THE IMPACT OF ICT IN DISASTER MANAGEMENT INFORMATION SYSTEM

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Abstract

The impact of extreme events across the globe is extraordinary, continues to handicap the advancement of the struggling developing societies and threaten most industrialized countries in the world. ICT has widely been used for efficient disaster management; but only to a limited extent though, there is a tremendous potential for increasing efficiency and effectiveness in coping with a disaster. Response to the particular situation and proper recovery are among the main focuses of an efficient disaster management system today. In this paper we re-shape the requirements and innovative technology are being under the utilization in this field and also perhaps, point out the other sophisticated tools in the IT for better utilization towards incorporated disaster management information system.

Key Words: Information and communication Technology (ICT), Disaster Management Information System (DMIS), International strategy for disaster risk reduction (ISDR)

1. Introduction:

The increasing complexity of societies and growing specialization in hazard management clearly demonstrates that no authority or discipline could identify and address all of the significant consequences of hazards. This applies whether hazards be natural (earthquakes, extreme weather events, etc.), human-induced (such as nuclear and hazardous chemical accidents), or the interaction of both. The impact of hazards cuts across economic, social and political divisions in society so that the adequacy of the cumulative response is greatly influenced by the degree to which proactive as well as reactive action can be effectively integrated and optimized. Successful integration of hazard reduction efforts, however, depends on the ability of organizations and individuals involved in all phases of the disaster management process (prevention, preparedness, response, and recovery/reconstruction) to work together to develop and implement solutions to commonly recognized problems. In this regard, key factors in effective mitigation are the information and communication infrastructures that contribute to building knowledge about hazards and the interpretive processes, which contribute to the formulation of options for collective action.

The structure of this paper is as follows: Following this introduction, we analyze disaster management system and ICT, in section 3 sketches how ICT is used in today's DMIS. Section 4 addresses future steps to be conducted regarding this issue, and section 5 concludes the paper

2. Disaster Management Information System (DMIS) and ICT:

It takes immense supremacy and courage to confront the situation, when man-made or natural disasters, such as earthquakes, floods, plane crashes, high-rise building collapses, or major nuclear facility malfunctions occurs. In order to cope with such disasters in a fast and highly coordinated manner, the optimal provision of information concerning the situation is an essential pre-requisite. Police, fire departments, public health, civil defense and other organizations have to react not only efficiently and individually, but also in a coordinated manner [1]. For establishing a controlled system, the information needs to be stored in and inter communicated among the various hierarchy levels. Thus, the requirements for an integrated communication and information system for disaster management information system (DMIS) becomes an essential need for providing efficient, reliable and secure exchange and processing of relevant information.

Over the course of the past decade, tremendous changes to the global communication infrastructure have taken place, including the popular uptake of the Internet, the staggering growth and plummeting costs of mobile telecommunications, and the implementation of advanced space-based remote sensing and satellite communication systems. These new technologies have begun to transform the field of disaster management with an ambitious, if not vague, promise of enhancing planning and reducing loss of life and property through improved communications. In effect, two major developments have taken place within the last decade: a conceptual shift in disaster management toward more holistic and long-term risk reduction strategies, and a communication revolution that has increased dramatically both the accessibility of information and the functionality of communication technology for disaster management. While these shifts hold great promise for significantly reducing the impact of disasters, many issues remain to be addressed or resolved [2]. These include risk management and sustainable development, emergency telecommunications policy and appropriate technology transfer.

2.1 Areas involved in DMIS:

Two major categories, different but closely depend on each other, involved in a Disaster Management Information System are:

- *Pre-disaster activities*: analysis and research (to improve the existing knowledge base), risk assessment, prevention, mitigation and preparedness; and
- *Post-disaster activities*: response, recovery, rehabilitation, and reconstruction.

Accordingly, there are two categories of disaster-related data:

- Pre-disaster *baseline data* about the location and risks; and
- Post-disaster *real-time data* about the impact of hazard and the resources available to combat it;

Decision making of disaster management, having done proper risk analysis and discussion upon appropriate counter measures, can be greatly enhanced by the cross-sectional integration of information. For example, to understand the full short and long term implications of floods and to plan accordingly requires the analysis of combined data on meteorology, topography, soil characteristics, vegetation, hydrology, settlements, infrastructure, transportation, population, socio-economics and material resources. This information comes from many different sources and it is often difficult in most countries to bring them all together

There are two essential preliminaries for establishing a disaster management information system:

2.1.1 Defining the purpose of the system

The system must be appropriate to the level of management at which it is used. Failure to have a very clear idea of the purpose of the system is likely to lead to the creation of an unnecessarily elaborate one which attempts to do more than is really necessary, with the attendant risks of it being costly, time consuming to maintain, the data being out of date and the system itself being *in*appropriate to the real needs of its users.

2.1.2 Investigating the existing databases and integrating with them

Often the information needs of disaster managers overlap those of other organizations and the data may, therefore, already be stored elsewhere. Disaster managers should resist the temptation to establish their own all embracing database. At the national level there are almost certainly existing databases for a wide variety of purposes. An example of a disaster-related international database is a commercially developed one on hazardous substances. UNEP is planning to introduce a similar one for environmental matters [3].

2.3 Components of a Disaster Management Information System

Key components of a Disaster Management Information System could be a database of

a) Hazard Assessment Mapping
b) Vulnerability Assessment
c) Demographic Distribution
d) Infrastructure, Lifelines and Critical Facilities
e) Logistics and Transportation Routes
f) Human and Material Response Resources
g) Communication Facilities
h) Forecasting Methodology
i) Efficient Infrastructure for Risk Analysis and Prevention

The usage of Disaster Management Information Systems (DMIS) could be in 3 contexts

a) Preparedness planning
b) Mitigation
c) Response & recovery

The hazard and vulnerability assessments and mapping components of a DMIS is the cornerstone of preparedness planning as well as planning and implementation of a mitigation program. All data is of critical use in the preparedness plan as well as in the actual response operations [4]. However, it is to be recognized that the development of these databases in communities has to be built bottom up from the lowest administrative unit in the system.

3 ICT used for DMIS

Information communication and technology (ICT) constitutes both a challenge and an opportunity for developing countries. It is one of the key driving forces behind globalization. ICT alone provides a powerful convergence of tools for handling information, from acquisition and production to transmission, archiving and storage. Combined with space technology, it has an enormous impact on all aspects of life by reducing time, distance and the information gap. It increases the scope for greater and faster interaction within different groups of people from different societies and civilizations. Thus, ICT has a greater impact various phases of a disaster management information system (DMIS).

Communication has been recognized by the counter-disaster community as integral to disaster management, making it the central focus for a number of international conferences and initiatives. The United Nations declared 1990-2000 as the *International Decade for Natural Disaster Reduction* (IDNDR) and, in so doing, has formally recognized the importance of communication in disaster management [5]

3.1 An open dialogue for disaster risk reduction

Traditionally information on disasters focused principally on their impacts. The subject now requires the integration of a growing number of subjects that need to be understood to reduce the risk of future events, as well as the involvement of a growing number of interested stakeholders, educational institutions, organizations and local community users.

Websites, networks, multidisciplinary and professional exchanges and other means of communication have been emerged to disseminate information about disaster risks, and to seek new ways through which people can work together in reducing risks. Within the ISDR framework, the use of Internet-based and electronic conferences and discussion forums is being increasingly utilized [6].

3.2 Satellite / GIS / remote sensing technology

Innovations in GIS technology are increasingly

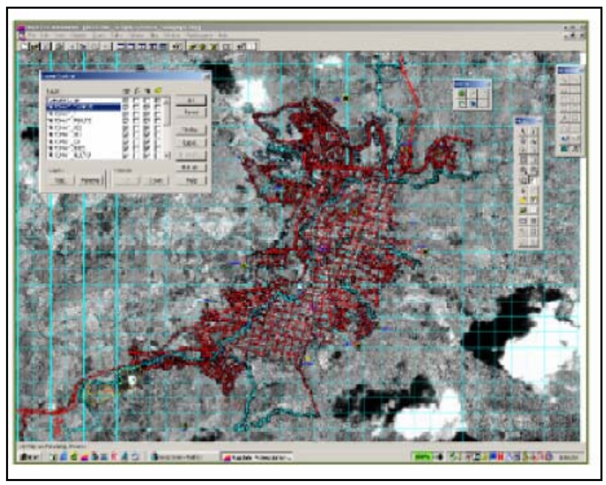

Figure 1: A typical example of GIS application with geo-referenced satellite and aerial photographs (Courtesy of UNOSAT)

accepted tools for the presentation of hazard vulnerabilities and risks. Other forms of information dissemination provide new insights about knowledge engineering, management techniques and cognitive sciences. Some of the most significant and useful developments in the evolution of information systems relate to innovative machine-user interfaces that rely on natural language processing for searching and analyzing data.

3.3 Prevention through Internet, radio programs and raising awareness

Enhancing the understanding of natural hazards and vulnerability to them has always been recognized as a crucial aspect of disaster risk management strategies. The Yokohama Strategy and Plan of Action (1994) noted that future strategies needed to develop a global culture of prevention as an essential component of disaster reduction. It specifically cited the improvement of awareness within vulnerable communities as a primary requirement [7].

In June 2002, the transmission of the radio soap opera "Tiempos de Huracanes" (Times of Hurricanes), very popular in the region, was initiated in over 74 local radios stations in 6 Central American countries at the start of the rainy season. The objective of this campaign is to provide an alternative type of information on disaster risks to the most vulnerable communities. "Tiempos de Huracanes" consists of four stories in the context of floods caused by the heavy rains and hurricanes. These stories take place in communities with different levels of preparedness, and deal with issues occurring before, during and after the disaster [8].

For this reason, increasing public awareness about reducing risk and vulnerability has become one of the four key objectives of the International Strategy for Disaster Reduction (ISDR). For example, the RANET project (www.ranetproject.net) being developed in Africa is an initiative showing the value of combining Internet and the radio to disseminate information on weather and climate to remote communities.

3.4 Early Warning systems depend on reliable information

Technical improvements in the provision and accuracy aspects of early warning systems, including expanded hazard monitoring instrumentation cover, has led to a better understanding of physical causes of disasters and modeling, therefore enhancing the prediction of disasters particularly in developed countries. The Second International Conference on Early Warning (EWC-II) held in Bonn, 16-18 October 2003 under the aegis of the ISDR, has launched a program to enhance the application and efficiency of early warning systems worldwide [9]. The use of the new information and communication technologies, particularly the Internet, in disseminating warning messages is useful in expanding the coverage and reducing time lags.

4 Future Steps and Research Agenda

Computer-mediated networking also challenges traditional approaches to disaster communications strategies. More specifically, new opportunities for self-organizing approaches have become possible with the Internet. The future study would be more congruent with self-organization on distributed networks than the traditional approach, and may be applicable in the future development of global disaster communications networks.

4.1 Structured Infrastructure

A communications lifeline infrastructure (CLI) is a complex network of social and technical elements. As such, it requires a framework for analysis which addresses not only the socio-technical elements, but also the types of information flows and levels of complexity manifest within a CLI. In order to assemble such a framework, combination Cate's functional differentiation [10] with Drabek's classification schemes [11] could be introduced to produce an integrated design for analyzing disaster communication networks.

Thomas's [12] presents a categorical framework for disaster communications based on an information flows, rather than functions or roles, and she adopts a four-fold typology to examine technology issues and general communication problems:

4.1.1 Intra-organizational: communication within organizations. *dominant media:* telephone, hand-held radio

4.1.2 Inter-organizational: communication between organizations *dominant media:* public telephone, teletype/fax

4.1.3 Organizations-to-public: communication from organizations to the public *dominant media:* face-to-face meetings, broadcast/print, sirens/public warning devices, on-site representatives

4.1.4 Public-to-organizations: communication from public to organizations *dominant media:* letters to authorities, telephone (911 calls), face-to-face meetings

There could be an approach of having four possible distinct levels of complexity that range from the individual to larger social and organizational system. In a framework for analysis these levels are illustrated by four concentric categories [13]. Commencing at the level of intrapersonal communication, the framework expands outward to include the categories of social interaction, representational communications, and the communications lifeline infrastructure (CLI):

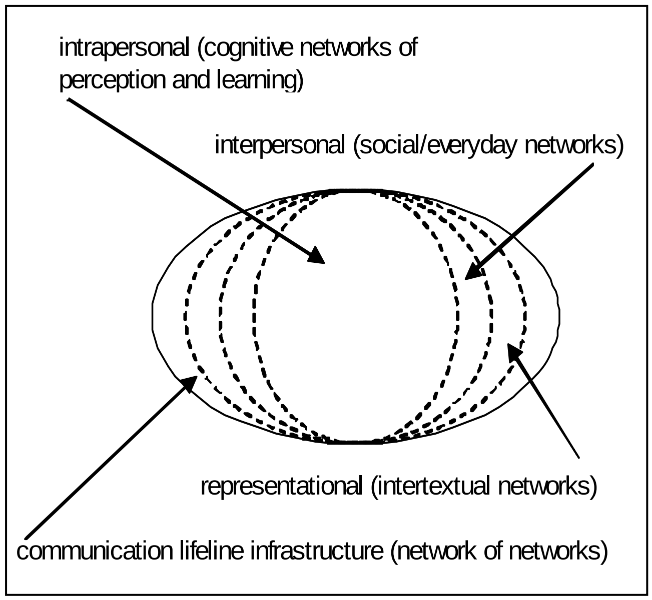

Figure 2: The CLI as a network of networks

4.2 Efficient Networks

Networks include terrestrial trucked radio (as envisaged for the European public safety sector) or satellite technology for wide area communication, wireless LAN ad hoc networks for disaster site hot spots, and personal or body area networks for frontline personnel, allowing them to act as data sources and sinks by means of smart connected devices, e.g. robust mobile terminals and sensors [14].

4.3 Artificial Neural Network (ANN) for Weather Forecasting

Recently, artificial neural network (ANN) has been used for a wide range of different real-world applications. Many complex areas of science utilize neural networks for different kind of learning problem and their derivatives. The ANN technique has been applied to the many communities (i.e.: Malaysia) for forecasting weather data [15]. The potential, ANN posses, is enormous and yet to be utilized with proper algorithm.

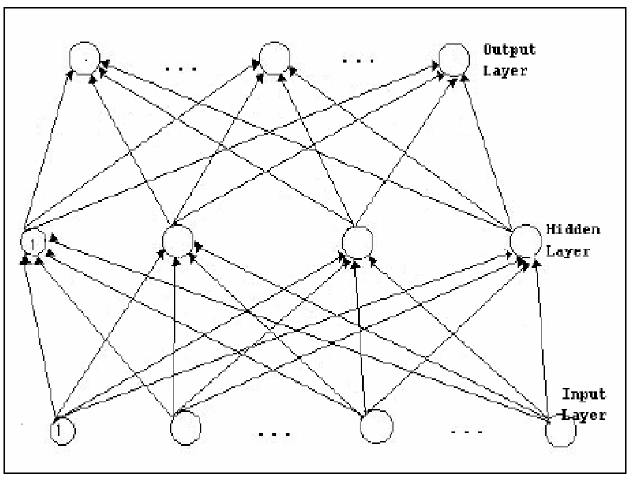

Figure 3: Structure of a neural network with one hidden layer

The values X*i* of the *i*th neuron of the first hidden layer is given by

$$X_i = f\,(\Sigma_i\, w_{ji} O_j + \theta_i\,),$$

Where w*ji* are the weights connecting the jth input neuron (whose value is O*j*) to the *i*th hidden neuron whose activation threshold (bias) is θ*i* and *f* is a smooth and bounded function called activation function. A similar rule applies to the neurons for the second hidden layer as well as output layer. The activation function being used in this work is sigmoid function:

$$f(x_i) = \frac{1}{1 + e^{-(x_i)}}$$

4.4 Effective data mining

Distributed applications for disaster management have to deal with unreliable communication environments, low data transmission rates, and different processing and storage capabilities of the devices used. Hence quality guaranties cannot be given for the communication. On the other hand, decisions in the command posts are based on information received from people working in the critical area. Vice versa, people in such areas act on instructions given by the headquarters. For both sides it is hence important to get complete information, as incomplete information delivery can result in wrong decisions or actions. Furthermore, decisions have to be taken quickly [16].

This means that information and instructions have to be delivered fast. Thus, as outlined in the following subsection, the main challenges for data management in mobile and unreliable environments, especially in disaster situations, are reliability and performance.

Communications technologies, skills, and media are essential to link scientists, disaster mitigation officials, and the public; educate the public about disaster preparedness; track approaching hazards;

alert authorities; warn the people most likely to be affected; assess damage; collect information, supplies, and other resources; coordinate rescue and relief activities; account for missing people; and motivate public, political, and institutional responses

5 Conclusions

Extensive research work on efficient methods of prediction and forecasting would be the next milestones for revising the Disaster Management and Information System. At present many activities concerning the physical hardware setup or software usage has been conducted successfully for the disaster management. However, vast and intense power of ICT has yet to be revised for the accuracy of data acquisition and integration. Using intelligent database and ANN with reviewed infrastructure, currently used in many communities would be a great collaboration of present and the future of ICT in an efficient disaster management. In many cases, the networking infrastructure could well be equipped with Wireless LAN and Ad hoc methodologies for faster and effective output probing the disaster management. Current activities and experiences in disaster communications, such as those associated with the U.N.'s International Decade for Natural Disaster Reduction are in deed playing an important role in global community.

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