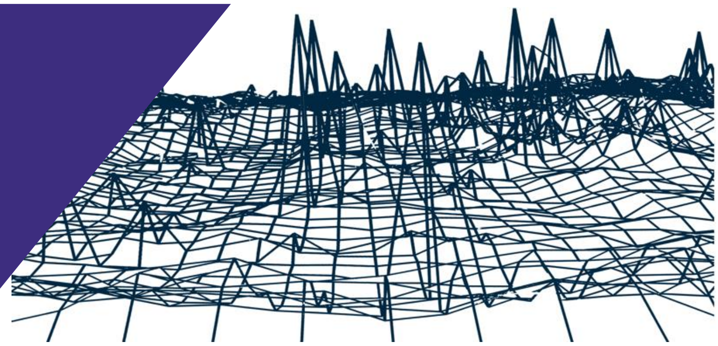
Briefing Note

ESCAP / APCiCT

ICT for Disaster Risk Management



Key Topics

- ICT Use in Risk Assessment and Risk Visualization
- ICTs for Mitigation and Prevention of Disasters
- Early Warning Systems
- ICTs for Community-Based Preparedness Planning
- Geographic Information System (GIS)
- Post-Disaster Response Using Satellite Data
- Participatory Mapping for Disaster Relief
- Disaster Risk Management and Gender Mainstreaming

Introduction

The Academy Module on "ICT for Disaster Risk Management" aims to equip policy makers and civil servants at the national and local government levels with the essential knowledge and skills to fully understand the overall framework of disaster risk management and the practical use of Information and Communications Technologies (ICTs) in disaster mitigation and preventions, preparedness, response and recovery through examples and case studies. With the opportunities being offered by ICTs for disaster risk management (DRM), policymakers are encouraged to consider the use of ICTs when developing strategies and plans to promote effective disaster management of all stages to bridge the digital divide and achieve Sustainable Development Goals.

What are disaster, disaster risk, disaster risk reduction and disaster risk management?

A **disaster** is a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to human, material, economic and environmental losses and impacts.

Disaster risk is defined as the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. Disaster risk comprises different types of potential losses which are often difficult to quantify. However, with knowledge of the prevailing hazards and the patterns of population and socioeconomic development, disaster risks can be assessed and mapped.

Disaster risk reduction (DRR) is aimed at preventing and reducing potential and existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development. It is the policy objective of disaster risk management, and its goals and objectives that are defined in DRR strategies and plans. The 'Sendai Framework for Disaster Risk Reduction 2015-2030' outlines the target and priority actions for making substantial reduction of disaster risk and losses, and also provides a set of recommendations for ensuring that policies, measures and investments use risk information properly, targeted towards effective risk reduction.

Disaster management is the organization, planning and application of measures preparing for, responding to, and recovering from disasters. This is often portrayed as a 'Disaster Cycle', with the various phases of prevention and mitigation, preparedness planning, prediction and early warning, response, and recovery.

Disaster risk management (DRM) is the application of DRR policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses. A general strategy for DRR must establish the disaster risk management context and criteria and characterize the potential threats to a community and its environment (hazard). It should also analyze the social and physical vulnerability and determine the potential risks from several hazardous scenarios in order to implement measures to reduce them. Therefore, disaster risk management requires a deep understanding of the root causes and underlying factors that lead to disasters in order to arrive at solutions that are practical, appropriate, and sustainable for the community at risk.

What is the role of ICTs in disaster risk management?

ICTs play a critical role in all phases of the disaster (risk) management cycle - disaster mitigation and prevention, preparedness and response, and recovery. ICT systems have become indispensable in data collection and also the analysis and dissemination of the outputs of the "last-mile" for an effective DRM. Earth observation remote sensing, communication satellites, Global Navigation Satellite System (GNSS), and Geographical Information Systems (GIS) are useful ICT applications which have been extensively used for DRM activities.

- **Earth observation satellites** are now providing sub-meter level data with very detailed information about the elements-at-risk as well as elevations (digital elevation model), which are critical inputs for multi-hazard risk assessment and developing solutions for mitigation and prevention activities, such as land use planning and building regulations. Earth observation satellites are also contributing to disaster monitoring (e.g., floods) and post disaster damage mapping.
- **Communication satellites** are also being used in disaster preparedness activities, such as early warning, evacuation, mobilization of emergency aids, etc.
- **Navigation satellites (GNSS)** are being used for (i) disaster preparedness activities - monitoring of earth movements (e.g., landslides), sending early warnings to remote locations (e.g., people in a rural and isolated community) using a few specific GNSS satellites; and (ii) disaster response activities – providing location-specific information through crowdsourcing.
- **Geographic Information Systems (GIS)** are widely used in all phases of disaster risk management cycle to ingest data coming from a wide range of sources, such as earth observation (remote sensing) satellites, communications satellites, navigation satellites, and surveys. GIS provide an environment to analyzing and integrating data coming from all these sources and prepare specific products targeting disaster mitigation and prevention, preparedness and response, and recovery. GIS technology is increasingly integrated with internet-based applications via so-called Web-GIS. Internet-based systems that enable to store, share and visualize the data, and make decision in DRR are also used in all phases of disaster (risk) management.

How are ICTs used for disaster risk management?

ICTs for Risk Assessment and Risk Visualization

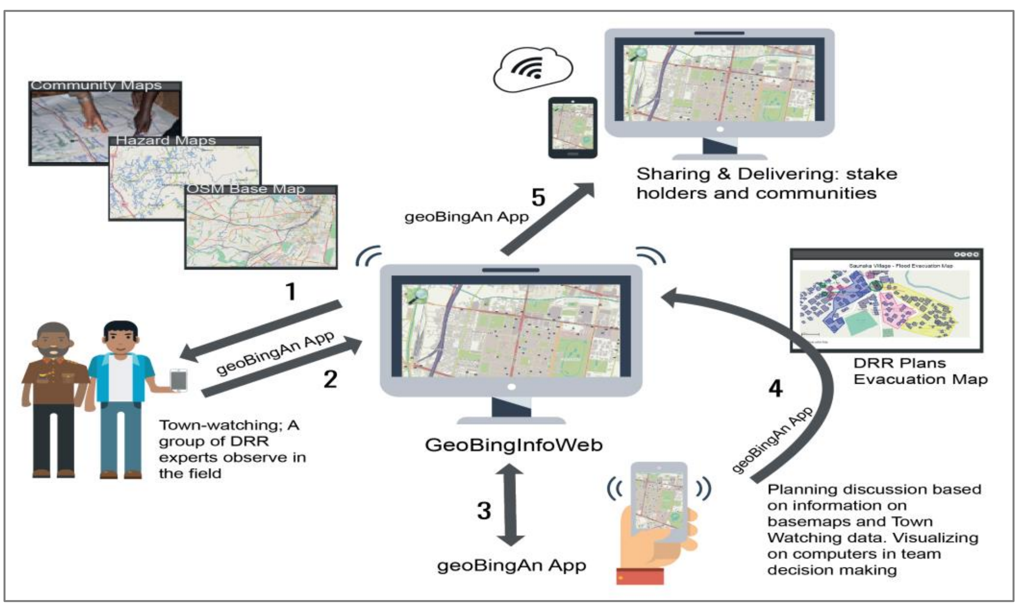


Figure 1: An activity flow of the community-based hazard/risk and evacuation mapping

Disaster risk assessment includes the identification of hazards; the analysis of hazard characteristics (location, intensity, frequency); the analysis of exposure and vulnerability (physical, social, health, environmental, and economic dimensions); calculation of expected losses; and evaluation of the severity of the risk. The emergence of various high-quality physical models and the availability of data have improved the capacity to analyze hazard, exposure, vulnerability, and risk. Remote sensing and GIS play a significant role here.

Risk visualization aims to communicate risk information to the end-users. Therefore, risk visualization needs to be specifically focused specifically on the targeted stakeholders. A risk assessment is done by a group of thematic experts and a risk map is produced based on the interpretation and cartographic skills of these experts. However, the risk evaluation is carried out by the relevant stakeholders with requisite knowledge and skills. Therefore, the risk information should be presented in a way that helps the stakeholders in decision-making.

Since the risk is a spatially varying phenomenon, GIS technology is now a standard tool for the production and presentation of risk information. Risk can be presented in the form of statistical information per administrative unit, risk curves, maps, animations, Web GIS applications, spatial data infrastructure or clearinghouse, and decision support systems.

Figure 2: A training on the use of ICTs on disaster risk management in Awao Barangay in the Philippines, where stakeholders at Barangay level were involved in community-based hazard and evacuation mapping using mobile-app

Communicating risk information to the people living in disaster-prone areas will lead to more effective outcomes at all stages of DRM, and will also provide valuable information to the communities in those areas to take greater control of their own lives by adopting risk mitigation measures and improving coping strategies. Policymakers are encouraged to consider the following to ensure effective risk visualization and communication plans:

- Communicating with communities at-risk even in remote areas to understand their vulnerabilities and capacities;
- Increasing ICT accessibility through infrastructure expansion, incorporating back up services as well as diverse and redundant communication channel; and
- Advancing the information access by translating DRM materials into local languages and making them widely available.

ICTs for disaster mitigation and prevention

The first phase of the disaster risk management cycle is mitigation and prevention. The term **mitigation** refers to the lessening or minimizing of the adverse impacts of hazardous events, while the term **prevention** focuses more on the aim of completely avoiding potential adverse impacts of hazardous events. ICTs contribute to the underlying risk assessment as well as the development of plans of adopting suitable structural and non-structural measures. Acquisition of geo-tagged information on hazards as well as elements-at-risk for the present situation and the possible risk reduction alternatives allows us to quantitatively compare the costs and benefits.

Hazard and risk maps can be overlaid on the existing local development plans in a GIS environment. The location of the existing and upcoming buildings and infrastructures can be compared with respect to several individual hazard scenarios, and the changes in risk for each scenario can be analyzed. For example, if any of the upcoming building falls in an area with (1) very high risk, the planning authority may deny permission; and (2) with moderate risk, a prior approval can be given in principle with specific measures that need to be taken before getting the permission. If the risk for the current situation is considered unacceptable, stakeholders could decide to enter into a new process for the evaluation of optimal risk reduction measures. The planning of risk reduction measures (alternatives) includes:

- planning alternatives which focus on where and what types of activities are planned and prevent future development areas from getting exposed to natural hazards, and
- specific risk reduction measures which can be engineering measures (such as dikes and check-dams) but also non-structural measures (such as relocation planning and early warning).

A selection of the optimal planning alternative should be carried out in close consultation with relevant stakeholders involved and adjustments to the proposed plan of action may be implemented. Policymakers are encouraged to consider the following issues when developing strategies and plans for identifying and using ICTs for disaster mitigation and prevention:

- Incorporating ICTs for DRM as part of sustainable development efforts;
- Providing an enabling policy environment through appropriate policies and institutional arrangements; and
- Calling for risk-informed policies and investments tailored to local situations and coupled with environmental protection.

ICTs for disaster preparedness

The second phase of the disaster risk management cycle is "preparedness" and it is defined as the knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters. ICT applications can contribute to several types of systems that are important in the disaster preparedness phase:

- **Forecasting systems**: predict the level of danger based on indicators at regional scale and regular intervals;
- **Monitoring systems**: measure the development of ongoing potentially dangerous natural processes (e.g., drought and flood) to plan further actions; and
- **Warning systems**: detect significant changes in the environment (e.g., maximum height of tsunami waves) to plan specific risk reduction actions (e.g., evacuation) before the onset of the disaster.

An Early Warning System (EWS) is one of the important elements of disaster preparedness and it is designed to provide early warning to people with as much lead time and certainty as possible, in order to allow individuals and communities threatened by hazards to act in time and in an appropriate manner to reduce the possibility of injury, loss of life, and damage to property and livelihoods.

ICTs have emerged as an essential set of tools, ranging from sensors to data transfer and analysis and communication to local communities.

ICTs are also becoming important tools for community-based disaster risk management (CBDRM), which can assist in collecting and sharing data, strengthen resilience and provide information related to hazards and the exposure to support disaster preparedness.

Figure 3: A control room operated by BNPB, the Indonesia's National Disaster Management Agency. Here, an integrated geospatial platform, InAWARE, was developed to facilitate early warning and decision making on disaster management in Indonesia.

Advances in ICTs, especially the latest generation of mobile phones and their state-of-the-art applications, have made it possible for stakeholders to collect and share local data in real-time, linking reports, geo-tagged photographs, and other multi-media data to their respective locations.

ICTs can be used for establishing an effective multi-hazard EWS, for example, by providing measurements through electronic sensors and subsequent data transmission to a monitoring center, and disseminating alerts and messages to those in affected areas through different platforms such as radio, television, mobile networks, satellite networks, and the Internet.

Policymakers are encouraged to consider the following when developing strategies and plans for identifying and using ICTs for disaster preparedness:

- Unlocking the potential of regional cooperation;
- Capitalizing on new technologies such as big data;
- Strengthening EWS by integrating geospatial data and satellite data to monitor hazards and assess the location-specific impacts; and
- Encouraging standardization to promote seamless and wider dissemination of early warnings.

ICTs for disaster response and relief

Disaster response refers to actions taken directly before, during, or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety, and meet the basic subsistence needs of the people affected. Disaster response is predominantly focused on immediate and short- term needs and is sometimes called disaster relief.

ICTs can play a major role in providing effective, efficient, and timely responses through the rapid use of earth observation satellites, for disaster extent and impact mapping. Satellite data have been extensively used for post-disaster response activities and a number of regional and international initiatives have been taken up by the space agencies as well as multilateral forums to establish mechanisms for making satellite data and products available for emergency response purposes, such as the 'Sentinel Asia' for the Asia-Pacific region and the 'International Charter on Space and Major Disasters' at international level.

Moreover, at the time of a disaster, the situational awareness is very important for directing the response efforts and mobile phones can provide location-specific real-time information through crowdsourcing. Information on high-risk areas as well as highly vulnerable groups such as the elderly and women-headed households can be captured and stored in a GIS platform for efficient emergency responses. A better response in the first 'golden hours' is always a priority, and GIS maps along with a navigation system empower the authorities to do so. With participatory mapping, where volunteers work together to carry out a mapping project, critical data can be quickly collected which can be extremely useful in the case of emergencies.

Figure 4: A mock drill on flood scenario in Sirajganj district in Bangladesh, to evaluate the effectiveness of the space-based technology (SBT) and ICT-based communication systems as well as to sensitize the concerned stakeholders regarding their roles and responsibilities in utilizing the SBT and ICT tools in disaster response planning and operation

Policymakers are encouraged to consider the following when developing strategies and plans for identifying and using ICTs for disaster response:

- Improving communication and ICT infrastructure to help the telecommunication services to become more resilient to disasters;
- Attempting high penetration of mobile phones to broadcast information to the last mile; and
- Unlocking the potential of regional cooperation.

ICTs for disaster recovery

Recovery involves the restoring or improvement of livelihoods and health as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and "build back better", to avoid or reduce future disaster risks. Recovery is the fourth and final phase of the disaster risk management cycle in which remote sensing technology, particularly satellite data-derived mapping products, can be helpful in quantifying post-disaster damage and monitoring recovery after catastrophic disasters. ICT tools can also be used to model the losses and recovery beforehand, in order to design measures to strengthen resilience. ICTs can also be used afterwards in order to monitor how the recovery takes place.

The extent, intensity and type of damage are essential information for planning recovery efforts. Remote sensing data is very useful for providing a quick assessment on the status of buildings when a disaster strikes and causes changes or damages to buildings. The identification of newly built buildings for reconstruction during the disaster recovery phase is another important utilization of remote sensing data. Post-disaster damage assessment from remote sensing images is being used by government organizations, international agencies and even insurance industries. The increased availability of this type of data and the frequently updated data archives make the high-resolution optical images well-suited as a pre-event reference data source for building damage assessment.

Visual interpretation and change detection using both pre- and post-disaster remote sensing images are the most commonly used methods for building damage assessment. More advanced processing techniques namely deep learning techniques, especially convolutional neural network (CNN)-based approaches, are state-of-the-art methods to extract information from remote sensing images for image-based structural damage assessments. An integration of multi-temporal satellite data, in particular, very high-resolution satellite images and pre-disaster OpenStreetMap (OSM) data using an automated deep learning technique provides an excellent opportunity for updating the post-disaster building database.

The recovery after major disasters is not limited to buildings. Post-disaster recovery monitoring has been carried out using a wide range of remote sensing tools (from satellite images to drone images) for vegetation, agriculture, transportation, landscape, and other aspects. Making disaster recovery activities as an opportunity to "build back better" requires strong management capacities in recovery institutions and enabling policies.

ICTs provide innovative solutions and encourage policymakers to consider the following when developing strategies related to using ICTs for disaster recovery:

- Strengthening resilience-capacity building with the knowledge and capacity to use spatial data including earth observation data and geospatial data along with available statistical and ground-truth data to assess the losses in order to prepare a good recovery plan; and
- Capitalizing on new technologies such as deep learning (artificial intelligence), cognitive technologies, big data and analytics.

Role of ICTs in addressing issue related to gender and disaster risk reduction

It is important to include gender issues in the DRR process due to the fact that disasters affect women, girls, boys, and men differently. Women and girls constitute half of the population and cut across all marginalized communities which are more likely to suffer more serious consequences from disasters. ICTs are powerful tools in addressing the critical issues of women empowerment to promote gender equality and in enhancing the DRR. The need to address gender issues in DRR requires sex-disaggregated data and information that could be useful for gender analysis at all stages of disaster—whether before, during, or after a disaster. In this regard, the ICT system is useful not only to collect the data but also to be used to process the data into meaningful information and share the information through communication media. The importance of placing gender issues at the center of DRR policies and strategies is essential, and the ICT tools offer innovative support to strengthen this inclusion. When used in a gender-sensitive way, the ICTs help to bridge the triple divide – digital, rural and gender divide, and advance the processes of social inclusion, with tangible results including a narrowing of the economic and social divide between women and men.

This Briefing Note is an abridged version of APCICT's Academy Module on "ICT for Disaster Risk Management"
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