Regional Perspectives on Digital Disaster Management in Latin America and the Caribbean

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I. Introduction

In January 2005 the World Conference on Disaster Reduction (WCDR) was realized in Kobe, Japan. The fact that the Conference was held only weeks after the tragic tsunami that took place in the Indian Ocean region on 26 December 2004, allowed the WCDR to gain a significance that few would have predicted only some weeks before. The conference aimed at defining clear plans for future progress. One outcome was the Hyogo Declaration. Another momentous approach to further commitment was fostered with the adoption of the Hyogo Framework of Action for 2005 – 2015. The WCDR once again highlighted what a problem recognized by the global community in a series of political declarations since the Earth Summit of Rio de Janeiro in 1992: The industrial development of the 20th century has put severe pressure on the environment. One major consequence of this is an increased vulnerability to natural disasters. This trend is likely to rise due to factors such as ongoing land-use changes, settlement in risk-prone areas, increased urbanization and location of strategic, economically important activities in coastal areas (oil extraction, tourism, etc.). Another non-negligible factor is the global climate change. The Intergovernmental Panel on Climate Change (IPCC) in line with manifold organizations, institutions and scientists states that an increasing body of observations gives a collective picture of the warming of the world and other changes in the climate systems. Temperature rise, sea-level rise, precipitation change, and an increasing number of droughts and floods will certainly impact human and natural systems such as food and water resources and human settlements (IPCC, 2001). The anthropogenic climate change can therefore increase the risk of weather-related disasters.

Meanwhile, the creation, processing, gathering and dissemination of information reached high levels of sophistication. It is often declared that our world has now entered the “Information Age”. This term does by no means imply that before no information flow took place. Ever since their existence, Homo sapiens were capable to exchange information. Information was communicated by deploying numerous communication tools and pathways. What has been changed, however are the ways of addressing information and the paths of information trade. Today nearly all information can be digitized and new Information and Communication Technologies (ICT) have experienced tremendous growth during the past decades, due to their qualitative improvements and decreased costs. In almost all sectors of modern society ICT is applied. In order to be able to adequately deploy these new tools, it is essential that it is relevant to the existing conditions in society. Wisely applied though, these technologies can fulfill both

functions: to enable and to facilitate directly (or indirectly) the approximation to a given problem (Haqqani, 2005). The rapid evolution of ICT therefore also offers a variety of opportunities to make use of these technologies in time where disaster management is required.

Recent experiences have shown the vast potential new communication tools offer for the facilitation of rescue efforts as well as regional and global mitigation, they also, however pointed out the weaknesses and limitations of information flow. The most prominent example may be the tsunami in the Indian Ocean on Christmas 2004 (ITU, 2005a). It is illuminating in two ways: It shows the inadequate use of available information to promote early warning and response on one hand and on the other hand, it revealed how after the event digital ICT allowed the replacement of fixed phones and traditional communication channels. At the heart of the devastation caused by the tsunami lies a failure to communicate scientific information adequately to either decision-makers or the community. Seismologists from as far away as Australia and the USA instantly detected an earthquake off the coast of Indonesia, and due to past experiences, predicted a major Tsunami. Without direct channels of communication to policy-makers, local decision-makers and the endangered communities, however, there was no way that the information could be communicated to the tens of thousands whose lives could have saved if the information had reached them in time (Dickson, 2005). Following the disaster, ICT became an essential component of rescue and response. The massive use of mobile phones and internet (including SMS and e-mail) facilitated relief efforts and the coordination of Humanitarian Aid Organizations and volunteers. The internet enabled people to contact their families and the posting of digital photos assisted in identifying injured people and lost children and assisted in reuniting families. Donations were requested through the websites of aid agencies and individual contributions were collected through electronic transfers in real-time. The global community in 2005 didn't ever have time to recover from the tsunami, before it was confronted with another series of catastrophic disasters: the earthquake that shook Pakistan and India in october, Nigeria had to face a famine after crops were destroyed by locusts, the United States was confronted with the most unrelenting hurricane season in recent history, Mexico hit with the passage of three hurricanes in a short period (Emily, Stan and Wilma), Guatemala and El Salvador having to deal with hurricane Stan and with the eruption of volcano Ilamatepec simultaneously.

The common call to make Latin America and the Caribbean more disaster-resistant is already reflected by a variety of statements and commitments made demanding the strengthening of the resilience of the region and its nations. This is a multilayered, multi-disciplinary, and multi-stakeholder undertaking. The deployment of ICT represents one integral approach, which is manifested in action item 18 of the Plan of Action for the Information Society in Latin America and the Caribbean eLAC2007: "Strengthen the regional and international interconnection of digital information networks for disaster prevention, while considering regional administration and coordination of assistance in the event of disasters" (ECLAC, 2005a). By researching potentials and impediments to apply new communication tools in the field of disaster works, the present study aims at supporting countries in the implementation of this ambitious undertaking.

Within this scope, the paper firstly defines disasters in their relation to Latin America and the Caribbean. Following this, the paper discusses, some basic requirements of disaster-related information conducted by ICT are discussed. The results model a three-layered approach to ICT use in disaster-management, which will be investigated by its single constituents and proximately lead to future challenges regarding the topic.

II. Disasters and ICT

Disasters are the result of hazards, people's vulnerability to those hazards and the resilience of the socio-economic infrastructure to these violent occurrences. A hazard turns into a disaster when a severe disruption of the functioning of a system (be it natural or man made) that interacts with the community or a society is provoked by widespread human, material, economic or environmental losses, which exceed the ability of the affected community or society to cope using its own resources. The complex dynamic of a variety of social, cultural, economic, and environmental factors make up the risk associated with and the susceptibility of loss to these catastrophes (UNISDR, 2004).

There are many distinct types of hazards that can provoke disasters: Technological (such as oil spills), biological (such as pandemics), geophysical (such as earth quakes) and hydro-meteorological (such as hurricanes). The latter three are often referred to as "Natural Hazards" that potentially turn into "Natural Disasters". These terms are somewhat delusive as there do not exist disasters that are natural nor are most hazards entirely natural. Disasters and indeed always only take place when there is an interaction of society with natural occurrences. To put this hypotesis more simply: No humans, no disasters. And even many so-called natural hazards are result of the interference of mankind with nature. The terms "Natural Hazard" and "Natural Disaster" therefore have to be used with caution. This paper will apply the term "Natural Hazard" corresponding to the definition of the United Nations International Strategy for Disaster Reduction (UNISDR), which defines natural hazards as hydro-meteorological, geophysical and biological occurrences in the biosphere that may evoke a damaging event, by taking into account that they are a result of the combination and interaction of natural factors and human activity (UNISDR, 2004a). Natural disasters in this scope are the result of the impact of these hazards and its interaction with socio-economic vulnerability.

Not neglecting the severity of technological and biological hazards, the following paper will emphasize on examples of geophysical and hydro-meteorological hazards and the disasters they potentially evoke. Geophysical hazards are generally sudden events accompanied by a high release of energy and difficult to predict to a high level of certainty.

Hydro-meteorological hazards on the other hand are principally connected to a slow release of energy and may be predicted with much greater accuracy.

Whereas the occurrences in the hemisphere that can crystallize into hazards and subsequently the hazards may not be prevented, their impact can be reduced. The risk of hazards is lowered or prevented by acting on the exposure of vulnerability to those hazards. This available possibility for prevention and mitigation of disasters is mirrored in the comparison between developed and developing countries. For example, despite similar seismic characteristics and overall disaster vulnerability, the average annual death toll from natural disasters in Japan is under 100 while in Peru it is nearly 3000 (Parker, 2004). An often-cited fact is that 90% of the three million people killed by natural disasters in the past 20 years lived in developing countries (WMO, 2005). These catastrophes pose an omnipresent threat to Latin America and the Caribbean. The Economic Commission for Latin America and the Caribbean (ECLAC) estimates that more than 150 million people have been affected in the region by over the past three decades (ECLAC, 2003). This includes more than 12 million direct victims and 108,000 deaths. Hurricane Stan, to name only one of the many hurricanes of the 2005 season,[1] destroyed the homes and livelihoods of thousands of Guatemalans with isolated indigenous communities being the hardest hit. The hurricane, related floods and mudslides affected about 1.5 million people (WFP, 2005)[2] and left 1,583 to die in its wake (ECLAC, 2005b). The total economic losses are estimated to constitute 3.6% of the Gross Domestic Product (GDP) of the preceding year.[3] Losses from disastrous impacts can even exceed GDP by far, as was the case in Grenada in 2004, where the total impact of economic damage and losses by hurricane Ivan amounted to more than twice the GDP of 2003 (Zapata Martí, 2005, and World Bank, WDI-html). While Latin America and the Caribbean have been hit badly by these recent hurricanes and their related effects, the region is prone to a variety of other natural hazards as well. Out of the 15 countries most exposed to multiple hazards, seven are located in Latin America and the Caribbean (World Bank, 2005). Natural hazards threatening the region include earthquakes, volcanic eruptions, and tsunamis (which are geophysical hazards) in addition to hurricanes, floods, mud/landslides, and droughts (which are hydro-meteorological hazards).

One elementary pillar of disaster mitigation and response is the management of relevant information. The Pan-American Health Organization (PAHO) points out that the efficiency of humanitarian response to a disaster and the number of lives saved is directly related to the ability of an organization to compile, analyze, and distribute information (PAHO, 2005). The overall goal therefore has to be a guarantee of the transmission of adequate information. Per definition, the most powerful tool to foster the flow of information and communication processes are ICT (Information and Communication Technologies).

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[1] Succeeding the 2004 hurricane season, which caused severe damage in the region, the 2005 season was even more severe with 27 named tropical storms, 13 of which were hurricanes, and three of those were category 5 on the Simpson-Saffir Scale.

[2] The WFP (2005) estimated that by Christmas 2005 the number of people facing a severe food crisis might be as high as 285,000 and with that in mind launched non-stop food aid throughout December and January to more than 60,000 families.

[3] The total losses as a sum of direct damage and indirect losses are estimated at USD 988 million. The total losses in the USA caused by Dennis, Katrina and Rita add up to 200,000 million. That is an approximate 1.7% of the GDP of 2004. Thus, hurricane Stan in Guatemala caused more than two times the economic losses relative to the GDP than the three equally violent and devastating hurricanes in the USA (ECLAC, 2005b).

Applications such as voice messaging, cellular and satellite telephony, and telephone conferencing -all of which could be beneficially deployed in disaster management- are among the newer services available on the market. Even though these are mainly low-cost services,[4] they are still not available in all areas of Latin America and the Caribbean (ECLAC, 2005e). Even in cases where they are available, their effective and efficient application in disaster management is not an automatic process. This very multifaceted problem is also attributed to the fact that ICT, in line with other critical infrastructure (transportation, handling of hazardous materials, banking and financing services), is becoming increasingly complex and interconnected. This poses new challenges for reliable management and operation procedures, particularly because the effectiveness of the risk bearing infrastructure -amongst them ICT- can lead to manifold levels and types of socioeconomic and environmental impacts.[5] Consequently, there is an overall demand to make disaster management ICT more reliable and resilient to hazards present in the region for the safeguarding of information and communication in emergency situations (PAHO, 2000).[6]

[4] Contrarily to the other mentioned services, satellite communication remains quite expensive. Whereas the equipment itself might not be that expensive, connecting to the network still is.

[5] Emphasis in disaster management was historically laid on the performance of inhabited infrastructure in order to avoid direct damages and losses. As understanding of indirect and secondary disaster damage increases (ECLAC, 2003), it becomes more and more evident that resistance and/or rapid recovery of networked infrastructure service systems is fundamental to reducing the impacts of natural hazards (DRM, n.d.).

[6] It must be taken into account that meteorological hazards (such as hurricanes) are fairly predictable whereas geophysical hazards are less so. Although geological disasters contribute to only about 15% of all recorded events between 1994 and 2004, they caused one-third of the 300,000 fatalities globally in this time span (UNISDR, 2005a).

III. Management of Disaster Information

The overall goal of disaster management is to keep socio-economic and environmental losses as low as possible. Public policies and legal framework, awareness building and education, early warning and well organized emergency bodies, environmental monitoring and protection of ecosystems with protective functions: all these are just a few of the integral points on the long agenda of disaster management. One basic requirement can be extracted in the managing of disasters: the management of information. Only with the provision of disaster information (which includes information on the territory, the kind and timelines of hazard and probable disaster, the actions to be taken prior, during and after the impact) disaster management can become effective. What must be realized is that the four W's are answered: Who takes When and Where What kind of action? This question appears simple, disaster management is not and often times the answer remains incomplete. The more efficiently the question is addressed and the closer its answer moves towards a holistic concept, the lower the vulnerability towards a disaster will be. Newly evolving technologies are certainly powerful tools and effectively applied they can facilitate managing disaster information. These technologies can be contributable in any aspect of disaster risk reduction.

The fact that there is still a lack of effective disaster management and operation procedures in the region becomes obvious with a mere glimpse at recent history. It can be observed that often national and regional communication structures and networks come under stress and are subject to failure under emergency situations, such as severe weather conditions during a hurricane, when communication is the most crucial. When hurricane Ivan made landfall in Grenada in 2004, the island state was practically unable to communicate neither internally nor externally.[7]

[7] Vulnerability to disasters varies greatly even in the same region exposed to the same natural hazards. Comparing the reactions of Grenada and Barbados to Ivan, the Barbadian response appeared to be much more coordinated and effective. Radio and television broadcasts were kept up during and after the impact and cell phones were used in the communities as the primary communication and coordination tool between the 30 District Emergency Organizations covering the whole island. In contrast to Grenada, Barbados was not hit directly by the storm and it is likely that the island might have been reduced to a similar level as Grenada by a full strike. Still, the dissemination of information and communication

3.1. Basic Requirements for Disaster-related Information

To communicate disaster-related information a variety of operational and technological aspects have to be taken into account. The use of ICT has to guarantee that the information fulfills the following basic, yet important needs:

- To reach a defined addressee
- To be comprehensible
- To be multi-sourced
- To be relevant
- To be on time
- To be reliable
- To be standardized

By giving an example of each of these basic requirements, the following sections will take a closer look at the different dimensions of the digital disaster management challenge.

3.1.1. Information and the Addressee

This point combines two crucial issues: How to define the addressee and how to ensure that information reaches the targeted addressee. Primarily, the intended addressee must be defined. This addressee will very probable not remain the same person/group throughout the whole progress of disaster management. It is very probable that the addressee will not remain the same person/group throughout the whole process of disaster management. so that the information therefore is passed to multiple changing addressees. With this changes the form of transmission and content of information.

Secondly, it has to be warranted that the information gets through to the addressee being focused on. Certainly, information flow can be interrupted by a variety of preconditions and incidents. A consistently important factor is, whatsoever, the durability of outdoor devices and shall serve as example in the following: Telephone poles are especially vulnerable to strong hurricane winds, which affect the transmission lines through breaking or knocking over the poles, as can be other physical infrastructure as cuts in underwater cables in the occurrence of tidal waves, damage to antennas given wind force, climatic disruption of wireless communications, etc. For cost reasons, telephone poles for instance, are often made of wood.[8] In addition, telephone wires are costly to install, time-intensive to maintain and difficult to repair (these problems intensify in rural, remote areas). Often in rural communication, if one pole is incapacitated, all communication past this point is some way affected. Since not only electricity lines but, in many cases, also generators and streetlights are attached to one single pole, the outage affects other critical infrastructures as well. Still, in many countries neither legal requirements, nor technical standards exist on how to set up these poles.

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resulting in the emergency work that took place appeared to be more effective in Barbados then in Grenada (CIVIC, 2004a).

[8] The World Institute for Disaster Risk Management (DRM) points out the problem of balancing public interests in reliability of service (including disaster survivability) and market pressure to reduce prices. This is inhered by the fact that many infrastructure systems formerly owned and managed by the public sector are now subject to privatization and, in turn, reduction of public regulations (DRM, n.d.).

3.1.2. Information and Comprehensibility

Effective information transmission not only requires a sender and a directed channel, but also a recipient that understands the message. Without prior education on the topic, it is likely to be misunderstood, misinterpreted, or simply ignored. Ongoing public awareness rising and education for all ages and segments of the population, as was the case with *radionovelas* in Central America,[9] is another important basic aspect of digital disaster management. This goes beyond familiarizing the public with standardized disaster vocabulary, and also concerns knowledge engineering and the continuous training of experts. The Caribbean Disaster Emergency Response Agency (CDERA), in cooperation with the corresponding National Emergency Management Agencies, facilitates workshops on Emergency Telecommunications throughout its 16 participating states.

3.1.3. Information and Multi-Sourcing

The CDERA workshops focus on the use of radio communication and satellite telephone communication (CDERA, 2005). These are two very distinct (analog *vs.* digital) yet very useful tools in disaster management. It is advantageous as well as advisable in disaster management to use more than one ICT application. This multi-sourcing of emergency communications is for two reasons: on the one hand it diminishes the possibility of failure of all sources and on the other warning messages are more likely to be taken seriously and reacted to if they are received through different channels. Reverting to existing communication structures (radio communication) and making them more effective in disaster management may be one part of the solution. Integrating newly evolving technologies (satellite telephone communication) in disaster management may constitute another.

3.1.4. Information and Relevance

The fact that bits and bytes reach the addressee does not necessarily indicate their usefulness. In the worst case, they could be irrelevant for the addressee, uninformative, or even entirely false. The information has to meet certain qualitative requirements.[10] Despite significant progress in technical and operational aspects of data processing and emergency communication,[11] much disaster-related information remains partial, dated, sporadic or fragmented. There may also be an

[9] These *radionovelas*, called "*Centroamerica en Sintonia*", were made possible by an interagency initiative of international organizations. The two novels "*Tiempo de Huracanes*" in 2001 and "*Réplicas en el Corazón*" in 2003 were broadcasted by 46 and 86 community radio stations respectively in Costa Rica, Panama, Nicaragua, Honduras, Guatemala, El Salvador, Peru, Cuba, the Dominican Republic, and Mexico. Due to their success an *audionovela* was prepared for the Caribbean Community in 2005.

[10] Otherwise its consumer may be confronted with the so-called information overflow, or information smog, which is characterized by the following attributes: Too much information, the inability to understand the information, the unawareness that the information exists, the inability to find the information, the inability to access the information, and the doubt if the information is accurate (SRINIVAS, n.d.).

[11] The Pacific Tsumani Warning System (PTWS), as just one example, is tasked to monitor seismological and tidal stations throughout the pacific basin in order to evaluate potentially tsunamic earthquakes and to disseminate tsunami warning information. It is part of an international cooperative effort. Amongst the 26 member countries are the eight Latin American counties Chile, Colombia, Costa Rica, Ecuador, Guatemala, Mexico, Nicaragua, and Peru (PTWS, n.d.). In Mexico City the earthquake alarm is linked to real time monitoring of tectonic plate movements and energy release in the Pacific coast in front of Acapulco. The constant monitoring of the Popocatepetl volcano is also realized in real time.

abundance of available information[12] leading to the paradox of disaster-related information: There seems to be too much and too little of it simultaneously, necessitating the ability to make a coordinated exchange of useful information. In this context of inadequate information, the Caribbean ICT Virtual Community (CIVIC) was the example of Trinidad and Tobago during hurricane Ivan, in which the media prepared the population for evacuation to the emergency shelters but neglected to describe where the shelters were. The information also wasn't easily accessible on the website of the National Emergency Response Agency (CIVIC, 2004a).

The other extreme is that relevant information is not passed or that its existence and importance is simply not known. Integrated into the aspect is the knowledge of the terrain: Knowledge on watersheds, river basins, mountain systems etc. is essential to understand the causes and effects of events that are able to trigger disasters. If neither the authorities nor population are aware of a threat, the population may remain highly vulnerable to possible impacts. One example could be the migration in Peru that is directed from the Andean region to the lower laying jungle. Long time residents of the region have traditional knowledge on the watershed of the Amazon and its tributary streams, as well as it's soil properties. Information the newer parts of the population may not have and which might even lack local authorities. Not being aware of possible threats common to the region such as landslides and flooding that might be triggered or intensified by their actions (erosion due to deforestation and mismanagement of the delicate soils) the growing population in those areas is exposed to a high vulnerability to disasters thit could tremendously reduced by specific knowledge on the territory and subsequent behavior that is orientated towards sustainability.

3.1.5. Information and Timeliness

ICT and its devices not only need to ensure that the right kind of information is delivered to the right recipients, but also that it is delivered at the right time, as seconds can make the difference life and death in a disaster situation. The public needs to be informed about the approaching event. In its aftermath, communication amongst response teams and between them and the public is vital so that proper planning of evacuations and relocations can take place. The eruption of Ilamatepec and the consequences of persistent torrential rains causing rivers to overflow and devastating mudslides triggered by hurricane Stan in Mexico, El Salvador and Guatemala that followed underlined the importance of timeliness. Succeeding these events, the government agencies of the affected Central American countries organized several disaster communication workshops with the media, social communicators and public institutions in which the important role of quick information dissemination was highlighted as one of the most important aspects (PAHO, 2005). Yet it must be noted that any kind of pre/post-disaster training and lessons learned workshops are insufficient if clear protocols, lines of command/control and decentralized response procedures are not established and tested.

3.1.6. Information and Reliability

The commonly referred to example regarding the consequences of an irresponsible child joking with a false fire alarm is another omnipresent aspect of disaster related information. Incorrect information might lead to a lack of trust and adverse future reactions, especially in countries where confidence in official institutions is already wavering. Once trust is broken, it is difficult to rebuild, particularly in the case of disaster management, which is related to security and the fears of the public. To give an example: According to a study, an 41% of Guatemala's population in

[12] A study conducted by Berkeley University estimates that in 2002 the yearly produced information could have exceeded 10^{18} bytes, which equals all words ever spoken by human beings (LYMAN ET AL., 2003) making the processing of such tremendous amounts seem impossible.

the community of San Sebastian fear that public institutions may misuse disaster prevention to increase control over the people (Voss, 2001).

3.1.7. Information and Standardization

As disasters do not recognize national frontiers, various national, regional, and international personnel are usually involved in disaster relief work. To ensure that information reaches these stakeholders it has to be standardized, i.e. interoperable. One big step in international coordination was the Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations.13 The treaty simplifies the use of live-saving telecommunication equipment. Until then, regulatory barriers made it extremely difficult to import and rapidly employ telecommunications equipment for emergencies without prior consent of the local authorities, impeding the trans-border use of telecommunication equipment (ITU, 2005b).

Another more specific example is the Common Alerting Protocol (CAP) v1.1. which was launched by the Organization for Advancement of structured Information Standards (OASIS). CAP is a universal adaptor for alert messages and functions as both a standalone protocol and a payload for standardized emergency messages. It allows a consistent warning message to be disseminated simultaneously over many different warning systems. Thus, just one single CAP message can be used to trigger sirens, the Emergency Alert System, Weather Radios and telephone notification systems. The format is compatible with emerging as well as with already existing technologies (OASIS, 2005).

3.2. Operational and Technological Aspects of Disaster-Related Information

A similar breakdown of information flows as experienced in Grenada, though not as severely, occurred in October of 2005, when both hurricane Stan in Guatemala -as the eruption of Ilamatepec in El Salvador- impacted the communication of the two Central American countries (ECLAC, 2005c and 2005d). Assessing the socio-economic damages of the above disasters, ECLAC found the communication infrastructure to not be severely damaged. Nonetheless communication experienced momentary disabilities and interruptions. If the physical structure of the ICT such as telephone towers, and other satellite or wireless systems, was hardly harmed it has to be asked which additional aspect hampered the communication flow. Other obstacles to effective management of information is inappropriate communication between stakeholders, victims or affected population. It can be concluded from the above-described experiences that the challenge of the effective application of ICT in disaster management is two-fold. The problem relates to the tools used to process and disperse disaster-related information, as well as the content and addressee of the information itself. It is therefore of use to distinguish between the two different aspects of disaster information management: The technological and the operational aspects.

All the basic requirements of disaster-related information posses both technological and operational aspects. If the physical ICT infrastructure is incapacitated transmission becomes impossible. However, even if the infrastructure is working to 100% it is still no guarantee that disaster information spreads or will trigger appropriate action. The information may not even be

[13] The Convention was adopted by delegations of the 60 states participating in the Intergovernmental Conference on Emergency Telecommunication (ICET-98) in Tampere, Finland, 1998. It came into force in 2005 by the ratification of the 30th state (ICET, 98)

sent because the sender may not know who the adequate addressee is, as happened with the tsunami in the Indian Ocean It must therefore be defined who the intended addressee is. The addressee will very probable not remain the same person/group throughout the whole progress of the disaster management. It is very likely that the addressees targeted will vary and that the information will be passed to multiple changing addressees. This transforms transmission and mode of information, which then has to vary accordingly in relation to criteria and purpose in order to remain relevant, on time, understandable, standardized. Once again to cite the example of the tsunami catastrophe: earlier in this paper it was stated the failure that relevant information had not been sent by seismologists. Even if it has been sent, it did not reach the persons in need of it. The International Tsunami Center in Hawaii sent information to its scientific counterparts that met most of the stated requirements: It was relevant, reliable, on time, multi-sourced, understandable and standardized. Since the corresponding offices were not operational 24/7[14] and, depending on the institutional structure of each country, had different insertion and connection to the emergency response mechanisms (or institutions) there was no automatic or guaranteed flow of this information to the latter, had been no early warning preventive mechanisms being set in motion and affected communities and countries remained unaware until it was too late. To clarify: an early warning system has a set of addressees but even that is not enough, procedures and protocols leading to that information being acted upon are not a technological but an organizational / institutional and cultural response issue, as to say on operational aspect.

Another example is the timeliness in availability of information and lack of timeliness in acting upon it as exemplified by response to Katrina and its aftermath in New Orleans and other coastal cities of the US such as Biloxi in Mississippi (see box 1). Whereas the whole world knew of the impeding disaster through CNN organizational inconsistencies and lack of clear automatic response mechanisms through the several layers of governmental institutions from the local order to the federal one led to inappropriate or untimely response this therefore highlights the importance of operational aspects.

BOX 1: THE CASE OF KATRINA
THE CASE OF KATRINA: BAD CASE SCENARIO?

Major disastrous events often times provoke a fragmentary or even interrupted communication. Once the flow of appropriate information is not realized, vulnerability to a disaster rises. This can subsequently cause higher numbers of loses in the aftermath. There are various reasons for a shortcoming of communication, of technological and operational nature, throughout all the stages of the disaster management cycle and throughout all layers of stakeholders.

The case of one of the severest natural disasters in the US, hurricane Katrina hitting the city of New Orleans, will therefore only serve as one example. Communication problems in New Orleans occurred prior, during and after the impact, impairing rescue and relief efforts. Fragments of the city's population remained insufficiently informed about the oncoming event and actions they should take. During the hurricane it was near to impossible for the remaining people to make themselves heard and when the hurricane had passed, it left a scenario of destruction behind. The city was flooded, infrastructure, amongst it telecommunication infrastructure, was incapacitated. Search and rescue was exacerbated as affected persons could note communicate their location and/or communication tools of the rescue workers were impaired or the workers encountered difficulties in reentering the city and repairing damaged structures.

Being located in an area prone to hydro-meteorological hazards the city is susceptible to disasters such as flooding. This vulnerability is caused by a number of preconditions. An important one certainly is that great parts of the city, which is surrounded by bodies of waster, lie below sea level. New Orleans is encircled by the Mississippi River to the South, Lake Pontchartrain to the north and Lake Borgne to the

[14] 24 hours a day, 7 days a week

east. Given that the extensive system of levees today appears antiquated as it had not been designed to withstand high wind forces and taking into account that it has been rather poor maintained over time, the city's capacity to cope with outstandingly severe hazards appears limited.

Unfortunately, that proved to be the fact on August 29, 2005 when the category 3 hurricane Katrina made landfall striking the states of Louisiana and Mississippi, badly hitting the city of New Orleans. One day after, about 80% of the city was flooded due to levee breaches, some parts up to six meters under water.

The strength of the hurricane and the proximate flooding provoked a breakdown of communication. Its shortcoming hampered rescue and its coordination in three different manners: The communication amongst the population, amongst rescue workers and the communication between affected population and rescue workers was cut. Crucial information like data on missing persons, number of injured etc. could therefore not be circulated. This outage was provoked by a combination of technical and operational weaknesses.

In the aftermath millions of residents were left without phone service and other media of communication. The telecommunications "infrastructure in New Orleans, Biloxi, and Gulfport is considered to be total write-off. ", as a memo from the Homeland Security Dept. stated. "Electric power is gone. Drinking water is gone. Sewage service is gone. Roads are destroyed. Tens of thousands of homes are buried in contaminated floodwaters. The dead -still uncounted- float in drowned neighborhoods or lie pinned beneath debris." (http://www.washingtonpost.com/wp-dyn/content/article/2005/08/31/AR2005083102758_pf.html.)

Vast areas across the Gulf Cost, from Louisiana to Florida, had neither landline nor wireless phone service. The biggest phone company in the region estimated that 750,000 of its customers in the areas most heavily affected were impacted by the breakdown of landline service. Since thousands of switches and cell towers that form the region's telecommunications network were inaccessible or left without power[15] if they were not demolished millions of cell phone customers were thought to be without connection as well. Furthermore, even if the equipment at the towers was running without landline connectivity to it there was basically no getting through. Many of the New Orleans residents with a 504 number for instance were unable to receive calls on their cell phones even if they had left the region. That was provoked by disabled switching stations in the city. Since all cell phones have a home switching office, which keeps billing and switching data, the incapacitated stations were unable to route the call.

Additionally, a collapsed bridge once crossing Lake Pontchartrain, was not only one of the main roadways into New Orleans but also held fiber-optic cables that transported calls and Internet traffic to and from the city.

Rebuilding was also correlated to the allowance to reenter the city as well as de-flooding and commercial power restoration and safety problems rather than to the restoration capabilities of the communications operators.

That was not only fact for private communication and communication between rescue workers and affected population. Also the communication between the various rescue helpers failed. One example is the operation of the New Orleans police radio system, which in the wake of the hurricane had been affected not only by floodwaters but also by a lack of natural gas to power generators. Accessory to these technical failures appeared operational drawbacks: It was reported that the state police turned away radio repair technicians attempting to enter the city, even though they had letters from the city police authorizing their access.

In some areas, the disconnection left emergency responders even less prepared for the succeeding hurricane season. By January, 2006, voice communications for emergency personnel in New Orleans had still not been restored to pre-storm levels.

The above-described problems brought to bear by the hurricane were many of the same problems that plagued rescue workers during the September 11, 2001 terrorist attack in the US or in the areas affected by the Asian tsunami December 26, 2004, and are certainly actual for disasters probable to occur in Latin America and the Caribbean. They illustrate the importance of establishing regulations that guarantee a robust communications infrastructure in times of such impacts, and equally important, a distinct plan of action for all stakeholders in case of national emergencies.

[15] With power outages in many parts of Louisiana and Mississippi, the switches and any infrastructure that runs the telecommunication networks were operating on backup power, either batteries or generators so that power outage was only a question of time.

Compilation of Web Research:
http://www.fcw.com/article90541-08-31-05Web
http://www.cellularsouth.com/about/news2005/20050907.jsp
http://www.redherring.com/Article.aspx?a=13409&hed=Phones+Failure
http://research.cibcwm.com/res/Equ/ArEquUSR200510.html
http://www.msnbc.msn.com/id/9176867
http://www.washingtonpost.com/wp-dyn/content/article/2005/08/31/AR2005083102758_pf.html
http://research.cibcwm.com/res/Equ/ArEquUSR200510.html

IV. Conceptual model for ICT in Disaster Management

Even though there have been several approaches initiated in regard to disaster risk reduction in the region since the 1990s (the International Decade on Natural Disaster Reduction) the effects of succeeding programs, particularly at local level remain largely unseen. The importance of reducing vulnerability instead of almost exclusively focusing on post-disaster work experiences requires more recognition. It is repeatedly animadverted that examination on disaster mitigation, i.e. reduction of vulnerability is not given adequate attention. This is owed to very fragile institutional organization, an emphasis on post-disaster relief and emergency work rather than implementing risk reduction. Today it is widely accredited that risk reduction is rather a long-term than a short-term process. Disaster management should therefore not only be concern of emergency bodies but is moreover a governmental issue. In almost all Latin American and Caribbean countries exist a legal framework for emergency management. Civil Defense, the country's legitimate disaster management institutions are characterized by a hierarchical structure, a reactive focus and very strict centralization. There is additionally a lack of coordination between governmental institutions, other organizations and communities as well as between entities of disaster relief and entities of investigation and capacity building (ECLAC, 2005f).

ECLAC (2005f) amplifies that despite cultural, economic, social and geographical differences, the counties of Latin America and the Caribbean posses certain equal aspects regarding disasters: The exposition to a variety of hazards including high social vulnerability reflected in the poverty indices, intense urbanization, deficits in infrastructure and problems of environmental degradation. Adjusting the system of disaster management to the requirements and needs of the region goes beyond simple restructuring administration but also involves a change of the perception the entire society expresses towards disasters and disaster management (Ibid.).

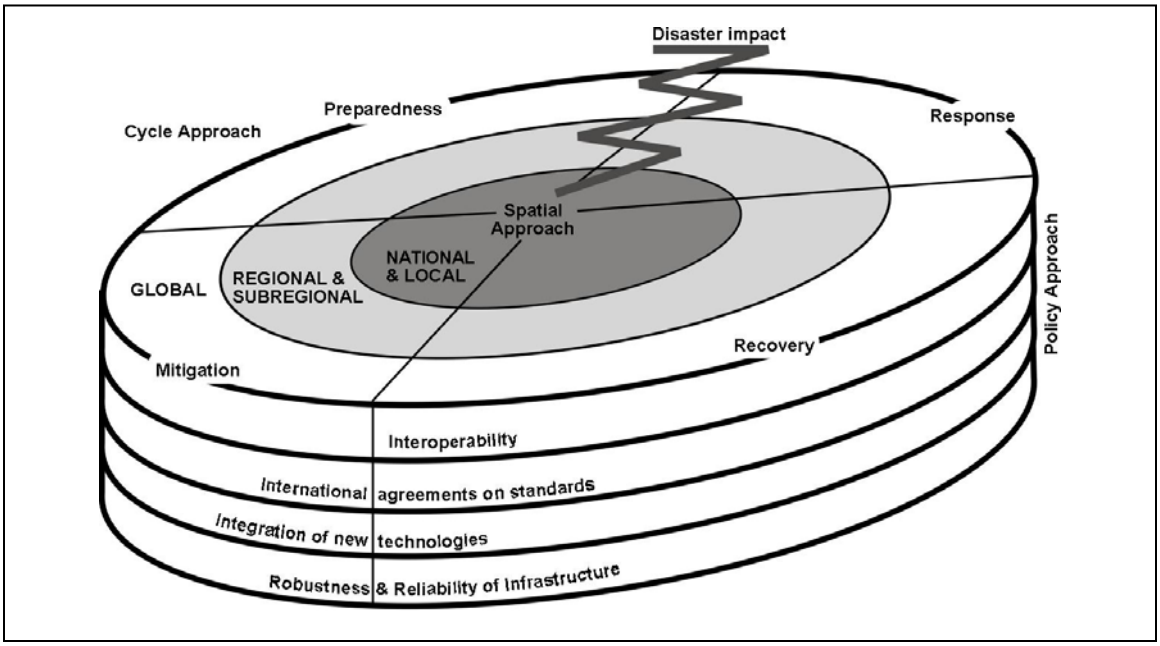
It becomes obvious that this task requires gathering, processing and dissemination of huge quantities of information. It has been discussed in chapter three that this information is required to meet certain criteria in order to efficiently and effectively serve its purpose. Qualitative management of disaster-related information is the key to lowering socio-economic vulnerability. ICT can serve as useful tool in this process.

The dynamic between management of disaster-related information and ICT is multi-dimensional and complex. To identify the opportunities and challenges these technologies offer for Latin America and the Caribbean this complexity needs to be reduced to a certain level of abstraction. Out of the multiple concepts of disaster management, three basic approaches have been identified for our purposes:

- Traditionally, natural disasters are analyzed by what is called the disaster management cycle, leading from disaster mitigation, to preparedness, response, and recovery. This approach will be referred to as the cycle approach.
- Especially important for the regional analysis is the fact that disasters, as well as ICT, are not bound by national frontiers. Therefore, disaster management needs to take into account the different spatial systems, which can be roughly divided into national, regional, or global systems. This approach will be called the spatial approach.
- Information and communication play a key role in every one of the different phases of the disaster management cycle. Additionally, they face different challenges when considered from different geographical perspectives. However, some crosscutting challenges can be found in all of them. Approximating ICT and disaster management from this action-oriented point of view will be referred to as the policy approach.

These three approaches constitute a model of intersection between ICT and disaster management (see Figure 1). They will be described more elaborately in the following chapters.

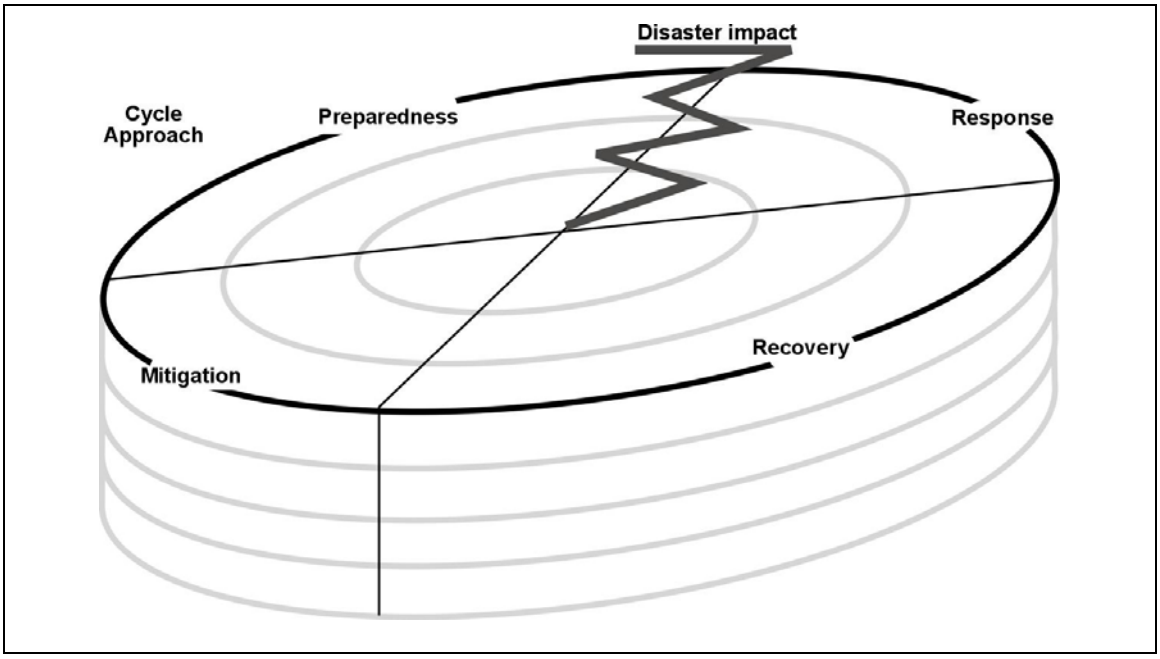
FIGURE 1
CONCEPTUAL MODEL FOR ICT IN DISASTER MANAGEMENT.
THE MODEL IS COMPOSED OF THREE APPROACHES: THE CYCLE APPROACH, THE SPATIAL APPROACH, AND THE POLICY APPROACH



Source: ECLAC, own illustration

V. The Cycle Approach

FIGURE 2
THE CYCLE APPROACH. THIS PARTIAL MODEL DESCRIBES THE FOUR PHASES OF THE DISASTER MANAGEMENT CYCLE



Source: ECLAC, own illustration

The disaster management cycle (see figure 2) is a model describing the enduring course in which all stakeholders prepare for the event of a disaster, respond during and proximately following the impact, and take steps to recover, after a disaster has occurred. The cycle is comprised of four phases:

- **Mitigation** – To reduce the probability of disaster occurrence and/or the impacts of unavoidable disasters.
- **Preparedness** - To ensure effective preparation and ability to respond to the impacts of disasters (This includes early warning systems).
- **Response** – To provide instant assistance focussed on saving lives and livelihoods.
- **Recovery** – To return to a proper level of functioning.

Mitigation and Preparedness, constitute the Risk Management (= managing the possibility of the occurrence of a disaster) while Response and Recovery represent the Crisis Management (= managing the impacts of the occurring/occurred disaster). There are no confined borders between the different phases of the cycle. They may even overlap in certain instances and the length of each iteration greatly depends on the severity of the impact. Since actions in the Mitigation Phase aim to limit negative impacts of natural disasters, it can also be seen as an integral part of the Preparedness and Recovery Phase. Moreover, effective mitigation may even prevent that disasters are brought on by natural hazards - thus making the Response and Recovery phase unnecessary in the next iteration.[16]

Each phase distinguishes itself from the others by involving different data sources and volumes, timeliness and specificity of information, target users (differing locations and levels of sophistication), as well as the dissemination or transmission of information. Hence, the effectiveness of all phases in the cycle depends on the availability accessibility, and comprehensiveness of information related to the hazard.

5.1. Mitigation Phase

Mitigation includes all activities meant to reduce vulnerability to disasters in anticipation of their occurrence. This is comprised of data collection and analysis, the creation of models for risk and vulnerability assessment and the transmission of useful information to all stakeholders by, for instance, public education and expert training. Mitigation also includes adaptation to increased force, recurrence and impact of extreme events and the monitoring of climate variability and change.[17]

Example areas or requirements for ICT deployment in the Mitigation Phase are:

- Remote Sensing[18]

[16] Whereas in the past more emphasis was laid on response and relief actions, a rising recognition of reducing negative impacts of hazards by lowering vulnerability through mitigation made this phase, in line with preparedness activities, to become increasingly important (UNISDR, 2004b). During the 10-year period 1989 – 1999, disaster prevention, mitigation, and preparedness activities accounted for between 35 – 45% of all disaster-related lending of the IDB. That amounts to approximately USD 280 – 360 million in Central America (including Dominican Republic and Haiti, excluding Mexico) (CLARKE, 2000).

[17] This monitoring is for example done for the ENSO (El Niño-southern oscillation), or ice caps and glaciers melting (both in the Poles and in high mountain ranges such as the Andes).

[18] Remote Sensing is a powerful tool in the pre-disaster stages such as planning, early warning and vulnerability analysis. Yet it must not be overlooked that acquiring images for disaster risk assessment may be too expensive for most developing countries (ECLAC, 2003). International agreements on collaboration can be of help to facilitate solutions for this monetary problem.

- Research on, collection of and digitalization of data, for instance with the help of Geographical Information Systems (GIS)
- Public education through television spots, online information and other media
- Expert training through – among others- online material, video conferences, or online courses (such as the ones used by the World Bank Institute for a number of topics)

5.2. Preparedness Phase

The aim of the Preparedness Phase is to gain the highest possible level of readiness to respond to a forthcoming emergency situation. This can be achieved by long- and short-term strategies. Basic strategies include response mechanisms and procedures, rehearsals, public awareness through, for example, broadcasted announcements, access to disaster web pages, and monitoring and early warning systems.

Examples for ICT deployment or requirements in the Preparedness Phase are:

- Raising public awareness through radio announcements and cell broadcasting
- Alternatives to primary ICT in order to handle unanticipated communication traffic
- Alternative electrical supplies and mobile communication devices in shelters
- Expert conferences via telephone, internet, and/or video

5.3. Response Phase

Rapid Response directed toward providing instant assistance to save lives, locate and rescue missing people, provide medical aid, food, and shelter, and to immediately start repairing damaged infrastructure in the initial aftermath of a disaster is crucial. Communications between response teams and the public is essential for urgent actions, such as evacuations and relocations, which have to be planned and executed. Rapid response can be impaired and experience major drawbacks caused by remoteness, inaccessibility and lack of appropriate communications infrastructure that is consistently observed in severely affected areas such as mountainous locations in Mexico and Guatemala affected by Stan.

Examples for ICT use in the Response Phase are:

- Global Positioning Systems
- Global Mobile Personal Communications via Satellite
- HAM Radio
- Telemedicine

5.4. Recovery Phase

As the basic emergency and humanitarian needs are met, recovery processes take place making up the Recovery Phase. The collection of information during the reconstruction phase includes data about the impact, documentation of lessons learned and data on rebuilding. Reconstruction can also be used as an opportunity to apply new methodologies to disaster management or to even leapfrog concepts that might have been in existence before.

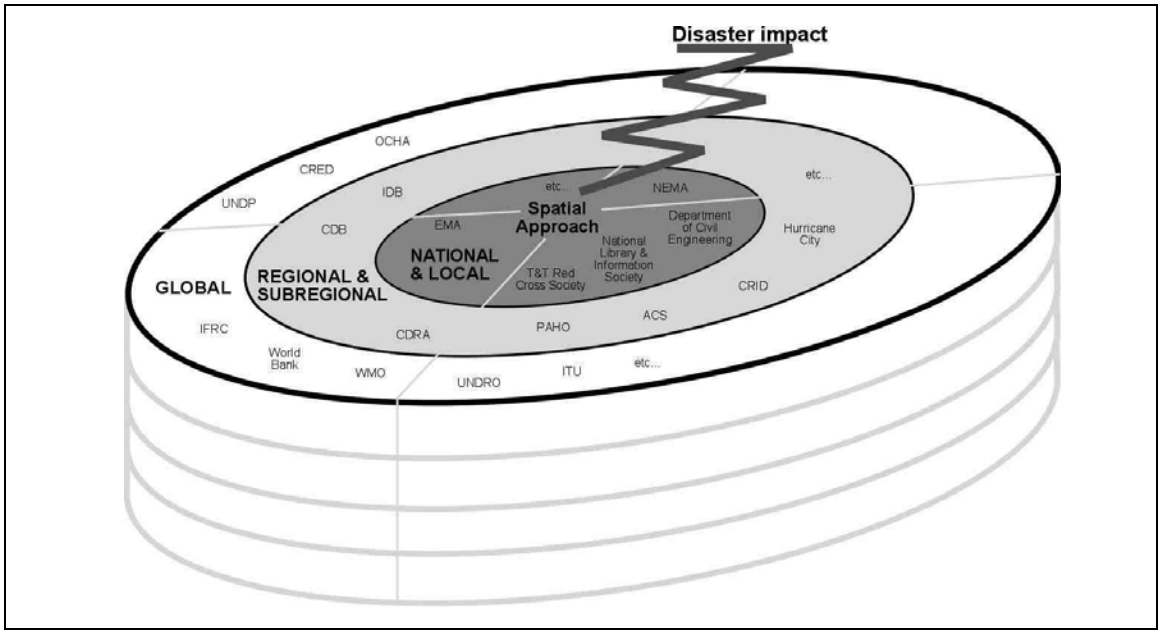
The reconstruction phase goes seamlessly into the mitigation phase.

Examples of the deployment of ICT in the Recovery Phase are

- Alternative voice communications such as satellite phones for key personnel
- Leapfrogging outdated concepts
- Implementation of backup services
- Real-time data support in community planning

VI. Spatial Approach

FIGURE 3
THE SPATIAL APPROACH.
THIS PARTIAL MODEL DESCRIBES THE DIFFERENT GEOGRAPHICAL SYSTEMS



Source: ECLAC, own illustration

The second dimension that co-constitutes the model of ICT and Disaster Management is the Spatial Approach. Hazards are not limited to administrative borders and even though succeeding disasters may often be bound to a distinct area, they are more likely to impact parts or even entire regions rather than just one area. Accordingly, disaster management does not only involve multiple agencies within the same geographical system, it also requires international cooperation. In this context ICT offer the possibility for synergy and shared approaches with disaster risk management, thus reducing individual costs and increasing overall capacities and resilience. However, decentralization is another crucial point as it allows the incorporation of local aspects (such as culture,

urban-rural aspects, conditions to prevention, response, and allows the spreading of risk of a centralized command and control management mechanisms).

As the interaction and cooperation within and throughout the different geographical systems is a highly complex manner, the division into the following three systems only serves as an example (see figure 3):

- National and Local Systems
- Regional and Sub regional Systems
- Global System

It has been indicated before that disaster management is a governmental issue involving local authorities and national powers, experiencing support by international cooperation. Consequently, it is reasonable to assume that the data, information and knowledge gathered by the various stakeholders in a regional layer are channeled into disaster management networks or platforms. These networks provide information relevant and understandable to a wide audience. Based on the given information agencies, respondants and the public will be able to make timely decisions to minimize loss of lives and livelihoods. Such an information tool requires a well-organized database on past disasters as well as real-time information for instance remotely sensed data, risk models and meteorological forecasts. The information sources vary widely in the different stages of the disaster management cycle and selecting them depends on the specific needs and tasks of the stakeholder. Therefore, the information is not only derived from various agencies at one regional layer, but also from the different layers involved. The interconnection of the national networks on a regional and sub regional as along with global cooperation becomes a necessity.

6.1. National and Local Systems

A very important precondition in disaster management is a "decentralized centralization": High responsibility for mitigation of disasters and emergency response lies with the local authorities. Yet, the local and national systems are interdependent and complementary. National authorities assist local mitigation, preparedness and response mechanisms and provide support not only when an impact excesses the local capacities but also much earlier by providing local authorities with disaster-related information that cannot or is extremely difficult to be gathered locally. Supervision, coordination, provision of education and research are responsibilities of the national government.

Though the national government has the responsibility of coordination, the organizational structure of disaster management still needs to be territorial. Whereas disasters are very likely to impact an entire region in terms of economic aspects and social involvement, the event itself is very likely to be connected to a distinct area. As residents of the local community in which they serve, local authorities dispose of specific risk experience as well as a more precise overview about available resources and possibilities to manage disaster risk. Public awareness programs can more precisely target the needs and concerns of the inhabitants by emphasizing local conditions or referring to past events that relate to individual experience within the community (UNISDR, 2004b).

National and Local Digital Networks established by the disaster management bodies ensure that the proper information reaches the public and all professionals involved in handling disasters. This networking role is usually taken up by National Disaster Response Agencies. If the capabilities and institutional resources within a country are fragmented,[19] it can be the role of these agencies to bring

[19] The Inter-Agency Standing Committee (ISAC) Task Force on Natural Disasters highlights the case of Ecuador where there is a high abundance of international agencies in the region with 54 NGOs. Many of those are active at a community level (ISAC, 2005).

them together. The importance of developing and supporting these agencies in disaster risk reduction has often been emphasized and described during international conventions, yet implementation is still lacking since the present number of operational platforms remains modest (UN, 2005). There are good examples of response networks and coordination among institutions for instance in Colombia, Mexico and Chile. In the case of natural events causing disasters Belize's National Emergency Management Organization (NEMO) is a relevant example.

The national disaster authorities are not isolated from other national entities. Disaster management has to be linked and coordinated with the work of multiple governmental bodies. Therefore, national disaster authorities are allocated to the national government and serve as disseminator, facilitator and catalyst of information relevant to the government, local authorities, emergency and humanitarian aid organizations, other national and international stakeholders and the public.

The following examples for National and Local Emergency Platforms and Agencies are generic and may be found in most of the LAC countries.

- National Emergency Management Agency
- Environmental Management Authority
- National Red Cross Society
- National Library and Information System
- National Institute of Marine Affairs / National Institute of seismology
- National Telecommunication Services

6.2. Regional and Subregional Systems

Regional and sub regional platforms interlink the different local and national agencies in the area by enabling them to work more efficently by disseminating information, for example, on best practice and lessons learnt. This is very reasonable as sub regions in Latin America and the Caribbean face similar vulnerabilities to similar disasters. Examples are the Caribbean and Central American region with their vulnerability to hurricanes and their related hydro-meteorological effect or the Andean region with the risk of earthquakes and tsunamis. There are many functioning information networks already in place in Latin America and the Caribbean yet the organization and structure of these systems vary widely depending on multiple factors such as the institutions mandate, its disaster policies, the availability of resources and the experience of their staff.[20] Using and improving the tools and networks that already exist can be the key to developing an integral approach to regional information management.

Examples for Regional and Sub regional disaster networks and platforms specific to disaster management are:

- Caribbean Disaster Emergency Response Agency (CDERA)
- Centro de Coordinación para la Prevención de los Desastres Naturales en América Central (CEPREDENAC)
- Red de Estudios Sociales en Prevención de Desastres en América Latina (LA RED)
- Hurricane City

[20] Compare CDERA (www.cdera.org) and Hurricane City (www.hurricanecity.com).

Other organizations play also an important role even though they have more broadly defined purposes, yet disaster management is a momentous component. Examples are:

- Economic Commission for Latin America and the Caribbean (ECLAC)
- Pan-American Health Organization (PAHO)
- Regional Disaster Information Center for Latin America and the Caribbean (CRID)
- Inter-American Developmental Bank (IDB)
- Caribbean Developmental Bank (CDB)
- Association of Caribbean States (ACS)

6.3. Global System

There are two different Relevant data and/or information that are not produced locally are not lost, and as long as they are made available and adapted to local needs, they can contribute to disaster resilience.[21] Moreover, operating systems for the collection and distribution of data are often costly and therefore not a realistic option for many developing countries. Consequently, jointly elaborated global data gives way to more cost-effective systems.[22] As a result, not only the provision with the above mentioned data is crucial for disaster management access and comprehensibility are also important. This cooperation is not only limited to international agencies and organizations. The recognition of advantages that partnerships with the private sector can offer also increased during recent years.[23]

International humanitarian assistance supports countries or regions whose capacities to deal with a disaster are depleted.

Involved in disaster management on a global level are manifold institutions the following can only serve as examples:

- United Nations International Strategy for Disaster Reduction (ISDR)
- United Nations Office for the Coordination of Humanitarian Affairs (OCHA)
- International Federation of Red Cross and Red Crescent Societies (IFRC)
- International Telecommunication Union (ITU)
- World Bank
- Centre for Research on the Epidemiology of Disasters (CRED)
- International Amateur Radio Union
- World Meteorological Organization (WMO)

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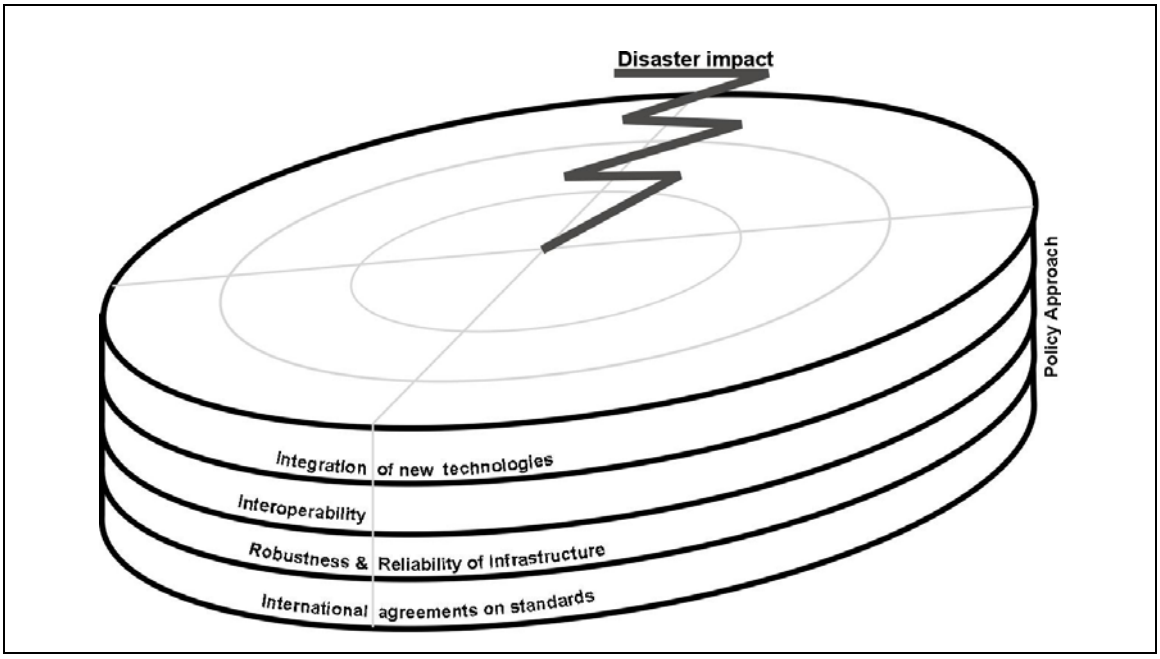
[21] CDERA, for example, receives parts of its data from NOAA whereas the local information centers refer to CDERA as information provider. Most platforms revert back to the CRED International Emergency Database (em-dat) for the compilation of disaster-related information.

[22] The World Meteorological Organization (WMO) names the dissemination of data via satellite systems through technologies such as Digital Data Broadcast (DDB) or Digital Video Broadcast (DVB) as a possibility to significantly reduce the cost of transition and reception of data by satellite distribution systems while serving basically all countries world-wide.

[23] The International Telecommunication Union (ITU) has entered into a partnership with the private sector; the London-based satellite consortium Inmarsat Limited, to obtain plug-and-play satellite terminals, which can be deployed at the request of a Member State whose telecommunications have been disrupted by disaster.

VII. Policy Approach

FIGURE 4
THE POLICY APPROACH.
THE PARTIAL MODEL INTEGRATES FOUR REQUIREMENTS ON PUBLIC POLICIES



Source: ECLAC, own illustration

Two entities of ICT and disaster management have been described so far: The Cycle Approach and the Spatial Approach. The Disaster Management Cycle presents the structure of the phenomenon. Its cyclical nature already implies that this partial model explains a dynamic process, which requires constant adjustments, decision-making, and policy-making. Interaction at

the different, yet interdependent, spatial systems and amongst various institutions and actors are depicted by the second integral part of the model, the Spatial Approach. This second approach enables the agents involved to be described in different phases of the cycle. The result of the dynamic correlation between structure and agents is an assured degree of uncertainty, which demands public policy intervention. These requirements make the model of ICT and disaster management three-dimensional and constitute the final entity, the Policy Approach (figure 4). Just like the partial concepts described above, the Policy Approach is an abstraction of a simplified reality. In digital disaster management, most of the public policy agenda is linked to the underlying technology, extracting four main policy areas:

- International Agreements on Standards – To make data collection, information dispersal, as well as the application of ICT'S devices more effective and cost-efficient.
- The robustness and reliabilty of ICT infrastructure – To minimize infrastructure and data failure.
- ICT interoperability – To guarantee dissemination and comprehensibility of relevant information.
- The incorporation of new technologies – To facilitate data and information processing and dispersion.

All four of these areas are correlated to one another and should be revised and implemented as a unit.

7.1. Robustness and Reliability

A lesson learned from the communication difficulties faced in Grenada (that immediately followed the landfall of hurricane Ivan) is that the robustness and reliability of ICT infrastructure plays an important role, since a basic necessity of disaster related information is that it needs to be able to reach the addressee. Therefore, detailed public sector regulation in order to assure the strengthening of ICT infrastructure against the hazards present in the region is of the utmost importance (PAHO, 2000).

Examples of technical and operational aspects to make ICT infrastructure more resilient to natural hazards are:

- Fortifying cell phone towers and antennas to withstand the forces of natural hazards
- Co-location of critical information so that information loses can be avoided
- Reliable electricity supplies. This aspect also included the possibility of redundancy or alternate systems that can be reverted to when normal supply sources, transmission and distribution fail
- Dedicated secure landlines or in the case of islands underwater lines
- Integration of various communication channels such as two-way-radio, phone, internet

7.2. International Agreements on Standards

As with all aspects of international information and communication systems, technical and operational aspects of ICT both succeed and fail with the introduction of standards. One of the

most basic policy premises throughout the disaster management cycle is, therefore, the continuous collaboration in the establishment of accepted standards.

Examples for Standards:

- Building standards for outdoor devices
- Common emergency language such as the UNISDR Glossary of Disaster terminology (UNISDR, 2004a).[24]
- Integration of cell broadcast across two-band systems
- Harmonization of frequency use by different relief teams

7.3. Interoperability

Three different types of interoperability can be differentiated: The interoperability of hardware, the interoperability of software and commercial interoperability.[25] Communication barriers resulting from inability to interact due to incompatible ICT might leave the hands of potential information disseminators (or helpers) tied and the work of different relief teams uncoordinated. Without a defined emergency language, the transmission of the information might fail due to lack of comprehensibility and interoperability.

The responsibility to implement interoperability standards lies with the national government, of which the national disaster management authority is an integral part. Standards on interoperability are not exclusive matter to disaster management. Moreover, in an ideal scenario, the disaster management authority will build upon a base of interoperability standards obligatory to all government bodies.

Examples for interoperability aspects are:

- Interoperability of the lower ICT layers, such as with hardware configuration
- Interoperability of the higher ICT layers, such as with proprietary or open source software

[24] The Organization for Advancement of Structured Information Standards launched an initiative to create an integrated framework for a wide range of emergency data exchange standards. The Emergency Data Exchange Language (EDXL) is focused on standardizing specific messages in order to facilitate emergency communication and coordination – especially when various professions are involved (OASIS, 2005).

[25] With the passage of the Wireless Communications and Public Safety Act of 1999 cell phone service providers in the USA are now required to introduce a system for emergency workers to find cell phones dialing 911. The enhanced 911 (E911), which has been offered by traditional landline phone providers for several years, ensures the automatic provision of location information. Specifically to rural cell phone providers, E911 poses new challenges on all three types of interoperability. The existence of many base stations and cell towers in cities makes it fairly easy to triangulate the position of a call. In rural areas it is unequally more difficult as cell phone towers are basically set up in straight lines. The deployment of E911 therefore requires the development of new technologies (which is hardware and software interoperability). As incoming calls from any cell phone – contracted with any company or even without contract or phone number - must be tracked, coordination among public safety agencies, wireless carriers, technology vendors, equipment manufacturers, and local wireline carriers becomes a necessity. This makes commercial interoperability a preliminary requirement. Acknowledging the progress in wireless technology E911 is broadened to other new technology such as Voice over Internet Protocol making the challenge of interoperability to be even greater (FCC, 2005).

- RSS Feeds[26]
- Allocation of radio frequencies

7.4. New Technologies

The optimal solution for ICT system application in disaster conditions are tools that run in a routine daily use, but also have the capability to function under these extraordinary circumstances.[27] Newly evolving ICT offer many features that can be beneficially integrated in disaster management[28] (see box 2). By making the processing of data and the transmission of information faster, easie and multi-channeled an appropriate mix of these new tools can facilitate data processing and information exchange.

This however, does not necessarily mean that the newest technology is the optimal tool for disaster management in any case. Effective disaster management is effective management of information. This can be handled in manifold ways, and always needs to be adapted to the particular case, socio-cultural aspects, the economic background. To give a very basic example: An indigenous Guatemalan woman may not have the educational background to operate a computer in the telecenter she visits weekly in order to await a call from a family member working abroad. Even if important information on disasters was provided online in Mayan language she may not be able to read it. It could serve much more the purpose to simply hang up a well structured poster which provides necessary information by universally understandable drawings.

Yet there are many examples of new technology being the best possible election as for example discussed in Box 2.

Examples for the application of new technologies in disaster management are:

- Peer to Peer Technologies
- WIFI and Wi-Max technology
- Common Alert Protocol
- Third generation mobile systems

[26] RSS Feeds are a family of web feed formats, specified in XML. These web feeds provide web content or summaries of the content together with links to the full version of the content and/or other metadata. RSS Feeds implemented on web sites allow consumers of information to have news constantly fed to the site. That avoids time-intense searching for it.

[27] Morse code telegraphy, single-sideband (SSB) voice at High Frequency, and VHF/UHF are forms of telecommunication that have proved to work in the past (ITU, 2005).

[28] With more than 2 billion mobile subscriber connections as of September 2005 and a number equivalent to nearly one third of the world's population it becomes evident that the use of mobile phone is widely established. Many Latin American countries leapfrogged the terrestrial telecommunications and telecommunication via mobile phone is widely established. Cell Broadcasting allows two-band cell phones in a determined geographic area to receive text messages, e.g. concerning weather and emergency alerts (the difference to SMS is that no phone number of the recipients is needed), making cellular emergency alerts for disasters appear to be an uncomplicated way to submit warnings and alerts. In a two-year pilot project the Dutch Government is testing the application of Cell Broadcast in disaster management as addition to other warning systems such as sirens. If a disaster occurs, a message is sent to all phones in the area. The government is working with the major mobile phone operator, which together cover some 85% of all Dutch cell phone users (http://www.cnn.com/2005/TECH/11/09/dutch.disaster.warning/index.html) (posted November 10, 2005).

- Software-defined radio
- Digital television

BOX 2: WI-FI AND HAM RADIO
WI-FI THE RIGHTEOUS HEIR OF HAM RADIO?

Disastrous events often times signify a neuralgic point to the application of newer ICT and its devices, as out of various reasons they tend to be incapable to withstand the impact and/or following up rises in demand. Therefore the traditional method of HAM radio communication remained a probable alternative when all other infrastructure was failing. This "exclusiveness" of HAM radio might vanish with the ongoing implementation of a new technology: Wireless Fidelity (Wi-Fi).[29]

The before-described case of Katrina reveals the question of to not only having to improve the operational part of emergency telecommunication but to also revise the technical aspects. In the wake of the hurricane many ICT and its tools failed, reestablishing communication was delayed by long periods of time. Wireline and wireless telephone services were disturbed. All local television stations were disrupted, but the news crews moved quickly to sister locations in nearby cities. Local newspapers moved out of the affected area. Communications shifted to different tools. Broadcasting and publishing on the Internet, for instance, became an important means of distributing information to evacuees and the rest of the world. Yet, within the city this communication tool failed as well due to incapacitated infrastructure. Here, Ham radio proved its robustness and provided tactical and emergency communications as well as health-and-welfare enquiries. Wi-Fi mesh radio and WiMAX (Worldwide Interoperability for Microwave Access), the succeeding technology could whatsoever be successfully deployed in the wake of the hurricane quickly reestablishing the communication between emergency shelters and the rest of the world. This was so effective due to private initiatives and semi-private initiatives such as of Intel workers, providing 150 shelters with Internet communication. Wi-Fi requires no wires, it can reach long distances, and a network can get up and running within half an hour.

For long time, HAM radio has almost had the monopoly on being the backbone of information flow following major disasters that had impacted most other forms of telecommunication infrastructure and its devices. HAM radio proved to be disaster resilient and robust, in many regions it is widely spread so that emergency communication networks can quickly be installed. Ham radio operators have at times played a vital role in disaster and post-disaster communication. They are generally highly motivated to support even under acute emergencies; yet, the accuracy of reports may vary widely.

Wi-Fi is a global set of standards for wireless local area networks (WLAN). It stands for product compatibility, as certified products are to be interoperable with any other Wi-Fi product. Once intended for use of mobile devices and LANs Wi-Fi is now often deployed for Internet access. Wi-Fi networks, as a form of wireless mesh network have some tremendous advantages contributable for disaster management: The infrastructure is decentralized, fairly inexpensive, and very reliable and resilient. Each node connects to several other nodes. In case of failure of one node, the neighboring nodes simply transmit via a different route. If extra capacity is needed, it is sufficient to add more nodes. The networks may involve both, either fixed or mobile devices. It can not only be put up quickly after a disaster but the actual survivability of these networks during and after disasters such as hurricanes is very high compared to other communication services.

Mesh and ad hoc Wi-Fi network might be the most survivable infrastructures.

These networks are additionally very cost-effective. To rebuild traditional telephone and cable infrastructure in New Orleans for example will be costlier than providing the city with a new mesh Wi-Fi network.

[29] It has to be annotated that Wi-Fi did not originally stand for Wireless Fidelity. The term "Wi-Fi" was invented by the Wi-Fi Alliance along with the Interbrand Corporation. Wi-Fi initially described wireless LAN products that are based on a certain standard.

With all the mentioned advantages in cases of emergencies, these wireless mesh networks appear to be a new and reliable alternative for emergency telecommunication and might even succeed HAM radio, thus, being its “righteous heir”.

http://en.wikipedia.org/wiki/Wi-Fi http://en.wikipedia.org/wiki/Wireless_mesh_network

http://en.wikipedia.org/wiki/WiMaxhttp://www.intel.com/technology/magazine/communications/hurricane-relief-1105.htmhttp://wifinetnews.com/archives/005910.html

VIII. Future Challenges

The relevance of integrating new technologies in disaster management for the region is widely recognized. Still it has to be clarified that ICT are not a solution. They cannot reduce the vulnerability of people being exposed to natural hazards if steps to disaster reduction are not taken accordingly. The cross-cutting nature of ICT, and in particular digital technology, make them part of a tool set by enabling and facilitating important steps within a risk reduction framework that has been described by the three-layered model. Within the disaster management cycle, throughout the various spatial dimensions and framed by public policies and international agreements ICT can - presuming they are effectively deployed - beneficially contribute to reducing the impact of a hazard and, therewith, its disastrous effects by data compilation, information dissemination, and communication. This calls for the combination of traditional and newly evolving technologies, and their devices, while considering and implementing the requirements disaster-related information has to fulfill. During the course of this special attention has to be paid to geographical, socio-cultural and economic particularities in order to use potential advantages of digital disaster management and to recognize and therefore avoid possible threats (digital exclusion).

Optimally applied ICT thus make sure that relevant disaster-related information reaches the address on time and is reliable, multi-sourced, understandable and standardized. The matrix in Appendix A relates aspects of ICT use to this three-layered approach. It however, should be seen as an open, unsorted compilation of different recommendations with the intention to give an impression on the various approaches related to adapting ICT for disaster management.

However, disaster management will fail when it is not legitimated by public commitment and the public commitment in turn must be implemented into legal framework. Only this gives warrantee that the authorities and stakeholders fulfill the commitments previously stated. It is therefore of high priority to investigate the current manifestation of disaster management in legal frameworks of the Latin American and Caribbean countries. They need to be revised on efficiency and effectiveness. Public commitment and institutional framework in combination with international cooperation and agreements on standards for ICT use in disaster management provide the legitimate basis for disaster management and give way to interoperability and resilience against hazards occurring in the region.

Analyzing the conceptual model of ICT deployment in disaster management, it becomes evident that further investigation on this topic is indispensable. A disaster-related SWOT (Strengths and Weaknesses, Opportunities and Threats) may be a suitable point to start at. The goal is to compile a variety of tools and advises on how to optimize disaster management in all the countries in the region with the aid of digital ICT.

The research performed within the scope of the presented paper revealed that in order to elaborate a constructive guideline on ICT and disaster management the following integral aspects should be given closer attention:

- Evaluating the state of research
- Public Policies and Current State of National Platforms
- Enabling, strengthening and linking of Regional Platforms
- Global Networking and Cooperation and International Agreements on Standards
- Integration of New Technologies

8.1. Evaluating the state of research

From Rio30 over Yokohama[31] to Johannesburg[32] and Hyogo,[33] many international conventions exist on restating the importance of ICT deployment in disaster management, and supporting national and regional platforms. Consequently, there is a lot of investigation undertaken in this field. For any kind of research, it is important to start with a stock taking exercise. Knowledge

[30] The global action plan Agenda 21 was adopted by more than 178 Governments at the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil in 1992. Agenda 21 stresses the interdependency of sustainable development and disaster mitigation (Paragraphs 12, 13, 17) (UN, 1992).

[31] The Yokohama Strategy and the Plan of Action for a Safer World were postulated at the World Conference on Natural Disaster Reduction in Yokohama, Japan in 1994. These documents re-emphasize the importance of disaster risk reduction especially for developing countries. They call for action to strengthen national capacities as well as regional and international cooperation. Risk assessment, monitoring and communication of forecasts and (early) warning, technology sharing, gathering and dissemination of information, and the mix of old and new technologies (I Principles and II Plan of Action) (UN, 1994).

[32] The Johannesburg Plan of Implementation was adopted at the United Nations World Summit on sustainable Development in Johannesburg, South Africa in 2002. The document highlights the necessity of integrated, multi-hazard, and inclusive approaches to disaster management by a variety of actions. These include the support of national capacities, regional strategies, international joint observation and research by deploying new technologies, and improved gathering and dissemination of information. (Paragraph 37) (UN, 2002).

[33] At the World Conference on Disaster Reduction executed in Kobe, Hyogo, Japan, in 2005, the Review of the Yokohama Strategy and Plan of Action for a Safer World and the Hyogo Declaration with its Framework for Action 2005 – 2015 were adopted. The Yokohama Review analytically covers the period from 1994 to 2005 reflecting the current state of awareness and accomplishments, impediments and gaps, and presents consolidated observations about global disaster reduction. Accomplishments and remaining challenges are identified in the four chapters Governance: organizational, legal and policy frameworks; Risk identification, assessment, monitoring and early warning; Knowledge management and education; and Reducing underlying risk factors. The Hyogo Declaration and its Framework for Action reveal objectives, expected outcome, and strategic goals of the World Conference. In part III of the Plan of Action, priorities on actions for the following 10 years are set. In line with earlier documents, information exchange and management by employing modern technologies through strengthening national and regional platforms and intensifying international collaboration is demanded (UN, 2005a,2005b).

exchange between the different ECLAC offices, other UN bodies, and relevant organizations is a precondition for later investigations. It is necessary to know the current state of disaster research in order to constitute a main focus and explore possible cooperation. Double efforts should be minimized and synergies should be explored.

8.2. Public Policies and current state of national platforms

It has been categorically stated by the international community that considerable opportunity to improve systems through strengthening and more effectively integrating present capacities and networks exist (EWC2, 2003). National Platforms take a pivotal role in stimulating these processes and subsequently need to be fortified. The UNISDR is thereupon proposing a joint work programming and reporting on the implementation of the Hyogo Framework of Action that suggests an initial list of priority areas of focus for 2006-2007.[34] A requirement is the rapid empowerment of the national platforms and, where they do not yet exist, their establishment. Before doing so, the current state of the National Platforms needs to be investigated.

The national platforms - the national disaster management authority – form part of the national government. National digital disaster management platforms correspondingly form part of the national e-government. An urgent necessity is the implementation of standards and requirements which will guarantee robustness and reliability of ICT and its devices, as well as interoperability between the varying technologies deployed and stakeholders involved. This also includes intergovernmental interoperability which should be realized by a uniform governmental base on technological and interoperability standards. Only this assures that information gathered and distributed will reach its destination while being understandable and relevant.

Research on public policies and the current state of national platforms is an ample field ranging from building codes for outdoor devices, such as cell phone towers, on a national level, to training manuals on emergency telecommunication on a regional level, integration of disaster management into e-government, to frequency allocations on a global level and is interweaved with the legal framework.

8.3. Enabling Regional Platforms

Regional and Sub-regional Platforms complement national and international efforts in advancing disaster risk reduction by sharing experience and identifying regional gaps and priorities (UNISDR, 2005).[35] They promote regional programs, support the region in capacity developmen, and carry out the development of standardized collection methodologies and definitions, which are still lacking. Some well structured information centers and networks already exist in the region and could serve as examples for good practice. By examining capacities of regional platforms, policy recommendations can be given on how to efficiently deploy ICT in national and regional disaster mitigation processes.

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[34] The first biennium of this work program should develop enabling mechanisms to more systematically identify country needs. The follow-up would be to progressively incorporate the countries' needs into the integrated work programming (UNISDR, 2005)

[35] Their role is defined in Paragraph 31 of the Hyogo Framework of Action, which was adopted at the UN World Conference on Disaster Reduction. The Framework of Action sets out strategic goals, priorities for action, as well as implementation and follow-up on national, regional, and international level. The expected outcome for the following 10 years is a "substantial reduction of disaster losses" (Paragraph 11).

8.4. Integration of Global Networks and International Agreements on Standards

Global networking can facilitate the management of necessary information in terms of time and monetary efficiency. Certain digital ICT proved to be extremely useful in disaster management. Amongst them is satellite imagery. This is a powerful tool for hazard risk assessment and post-disaster recovery ,yet is still too cost-intensive for many developing countries. Global networking and cooperation therefore offers a wide variety of opportunities for shared synergies. International agreements, such as the Tampere Convention, and collaboration between international organizations and the private sector, as was the case between Inmarsat Ltd. and the ITU, give way to successfully integrate new technologies into national and regional disaster management.

Digital ICT cannot yet fully replace other communication devices and they do not have to: Traditional communication tools such as analog radio have repeatedly proved to be highly reliable in disaster management. They also have additional advantages in comparison with digital ICT, such as their cost-efficiency and universal infrastructure. Even though taken one by one, most digital ICT infrastructure appear highly cost-efficient. However, it is still implausible to believe that each country and household respectively can afford the “whole package” of digital ICT, which fulfills the aforementioned requirements. Certain required digital information, as satellite imagery, can be elaborated/analyzed collectively thus enabling Latin American and Caribbean countries access to important information that could not be obtained otherwise.

8.5. Integration of New Technologies

New technologies evolve at a breathtaking pace. By incorporating them into disaster management, working routines can be simplified and enhanced. In order to detect the appropriate tools for specific tasks and geographical regions, it would be useful to investigate new ICT and their potentials or impediments. Advancements in fixed and mobile wireless technology, such as the possibility to integrate an upload communication channel in digital television networks, for example, open an entirely new set of tools to improve digital disaster management.

It is undisputable that various hazards threaten the region. Countries face distinct levels of vulnerability of people and resiliency of socio-economic infrastructure and will subsequently leave distinct impacts on sustainable development in each of the region's countries. Because of this, the mix of ICT and its enabling policies for disaster management may vary widely throughout Latin America and the Caribbean. Yet there may exist multiple similarities that can contribute to regional collaboration, thus giving way to optimization of disaster-related work. Possibilities for standardization and joint international work make regional and global cooperation more effective. Further investigation on the previously mentioned aspects of ICT and disaster management can highlight how the region will be able to capitalize on new technologies in order to lower its vulnerability to disasters.

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Annexes

Annex A

TABLE 1
DIFFERENT RECOMMENDATIONS ON ICT AND THE THREE-LAYERED APPROACH OF ICT IN THE COURSE OF DISASTER MANAGEMENT

Recommondations	Disaster Management Cycle				Underlying Requirements				Regional Layer		
	Mitigation	Preparedness	Response	Recovery	Robustness & Reliability	Interoperability	Standards	New Technologies	National & Local	Regional & Subregional	Global
Framework (Compilation, Education, Dissemination, Coordination, Cooperation)											
Mapping of hazard vulnerability and risks & Environmental Vulnerability Assessment											
Remote Sensing	■			■		■	■	■		■	■
Research on / collection of historic/recent data	■			■			■		■	■	■
Public and expert awareness building, education and advancement of commonly understood technology											
Television Spots	■	■							■		
Radio Novels	■								■		
Online Information	■	■	■	■			■	■	■	■	■
Online Training	■			■		■	■	■	■	■	
Video Conferences	■	■	■	■		■	■	■	■	■	
Training materials / games used on PC	■					■	■	■	■	■	
Dissemination of information to experts/stakeholders/affected and interested public											
Data digitalization	■			■		■	■	■	■	■	
Internet networks	■	■	■	■	■		■		■	■	■
Telephone / internet / video conferences	■	■	■	■	■	■	■	■	■	■	■
Cooperation with /Requirements of providers											
Cell phone providers to integrate cell broadcasting across 2-band systems	■	■	■	■	■	■	■	■	■		
Internet providers to provide full applicable band width	■	■	■	■	■		■	■	■		
Allocation of specific radio frequencies and equipment to emergency services		■	■			■	■		■	■	■
Integration of HAM radio operators	■	■	■	■	■	■	■		■	■	■
Integration of marine operators	■	■	■	■	■	■	■		■	■	
Integration of pleasure craft	■	■	■	■	■	■	■		■	■	

Recommondations	Disaster Management Cycle				Underlying Requirements				Regional Layer		
	Mitigation	Preparedness	Response	Recovery	Robustness & Reliability	Interoperability	Standards	New Technologies	National & Local	Regional & Subregional	Global
Introduction of dedicated emergency infrastructure											
Interoperability of IS / Message (meta-) formats compatible with existing and emerging technologies											
Open Source Software	■	■		■		■		■	■	■	■
Three-band cellular	■	■		■		■	■	■	■		
RSS technology (e.g. news summary for the broadcast media and relevant internet news sites)	■	■		■		■	■	■	■	■	■
Emergency Broadcast System		■	■			■	■	■	■		
Standardized common alert message (such as CAP standard)		■	■		■	■	■	■	■		
Emergency language (such as EDXL)	■	■	■	■		■	■	■	■	■	■
WIFI technologies (could help to bypass monopoly of providers)	■	■	■	■	■	■	■	■	■	■	■
Radio communication using data modes such as Clover, Pactor and technologies such as software defined radio	■	■	■	■	■	■	■	■	■	■	■
Resilience of outdoor devices											
Ensure that all cell phone towers, antennas etc. are built to specifications that withstand natural hazard impacts	■			■	■		■		■		
Reliable (alternative) electricity supplies											
Generators		■			■				■		
Inverters		■			■				■		
Battery storage		■			■				■		
Solar Energy		■			■				■		
Multi-sourcing of emergency infrastructure											
Integration of different types of communication such as two-way radio, phone, internet, telegraphy		■	■		■	■	■	■	■	■	■
Application/allocation of differing radio frequencies and systems	■	■		■	■		■		■		■
Secondary and/or standby alternatives to primary ICT e.g. to handle outages and unanticipated communications											

Recommondations	Disaster Management Cycle				Underlying Requirements				Regional Layer		
	Mitigation	Preparedness	Response	Recovery	Robustness & Reliability	Interoperability	Standards	New Technologies	National & Local	Regional & Subregional	Global
traffic											
Communication equipment in emergency shelters											
P2P technologies communications between shelters and between shelters and local response agencies on a separate network											
Internet access											
HAM radio											
Mobile PC / communication devices (PDA)											
Appropriate management software and processes that would provide combination of the following for critical electronic information											
Backup											
Co-location and/or re-location											
Archiving											
Logistic support for dispersal of relief supplies and location of (missing) population											
GIS											
Telemedicine											
Satellite Phone / Mobile Satellite Devices (such as INMARSAT, VSAT)											
HAM radio, telegraphy, television, internet (mobile devices)											

Compilation of recommendations given by CIVIC 2004b, ITU 2005, PAHO 2000.