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SPATIAL DATA INFRASTRUCTURE (SDI): A PLAUSIBLE SOLUTION TO IMPROVE DISASTER MANAGEMENT PROCESSES IN NIGERIA

[1]Olajide Kufoniyi, [2]Olukunle Ayodeji Ogundele and 1David O. Baloye

[1]Department of Geography,Obafemi Awolowo University Ile-Ife, Nigeria.
[2]School of Maths, Stats and Computer Science, KwaZulu-Natal University, South Africa.

ABSTRACT

Nigeria, like many other countries of the world, is not immune from natural and artificial disasters which regardless of their origin, type, onset and impact, have the potential to destroy decades of investment and effort, and cause the deviation of resources intended for primary tasks such as education, health and other critical infrastructure. Although, the scale at which disaster happen in Nigeria cannot be compared with their occurrences in some other parts of the world, the fact that it is one the most significant challenges of sustainable development, makes it an important issue worthy of considerable attention. Consequently, measures and mechanisms must be put in place for rapid response to disaster events in the country to enable efficient management of resources during such events. It is axiomatic to state that availability of data and information will go a long way in effectively mitigating the effects of any disaster. A very vital component of the required data is the geospatial data. Global efforts at national and international levels are on to ensure that disaster management personnel have access to reliable geospatial datasets when they need them and in usable format through the implementation of spatial data infrastructure. This paper discusses the role of SDI in the efficient management of natural and artificial disasters in Nigeria in the light of ensuring frugal allocation of resources during a disaster management process.

Keywords: Spatial Data Infrastructure, National Geospatial Data Infrastructure, Disaster Management, Geographic Information System, National Emergency Management Authority

INTRODUCTION

When the Millenium Development Goals (MDGs) were set in 2000 by 189 Head of States at the UN Millennium Summit in Rio de Janeiro, all hopes were raised about creating enabling environment for the present generation of earth occupiers and most importantly, the generations to come. However, the increasing rate of both natural and man-induced disasters have caused many countries, especially those of the developing world, to be lagging behind in the achievement of these goals. For instance, the number goal of the MDG, which is associated with halving poverty by 2015, has almost become a mirage, thanks to recent phenomenal increase in disasters, especially in the last two decades (DFID, 2004; UNISDR, 2012; UN System Task Team on the Post-2015 UN Development Agenda, 2013). Disaster as a development antagonist, has the potential of putting development gains at risk and this has a multiplier effect on poverty (Chien, 2011). While the developed countries of the world have put in place proper and effective procedures of mitigating disaster and its associated vicious effects, many developing countries are still groping about. The adoption of Spatial Data Infrastructure (SDI) as a veritable tool in mitigating the impact of disaster becomes very obvious.

Spatial information and information communication technologies are the important elements in disaster management well-known worldwide (Rajabifard *et al*, 2004). Although emphasis are laid on other resources such as funding, personnel and equipments, the effectiveness of disaster management process lies in the ability to acquire data and to process as well as transform such into useful information for decision making. The acquisition of data is one of the main challenges faced in management process in Nigeria and this is because spatial data resides with various geospatial information (GI) producers. The effort of management institution to purchase and manage these data has only increased the problem of man power capability among other transaction costs. Hence, there is need for a framework which can be employed in providing access to quality and authoritative information that is needed to support disaster management activities.

SDI has become a framework that facilitates coordinated production, data sharing and access to services via the network to support various community and organization activities. These activities include land management, public health and disease control, resource management, rural development and poverty alleviation, water management and so on. Disaster management is one of the main applicable areas where SDI has greatly helped in developed and developing nations alike. Access to information via national SDI has helped in proper planning against disaster occurrence, emergence responses during disaster and several post disaster activities.

SDI is already being introduced in Nigeria and its implementation has already started at various governance levels since the year 2000. But it has not reached the stage where stakeholders and other users will start to fully benefit due to some challenges including and most especially cooperation of stakeholders and GI producers to facilitate the system. Likewise, disaster management in the country is already formalized, having been re-institutionalized in 1999; it has been making impact in the aspect of coordination of emergency response activities during disaster events in the country. Also, it has developed its Geographic Information Systems (GIS) process to support several of its functions. But there is a gap of data need which can only be filled with the institutionalization of SDI at various governance levels of the country.

Currently, there is not yet a tangible instance where SDI at any level in Nigeria is used to support disaster management. Still, access to quality data constitutes a great challenge to disaster management in the country. Proper implementation of

SDI in Nigeria is a key solution to intelligence support for disaster management. Moreover, a successful implementation of national SDI (officially known as National Geospatial Data Infrastructure (NGDI)) in Nigeria is a significant prospect that disaster management institution and safety organizations stands to benefit from.

This paper examines the role of spatial data infrastructure in disaster management activities. In the next section, we explain the term disaster in the context of this paper followed by an examination of disaster management profile in the country. In section 4, we look at the spatial data requirements for efficient disaster management while sections 5 and 6 focus on SDI and framework for disaster management.

DISASTER EXPLAINED

The ISDR (2003) definition of disaster sees it as a serious disruption of the functioning of a community or a society that result in widespread human, material, economic or environmental losses exceeding the ability of the affected community or society to cope using its own resources. In this sense, disaster refers to any sudden, calamitous event bringing great damage, loss, and destruction and devastation to life and property of the affected area. This description of disaster shows that it relates to emergency or sudden situation that causes immeasurable damage and which in most times have large spatial coverage. Although it varies from place to place, region to region, yet whatever its form, magnitude or location, disaster disrupts the normal day-to-day life of the affected people and place, it also negatively influences the affected area's emergency system while at the same time it has every tendency of depleting the resources or stock of the affected community.

Although many studies have attempted classifying disaster, a general division of this phenomenon is that which is based on the causative factor of the occurrence of the disaster. Using this criterion, disaster can be grouped into two classes. The first class of disaster are called natural disasters and they include those occurrences caused by natural factors or what some people referred to as act of God. This type of disaster includes tsunami, cyclones, landslides, volcanic eruption among others. The second class or group of disaster are those referred to as man-made or rather man-influenced disasters, usually caused by human errors or in other ways traceable to human activities. They include oil spill, hazardous or toxic spill, fire outbreak, landslide, and flood among others.

However, whatever the type or causative factor, disasters are in most cases unpredictable, fast and spontaneous. Also, risks and benefits, if any, are difficult to assess and compare. Most importantly, disasters are dynamic events which mostly occur rarely. These characteristics of disaster make them to have very profound effect on the affected area and people, and in most cases the cost are usually beyond the limit of such community. For instance, the Economist, a British high riding newspaper in its March 21st, 2011 edition put the financial cost of the Japanese March 11th earthquake and tsunami at $235 billion, around 4% of the country's Gross Domestic Product (GDP), with more than 10000 people unaccounted for. The cost of a complete cycle of a disaster can be very huge and in recent times has been on phenomenal increase.

Ritchie (2004), citing the works of Faulkner (2001), Fink (1984) and Roberts (1994), gave a vivid description of the lifecycle of disaster. A disaster cycle starts with the pre-event stage which is associated with action plans aimed at preventing the disaster. The second stage called prodromal starts when it has become clear that the disaster is imminent.

The third stage, referred to as emergency or acute phase (Flink 1984), is the stage when the disaster has struck and its impact felt by the people. The fourth stage also called the intermediate stage sets in when the short term needs of the people like search and rescue, emergency medical relief and essential services are in top requirement and the need to restore the community to normalcy is felt more than ever before. The fifth stage called chronic stage starts at the point where the community has an opportunity to redefine or reposition itself with regards to sustainable development. The last stage is the resolution phase where the community's routine business is restored and a new, where possible, improved state achieved. Because of the huge socio-economic cum psychological cost associated with disaster, countries and regions of the world have worked extensively on developing ways of managing or handling occurrences referred to as disaster. The sum of the process and activities aimed at mitigating the effect of disaster on a community is called disaster management.

Disaster management can be defined as the effective organization, direction and utilization of available counter-disaster resources (Westen and Arambepola, 2005). It also refers to the actions taken in response to unexpected events that are adversely affecting people (Wikipedia, 2011). Like any other management field, it is a by-product of the identification of series of vital gaps, which in this case relate to the cycle of disaster. In other words, disaster management provides the basis for the effective allocations of resources targeted at mitigating the multidimensional effect of disaster in a community. The paramount goal of disaster management activities is therefore to reduce, as much as possible, the degree to which a community's condition is worsened by a disaster relative to its pre-disaster condition. Because it is tied to lifecycle of disasters, disaster management has been divided into four main cyclical phases. These are i) mitigation- concerned with the application of measures that will either prevent the onset of a disaster or reduce the impacts should one occur; ii) preparedness- involving activities aimed at making a community respond when a disaster eventually occur; iii) response– involving the employment of resources and emergency procedures, guided by plans, to preserve lives and property, as well as the environmental cum socio-economic and political structure of the affected community, at the onset, impact stage, and aftermath of a disaster; and iv) recovery– concerned with actions taken in the long term, well after the immediate impact and shock of the disaster has passed, to stabilize and bring the community to a state of normalcy.

SPATIAL DATA NEED FOR DISASTER MANAGEMENT AND SUSTAINABLE DEVELOPMENT

Information acquisition is one main process in disaster management where data is accessed about disaster. The other part is the information communication where the derived information from processed data is communicated to the community for decision making and proper action. It should be noted that disaster management is data driven. And because it has to do with people and location, spatial data becomes an integral part of the management process. In other words all disasters have a temporal and geographic footprint that identifies the duration of impact and its extent on the Earth's surface (Committee on Planning for Catastrophe, 2007). The ability therefore of geospatial data to link a location to the properties of events, features, or entities at that location gives geospatial data their place of respect and value in disaster management.

A disaster, whether artificial or natural, can overwhelm even the best prepared segment of a society and so when not properly managed, the same disaster inflicts far more damage than necessary. At the core of disaster management lie the monumental tasks of collecting, distributing, processing, and presenting disaster-related data (Ryoo and Choi, 2006).

This implies that the effectiveness and efficiency of disaster management institution lies in its ability to observe and analyse spatial data in relation to disaster and to generate real-time and valuable information for the benefit of affected community.

The availability of this type of time-sensitive information, in the right format for the right users, is an essential part of disaster management that helps in creating the much needed resilience for the affected community, thereby increasing the sustainability of such communities.

Disaster preparedness and response depend on gathering, analyzing and acting on timely and accurate information. Rego (2001) categorized the information needs of disaster managers into two distinct, but closely related classes namely; the pre-disaster information needs which are suitable for the analysis and research that will help to improve existing knowledge, risk assessment, prevention, mitigation and preparedness; and the post-disaster information needs: concerned with response, rehabilitation and reconstruction. These information needs rely on two categories of disaster-related data which are the pre-disaster baseline data of the areas under study as well as the potential risks; and the post-disaster real-time data required for the impact of a disaster and the available resources to combat it.

A similar categorization of information needs for disaster management was given by IFRCRCS (2000). In this classification, the pre disaster stage is referred to as hazard and early warning information and the post-disaster information needs referred to as progress of post disaster recovery. The third tier of disaster information need is the in-between situation referred to as disaster needs assessment. This phase relies on the information already gathered and analysed before the disaster struck and it also forms the basis for the post disaster recovery stage. However for the disaster information needs to be useful, the participating agencies in the whole process must have pre-determined what information need is required, the process of acquisition, the form of analysis to be adopted and the process of integrating the volume of information obtained into a timely decision-making process.

To buttress the significance of real-time information in disaster management, Rego (2001) further emphasized that the ability of disaster managers to analyze risks and decide upon appropriate counter-measures depends on the availability of cross-sectoral integration of information. It is in this vein that the Global Data Infrastructure Network (GDIN) sets as its vision the creation of a robust, integrated, virtual network for cooperative exchange of timely, relevant information used during all phases of disaster management to save lives and reduce economic loss (GDIN, 1997).

Data from sensor observations, satellites and demography are core data for managing disasters. For instance, risk maps are made from analysis made on weather data, terrain and topographic features to show possible occurrence of flooding in an area. It can be made into a risk and vulnerability maps which can serve as early warning for community dwellers. The process of analysis is supported with the use of GIS for spatial analysis and simulations.

SPATIAL DATA INFRASTRUCTURE AND DISASTER MANAGEMENT

According to Rajabifad et al (2004),

> *"The growing need to organize data across different disciplines and organisations and also the need to create multi-participant, decision-supported environments has resulted in the concept of*

spatial data infrastructure (SDI). SDI is an initiative intended to create an environment that will enable a wide variety of users to access, retrieve and disseminate spatial data and information in an easy and secure way."

The initiative is therefore expected to facilitate efficient disaster management activities at all levels.

The main question is: why collecting data that is already collected by another organization? In Nigeria today, independent data collection by ministries and agencies still hold sway and this has resulted in duplication of processes, which has consequently led to wastage of government resources and funds. Furthermore, required data for meaningful development are scattered among numerous agencies, thereby creating impediments to rapid access to skilled personnel, data and tools. The implication is endless confusion, with no major achievement made.

SDI is therefore presented as a way to minimizing wastage and duplication of efforts. It is to allow sharing of data and reuse of data. This will enable users to save resources, time and effort when trying to acquire new datasets by avoiding duplication of expenses associated with generation and maintenance of data and their integration with other datasets (Rajabifad et al, 2004). This singular advantage of SDI has endeared it to decision makers and MDGs'protagonists. In this sense, SDI provides the much needed platform for effecient allocation of the limited resources in a more frugal way that ensures sustainability.

The present era of heightened requirements for prompt and effective response, rapid access to disparate geospatial information sources has made SDI to become critical in the national disaster management framework. SDI as an innovation in spatial data management can provide an appropriate environment in which spatial datasets are always available and accessible as well as integratable for use in disaster management, particularly disaster response (Samadi and Delavar, 2009). For meaningful and timely decisions to be made, especially in emergency situations, access to all possible locations of relevant geospatial data is required. SDI provides the enabling framework and environment that make this possible. It is important to establish at this stage of the study that the use or integration of SDI into disaster management involves the intersection of two distinct communities namely, the emergency response community and the geospatial community.

Because of the multidisciplinary nature of disaster management, many organizations are often involved at different level. These organizations are usually drafted either as full time member of the disaster management processes or as ad-hoc member. On one hand of the divide is the coordinating agency as well as other related agencies like fire fighters, security operatives, mass media, hospitals and utility companies. Some of these companies may not be directly involved in the disaster mitigation process, but because they have access to geospatial data and facilities useful in disaster management, they become essential stakeholder in the disaster management business. The other groups of organizations are those directly or indirectly involved in the provision of geospatial data.

Since no organization is capable of collecting and having access to all the up-to-date geospatial datasets required for the pre and post periods of disaster, an enabling environment for collaborative effort is often created in the disaster mitigation processes, especially with regards to geospatial data collection, use and sharing. The rationale behind this cooperative gesture is to provide access to wider range of information useful in handling the emergency situation at hand, to a wider range of stakeholders (Rajabifard *et al*., 2005). In this sense, an SDI for disaster gives access to any authorized personnel who is in need of geospatial data for disaster management purposes.

However, because individual organization and people are involved, there is the need for a platform that will support the integration of these myriad of information from different sources. An SDI provides the necessary framework for data access and sharing in emergency situation, by ensuring interoperability of data, procedure and standard. SDI also creates workable agreements such as the type of geospatial data that can be used before, during and after a disaster, guidelines for sharing the data with public media and level of cooperation expected within a well stated legal and structural frame. The access to and sharing of data provides the opportunity for reducing the overhead cost, in terms of financial implications, resources, time and most importantly human lives, associated with disaster.

This makes an SDI the appropriate framework for facilitating disaster response and disaster management, thus providing great opportunity for the disaster response and recovery stakeholders to make informed decision, thereby ensuring the overall success of the whole exercise. In addition to the above stated purposes of SDI, it also eliminates data duplication by collecting data once and filtering any form of duplication of such data. Closely related to this is that security could be enforced and restricted to only authorized personnel. Figure 1 shows the summary of the roles of SDI in disaster management. A typical SDI adapted for disaster management plays prominent roles in hazard vulnerability analysis, early warning involving hazard risk communication, hazard coordinating activities, impact assessment and updating of hazard baseline profile.

At the vulnerability analysis phase of disaster management concerned with evaluating the potential impacts of a disaster, SDI provides access to all physical infrastructures that may partake in the disaster. Datasets such as names, location, condition and size or dimension of physical infrastructure, as well as the size and demographic cum socio-economic characteristics of people that may be involved in the disaster can be accessed or created with the SDI. Regardless of the source of the datasets, SDI provides ample opportunity for real-time access to them, since protocols and standard have been clearly defined.

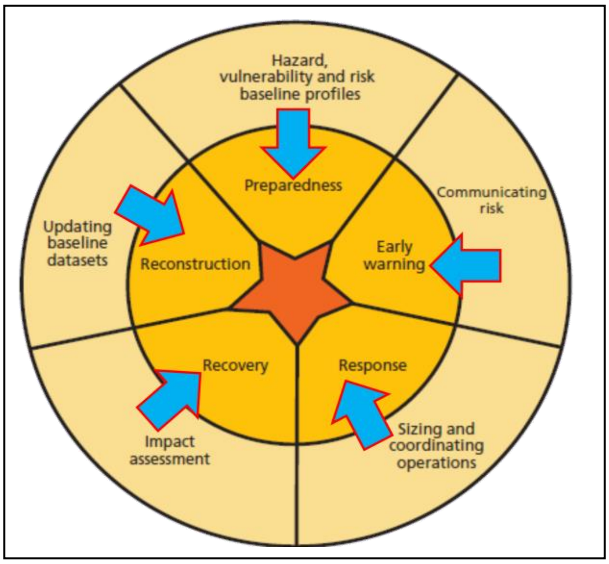

Figure 1: SDI roles in relation to the disaster management cycle *(Asannte et al, 2007)*.

SDI also plays crucial role in the response phase of disaster management which is concerned with recommending sets of action, targeted at reducing or mitigating the disaster's impact, to on-the-ground disaster management personnel in the affected community. The action plan, which is mostly based on assessed disaster vulnerability, involves the deployment of many geospatial data, models and techniques. The entire plans are executed or implemented under very intensive decision-making scenarios which work better in an SDI. In the words of Asante et al (2007), the integration of service architecture and map server technology with satellite-based communication systems could bring about the integration of available geospatial data and field reports into a coherent picture of disasters in near real time and would significantly increase opportunities for SDIs to contribute directly to disaster response and to policy analysis in general.

After the disaster had taken place, the affected community no longer looks the same. Profound changes had taken place in both physical and socio-economic cum cultural aspects of the community. It therefore implies that the pre-disaster data existing can no longer represent reality, hence the need for the updating of the database. New datasets acquired from the reconstruction phase of the disaster will have to be incorporated into the disaster database for the next phase of preparedness. An SDI becomes a useful mechanism for updating the baseline data acquired by the different organization and people involved in the whole exercise, especially the post-disaster phase. The updated database provides an invaluable opportunity for knowledge gained from the management of a disaster to systematically contribute to planning for future disasters. Figure 1 summarizes the cycle of disaster as viewed from SDI perspective.

SDI FRAMEWORK FOR DISASTER MANAGEMENT

As emphasized earlier, geospatial information and information communication technologies (ICT) play prominent role in disaster management. The blend of these two components is typified in the development of SDI. It implies that SDI provides the platform for data handling facilities, policy integration and access to the established network. As shown in figure 2, it also defines all necessary standards and protocols while at the same time creating avenue for coordinating human resources necessary for the effective collection, management, access, delivery and utilization of spatial data.

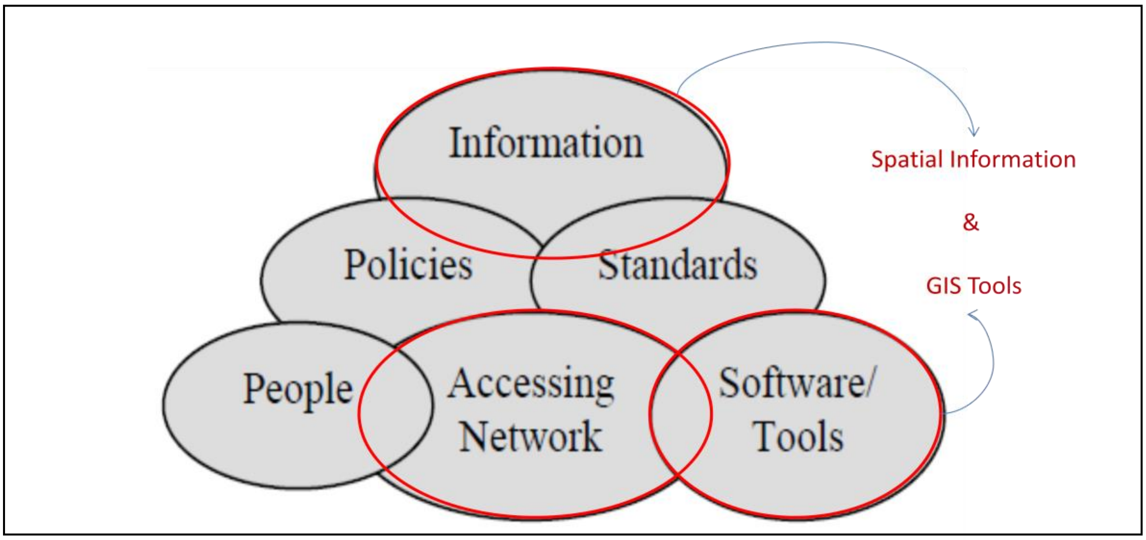

Figure 2. Required components of SDI for proper disaster response (Rajabifard 2004).

However, for an SDI to effectively play out its role in disaster management, an appropriate framework which recognizes the relationships between different participating components much be established. This framework is the proper environment for the SDI to function. The framework defines the interaction within a component and across many components. It also establishes in clear terms, the effect that the components have on each other, external factors affecting each component, as well as the internal elements of each component. For instance, under the data component, it states the expected sources of data, their resolution or scale, standards as well as guidelines for the acquisition, use and exchange. Policy, people and access are also defined bearing in mind how they affect each other.

Basically, an SDI facilitates the relationship between data and its multi-varied users including collectors, managers and decision maker, within the confine of access to the network, standard and operating policies. Put more explicitly, with SDI's standards and policy components, producers can produce data free of duplication of efforts and share them to be accessible and applicable for users including value-adders and end-users, who can easily access and use through the provided access network (Mansourian 2005). Nebert (2009) gave a summary of the components of a typical or generic SDI in table 1 below. These components, working within the frame of organization arrangement and data access policies, form the core of any robust SDI. The level of this interaction is shown figure 3.

Table 1: Description of Components of a typical SDI

Componets	**Characteristics**	**Formats**
Metadata	* Inventory of who has what data of what type and quality. * Descriptive elements that characterize an information source. * Describes all types of data, with emphasis on 'truth in labeling * Applies to data, services, and other resource types. * Provides documentation of existing internal geospatial resources within an organization. * Permits structured search and comparison of held geospatial resources by others. * Provides end-users with adequate information to take the resource and apply it in an appropriate context.	* ISO 19115/TS19139 provides an international standard for metadata and its encoding. * XML metadata may include reference to an XML Style Sheet (XSL) to present the XML data in a browser. * Format may also be presented by requesting the HTML format. * Can be converted to an X-HTML format that can be parsed and presented.
Framework data (referred to as Fundamental data in NGDI)	* Commonly used and shared digital geographic data that are created, updated, integrated or distributed. * Community development of sets of spatial primitives, feature representation, and attribution to a lowest common denominator. * Multiple representations of real-world features at different scales and times by feature identifier and generalization.	* Elevation * Orthoimagery * Hydrographic Data * Governmental Unit * Boundaries * Cadastral * Geodetic Control * Transportation
(Other) Geodata (classified as thematic datasets in NGDI)	* Built special-use thematic layers	
Services:	* help discover and interact with data	
Discovery	* Core function of the Clearinghouse for geospatial information * Discovery of resources through Metadata. * provided by a national catalog of geospatial information which can be accessed by a geo portal. - locate data and services. - support download of data and provide link to related websites, and applications for others to access. - support self-organizing communities post and manage selected content. - share data collection plans and requirements to support partnerships and collaboration.	
Access	* standardized access to geospatial information. * delivers 'raw' data and not maps. * made via static files on ftp or via online data streaming services.	
Processing	* provides additional processing on geospatial information * includes capabilities that extend and enhance the delivery of data through processes applied to raw data.	* Web Mapping Services * Symbolisation * Coordinate Transformation * Analysis or topologic overlay services * Routing services
Standard	* makes SDI work. * touches every SDI activity. * includes specifications, formal standards, and documented practices.	
Partnership	* Extend local capabilities in technology, skills, logistics, and data.	

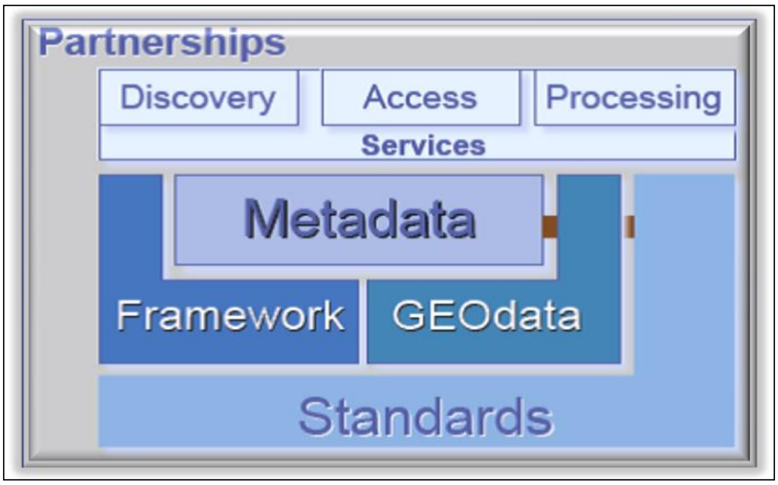

Figure 3: Components of an SDI (Nebert, 2009)

The application of the SDI model for disaster mangement emphasizes the data, people and policy components of the model. The dedicated SDI capable of use in disaster management must be explicit enough, bearing in mind the different stakeholders and the need for urgent and timely information driven decisions. It implies therefore that the 'people' component of the SDI must take into cognisance the data providers which should include the coordinating agency as well as those drafted from other agencies like mapping agencies. Those who add values to the aquired data, at one stage or the orther nust also be properly incorporated. The end users, inclucing field disaster workers as well as those at the decision making cadre, must be properly grafted. In terms of the data, different aspects including resolution or scale, contents, updating, database management and metadata must be carefully integrated. It becomes essential therefore, that issues pertaining to data sources and acquisition must take into consideration all possible means or techniques, at the onset of the disaster, the response stage and the recovery. This component goes a long way in determing the ability of the disaster managers to make useful decsions.

Because large volumes of data from different sources and scale are involved and because people from different agencies and field of interest are involved, well-defined standard aimed at creating a seamless database must be included. Issues involving metadata and metadata standard, data quality, interoperability, as well as specification and guides must be explicitly stated. This will enable disaster managers to gain the much needed time, since there are no delay due to the fact that data, regardless of the sources and scale have already been fine-tuned to the same standard. 'Standard' component of the SDI also ensures that ambiguities in data have been resolved. The availability of metadata, based on the guides and specifications defined will ensure that the SDI works and adapt to disaster in a very short time.

Policy issue is a very important component that facilitates participation of organizations by creating the necessary conducive environment for data production, use and exchange. Since data have to be relocated outside the domain of the data provider and value adders, issues relating to access to data in the form of copyright, privacy laws, data pricing and security must be properly defined. The various operating environment like political, cultural and organizational framework of the SDI must also be thoroughly considered.

Lastly, the network access depends on the communication system, network mechanism and response time, provided within the platform of Information and Communication Technology (ICT). This component also plays crucial role because the information sharing capabilities of the SDI is dependent on it. This in turn determines the response time of the decision makers, data providers and the end users, throughout the life cycle of a disaster.

Given that the above exists and that all locally available and maintained data reside in one common database or properly networked in distributed databases, then there would be a tight mesh of timely and compatible information that can be used in a disaster situation. Figure 4 shows the various components of an SDI-based conceptual model for disaster response.

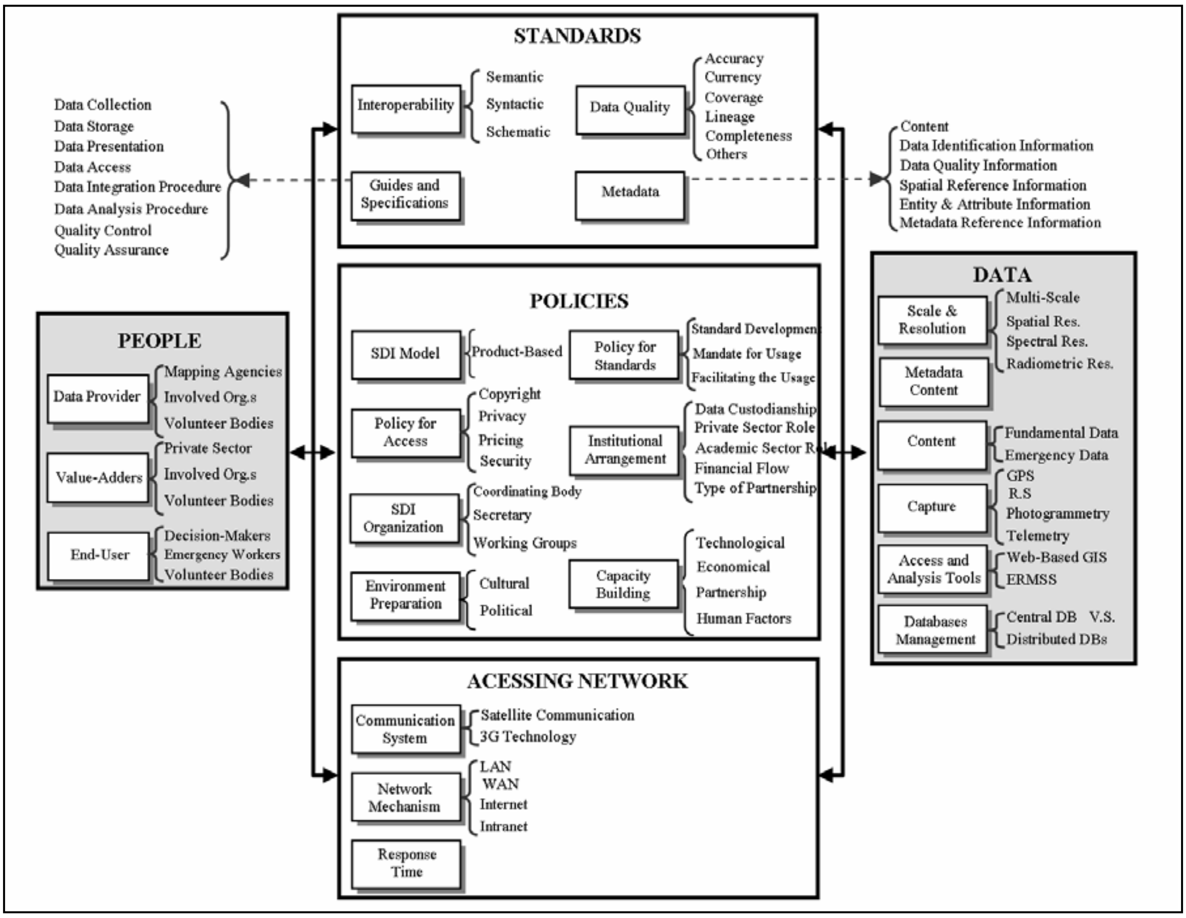

Figure 4: Schematic Presentation of a Developed SDI Conceptual Model for Disaster Response (Mansourian, 2005)

Disaster Management Profile in Nigeria

Nigeria, like many other countries of the world has had and till date is still having its share of disaster and emergency situations. Indeed, the occurrence of disasters and emergencies in Nigeria has been on the increase, especially in the last few decades. Many of these emergency situations have been attributed to rapid population growth and unchecked urbanization coupled with social-political issues that are compounded by ethnic plurality. Although while it can be said that the magnitude of disaster in the country cannot be compared to some other parts of the world, yet the incidence of disaster in the country has increased radically and when viewed at a larger scale, it has become a major issue in Nigeria's development programmes and general sustainability. The series of recent floods, drought and fire outbreak across the country attest to this fact. A typical example is the Ibadan flood case of August 2011 which claimed many lives and destroyed property worth several millions of Naira.

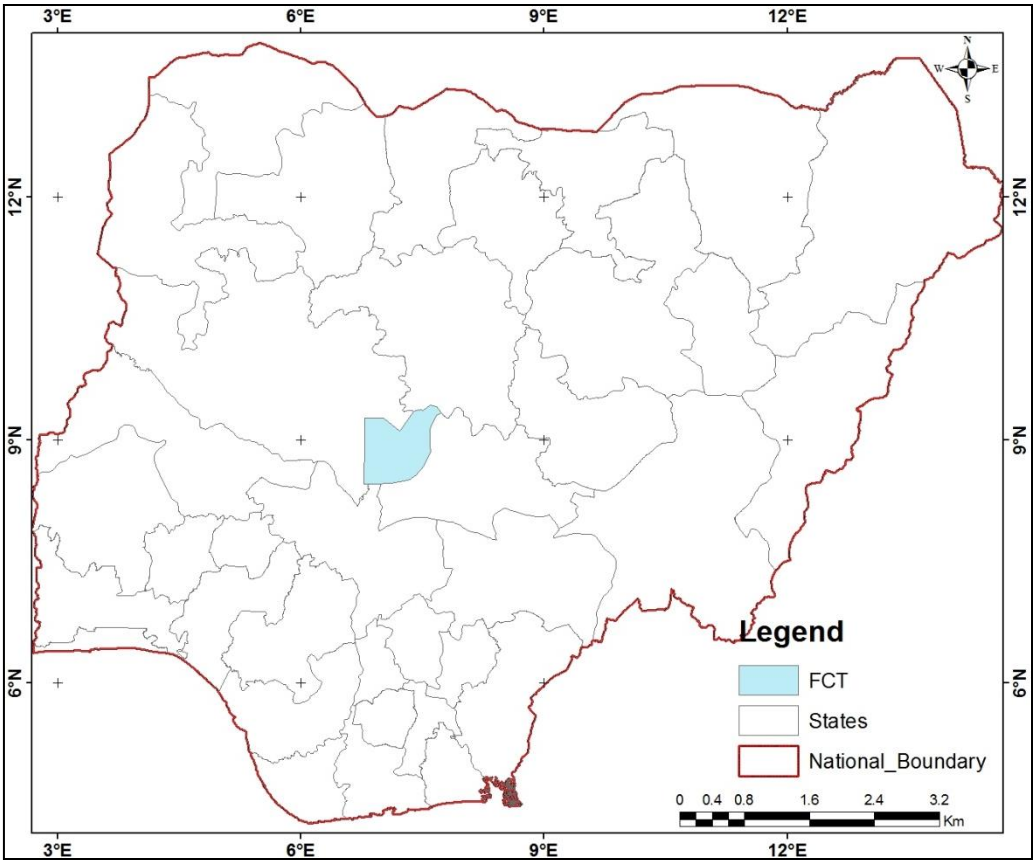

Figure 5. Map of Nigeria showing the 36 States and the Federal Capital Territory

A disaster and emergency profile of the country shows among others the under listed.

- Frequent oil spills; pipe line vandalisation
- Outburst of urban industrial pollution and waste
- Severe floods, in both Northern and Southern States
- Desertification in Northern States, droughts and general land use degradation
- Pest infestation as in Quella birds and locusts in the Yobe - Borno axis
- Avian influenza H5N1 (bird flu)
- Gully erosion in South Eastern States, also Auchi and Bida.
- Wind storms in the northern parts of the country
- Fire disasters, especially market infernos in Sokoto, Jos, Anambra and Lagos
- Collapsed buildings in Lagos, Abuja and Port Harcourt
- Ethno-religious conflicts such as Jos mayhem and Modakeke-Ife Crisis among others.

Because of the huge human and material cost associated with disaster and emergency situation, many countries and regions of the world have set up specialized and institutionalized bodies charged with providing quick, real-time and efficient management of disaster at all levels. Institutional response to disaster in Nigeria can be traced back to 1906 when the Fire Brigade (now Federal Fire Services) was established, with its functions going beyond fire fighting, to saving of lives and property and providing humanitarian services during emergencies. Between 1972 and 1973, Nigeria was hit by a devastating drought with socio-economic consequences that caused the nation loss of lives and property worth millions of Naira. This made it important for the Government to consider a response body to take care of disaster related issues. Thus, the National Emergency Relief Agency (NERA) was set up in 1976 and it was charged with the task of collecting and distributing relief materials to disaster victims (Shaba, 2009).

However, faced with increased disaster activities in the country and the need for a more proactive management of disaster in the country, the National Emergency Management Authority (NEMA) was established in March 1999. The Agency was saddled with the responsibility of coordinating disaster management activities for the country with the purpose of reducing loss of lives and properties and of supporting disaster management stakeholders in a comprehensive risk based emergency management program of mitigation, preparedness, response and recovery.

GIS Support for NEMA Activities

It is important to know that through all the above institutional interventions on disasters in Nigeria, there has not been a formal involvement of GIS in event managements. Although there have been some cases of map production within the institution but not for strategic intervention and management of disasters. In view of this NEMA set out to involve GIS in enhancing effectiveness and efficiency in their service delivery. Although GIS is not one of the main units in the institution, efforts have been made to develop more a GIS base disaster management activities for the country for early warning for disaster responses (Shaba, 2009).

The (former) Director General of the Agency, AVM Muhammad Audu-Bida, said at the first 2009 Ministerial Press Briefing in collaboration with Federal Ministry of Information and Communications that the GIS Lab is one of the significant facilities of the agency for its disaster risk reduction programme; it collects spatial data on disasters, analyses and prepares useful information that can help in aid responses to disaster. Among other things the agency adopted for coordinating disaster management is the Mission Control Centre, which is a computer based satellite technology that uses the "COSPAS-SARSAT hi-tech system". This system is designed to pick distress alerts and location data to assist in Search and Rescue Operation (SRO), by using satellite and ground facilities to detect and locate the signals of distress beacons operating on 406MHz. (Kendall, 2009; GSDI, 2009)

One other effort to adapt GIS actively in disaster management embarked upon by the institution is capacity building towards GIS proficiency for its relevant staff members. In 2009, NEMA organized a training session with the Regional Centre for Training in Aerospace Surveys (RECTAS), Ile-Ife for its staff members; this was to train the staff in application of GIS for disaster management. The training package included mapping geographic features for disaster management, creation of spatial databases and development of SDI for the purpose of disaster management.

Spatial Data Infrastructure in Nigeria

Nigeria launched her first Earth Observation (EO) satellite (NigeriaSat-1) with 32m spatial resolution to monitor the environment in 2003 and in 2011 two other EO satellites (NigeriaSat-2 with 2.5m PAN and 5m MX resolutions and NigeriaSat-X with 22m resolution, the latter built completely by Nigerian Engineers) were lunched to support the provision of spatial data in Nigeria and to the entire world. These developments are avenue for several chances for GIS development within the country. Since the first satellite launched, there have been several developments in GIS both at the national level and state level. Various Geoinformation (GI) Ministries and Parastatals started using GIS for data management, services delivery and also for the purpose of decision support. Private organizations such as telecom companies, banks as well as oil and gas sectors also contributed a lot to the development of GIS in the country. Many of these companies possess digital data of various utilities as well as satellite imageries covering greater area in the country.

Prior to the NigeriaSat-1 revolution, many public GI organizations have staged plans of digitalizing their maps and introducing GIS into their routine map production techniques. Amongst organizations that started this was the Office of the Surveyor General of the Federation (OSGOF). OSGOF is the custodian of geodetic and topographic data in Nigeria and is responsible for preparing national topographic database. It embarked on the analogue to digital conversion of its old maps by scanning and later digitizing them into vector data. Their outputs include scanned topographic maps and vector data of national boundaries for the whole country.

In general, GIS is established in Nigeria and its applicability to all fields is becoming clearer through training from home and foreign institutions. But there is still the advanced level of data sharing and reuse through setting up of a national or regional infrastructure on GIS. This is the next stage in GIS development in the country. This will help solve the challenges of duplication of data and collection process that is common in practice currently. It will also help all organizations to find what data exist within the country and how to use them.

SDI development has already begun in Nigeria as far back as 1999 when the new political dispensation started in the country. The country has been taking series of steps in implementing the National Geospatial Data Infrastructure (NGDI). In September 2002, the Hon. Minister of Science and Technology inaugurated a 10 – man Committee to draft a Geospatial Information (GI) Policy that will guide the implementation of the NGDI. The draft GI Policy was circulated to stakeholders for comments and was a subject of an international workshop of NGDI stakeholders/users held in Abuja, Nigeria in February 2003. The policy is an essential backbone for the efficient realization of the NGDI. Data sharing is to be facilitated through a coordinated and structured access to geospatial data owned by public and private sector organizations within a legal framework in order to ensure the rights of all parties (Agbaje and Akinyede, 2005; Kufoniyi, 2004; NASRDA, 2003 and UNECA, *et al.* 2003).

Since then, several efforts have been made towards implementation of NGDI in the country. One most recent effort is the completion of the pilot phase I of NGDI implementation where a geoportal was developed for metadata search. Some stakeholders (mainly GI producers) were selected for the project, considering some fundamental datasets which include Geodetic Control database, Topographic database/DEM (at scales 1:25,000 – 1:50,000), Administrative boundaries data, Geological database, Hydrographic data, Landuse / Landcover data, Demographic databases and Satellite Images. Trainings were conducted for these stakeholders on how to collect metadata and publish it on the web for public access (Kufoniyi *et al* 2010).

Nigerian SDI in Disaster Management

Presently in Nigeria, disaster management institutions and agencies work with standalone GIS databases to support their functions. They rely more on internally collected and processed data to produce needed information in the form of maps and charts. In another instance, they also rely on individual geospatial data collector and producers to facilitate the spatial data needed for their activities. In this setting, there exists fundamental gap between the disaster managing institutions and the GI producers that are the custodians of the spatial databases, as the two have been growing in parallel, with little or no interaction.

From the inception of Fire Brigades to the Era of NEMA, there has been less reliance on spatial data for disaster managements. More attention is given to sophisticated equipments and man power to tackle disaster in the country instead of spatial data support. It is evident in the current structure of NEMA that less consideration was given to spatial data at the conception of the institution in 1999.

Presently, there has not been any major implementation of SDI at all levels in the country. The Nigeria NGDI pilot geoportal is still not stable offering only search services for fundamental datasets whose limited metadata have been captured by four NGDI node agencies namely, OSGOF, National Space Research and Development Agency (NASRDA), National Geological Survey Agency and National Population Commission. At the State level, very little has been achieved except for Lagos and Ondo States that have started with the institutionalization of the State SDI through GI policy formulation, but not much has been done on the technical implementation of the system.

Even with the effort of NEMA to integrate GIS in its business processes, it is still faced with other challenges which include lack of adequate finance and dedicated man power to handle spatial data while at the same time concentrate on its application to disaster management. In the light of the foregoing therefore, there is need for a rapid realisation of the national SDI (NGDI) to bridge the gap of accessibility to data among other challenges of information support for disaster management. Such a system will help to create a GIS facility that will allow non-GIS organization to have access to spatial data and processes needed for effective disaster management.

With a properly developed and well implemented SDI, organizations like NEMA and other stakeholders will be able to identify hazards and their potential risk, determining capability to mitigate against, prepare for, respond to, and recover from major emergencies, identify and employ methods that can improve affected community’s restoration through efficient use of resources, improved coordination, and cooperation. The system will also be able to develop and coordinate realistic preparedness plans, establishing early warning systems, assess extent of damage caused by the emergency and activate timely response plans and rescue operations.

CONCLUSION

SDIs in Nigeria are still at the early stage and these are the systems that can create a strong platform for inter-organizational cooperation that will facilitate exchange and sharing of data at various levels of governance. And data sharing is the backbone for intelligence, effective and efficient decision making processes. Disaster management requires a thorough process of multi-source data to support decision and timely actions. Therefore there is the great need to explore the strength of the NGDI at the national level to support NEMA activities for effective disaster management, community resilience and sustainable development.

Presently, there seems not to be direct benefit of SDIs to disaster management and other sectors in the country for that matter, but there is need for all institutions involved in establishing national and State SDIs to actively take part in its implementation. Considering the great prospects that lie ahead of SDI implementation for disaster management, the need for SDI at every State Government level cannot be over emphasised. In conclusion, SDI will help all kinds of organizations to use data from GI organizations to support their functions (instead of relying on standalone system), thus facilitating data reuse and boosting its values.

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ABOUT THE AUTHORS:

Olajide Kufoniyi: Department of Geography,Obafemi Awolowo University Ile-Ife, Nigeria.

Olukunle Ayodeji Ogundele: School of Maths, Stats and Computer Science, KwaZulu-Natal University, South Africa.

David O. Baloye: Department of Geography,Obafemi Awolowo University Ile-Ife, Nigeria.