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The Resilience of ICT Infrastructure and Its Role during Disasters

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Acronyms

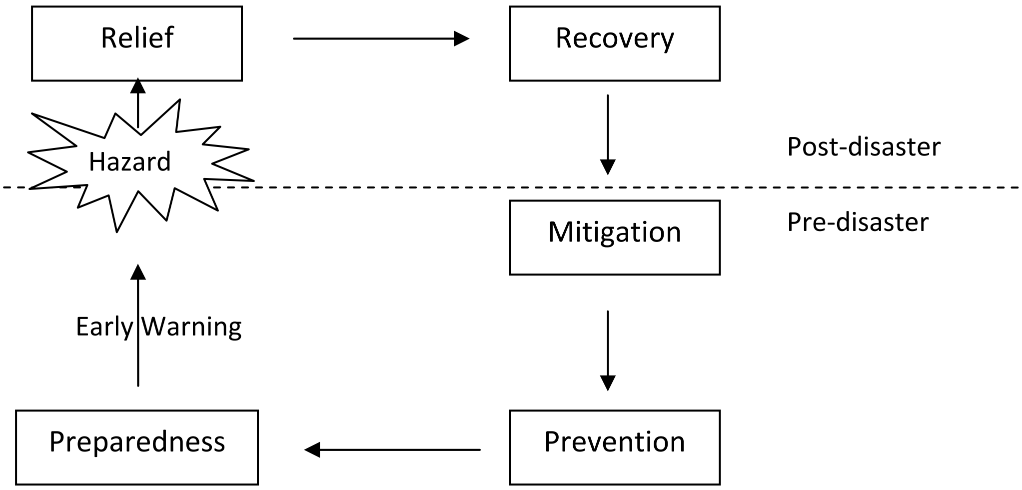
ASEAN	Association of Southeast Asian Nations
BTS	Base transceiver station
CBC	Cell Broadcast Centre
DMC	Disaster Management Centre
FCC	Federal Communications Commission
GIS	Geographical information systems
GPS	Global Positioning System
GSMA	Global System for Mobile Communications (GSM) Association
HF	High frequency
ICT	Information and communication technology
IEPS	International Emergency Preference Scheme
IT	Information technology
ITU	International Telecommunication Union
MNO	Mobile network operator
PCRAFI	Pacific Catastrophe Risk Assessment and Financing Initiative
PIC	Pacific Island Country
SEA-ME-WE	South-East Asia – Middle East – Western Europe
SMS	Short message service
TETRA	Terrestrial Trunked Radio
VHF	Very high frequency

1 Introduction

It is customary in the disaster risk-reduction field to place various actions in the context of the "disaster cycle" shown in Figure 1. Of these phases, mitigation, prevention, and preparedness are pre-disaster activities that constitute actions to be taken to limit the impact of a natural disaster. Post-disaster activities, particularly relief and recovery, include the processes of damage assessment, relocation, and repair of damaged infrastructure.

There is no doubt that natural disasters and humanitarian crises cause disorder and panic. There are many instances in which communication services are not considered a priority when there is lack of access to basic needs, such as food, clean water, and shelter, among others. However, it is often access to accurate information that calms the societal turbulence, and in order for information to be communicated, the underlying network must function. Similarly, in order to communicate accurate information, the supporting soft infrastructure (e.g., institutions and policies) must exist.

Figure 1: Disaster cycle



Information and communication technology (ICT) infrastructure plays different roles in different phases of the cycle. Generally, "during disaster" connotes the period beginning with the hazard making contact with humans (thus becoming a disaster) and up to the start or mid-point of the recovery phase. Services provided over ICT infrastructure can play perhaps their most decisive role in the early warning of natural disasters (see Annex), and there is much research documenting its role;[2] the emphasis in this report, however, is not placed on this phase, which is prior to the disaster. Further, the emphasis is on ICT infrastructure, primarily telecommunication networks and the facilities needed to keep them operational.

A disaster disrupts all activities in that region. Recovery from disaster requires the restoration of routine ways of doing things and of decreasing uncertainty. Relief is the immediate response to the disruption. Both require control and coordination.

[2] Rohan Samarajiva and Nuwan Waidyanatha, "Two complementary mobile technologies for disaster warning", *Info*, vol. 11, No. 2 (2009), pp. 58-65;
Rohan Samarajiva,"Mobilizing information and communications technologies for effective disaster warning: Lessons from the 2004 tsunami", *New Media and Society*, vol. 7, No. 6 (2005), pp. 731-47;
J.C. Villagran de Leon, J. Bogardi, S. Dannenmann, and R. Basher, "Early warning systems in the context of disaster risk reduction", *Entwicklung & Landlicher Raum*, vol. 2 (February 2006), pp. 23-25. Available from http://www.ehs.unu.edu/file/get/10735.pdf.

Information and communication technology, usually understood as electronically mediated communication, storage, and manipulation, allows for the necessary actions related to relief and recovery to be done in ways that are qualitatively superior to the alternatives:

- **Documentation of needs and resources**. The enhanced information processing and visualization capabilities of modern computing hardware and software can, by themselves, enable better documentation of the needs that have to be met, ranging from registries of the missing and injured, to medicines and food for the affected, to housing and infrastructure damage assessments. When combined with geographical information systems (GIS), these capabilities are further enhanced. If the information processing capabilities are coupled with communication technologies to enable both superior field data collection (faster and with fewer errors) and effective dissemination to those who can address the needs, the performance is even greater. If databases are organized and populated prior to the incident, especially in terms of resources such as earth-moving equipment, locations of food stocks, and skills, the efficacy is greater.
- **Spatial coordination**. ICTs allow for synchronous and asynchronous communication across space, enabling greater coordination of spatially separated actors. This is especially important when a disaster has a geographically wide scope (a tsunami or a cyclone versus a localized landslide) and when physical transportation systems may have been degraded or even destroyed in the disaster. Even with localized disasters, ICT enables the coordination of assistance from unaffected areas.
- **Publication**. ICT can also give a voice to the affected people, especially in terms of empowering them in their interactions with the relevant authorities, be they governmental or non-governmental bodies.
- **Facilitation of payments**. This particular function has not thus far been implemented in a disaster situation because payment through mobile telephones is a relatively new phenomenon. However, it has potential, owing to the fact that the payment functions of mobiles have become relatively ubiquitous in several countries.

2 What ICT can be used for

2.1 Documentation of needs and resources[3]

Systems that document needs and resources rest primarily on information technology (IT) and may, in extreme conditions, function even in the absence of the communication infrastructure. For example, a computerized database system could work even with no remote data entry capabilities, with data gathered in the field being entered onsite, as long as the location of the equipment is not affected by the disaster and some form of electricity supply is in place. There is, in fact, no need for the databases to be physically located in the disaster-affected area at all. These types of databases should ideally be located in "the cloud", or at least backed up in the cloud.

A premier open source software suite for post-disaster response is Sahana, developed by volunteers mobilized in Colombo by the Lanka Software Foundation in the aftermath of the 2004 Indian Ocean tsunami, further developed by a network of disaster and software professionals, and spun off as a separate non-profit

[3] Thorough detail on data collection and standardization efforts of the United Nations and humanitarian organizations is provided in B. McDonald and P. Gordon, "United Nations' efforts to strengthen information management for disaster preparedness and response", in *Data against Natural Disasters,* Samia Amin and Markus Goldstein, eds. (Washington, DC: World Bank, 2008). Available from https://openknowledge.worldbank.org/bitstream/handle/10986/6511/449830PUB0Box3181OFFICIAL0USE0ONLY1.pdf?sequence=1.

organization.[4] Such software can be deployed after disasters quite quickly but there are advantages to prior deployment and population of certain databases (e.g., with disaster relief supply locations), along with training of personnel who will work with it in disaster situations.

Box 1: The Sahana Disaster Management System[5]

The overwhelming relief efforts in Sri Lanka following the tsunami, carried out by multilateral organizations and individual volunteers, confirmed that, without a disaster management system, the coordination of these efforts would be near impossible. Based on free and open source software (FOSS), the web-based tool addresses problems that arise post-disaster, such as locating missing people, managing humanitarian aid, organizing volunteers, and surveying temporary camps, among others. Coordination between government entities, civil society, aid organizations, and survivors is a core function of Sahana. One of the main barriers to its adoption in Sri Lanka was caused by the lack of a proper institutional framework. The multiple changes in the government-led disaster management effort meant that there was no proper transfer of data.

With aid from Sweden, the scope of the system was enhanced for use in large-scale disasters; a particularly helpful feature was the ability to rally global support. The 2005 earthquake in Pakistan was its first international deployment, and the most recent was in New York City and New Jersey during Hurricane Sandy in 2012.

Since 2007, the Office of Emergency Management of the City of New York has been managing the all-hazards sheltering plan through its customized version of Sahana known as SEMS (Sahana Emergency Management System). This system consists of two components: one used for the management of staff assignments at shelters, and the other for staff and family registration at shelters. Having this system in place enabled New York City to better manage its responses to Hurricane Irene (2011) and more recently Hurricane Sandy (2012). Additionally, and in response to Hurricane Sandy, community-based organizations (e.g., Occupy Sandy) deployed another customized version of Sahana that was capable of integrating with existing systems and adapting processes. The adaptable nature of the system enabled rapid customization, so it could be configured to the specific needs of disaster response operations for Hurricane Sandy. The initial design supported the collection and aggregation of requests for material assistance and volunteers from the neighbourhoods hardest hit by Hurricane Sandy. This allowed organizations, relief drop-off workers, and volunteers to prioritize the drop-off and dispatch of resources to areas that were most in need. The option of conducting daily inventories to provide visibility and transparency was also available, thereby allowing for more efficient and effective distribution of aid. This latest deployment is now being institutionalized by the community groups, with the aim of everything being in place before the next disaster occurs.

The registries (e.g., injured and missing persons) require data inputs, and updated reports must also be disseminated appropriately. Ideally, these actions can take place over a communication network, through e-mail, short message service (SMS), Google Talk, and the like. However, most disaster management software packages are designed to be usable under harsh conditions, where, for example, information can be moved around in universal serial bus (USB) drives.

A good disaster management software package will include mapping and visualization features that can leverage the potential not only of GIS and the Global Positioning System (GPS), but even of location-aware smart phones. They also tend to be equipped with polling capabilities, in which, for example, the package can be programmed to poll field coordinators via SMS, e-mail or other means at specified intervals and collate the responses automatically.

[4] See the home page of the Sahana Foundation at http://sahanafoundation.org/. See also M.A.L.R. Perera, "Ex ante preparedness for disaster management: Sahana in Sri Lanka", in *Data against Natural Disasters,* Samia Amin and Markus Goldstein, eds. (Washington, DC: World Bank, 2008).
[5] See the Sahana Foundation products at http://sahanafoundation.org/products/.

These packages can also be used to alert first responders through cell broadcasting on non-public channels, through SMS, or by other means and then to keep track of their requirements as the disaster response moves from warning, to rescue, to relief.

2.2 Spatial coordination

Disasters disrupt normality. Physical transportation links break. People become displaced. Routes by which supplies of necessities are taken to users become disrupted.

First responders need to find other first responders.[6] The authorities need to find all sorts of people and things and move them from one place to another. People need to find their loved ones. They need to grieve. They need reach those who can help them restore normalcy to their lives.

All this requires spatial coordination. When buildings have collapsed and roads have buckled, spatial coordination is difficult. Even in normal times, electronic communication, which is increasingly to people instead of places (i.e., via mobile devices), is the primary mode by which spatial coordination is managed. During and immediately after a disaster, the need for spatial coordination is even greater, but the physical infrastructure works less effectively. Hence, a greater burden shifts to the ICT infrastructure.

But ICT infrastructure is located in physical space: it is powered by energy sources; it is operated by people. All these elements are susceptible to the effects of disaster. The cables can break; the towers can topple; the power sources (and the backups) can fail; the people who operate the systems may die, be injured, or be unable to get to their stations. Depending on the technological platform, ICT infrastructure is vulnerable in varying degrees to damage and disruption from the physical causes described above.

The destruction of a country's ICT infrastructure by a natural disaster is exemplified by the Mexico City earthquake of 1985, which caused a collapse of the central communication facility of the Ministry of Communication and Transportation, cutting off most of the communication with the world. This catalysed the formulation of the Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations (see Box 2).

To the extent that ICT networks can be kept functioning in the midst of a disaster, spatial coordination can be done not only by emergency first responders (who are the most important in such situations) but also by public and private entities responsible for restoring services and by members of the public.

Prior to liberalization, communication services were supplied by integrated monopolies, in most cases owned by the government. This allowed for certain advantages, particularly the ability to absorb additional costs for public-service objectives (such as redundancy beyond what market dynamics would support, and even cross-subsidies for emergency first responder services) and creating a single point of contact. However, the monopoly structure also had significant disadvantages. Decision-making procedures were diffused and accountability weak. And if the network went down, there was no alternative.

Box 2: The Tampere Convention[7]

The Tampere Convention was negotiated in 1998 and came into force in 2005, shortly after the 2004 Indian Ocean tsunami. It simplifies the import and rapid deployment of telecommunication equipment in the event of an emergency. This treaty defines aspects of the provision of telecommunication equipment and human resources, the procedure for requests for assistance, and the termination of assistance, among other facets. It makes specific reference to the reduction of regulatory barriers,

[6] Darrell M. West and Elizabeth Valentini, "How mobile devices are transforming disaster relief and public safety", 16 July 2013. Available from http://www.brookings.edu/research/papers/2013/07/16-mobile-technology-disaster-relief-west.

[7] International Telecommunication Union, "Tampere Convention", 1998. Available from http://www.itu.int/ITU-D/emergencytelecoms/Tampere_convention.pdf.

including, but not limited to, recognition of foreign type-approval of telecom equipment and/or operating licenses.[8] As such, it requires all states to maintain an inventory of telecommunication resources (equipment and personnel) available in the event of disaster relief. Signatories of the treaty are also required to develop action plans with detailed information on emergency deployments. It also recognizes that within its territory, a state has the right to direct, control, and coordinate assistance.

Forty-six countries have ratified the treaty to date, with the most recent being Luxembourg in June 2012. It does not appear that it has been invoked in any disaster up to now. It appears that the state-to-state request and offer procedures embodied in the Convention may be of limited relevance in the new liberalized markets, in contrast to the government-owned or sanctioned monopoly markets that existed when the Convention was conceptualized.

Sri Lanka played an important role in negotiating the Convention and became a signatory in 1999. Studies were conducted and an inventory was prepared. Yet it played no role when the country experienced its greatest natural disaster in the form of the 2004 Indian Ocean tsunami. For one thing, the communication networks did not suffer widespread destruction, unlike in the 1985 Mexico City earthquake, which shaped the formative discussion on the Tampere Convention. In Mexico City, the central communication facility of the Ministry of Communication and Transportation collapsed, cutting off most communication with the world. In the case of the tsunami, damage occurred only in limited coastal areas and none of the core facilities were affected. Therefore, there was little need for bringing in containerized exchanges as was done in Mexico City.

The Convention sought to ease the bringing in of communication equipment, but still left it to national authorities to decide the form of the relaxation. There was a need for point-to-point wireless communication that could have been operated by amateur radio enthusiasts, and equipment was donated to Sri Lanka for their use. However, security concerns from the ongoing civil war resulted in the equipment not being cleared from the port. Whether or not the Tampere Convention was invoked, it is unlikely that the equipment would have been cleared. Yet it must be noted that the telecommunication infrastructure, comprising the nationwide networks of three fixed operators, four mobile operators and one trunked-radio operator, was fully operational within 2-3 days of the disaster, with the needed repairs and replacements in coastal areas being completed.

The Tampere Convention sought to address the problem of almost complete destruction of the telecommunications infrastructure in a city or a larger area. It appears that the only natural hazard that is likely to yield such an outcome is an earthquake by itself or combined with a tsunami, as was seen in Lisbon in 1755, in Aceh, Indonesia in 2004, and most recently with the Great Tohoku Earthquake in eastern Japan in 2012. It appears that governments are wary about invoking the Tampere Convention even in these circumstances. In the case of Indonesia and Japan, it may have been because there were plenty of resources within the unaffected parts. There may be value in raising the awareness of the Tampere Convention among decision makers, especially in small countries located in earthquake zones or tsunami paths. But the possibility that multiple networks operating independently of one another are inherently more robust and disaster-resilient than the old monopoly networks that shaped the thinking behind the Tampere Convention cannot be ruled out.