GIS as a High Performing Computing Tool for Disaster Management and Control: The Nigerian Challenges

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***Abstract*—**Geographic Information Systems (GIS) are an indispensible tool in providing timely and accurate information necessary for making excellent decisions. Emerging technologies in data collection, information management, web and cloud services, and visualization have opened up significant new avenues for sharing solutions across local, state, federal, and international levels. GIS are incredibly useful and effective tools in disaster management. These technologies are becoming the object of substantial interest for all countries and bodies concerned with emergency services and disaster management. In disaster management, the objectives of the disaster experts are to monitor the situation, simulate the complicated disaster occurrence as accurately as possible and come up with better prediction models, suggest appropriate contingency plans and prepare spatial databases. The difference between good resources management decisions and catastrophe (disaster management) is often the proper information flow available to the right people at the right time and in the right context. This is the ability of GIS to provide exactly this kind of information. Geographic Information System (GIS) is a high performing computer mapping system developed for capturing, storing, querying, analyzing, modifying and displaying spatial data about places existing in the universe. It can display all kinds of data related to places in different ways such as tables, charts and maps based on the information entered into the system. GIS is used in managing the huge levels of data required for vulnerability and hazard assessment. This paper tries to look at GIS as a core IS (Information System) in disaster management and control and review the challenges in Nigerian context.

Keywords— GIS, high performing computing, tool, disaster management, control, Nigerian challenges.

I. Introduction

PREVENTING and managing disaster situations effectively have being a source of major concern of academics, engineers, planners, decision-makers and different levels of government. In making plans and decisions about disaster prevention and management, more considerations ought to be paid to the spatial features of disasters. Most natural hazards according to [1] have patterns That have leave spatial footprints and within these patterns are human places, cultures and interactions. There is a clear nexus between environmental degradation and disasters in many regions of the world and it is those countries that suffer most from disasters, are the same ones in which environmental degradation is proceeding most rapidly [4]. In addition, it is the poor people that are more vulnerability to disasters. Continuous and increasing occurrence of devastating disaster events often poses substantive danger to the achievement of sustainable development and poverty-reduction initiatives [11]. Disaster reduction and risk management is rapidly being adopted into the policy agenda of governments as well as multilateral and bilateral agencies and NGOs. The International Strategy for Disaster Reduction [I1] through the Resolution UN General Assembly 54/219 aim to mobilize Governments, UN-agencies, regional bodies, private sector and civil society to unite efforts in building resilient societies by developing a culture of prevention and preparedness. The devastation caused by the disasters is a reflection of the lack of disaster preparedness nationwide in Nigeria. Most of the risk to populations is associated with the incapacity of governments to ensure provision for infrastructure and for disaster risk reduction and disaster preparedness and general lack of proper planning. The consequences of inaccurate planning in Nigeria are of interest to different stakeholders including those involved in research studies and policy making.

Preparing for the possible occurrence of disaster and it effects is vital, to reduce the impacts of the problems and its attendant hazards. Majority of the people including the government are not adequately prepared for the level of devastation that usually accompanies such disaster events. The concept of disaster preparedness has been used by many development professionals and practitioners from the biophysical and social sciences in diverse but technically precise ways ([10]; [4]). The level of disaster preparedness depends on the existing capabilities at individual or institutional levels. At the institutional level, the establishment or improvement of monitoring and early warning systems that ensures prompt and adequate preparation and response to disasters is part of a preventive strategy and an important ingredient of preparedness is often proper information flow available to the right people at the right time and in the right context. Preventive strategies according to [12] can be made more effective if the capacity and the will are there, the priorities are right, legal and institutional frameworks are developed,

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policies are implemented and the planned activities are well coordinated. Geographic Information System (GIS) is a computer mapping system developed for capturing, storing, querying, analyzing, modifying and displaying spatial data about places existing in the universe. It can display all kinds of data related to places in different ways such as tables, charts and maps based on the information entered into the system ([8]: [6]), thus served as a high performing computing tool for disaster management and control.

GIS as information system in disaster management

The present society is characterized with an intensive development of new technologies and materials. Due to the complexity of current man-made systems and unexpected nature of present environmental disasters globally, large amounts of information have to be included in decisions related to disaster management. A possible way to reflect present requirements to disaster management is introducing GIS (Geographic Information Systems) to decisions related to disaster management. GIS allows linking various digital map layers and databases and performs various unique analyses of those data, which cannot be realized any other way. Those analyses start with simple overlay operations and end with advanced real-time mathematical models analyzing behavior of various phenomena. The GIS data can be combined with other types of data (e. g. air photos, satellite pictures), which could be acquired and sent for the analysis in real-time. Therefore GIS could make disaster management more efficient and perform its procedures faster.

Comprehensive geographical information system (GIS) is very critical for making important decisions because of the spatial coverage of most disasters and the fact that disaster management usually involves large number of different agencies working in different areas. It allows sharing of information in real-time, thus saving the time which have been spent to gather these resources. In addition, GIS provides a mechanism to centralize and visually display critical information during a disaster by showing an interactive risk map. Risk mapping defines the area at risk and should be the basis for all disaster reduction programmes and subsequent actions. The purpose of a disaster risk map is to:

- ❖ Increase public awareness of the areas at risk of disasters
- ❖ Provide information of areas at risk by defining disaster risk zones to give input to spatial planning.
- ❖ Support the processes of prioritizing, justifying and targeting investments in order to manage and reduce the risk to people, property and the environment

Furthermore GIS is an important variable for spatial planning and land management that can provide various tools to prevent natural hazards (Kötter, 2003). In the context of natural disasters, spatial planning and land management can be used to support the following essential functions:

- ❖Early warning system: Spatial planning needs a detailed data base, to get sound information about the spatial development. In practice monitoring systems have to be extended systematically to inform about natural and environmental risks ([12]; [13]; [9]). The efficient data acquisition needs special measurement methods that have to be investigated and implemented.
- ❖Risk assessment and mapping: Prevention of disasters needs comprehensive information and data about the reasons and effects of the hazards. Therefore a comprehensive vulnerability analysis need to be undertaken for disaster-prone areas, incorporating information about past disaster events, the socio-economic conditions of the population living in the affected area, and inventories of major structures liable to damage. Risk assessment and hazard mapping would then be used to delineate areas vulnerable to natural hazards and determine the frequency, intensity, impact, return period and other data in relation to each category of hazard.
- ❖Prevention and reduction: Spatial planning has to analyze the interrelations between the spatial influences and the environmental disasters in order to reduce the impacts.
- ❖Risk Management: During and after disasters, certain infrastructure (evacuation routes and spaces) and a database are needed to realize the emergency plan and risk management.
- ❖ Reconstruction: When damages occur, there is the need to plan reconstruction of infrastructures. Spatial planning using GIS can assist the reconstruction efforts and also the future prevention of disasters. GIS-based space technology can be used in different phases of dealing with natural disasters.

Disaster management and control in Nigeria.

Throughout the world, countries have recognized the need to formulate a clear regulatory agenda aimed at the prevention, management and reduction of disasters. A number of steps taking in the right direction would boost the capacity to confront most natural disasters. Confronting disasters involve the individual, institutional and systemic levels. Individual level includes the availability, the knowledge and skills, as well as the performance of human resources. The capacity question focuses on all aspects of the disaster management system at national and local levels, and also includes an assessment of the political, cultural, social, economic and environmental factors which influence vulnerability to disasters. The institutional level focuses on overall organizational performance and management capacities. They include, the existence of an organization with a specific mandate on disaster management, thus the systemic level focuses on the creation of enabling environment, such as the overall policy, economic, regulatory, and accountability frameworks within which organizations and individuals operate, which[5] observed in many developing countries the weakness of State infrastructures, absence of appropriate legal and policy frameworks and sometimes inadequate resources particularly render them more vulnerable to consequences of large-scale disasters especially in Africa.

Disaster management is at formative stage in Nigeria, the year 1906 marks the earliest efforts at disaster management in the country, with the establishment of the Police Fire Brigade (now Federal Fire Services) with functions beyond fire fighting role to saving of lives, properties and provision of

humanitarian services in emergencies. By 1999, the National Emergency Management Agency (NEMA) was established via Act 12 as amended by Act 50 of 1999, to manage disasters in Nigeria. NEMA was set up to tackle disaster related issues, through the establishment of concrete structures and measures. The Agency has put in place structures that enable it detect, respond and combat disasters in a timely manner. Prevention is better and cheaper in disaster management due to the fact that if care is not taken, once there is a disaster the entire budget of a country may be diverted to contain it, [2].

In addition [2] reports states governments in Nigeria are been encouraged to establish their own separate State Emergency Management Agencies (SEMAs) to complement the role of the federal agency in their areas, through SEMAs, the states are actively involved in disaster management and presently, 36 states have so far responded positively in this regard. However, some of these states have not properly empowered their SEMA to be functionally independent and proactive in the discharge of their responsibilities. In recent times researchers have pointed out the fact that one of the ways to study and understand the disaster behavior is by generating the disaster extent or disaster risk map, such maps can be used for spatial planning and management of land. In addition, there are also some researches concerning GIS-based integrated assessments of populations' vulnerabilities for famine, agricultural drought vulnerability ([14; [7]) and economic vulnerability of households.

Significance of GIS in disaster management

Present disaster management represents a complex set of operations including various pre- and post-disaster measures. Those measures are planned and realized by various organizations such as fire and rescue services, emergency medical services, police, or local authorities. Those organizations have different structures, routines, etc. It brings new problems to disaster management and also increases its complexity. To overcome such problems a new concept, which could be resistant to different types of organization structures and various diversities, seems to be necessary. This concept is based on GIS that is independent on number of participants in disaster management, their structure, routines, and possible changes of those factors. GIS in disaster management can be seen as a cycle (Fig. 1), consisting of eight elements: (1) assessment, (2) prevention, (3) mitigation, (4) preparedness, (5) disaster event, (6) response, (7) recovery, and (8) evaluation. Over the classic disaster management scheme, the scheme for GIS includes new element called 'evaluation'. This element is added to the cycle to evaluate GIS and its performance in disaster management, and also emergency management itself. The outcomes of the element lead to changes in organizations, methodology, technology, or data involved in disaster management according to Bernhardsen's GIS chain (Bernhardsen 1999).

Fig. 1

The Challenges

A major challenge is to understand what and where the obstacles are and to learn what strategies exist for dealing with these hurdles. The most common barriers are listed below:

All phases of disaster management depend on quality data from a variety of sources. Access to the appropriate data is very limited, thus the issue of data standardization in Nigeria and the lack of established Spatial Data infrastructures.

The limited availability of trained staff to utilize the functionalities of a GIS or even the limited ability of disaster officers to use GIS as a tool that will add power to and make disaster management more efficient.

- The issue of politically define boundaries- Natural hazards does not recognize political boundaries, yet policies generated to mitigate against disasters inevitably speaks political boundaries.
- Inadequate administrative systems, it is found that administrators resist change and therefore an important issue is to gain senior management acceptance and make the necessary arrangements to facilitate sustainability. It is important that disaster managers recognize that proper planning is a key to a successful GIS.

Lack of funds for the support and implementation of GIS. The implementation of a GIS can be a very expensive process however; one should bear in mind that disaster management is an investment, thus the need for adequate budgetary provision by all tiers of government in Nigeria.

The lack for greater responsibility and accountability for vulnerabilities and lack of greater emphasis placed on disaster management through greater public education in matters of disaster management by meaningful stakeholder consultation and collaboration.

Conquering these challenges demands the commitment of key disaster and related personnel, the expenditure of energy and money.

The Way Forward

The institutional, political, managerial and social dimensions of implementing a GIS based disaster support system through integrated GIS databases must be addressed. This GIS should be used in identifying and quantifying natural disasters and in conducting vulnerability and impact assessment in a seamless manner using an easy to use Graphical User Interface. This system will facilitate effective planning and in the event of a disaster, quick, organized and effective response. The suggested approach for system development is briefly outlined below:

* Review of existing documentation on GIS and disaster Management, Hazard modeling by liaising with disaster Management agencies and hosting of consultative workshops.
* Collect pertinent spatial and attribute data; create GIS hazard database and development of national spacial data infrastructures in the country.
* Conduct Hazard modeling & analysis through developing disaster management applications by creating Graphical User Interface that can test the system by deploying the applications to evaluate feedback from end-users

II. Conclusion

The integration of GIS to Disaster Management requires a careful and well-developed plan, which addresses administrative issues, costs, the range of users and the anticipated information products as well as the need for sustainability. There must be buy in to the need for incorporation of GIS in Comprehensive Disaster Management. It is important to understand that while GIS can enhance the existing disaster management programmes in Nigeria, its integration requires broader management and institutional issues be addressed. Technological advances and extensions of geographic information systems have opened the way for several applications in disaster management. The kind of analysis available to researchers, policy advisors and decision makers were only being dreamed of ten years ago (Amdahl, G., 2001). It is envisaged that disaster management in Nigeria will progress to the point of an automated disaster management information system built on web enabled GIS Technology in a multi-user and multi-agency environment. GIS is not a panacea but can facilitate loss reduction and event prevention in some instances as well as lead to more efficient means of recovery and rehabilitation in disaster management. This is however only possible through much research and education in this field.

References

[1] Curtis, A. and Mills, J.W. (2010). GIS, Human Geography and Disasters, Cognella, University Readers, Inc. USA

[2] Hakeem A. Bashir O. O, and Olusegun, H. A.(2012) BUILDING CAPABILITIES FOR FLOOD DISASTER AND HAZARD PREPAREDNESS AND RISK REDUCTION IN NIGERIA: NEED FOR SPATIAL PLANNING AND LAND MANAGEMENT Journal of Sustainable Development in Africa (Volume 14, No.1, 2012) Clarion University of Pennsylvania, Clarion, Pennsylvania

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[4] Kötter, T. (2003). Prevention of Environmental Disasters by Spatial Planning and Land Management.TS13.1 2nd FIG Regional Conference. Marrakech, Morocco, December 2-5, 2003.

[5] Olowu, D. (2010). The Hyogo Framework for Action and its Implications for Disaster Management and Eduction in Africa. JAMBA: Journal of Disaster Risk Studies, 3(1):303-320

[6] Pottle, T. (2001). Geography and GIS: GIS Activities for Students. Toronto: Irwin Publishing Ltd.

[7] Pradhan, B. (2010). Role of GIS in Natural Hazard Detection, Modelling and Mitigation, Disaster Advances, 3 (1): 3-4

[8] Rubenstein J.M. (2005). An Introduction to Human Geography: A Cultural Landscape. New Jersey: Pearson Prentice Hall.

[9] Samarajiva, R., Malathy, K.J., Peter S. A. and Ayesha, Z. (2005). National Early Warning System: Sri Lanka – A Participatory Concept Paper for the Design of an Effective All-Hazard Public Warning System, Version 2.1, LIRNEasia, Sri Lanka. http://www.lirneasia.net/2005/03/national-early-warning-system

[10] Suda, C.A. (2000). Natural Disaster Preparedness, Environmental Degradation and Sustainable Development in Kenya. African Study Monographs, 21(3): 91-103, July 2000.

[11] UN-International Strategy for Disaster Reduction (UN-ISDR) (2009). "Reducing Disaster Risks through Science: Issues and Actions, the Full Report of the ISDR Scientific and Technical Committee 2009". Available at www.preventionweb.net/globalplatform/2009/ background/ documents (Accessed 16 Oct. 2011).

[12] UNDP (1997). Sustainable Human Development: An Analysis of the Kenyan Situation. Prepared by J.M. Behemuka & P.N. Mbati.

[13] Uitto, J.I. (1998). The Geography of Disaster Vulnerability in Megacities: A Theoretical Framework, Applied Geography, 18 (1):7-16. http://dx.doi.org/10.1016/S0143-6228(97)00041-6

[14] Wilhelmi, O.V. and Wilhite, D.A. (2002). Assessing Vulnerability to Agricultural Drought: A Nebraska Case Study, Natural Hazards, 25:37-58 http://dx.doi.org/10.1023/A:1013388814894