWC, scientists there nevertheless decided to post a bulletin on the Center's public website at 02:04 Zulu time (08:04 local time in Sri Lanka) warning of the possibility of a tsunami in the region.

Minutes after the earthquake, places near the epicenter like Banda Aceh saw the first waves arrive. However, in locations like Kalmunai and other areas along the east coast of Sri Lanka it took 90 minutes or more before the initial tsunami reached the shoreline. Then, for another hour, several more tsunamis inundated the region, destroying fishing villages and tourist resorts throughout the basin. A quarter of a million people would eventually perish—over 40,000 in Sri Lanka alone. In hindsight, many now agree that the major failure of that day was not in the *detection* of a potential tsunami—the scientists at PTWC had issued a public bulletin—but rather in the ability and/or willingness of national and local authorities to *disseminate* a warning to local populations. As noted, many communities and resorts along the coastline had ample time to take action and evacuate at-risk areas well before the tsunami arrived, had only they been given that decisive bit of information that resided on the PTWC website.

A central lesson from the 2004 Tsunami is that improvements to hazard detection in the Indian Ocean and elsewhere may be necessary but they are only one half of a comprehensive approach to more effective

public warning systems. The account of the unheeded PTWC bulletin suggests that a more fundamental challenge going forward will be to establish—and to sustain—socio-technical systems that will link the global information infrastructure with the means to alert local populations at the community level, or what is sometimes termed the "last mile."

As we will argue in this chapter, mobile phones can play a vital role in building sustainable last-mile early warning systems provided that they are deployed within an effective use strategy. Our argument is based on empirical observations drawn from the HazInfo Sri Lanka project—a multi-year action research study that examined the role of information and communication technologies in supporting last-mile early warning. Those observations are then considered in light of a theoretical framework that blends the concept of "effective use" from the community informatics literature with Ling's theory of mediated ritual interaction. The framework advances our understanding of the sustainability challenge by offering insights as how the mobile phone can contribute to social policy in support of local early warning capability through community participation.

Mobile Phones and Last-Mile Warning

In spite of all the initiatives and attention paid to early warning systems since the 2004 Sumatra tsunami, there remains a persistent challenge in building and sustaining local warning capability at the last-mile. The last-mile refers to the final stage in a warning system that connects individuals within local communities to urgent risk information, such as a tsunami warning. Often the vulnerability of a local community to risk can be mitigated if there is a capability to reach people at the last-mile with timely alerts or warnings, enabling them to take action to save lives and protect property. Specialized technical systems such as pole-mounted sirens are effective in some cases but there is ongoing uncertainty as to the level of public understanding of and response to these kinds of single purpose systems. Research on tsunami sirens in Hawaii, for example, suggests that even when they have a long history in the community, a high level of public awareness does not "equate with increased understanding of the meaning of the siren, which remains disturbingly low" (Gregg et al., 2007). Having examined decades worth of research on human response to warning messages, a leading expert in the field has concluded that "[a] siren—like any other noise—is not a warning; at best it may alert some, but many will ignore it" (Drabek, 2010, p. 60). Moreover, even if siren systems are proven effective in some cases,

maintaining specialized technology, particularly in remote areas, can be a costly undertaking for low probability events like tsunamis and may simply be deemed uneconomical in certain settings.

By contrast, major media sources including radio and satellite or cable TV systems are often distributed from centralized head-ends located far away in major urban centers, usually with a limited capability for cutting into programming with information messages targeted to smaller geographic segments within their larger footprint. Nonetheless, blanketing large areas with region-wide alerts could be (and is) done in the name of public safety, but over the long term it runs the risk of desensitizing local communities to these alerts, as many of the messages may not be immediately relevant to them. Findings from research on human response to warnings suggests that well-targeted messaging is an important consideration in maintaining the credibility of an emergency alerting system over time (Partnership for Public Warning, 2003).

In one sense, then, the challenge in developing countries like Sri Lanka is not unlike that in the rural and remote parts of developed countries like Canada. Local warning capability is limited by access to communications technology and the ability to reach populations with localized alerts (LIRNEasia, 2005). However, in the case of developing countries the problem is somewhat more acute inasmuch there are serious challenges in terms of establishing a reliable source of local warning messages in the first instance. In some cases this stems from political situations that systemically hinder the development of reliable local warning information (Samarajiva, 2005).

The challenge of establishing a reliable last-mile warning system is threefold: (1) how to reach individuals with urgent messages on a 24/7 basis—especially late night/early morning hours; (2) how to establish a system that will target populations with local warnings that are specific for their community while avoiding inundating them with non-relevant messages; and (3) how to sustain the system over the longer term, particularly when sources of funding are limited or uncertain.

In light of these requirements, the mobile phone is a promising technology. As an "always-on" personal communications device, the mobile phone would at first blush appear to be an emergency alerting tool par excellence. Alerts can be targeted to specific individuals using SMS or to specific geographic locations with the use of cellular broadcast (Wood, 2006). The mobile phone is also a form of social media that enables peer-to-peer warning practices to evolve where there is otherwise uncertainty as to reliability of official sources of information. Drabek has observed,

for instance, that unofficial warning through friends and family members is a significant and effective phenomenon during emergencies (Drabek, 2010, p. 52). Moreover, the mobile phone is a communications tool that tends to be integrated into the everyday communicative practices among individuals, thereby increasing the likelihood that it will be maintained and functioning should an alert be issued. In other words, the mobile phone has the potential to respond to the first two requirements noted above. The next two sections describe the HazInfo project in Sri Lanka and a set of observations emerging out of that project that confirm a vital role for mobile phones in sustainable early warning systems but also reveal that the goal of sustaining a system over the long term remains somewhat more elusive.

The HazInfo Project in Sri Lanka

From late 2005 to mid 2008, the authors were involved in a research project in Sri Lanka intended to address concerns related to last-mile warning. The HazInfo Project was made possible with funding from Canada's International Development Research Centre (IDRC) and headed by the policy and regulation capacity-building organization LIRNEasia, along with support from several local organizations including Sarvodaya, the largest and most established NGO in Sri Lanka. A primary aim of the project was to establish and evaluate a community-based hazard warning system that would act in concert with any initiative that the national government might introduce in future. The system used a range of wireless technologies including but not limited to mobile phones.

The first step was to establish a reliable source of early warnings for tsunamis and other hazards. Sarvodaya introduced a "Hazard Information Hub" at its Community Disaster Management Centre in Moratuwa, where volunteers were recruited to monitor various websites on a 24/7 basis for "events of interest" that might be cause for concern (e.g., an earthquake off the coast of Indonesia). From here, information bulletins would be issued to individuals within 32 participating communities. These individuals—referred to as "ICT Guardians" by the project team—were equipped with one or more wireless communications devices that they were to maintain in good working order at all times. The devices introduced by the HazInfo project included mobile phones, CDMA fixed wireless handsets, addressable satellite radios donated by a corporate partner, and specialized GSM-based Remote Alarm Devices designed by engineers at the University of Moratuwa. (The HazInfo inventory was comprised of several desktop PCs located at the Hazard Information Hub, connected to the Internet by means of a 128 Kbps microwave link provided by Dialog Telecom. The field component was comprised of 10 mobile phones (Nokia 6600) with service provided by Dialog Telecom; 8 CDMA fixed wireless handsets, with service provided by Sri Lanka Telecom; 56 Worldspace satellite radios with the Disaster Warning Response and Recovery service provided by Worldspace. (A transponder channel was also made available to Sarvodaya on a temporary basis for broadcasting news and information to its villages); and 15 GSM Remote Alarm Devices donated by the University of Moratuwa.)

When an ICT Guardian received an information bulletin over one of their devices, they were instructed to take action based on training provided to them by staff from Sarvodaya. Depending on the nature of the event, this action could range from simply informing the community about a potential risk, to initiating an immediate evacuation. In this respect, the HazInfo was not a "public warning" system in the strictest sense, but instead a social network of designated first responders who would in turn alert their communities through other means, including loudspeakers, temple bells, and word of mouth—a two-step flow, as it were.

Despite various technical issues that were encountered at various stages during the project, a series of exercises conducted over the course of a year (as well as a genuine tsunami alert issued on September 12, 2007) have provided evidence to suggest that a community-based initiative like this can improve the supply of local warnings, even with minimal support from the national government (LIRNEasia, 2008).

However, and perhaps not unexpectedly, the local warning capability established under HazInfo began to diminish when the project came to an end. Local communities are now more aware of the tsunami hazard, but both the communication links and the general state of readiness in these communities have declined significantly in recent months. At the same time there remain unanswered questions as to the reliability of country's official public warning system. Events surrounding the September 12, 2007 tsunami warning in Sri Lanka reinforce the view held by some that numerous practical and procedural matters remain to be resolved before the national system can be considered reliable (Samarajiva, 2007).

Lessons Learned from HazInfo

One of the key objectives set out by HazInfo project team was to support the integration of the various communication tools into the everyday activities of the community. The view held by the project team was that

integration is essential to creating long-term demand for the system and to support ongoing response readiness for future emergency incidents.

Yet by looking at the results achieved, it became clear that there were significant barriers to integration. On the one hand, the expectation for the satellite radios was that they would be reasonably well integrated into community life because they also offered access to a variety of daily information and entertainment programming to the communities. (Worldspace in fact made a transponder channel available to Sarvodaya for its news and information service to be broadcast to the communities over the basic tier of the AsiaStar WS satellite. The use of this channel is, however, temporary and it was reported to me that it is to cease.) Technical challenges faced by users within the communities played a role in reducing this outcome. On the other hand, the expectation for the Remote Alarm Devices was less certain because they were highly specialized devices designed largely to perform a single function. As it turned out, these devices are more likely to be disregarded by community members in part because there is otherwise little call for them to be used on a regular basis.

However, the villages that were given access to mobile phones and wireless CDMA handsets appear to have made the most progress in terms of integrating these devices into the daily life of the community. In fact at one point, Sarvodaya had to take steps to constrain the use of the deployed mobile phones after it became apparent that the cost of calls was exceeding the allocated budget. The "problem" was that individuals in the communities were using the phones more frequently that was expected—typically to make personal calls. Although the mobile phones did present some minor technical issues in terms of their Java-based alerting feature, the fact is that they were the most actively used and integrated technology deployed within the project.

The lesson here is important: in contrast to the satellite radios and Remote Alarm Devices, the mobile phone offered personal access to peers, to chat and exchange information, and to maintain important social connections—albeit sometimes unrelated to the intended purpose of hazard warning. With that possibility open to them, it seems plausible that the ICT-Guardians and others in the community were far more likely to want to use the phone on a daily basis, to want to take care of it by keeping batteries charged, to want to keep the phone turned on at all times in anticipation of incoming calls, and to want to be more aware of the functional capabilities (and limitations) of the device.

Based on this observation, one might be tempted to argue that the sustainable solution for local hazard warning is simply to supply every

village with access to a telephone or mobile phone. Indeed, the case of an Indian village in Pondicherry, saved from the tsunami by a phone call from a concerned relative in Singapore, validates this to a certain extent (Muthalaly, 2005). However, we must also be mindful of the fact that thousands of locals and tourists in other places were caught in the tsunami, many of whom did have a mobile phone, thereby suggesting that access to a technology is not enough on its own to provide assurance that people will be alerted during an emergency. Even with the mobile phone, social networks are necessary to circulate information in a timely manner if people are to be alerted.

Nonetheless, in the face of wide variety of solutions available for public warning, the findings concerning the mobile phones deployed for the HazInfo Project reveal one very important relationship in terms of access: give individuals a tool that they want to use, keep it simple, and they are more likely to use it, maintain it, and even possibly experiment with it. In other words, basic communication capabilities are more likely to be sustained if individuals in the community take a personal interest in them. Moving beyond access to achieve everyday integration of last-mile technology into the community is therefore a key consideration in working toward a social policy that supports sustainable early warning systems. The mobile phone can play an important role in this regard provided that it is incorporated into a strategy that enables and promotes the sharing of local risk information.

Going Beyond Access to Achieve Effective Use

A theoretical model that goes beyond access to consider the broader social context for ICT adoption is necessary if we are to develop an actionable strategy that can lead to reliable and sustainable local warning systems. In this respect, the concept of effective use is helpful. Michael Gurstein, a leading thinker in the area of community informatics, adopted the term in an effort to define a more holistic, participatory approach for studying and encouraging ICT adoption:

> The ongoing process of seeing the DD [digital divide] only in terms of "access" further aggravates and perpetuates the notion that with an ICT platform there will be a relatively small number of producers and a very large, even universal, set of consumers. Meanwhile, of course, the technology is such as to allow for each to be both a consumer and a producer of information and … productive knowledge-intensive goods and services within an electronically enabled environment. … The challenge thus, is to ensure not simply "access" but "effective access" or "use," that is, access which can be used and made effective to accomplish the purposes that individuals might set for themselves (Gurstein, 2003).

This distinction between passive consumers and active producers of information is an important consideration in light of the massive investment in sophisticated tsunami early warning systems that seem to provide little opportunity for community's themselves to become directly involved in the management of local risk knowledge. Along these lines, the concept of effective use appears again in Gurstein's observations about the 2004 Tsunami, noting that the disaster was a prime example of the gap between access and effective use. He reminds us that information about the hazard was available but that individuals and communities in harm's way had little or no ability to make use of it. He contends that in this case "as elsewhere, it is the 'social' organization of the Last Mile which will mean whether the information is used or not and whether lives are or are not saved" (Gurstein, 2005, p. 16).

Gurstein argues that an effective use response to the 2004 Tsunami would place more emphasis on developing local capabilities to manage and use information that is currently available and, moreover, to develop community-based networks for dissemination and emergency response (2005, p. 17). Similar to a 2005 UN report that identified "people-centred" early warning as a future priority (United Nations, 2006), Gurstein contends that a long-term strategy must seek to develop and integrate local knowledge by cultivating extended communities of practice linked through ICTs and shared social arrangements. Similar views are now commonplace among those in the disaster research community (National Research Council, 2006).

Mobile Phones and Local Risk Knowledge as Ritualistic Interaction

In certain respects the HazInfo Project was well aligned with an effective use strategy as defined by Gurstein. In fact, the project organizers had recognized from the outset that access to the technology was only a pre-condition for the long-term success of the system. To the extent that HazInfo established a basic administrative structure and provided training to the participating communities it achieved a modest level of success in going beyond access to promote effective use of technology. However, in terms cultivating an extended community of practice around local risk knowledge, the project was never able to achieve significant gains; this despite best efforts on the part of the project team to encourage local interaction by planning for a communications network that would eventually function with two-way interactions between the Hazard Information Hub and local community members.

Further empirical study is needed to understand how the enthusiastic uptake of the mobile phone as observed in the HazInfo project can be capitalized upon to foster a sustainable community of practice around local risk knowledge and, in turn, improve local warning preparedness on a long term basis.

Recent theoretical work suggests a promising line of inquiry in this regard. Ling has argued, for example, that the mobile phone can serve to reinforce "social coherence" through the ritualistic elements it engenders within small groups (Ling, 2008b). Ling's notion of ritual is an amalgam drawn from various sources, offering a plausible approach to fostering a community of practice through mediated peer interaction:

> [Ritual] ... involves the establishment of a mutually recognized focus and mood among individuals, and it is a catalyst in the construction of social cohesion. The focus is not on obsessive or repetitive behaviour, although ritual interactions can take place in these settings. Rather, the emphasis is on a group process and the outcome of that process (Ling, 2008b, p. 9).

A potentially significant line of inquiry emerging out of this claim is how social policy can work to encourage the formation of ritualistic patterns around the sharing of local risk knowledge such that it becomes integral to everyday communications among the ICT-Guardians within these communities. One vehicle for doing so could take the form of community-based risk mapping that uses mobile phones to collect and share data. Along these lines, a recent study reported by Tran, et al., on the use of GIS technology for flood risk mapping in Vietnam offers some interesting possibilities for adaptation by using mobile phones as tools for community members to produced and share risk information (Tran et al., 2008).

Tran and his collaborators share the view that "communities have shown themselves to be a source of strength, contributing innovative ideas and local knowledge which, when mobilized and used appropriately, can lead to solutions that can make a fundamental contribution to mitigating the negative impacts of natural disasters." Building from this premise, they conclude that "the most successful way to do this is to engage in a process that enables local knowledge to be transferred from the mind to the map." The mobile phone can be a valuable tool in this regard, especially when combined with the power of a digital camera and GPS functionality. ICT-Guardians could be tasked with identifying and sharing information about local risks through both visual and textual methods as a form of "public authoring" (Proboscis, 2008) within the context of a hazard mitigation initiative. The aim of such a project would be to promote community participation in capturing and representing

local knowledge on shared maps. A key finding from Tran's study is promising in terms of this potential:

> This flood risk mapping successfully transferred unrecorded local knowledge into maps. The process of developing risk maps also mobilized the participation of the local population and succeeded in establishing trust, respect and an exchange of information among local communities and local authorities as well as local planners. This involvement assisted enormously in the development of a safer community plan.

Moreover, the results also suggest that participants experienced a level of "mutually recognized focus and mood," leading to greater commitment to the process and its outcomes:

> Another experience from the mapping process showed that villagers have subsequently become more aware of their risks. Incorporating existing and traditional disaster coping mechanisms of the community into the disaster management plan increased the plan's acceptance among villagers and ensured an independent commitment. Once plans have been implemented, farmers feel responsible for their involvement, since they drafted the plans themselves. This reduced the costs of external monitoring and ensure the long-term sustainability of the approach.

The authors note that "community spirit" is a vital force in maintaining motivation, and that this may need to come from local boards or other organizations with roots in the community. By putting the data gathering capabilities into the hands of local community members with support from a coordinating body and open GIS platform, perhaps in conjunction with a community group such as Sarvodaya's Disaster Management Centre, the mobile phone might prove to be a cost effective means of generating and sharing risk knowledge. A working example of this proposed approach can be seen in the Ushahidi online platform that has demonstrated the practical use value of crowdsourcing to support crisis management specifically within developing countries. Ushahidi is a free and open source (FOSS) geospatial platform "that allows anyone to gather distributed data via SMS, email or Web and visualize it on a map or timeline. Our goal is to create the simplest way of aggregating information from the public for use in crisis response" (Ushahidi, 2010). A similar approach based on the Ushahidi model might be suitably adapted for risk mapping and emergency preparedness in an effort to mitigate crisis situations at the outset.

Risk mapping could be an initial focus for the initiative but the extended benefit for public alerting, as well as reducing community vulnerability to natural disasters overall, would derive from the social capital and "interaction ritual" that emerges as a result of ongoing interactions among community members on risk and risk-related topics. Ling, for example, suggests that a process of entrainment might unfold when routine patterns of telephone contact between colleagues "result in a type of solidarity .... and revitalization of group identity" (Ling, 2008a, p. 172).

Risk awareness and, ultimately, community disaster preparedness might thereby be enhanced within the community in part because members become more informed, but also because of the social capital created and sustained through the use of mobile phones in contributing to the risk-mapping project. In this sense, the local community designates working on the risk knowledge project would act as "weak ties" or "bridging capital" that connects local communities to each other and to the coordinating Disaster Management Centre.

Insofar as funding constraints remain a key consideration in countries like Sri Lanka, the mobile phone offers a relatively cost-effective tool that reduces transaction costs in specialized group forming (Benkler, 2006; Shirky, 2008). Moreover, the perceived benefit of participation in a hazard information network might be further enhanced if members of the community were also to recognize the value of risk knowledge sharing to support decision-making around commonplace activities involving household and community planning. In this way the investment in a mobile phone also serves to support a social network that could reinforce local emergency preparedness within wider effective use strategy sustained through ongoing development related initiatives such as health services and local business projects (Mecheal, 2008; Overa, 2008).

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5

Mobile Communication and the Environment

Rich Ling and Nisar Bashir

The mobile phone has become a well-recognized part of everyday life around the world. In the developed world, there are often more subscriptions than there are people in a given country and in the developing world they are quickly spreading (ITU, 2007). The mobile phone has made many contributions to modern society and it has also had some less than desirable effects (Ling & Donner, 2009). The mobile phone has also had broader impacts on society. It has changed the way we exchange time-sensitive information.

Mobile phones also have the ability to facilitate the reduction in energy consumption. There are, however, environmental issues with mobile phones that need to be addressed. This chapter will examine these issues.

On the one hand mobile communication in its different forms can contribute to a more energy efficient and greener environment. We will examine the use of mobile communication in traffic management, in developing countries and in the area of digital distribution. At the same time, the mobile phone is not environmentally neutral. The production, use, and disposal of mobile phones each represents a environmental challenge. We will also look at the question of energy consumption and issues of production and recycling of mobile telephone equipment. As the processing power and the capabilities of mobile phones grow, they also produce a larger impact on the environment. In the conclusion we will outline broad policy issues that should be considered.

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