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Role of ICT in Disaster Response and Management: A Review Study of ICT Challenges and Adoption Approaches by Developing Nations

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Abstract— Disasters are imminent everywhere and coupled with the impossibility to stop them means a new dynamic approach should be developed to respond to and manage the damages that come alongside, Information and Communication Technologies (ICTs) are useful tools that can be applied. This paper has reviewed various types of disasters by looking at key terminologies, challenges in managing disasters from a technological point of view, ICT tools that can be used in responding to and managing disasters from the context of developing countries with the latest technology being Web 2.0 that utilizes the power of social media and social Networks. The review concludes by proposing the adoption of an efficient E-Government infrastructure that supports various ICTs used in disaster management.

Keywords— ICT, Disaster, Challenges, Adoption, Developing Nations.

I. INTRODUCTION

Advances in Information and Communication Technologies have provided all stakeholders with more ways to seek information during disaster situations and to look for support in the emergency management process. Recent disasters and emergencies have highlighted the role that ICT play in disaster management. With a century old history of investigation, the sociological study of crises is aware that ICT has expanded the reach of disaster sociology, adding new challenges to this area [1] Successful disaster response exercises in managing human resources under very difficult conditions. Catastrophic disasters can disrupt both the physical communication networks and the social networks critical for efficient response and recovery. While [2] notes that a well-designed disaster plan serves as a framework, it often requires communication and collaboration between responders to adapt it to the situation at hand, this therefore means that in order to cope with disasters in a fast and highly coordinated manner, the optimal provision of information concerning the situation is an essential pre-requisite. Since coordination requires current information, and such information must be communicated in real-time, there is need for an Integrated Communication and Information System for Disaster Management that provides efficient, reliable, secure exchange and processing of relevant information [3]. Whereas Climate changes are impressive, the impacts are not negligible, in long terms theses impacts can be consequences for various types of destructive events like natural disasters. Technology adoption and integration in Climate Changes Monitoring, Mitigation and adaptation can help to save environment from destruction and degradation. ICT can play a pivotal role in monitoring, mitigation and adaptation of Climate changes challenges. Both developed and developing countries suffer the impacts of climate change and to get ride off these challenges they are emphasizing use of ICT. Much as developed countries are enrich in using technology in observing climate changes or disaster management, developing countries are still looking at deploying these technologies in climate change and Disaster Management a factor which [4] attributes to insufficient budget, short term planning, lack of awareness, uneducated community, inadequate training and many social, economic and political factors as the main obstacle in deploying and adopting ICT in developing countries.

II. KEY TERMINOLOGIES

According to [5] ***ICT*** refers to "Electronic means of capturing, processing, storing and disseminating information". This means can be further grouped as *"New ICTs":* Computers, satellites, wireless one-on-one communications (including mobile phones), the Internet, e-mail and multimedia generally fall into the *New ICT* category. Most of these, and virtually all new versions of them, are based on digital communication whereas "*Old ICTs"* include; Radio, television, land-line telephones and telegraph. They have been in reasonably common use throughout much of the world for many decades. Traditionally, these technologies have used analog transmission techniques, although they too are migrating to the now less expensive digital format [5].

[6] Defines a disaster as "a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering."

Disaster management- refers to a collective term encompassing all aspects of planning for and responding to disasters including both the pre- and post-disaster activities [6] According to this definition it means it may contain both the risk and consequences of a disaster.

Disaster preparedness- Activities that contribute to the pre-planned, timely and effective response of individuals and communities to withstand reduce the impact and deal with the consequences of a future disaster [6] ICTs play a mojor role by deploying early warning systems espcially in trying to prevent future occurances.

Disaster response-Coordinated activities aimed at meeting the needs of people who are affected by a disaster". [6] By this ICTs can be adopted in locating those in affected areas especially in landslides, floods volcanic erruptions, facilitating communications through setting up direct channels.

III. CATEGORIES OF DISASTER AND DISASTER MANAGEMENT PHASES

Disaster and its management phases can be grouped in five categories, the response and management depends on these categories as [6] presented;

i. **Geophysical:** Events originating from solid earth
ii. **Meteorological:** Events caused by short-lived/small to meso-scale atmospheric processes (in the spectrum from minutes to days)
iii. **Hydrological:** Events caused by deviations in the normal water cycle and/or overflow of bodies of water caused by wind set-up
iv. **Climatological**: Events caused by long-lived/meso- to macro-scale processes (in the spectrum from intra-seasonal to multi-decadal climate variability)
v. **Biological:** Disaster caused by the exposure of living organisms to germs and toxic substances

Table 1: Natural Disaster Categories, Types, and Subtypes

		Hydrometeorological	
Biological	**Geophysical**	**Hydrological**	**Meteorological**
Epidemic	**Earthquake**	**Flood**	**Storm**
■ Viral infectious disease	**Volcano**	■ General flood	■ Tropical cyclone
■ Bacterial infectious disease	**Mass movement (dry)**	■ Storm surge/coastal flood	■ Extra-tropical cyclone
■ Parasitic infectious disease	■ Rockfall	**Mass movement (wet)**	■ Local storm
■ Fungal infectious disease	■ Landslide	■ Rockfall	**Climatological**
■ Prion infectious disease	■ Avalanche	■ Landslide	**Extreme temperature**
Insect infestation	■ Subsidence	■ Avalanche	■ Heat wave
Animal stampede		■ Subsidence	■ Cold wave
			■ Extreme winter condition
			Drought/wildfire
			■ Forest fire
			■ Land fire

Source: UCL, "EM-DAT: The OFDA/CRED International Disaster Database," UCL, http://www.emdat.be.

The Federal Emergency Management Agency, USA divides emergency management into four phases namely: Mitigation, Preparedness, Response and Recovery. These phases are currently widely accepted by all kind of agencies all over the world. [6] it is therefore critical that ICTs should should be embraced by developing countries in all phases of emergency management

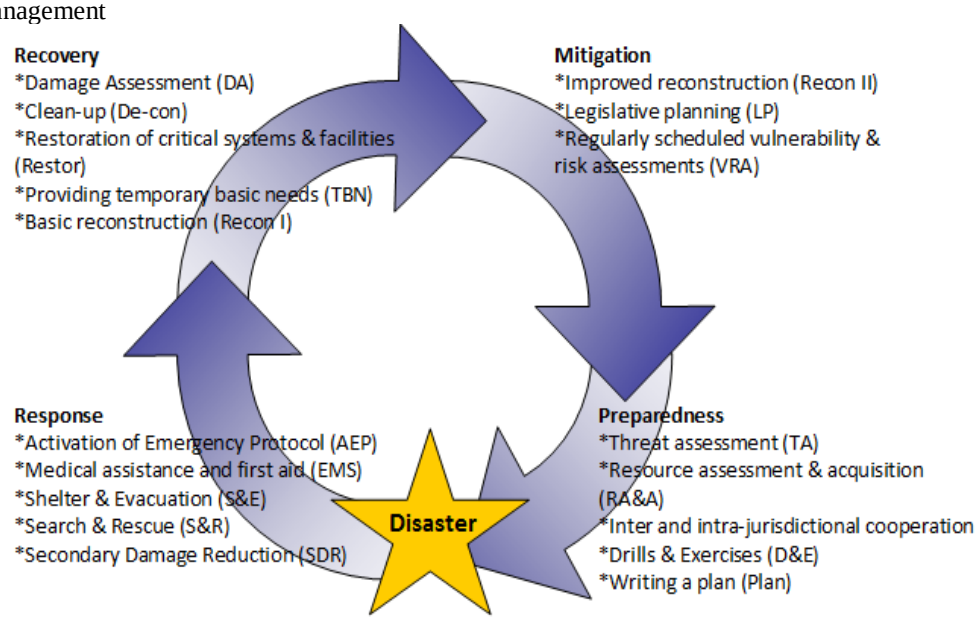

Fig.1: Disaster Management Cycle: *Source:* UCL, "EM-DAT: The OFDA/CRED International Disaster Database," UCL, http://www.emdat.be.

IV. CHALLENGES RELATED TO DISASTERS – THE NEED FOR DISASTER MANAGEMENT

Current day emergency services rely on data communications especially public radio networks like GPRS. Sometimes in disaster situations, even GSM is used for voice communication between relief workers. However, in case of emergency the public networks may get overloaded. So, the use of generally available public networks is not considered to be reliable enough for emergency situations. Moreover, GSM/GPRS is an infrastructure based network, highly susceptible to disasters in small and medium sized urban areas [3]**.** This therefore, demonstrates great deficiencies in all the phases of disaster management cycle because whenever there is emergency situation and response time taken is too long, the result is normally in form of great damages of lives and property hence, disaster recovery and response require a timely coordination of the emergency services. ICT provides a tremendous potential to increase efficiency and effectiveness in this area by propagating information efficiently to all the right locations. While ICTs have a crucial role to play in disaster management, there are tough challenges in making use of ICTs for the betterment of communities, in support of this, [7] presents three phases of information systems that can be used for disaster response which are: the pre-phase addressing the preparations before, the post-phase analysing what happened during the disaster (lessons learnt e.g. for training) and the phase in between, that is the situation during the emergency which should be a center focus for developing countries in an attempt to adopt to ICTs for the response and management of disaster situations.

V. ICT's IN DISASTER MANAGEMENT

Geographical Information Systems (GIS): GIS can provide a valuable support during various phases. During the preparedness and response phases, GIS can support better response planning for determining evacuation routes or locating critical infrastructure and vital lifelines, etc. Based on the information provided by GIS, it is also possible to estimate what quantity of food supplies, bed space, clothes, and medicine. Similarly, GIS facilitates online monitoring of the status of ongoing work in the recovery phase. Thus, planned infrastructure for disaster information dissemination should offer an appropriate mix of communication technologies to respond to diverse requirements [7]. The Utilization of wireless technologies for disaster management and inclusion of GIS platform for holistic disaster management by developing nations can play a crucial role in all phases of disaster management especially where such application is still not wide spread perhaps due to limitation in infrastructure. [8] also maintain that the geospatial aspects of GIS may be explicit, such as topographic maps, providing background information, or implicit, for example demographic data about population distribution in an affected area. In the same way this can also be exploited by using either dedicated tool to analyse or incorporate geospatial aspects such as the usage of a GIS by a Geographical Information expert or the information is integrated via interoperable Geographical services in a specific emergency management application to try and respond or manage disasters.

GSM Networks: In GSM networks one key feature called"marking of origin" plays a significant role in emergency response. [9] In this case the phone number of the caller is transmitted to the network, and the address corresponding to the phone number can be found in the database of the phone network provider by using digital maps and mapping applications, the position of the address can be shown on the map instantly as calls arrive. Such a function is very valuable for the emergency call operator, as the help can be sent in the correct direction more quickly. It is therefore desirable for the emergency call Centre that a location service for cellular phones is established and the location service is called "Mobile Station Location" (MSL) which must be unique within the GSM coverage[9].

Satellite Radio Communications Technologies and Applications-[10] notes that, there are numerous satellite networks in orbit which provide support for disaster relief operations on a global basis, with a wide range of support for voice, data and video applications that enable first responders and relief workers to have access to critical communications when the terrestrial network infrastructure is damaged or the fixed and mobile is overloaded. These can address a wide range of telecommunications requirements including;

- Fixed-to-Fixed (connecting emergency response headquarters to the field)
- Fixed-to-Mobile (connecting emergency response headquarters to mobile response units)
- Mobile-to-Mobile (connecting mobile response units to teams in the air or at sea)
- Point-to-Multipoint (broadcasting critical information to citizens)

This therefore means that such ICTs can provide direct connectivity to remote areas and rapid deployment, short-term solution for emergency response or relief teams, and enable interoperability among user groups and between different systems and networks. [11] Argue that importantly, satellite services are invaluable in developing countries where infrastructure may not have high levels of built-in redundancy to protect it from disasters, and in remote and rural areas where terrestrial networks may not be available. In the case of a disaster, satellite applications offer reliable solutions that should be incorporated in some way into disaster telecommunications management plans.

Web 2.0 - Web 2.0 is a stage of development of the Web, a step forward from Web 1.0 characterized by top-down communication and communication from one-to-many, technologies enabling effective communication for both improving human knowledge and fostering collaboration. It tries to sort out the inherent information problem – that there is a huge amount of information on the internet that is sometimes difficult to find, retrieve and make sense of - and it proposes a changing model of communication which is a many-to-many. Web 2.0 tools and services – such as Folksonomies, RSS feeds, blogs, wikis and social networking applications – create an environment tackling the information problem that can be a key challenge in disaster management. In other words, it has depicted a new way in which technologists and users started to use and design the World Wide Web (WWW) as a platform[12].

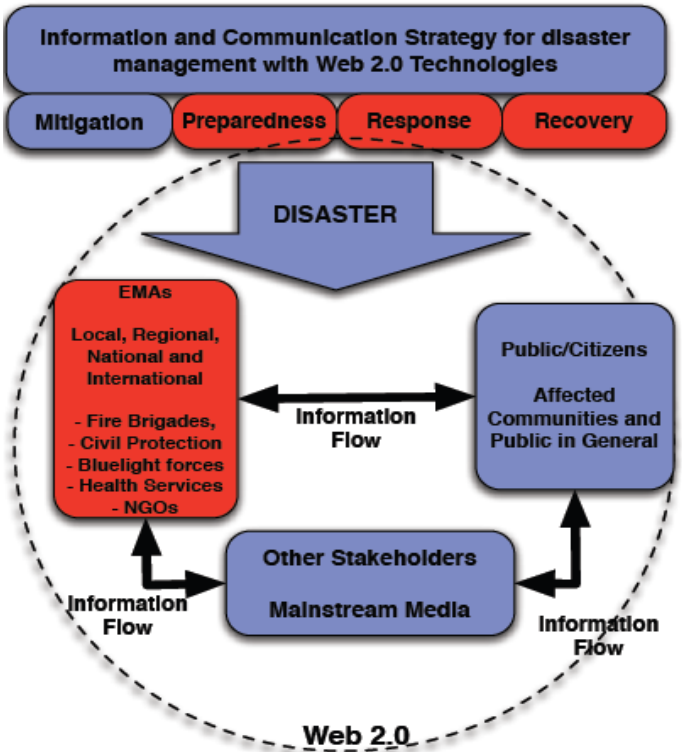

Fig2: Framework of the Disaster 2.0 project Source: Emergency Management Agencies use and adoption of Web 2.0 http://www.disaster20.eu

The domains of usage of web 2.0 in disaster management

From the framework presented in Figure(2) one can deduce that there are several domains of this technology, Twitter is one of them offering a free, platform-independent, Web 2.0 communication application that allows users to send short up to 140 characters electronic messages to other individual users and user groups. Users of Twitter can send messages to one another via most internet-enabled devices capable of text messaging. This new and unique service offers great potential for rapid and integrated response to disasters [13].

Social Media: As with Web 2.0, the fundamental feature of Social Media is the cultural shift that changes one-way or "linear give and take" communication into two-way communication or "collaborative discussion"**.** [13] This cultural shift enables information sharing of any disaster related events

Social Network Sites

The use of Social Network Sites (SNS) has been one of the most innovative applications of Web 2.0 tools in disaster and emergency management. Though it is a controversial term as it is often used synonymously with Social network which is a network of social interactions and personal relationships including off-line exchanges, and with Social Media, [14] define Social Network Services or Sites (SNS) as a websites or applications which enable users to communicate with each other by posting information, comments, messages, images, links, etc. and further outlined how SNS are "web-based services that allow individuals to;

- Construct a public or semi-public profile within a bounded system,
- Articulate a list of other users with whom they share a connection,
- View and traverse their list of connections and those made by others within the system.

Such web-based services plays a pivotal role in all phases of disaster management as it facilitates information sharing for emergency response teams and the areas affected, this is a new dimension of ICT's in disaster Management.

VI. CONCLUSION

It is understood that disaster cannot be eliminated from the earth but effective management and response can save thousands of lives and property. As natural disaster occurrence increases, ICTs should be utilized to try to respond and manage its effects on environment and human. This review has covered various types of disasters that face human beings as seen, different ICT tools that can be used to respond to them with the most recent being the Web 2.0 that has just emerged. From this review it is worth noting that for effective disaster response and Management, developing countries should establish and adopt an E-government Infrastructure that embraces Various ICTs as those discussed above but notably should encourage the use of web 2.0 that presents a more reliable platform for information sharing and with most of the population adopting the use of mobile phones which can access internet, this technology offers a cheaper platform for information sharing than any of other technologies used in Disaster response and management. Use of web-based social networking services, such as Twitter or Facebook, has increased and matured sufficiently to suggest that local and

government agencies could engage residents' participation before, during, and after major disasters through reporting incidents and receiving emergency information that would facilitate coordinated responses with emergency services. This can be achieved if developing nations establish and adopt an effective E-Government infrastructure that incorporates at its center all relevant technologies that are geared towards coordinating information related to disasters.

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