IMPROVING CRITICAL DISASTER INFORMATION FLOW AMONG COORDINATING AGENCIES IN A DEVELOPING ECONOMY: A CASE STUDY OF LAGOS STATE, NIGERIA

BY

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ABSTRACT

This study characterized the critical disaster information flow among coordinating agencies in Lagos State. Key Informant Interview (KII), administered on heads of 6 disaster management coordinating agencies in Lagos States was used to elicit information on the flow of critical disaster information in the study area. Content analysis was used to analyse the data from the KII. Archives of disaster data from existing standalone databases of coordinating agencies served as secondary data for the study. Both primary and secondary data obtained were used to build the Lagos State Critical Disaster Information Database System (LACRIDS) as a decision support system for managing disaster information among coordinating agencies in disaster management in Lagos State. Findings from the study show that phone call is the agencies' major (100%) source of critical disaster information followed by control room which accounts for 50%. On comparing previous and current methods of disaster mitigation in the state, 83% affirm that though the current method is still limited, it provides a more efficient platform for disaster mitigation. This limitation, according to the respondents include high cost of maintenance, corruption, inadequate funding as well as non-compliance to safety measures and misinformation among agencies. Further finding from the KII reveals that majority (83%) of the respondents confirm the absence of a shared database among coordinating agencies, thereby limiting the flow of critical disaster information. In response to this, the LACRIDS was developed to further improve on the status quo by promoting interoperability and critical disaster information sharing among first responder agencies and stakeholders in the study area.

Key words: Coordinating agencies, Critical disaster information, Data interoperability, Lagos State Critical Disaster Information Database System

INTRODUCTION

One of the most challenging, yet, in many cases, inevitable components of human society and its development, is disaster (Thywissen, 2006). Though severally defined in literature, the common denominator among the varied definitions of disaster is, its ability to destroy socio-economic base of affected communities (Bradshaw, 2004). In this regards, International Strategy for Disaster Reduction (ISDR, 2003), and International Federation of Red Cross and Red Crescent Societies (IFRC, 2012) described disaster as a serious disruption of the functioning of a community or a society, with potentials for causing widespread human, material, economic or environmental losses which in many cases exceed the ability of affected communities or

societies to cope using its own resources. Whatever the type and scale, disasters have the potential of destroying years of development and it is in this sense that it is described as a major developmental challenge facing both developed and developing regions of the world.

The process by which disaster is managed is referred to as disaster management and it is defined as the discipline of avoiding and dealing with risks (Haddow, Bullock & Coppola, 2011). It includes all activities necessary to build, sustain, and improve the capability to prepare for, protect against, respond to, and recover from threatening or actual natural or human-induced disasters. It is a cycle of processes involving multi-jurisdictional, multi-sectoral, multi-disciplinary and multi-resource initiative (Rivera, Hawkins & Kapucu, 2013).

Information plays critical role in determining the success or otherwise of the entire disaster management process. The gap in disaster management between the developed and the developing countries of the world has been attributed to access to timely and critical information at all phases of disaster management. Accessibility to quality critical disaster information has been noted as an important aid for coordinating agencies to effectively and efficiently discharge their duties as the right kind of information leads to a deeper understanding of the disaster event and thus a better response decision. A Geographic Information System (GIS) provides a robust platform for data harnessing, use and seamless sharing. Hence, it has become a veritable tool in disaster management (Abbas, Srivastava, Tiwari & Ramudu, 2009; Kafi & Gibril, 2016; Song, Choi, Lee & Choi, 2019).

However, the use of GIS in disaster management, particularly in developing countries like Nigeria, has been limited to stand alone applications, thereby grossly inhibiting access to critical disaster information required by coordinating agencies like the National Emergency Management Agency (NEMA), other first responder agencies, relevant stakeholders and decision makers.. The effect of this is often seen in the unorganized and uncoordinated response of participating agencies in disaster management in many developing countries like Nigeria. Since there is hardly any disaster event that does not involve more than one first responder agencies, the flow of critical information vital to successful disaster management becomes very essential. Furthermore, recent studies (Adefisoye, 2015; Mansourian, Rajabifard, Valadan & Williamson, 2016) have shown that considerable problems are associated with managing disaster particularly in developing countries like Nigeria (Baloye & Palamuleni, 2016**)**.

Unlike previous studies, this paper seeks to assess critical disaster information flow among disaster management coordinating agencies in Lagos State. This was done by characterizing the information flow for disaster management in Lagos State, Nigeria; developing a decision support system for disaster information management in the area and integrating disaster data from different agencies into a web-enabled geospatial database that can be used as a decision support system to improving the flow and interoperability of data for critical information flow among stakeholders in disaster management in one of Nigeria's most socio-economically growing geographic administrative space.

THE STUDY AREA

Lagos State is one of the fastest growing cities in the world with over 9 million people, which owing to its geographical location, serves as the major commercial centre in Nigeria with high inflow of people from across the country. Because of the high mix of population and socio-

economic activities, the occurrences of disasters in Lagos State usually claims more lives and causes damage running to millions of Naira to properties (Ibem, 2011). Table 1 summarizes the geography of Lagos State while Figure 1 shows the location of Lagos State with respect to the Nigerian National boundary and States.

Table 1: Geographic description of the study area

Thematic	Summarized description
Spatial Extent	South-western Nigeria. Boundary: Ogun State (North and East), Republic of Benin (West), stretches over 180 kilometers along the Guinea Coast of the Bight of Benin on the Atlantic Ocean.
Location	3° 6' E to 3° 24' E longitudes and 6° 30' N to 6° 48' N latitudes
Land Area	3,577 sq.km
Climate	Tropical savanna climate (Aw) according to the Köppen climate classification. The wettest month is June with precipitation total 315.5mm, while the driest month is January with precipitation total 13.2mm. The hottest month is March with average temperature 28.5°C while the coolest month is August with average temperature 25°C
Population	13,299,845 (2018 est.)

Sources: Ogundele, 2012; Ugonna, 2013; Ezenwaji et al, 2014

Figure 1: The Study Area
Source: Adapted from Makinde and Oyelade, 2018

MATERIALS AND METHODS

Primary and secondary datasets were used for this study. Primary data was sourced from 6 disaster coordinating agencies of Fire Service Department, The Nigeria Police, Nigerian Red Cross Department, State Teaching Hospital, Federal Road Safety Corps and the State's Emergency Management Agency (LASEMA). Critical disaster information flow and method of sharing data among the agencies were collected through Key Informant Interview (KII) administered on heads of the 6 disaster coordinating agencies who were purposively selected as key informants based on their knowledge of the operation in their respective agencies. A structured interview guide was designed to guide the interviewer during the in-depth interview. The adoption of this method was necessitated by the need to circumvent the difficulties of administering questionnaire to respondents with inadequate knowledge about current state of disaster information management. Content analysis technique, a qualitative analytical tool that gives in-depth information, by probing interviewer's responses thematically (Huggins et al., 2016), was used to analyze data from the KII. The use of percentages in the analysis was based on the number of respondents that expressed opinion on each thematic issue and not as average of the overall responses. For instance, where 1, 2, 3 or more of the 6 key informants used in the study agree to a particular issue, the frequency of their responses will be 17%, 33%, 50% respectively. In other words, the percentage is horizontal along each theme of discussion rather than vertical total of all the responses.

Results from the KII were presented using tables. On the other hand, data in the form of disaster records from 1997 up to 2017 were also collected from the archives of the coordinating agencies. The data collected from the archives were used to develop the Lagos State Critical Disaster Information Database System (LACRIDS) geospatial decision support system used as pilot in this study. Also, high resolution satellite imageries covering the study area was downloaded from the archive of Google Earth and this was used as the backdrop for the developed webpages. Data collected from both the KII and the archives of the agencies were used in a relational database management system (RDBMS) that stores data in the form of related tables. The design of the database followed the 3-tier architecture of conceptual, logical and physical design as shown in Figure 2.

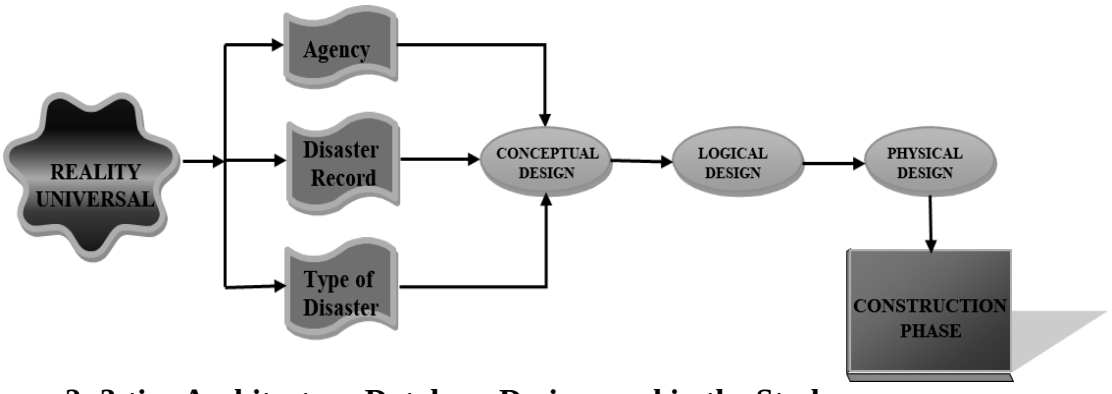


Figure 2: 3-tier Architecture Database Design used in the Study

A vector data model (Figure 3a), which distils reality into point, line and area was adopted for the study while an entity-relationship (E-R) diagram (Figure 3b) was used to show mapped relationships between the various entities or objects of representation in the study. Figure 4 on the other hand shows the logical model for the study. MySQL was used to implement the last (physical) stage of the database design.

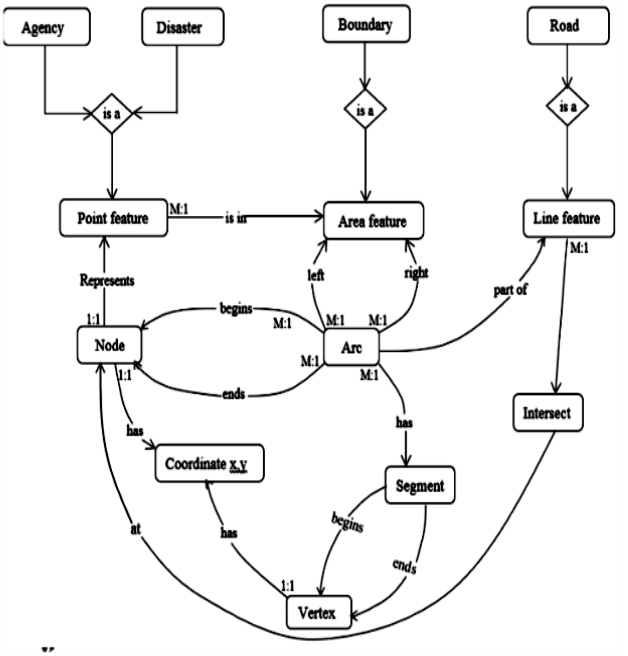
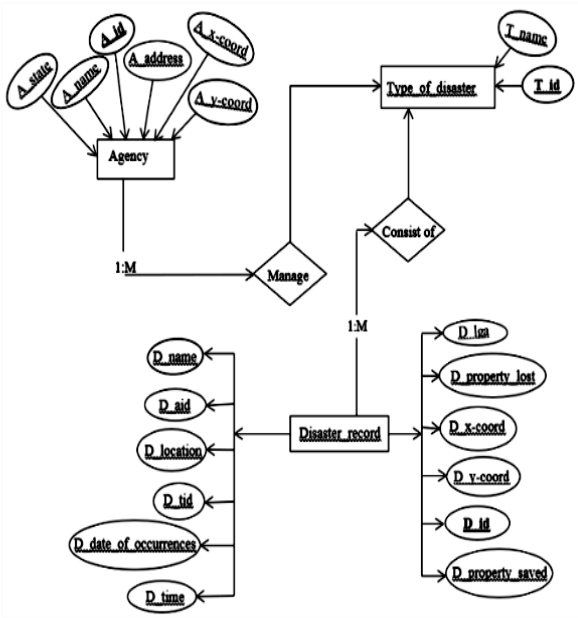


Figure 3. a) Vector Data Model Designed for the Critical Disaster Information Flow



b) E-R Diagram for the Study

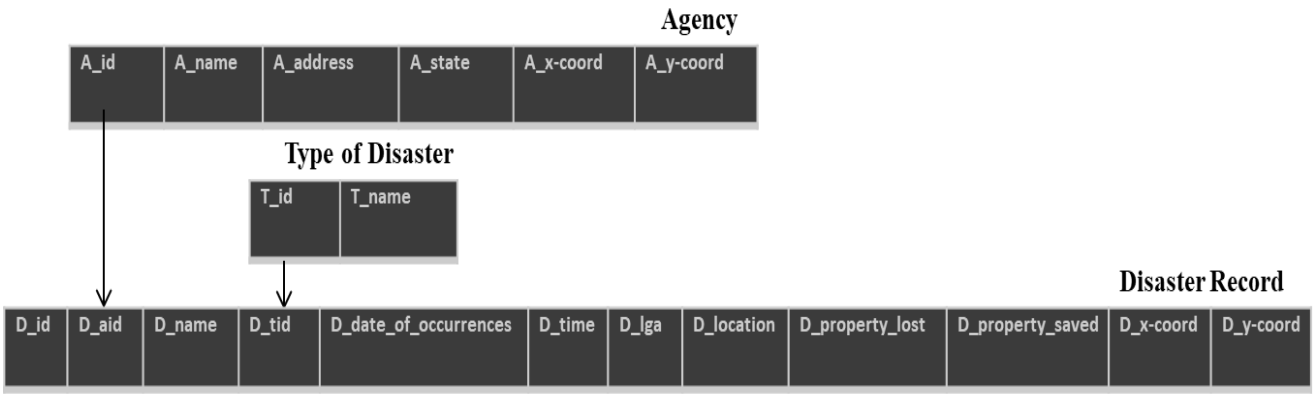


Figure 4: Logical Model Designed for the Study

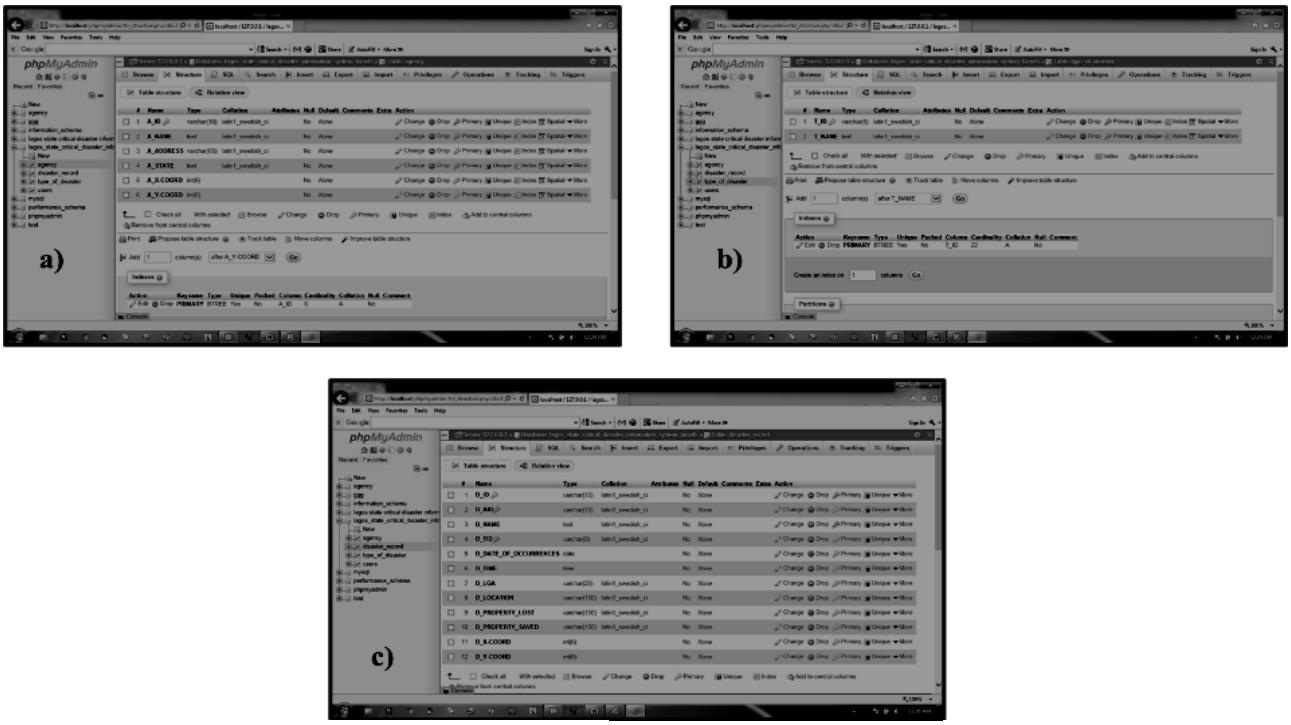


Figure 5: Structure of the 3 participating tables a) Agency, b) Type of Disaster and c) Disaster Record

RESULTS AND DISCUSSION

Characterization of Information Flow for Disaster Management

A number of cogent issues relating to the flow of critical information in individual agency and among other agencies were considered. As noted in literature, effective critical information flow plays pivotal role in disaster management and this is mostly required at the preparedness phase of disaster management (Kapucu, 2006; Perry, 2007). On how information was sourced for during disaster, Table 2 shows that all the informants (100%) agreed that phone call is one of their main sources of critical disaster information.

Table 2: Frequency of Response Based on Source of Critical Disaster Information

Interview question	Broad code	Response	Frequency of response	Frequency of response (%)
How do you source for critical information in your agency?	Source of critical information	Operation Officer	1	17
		Phone call	6	100
		WhatsApp group	1	17
		Control room	3	50
		Scene of incidence	1	17
		News	1	17
		Victim relationship	1	17
		FAQ	1	17

Source: Authors' Analysis, 2018

Other source of critical disaster information, as cited by the informants, are control room (50%), WhatsApp group (17%), scene of incidence account (17%), news (17%), victim's relationship (17%) and frequently asked questions (FAQ) constituting 17%. The implication of this is that critical disaster information among the agencies rely heavily on phone calls which are usually characterized by no network coverage and call drops. As cited by Owolabi and Ekechi (2014), most developing countries of the world have poor or no network coverage which makes reliance on phone calls and social media method not efficient. This presents the likelihood of loss of core information between the different sources and the control room.

On whether current measures of mitigating disaster is better than previous methods that had been used by the agencies, Table 3 shows that 83% of the informants affirms the superiority of the current method. Some of the explanations given for this include reduction in disaster rate (67%), reduction in mortality rate (33%) and reduction in workload (17%). A further probe of these responses reveals that the current method in its modus operandi is still limited.

Table 3: Frequency of Response Based on Comparison of Methods

Interview question	Broad code	Response	Frequency of response	Frequency of response (%)
By comparing the current method with the previous method, which one do you think is better and why?	Comparison of Methods	Current method	5	83
		Reasons:		
		Reduces disaster	4	67
		Old method is ineffective	1	17
		Reduces mortality	2	33
		Correct old method	1	17
		Reduces workload	1	17

Source: Authors' Analysis, 2018

Further on the efficiency of the current method, Table 4 shows that 50% of the informants responded that the current method of disaster management is very efficient. Another 33% of the informants responded that the current method is efficient while the remaining 17% of the informants responded that the current method is not efficient. This is reflected in the response of one of the informants;

> *The current method is very efficient because there is improvement and if we are to base it on percentage, let say 70% efficiency when compared with the previous method.*

Table 4: Frequency of Response Based on Efficiency of Current Methods

Interview question	Broad code	Response	Frequency of response	Frequency of response (%)
How efficient is the current methods of disaster management with respect to the outcome?	Efficiency of current methods	Very efficient	3	50
		Efficient	2	33
		Not efficient	1	17
		Reasons:		
		Tested on ABC transport	1	17
		Reduces response time	2	33
		Better result	1	17
		More people are sensitized	1	17

Source: Authors' Analysis, 2018

On the challenges of acquiring and managing critical disaster information, Table 5 shows that 33% of the informants responded that high cost of maintenance is one of the challenges hindering seamless access to critical disaster information. Other challenges are corruption (17%), unhealthy competition among agencies (17%) and low turnout (17%).

Table 5: Challenges with Methods of Acquiring and Managing Disaster Information

Interview question	Broad code	Response	Frequency of response	Frequency of response (%)
What challenges are you facing with your current methods of acquiring and managing disaster information?	Challenges with current methods of acquiring and managing disaster information	High cost	2	33
		Corruption	1	17
		Non compliance	2	33
		Low turnout	1	17
		Competition/rivalry	1	17
		Funding	2	33
		Inadequate equipment	2	33

Source: Authors' Analysis, 2018

With respect to the methods of sharing critical information among agencies, Table 6 shows that 83% of the informants responded that one of the methods that they use to share and disseminate critical disaster information among other disaster management agencies is through the command centre which serves as the hub of information where majority of these agencies have access to and disseminate critical disaster information. According to one of the informants,

> *Humm… at the control room, all the disaster management agencies have their representatives who are responsible for sharing and disseminating critical information to their prospective agency.*

Table 6: Methods of Sharing Critical Information among Agencies

Interview question	Broad code	Response	Frequency of responses	Frequency of responses (%)
How do you share and disseminate critical information among other participating agencies?	Methods of sharing of critical information among agencies	Toll free line	2	33
		Command centre	5	83
		Seminars	1	17
		Meetings	2	33

Source: Authors' Analysis, 2018

Although an essential part of disaster information flow, the choice of command room for critical disaster information flow has been noted to be limiting, particularly with respect to loss of information in crowded rooms typical of control commands or rooms (Bharosa & Janssen, 2010; Waring et al, 2018).

Another 33% of the informants responded that toll free line and meetings are other methods they used to share and disseminate critical disaster information while yet another 17% of the informants responded that they share and disseminate critical disaster information through seminars.

In terms of the limitations in accessing and disseminating critical information among coordinating agencies in disaster management, Table 7 shows that 83% of the informants responded that lack of a single integrated database system that unifies and standardizes access to and dissemination of critical disaster information is a major limitation. A reflection of this is shown in the response of one of the informants;

> *There is no system that connects all the agencies together except that the directors have each other's phone number which they can use to communicate. Using this, the directors can easily share and disseminate critical information to appropriate agencies and departments.*

Furthermore, 33% of the informants responded that wrong information dissemination is a major challenge. As pointed out by one the respondents,

> *There was a disaster information we needed and got it from one of the coordinating agencies and after we compare and contrast, we discovered that the information sent to us was false and when we contacted them back, the responses of the agent revealed that it was intentional. They actually intended to confuse us so that we can commit errors in our documentation.*

Table 7: Limitations to current method of sharing critical disaster information

Interview question	Broad code	Response	Frequency of response	Frequency of response (%)
What are the challenges of accessing and disseminate critical information among participating agencies?	Limitations to critical information access and dissemination	Lack of integrated database	5	83
		Wrong information dissemination	2	33
		Hoarding of information	1	17
		Agency in charge	1	17
		Paper-based data storage	1	17
		Obsolete technology and protocols	1	17

Source: Authors' Analysis, 2018

Other limitations to free flow of information among the disaster coordinating agencies, as flagged by the key informants are hoarding of essential information (17%), which agency will be in charge of which type of disaster event (17%), paper-based data storage (17%) and obsolete technology and protocols (17%). The implication of this is that the absence of a single unified database coupled obsolete equipment and protocols inhibits free flow of critical information among agencies saddled with the responsibilities of managing disaster in the State. As cited by Li et al. (2019) and Zhang, Zhou and Nunamaker (2002), ineffective access and sharing of critical disaster information among first responder and coordinating agencies hinders effective decision making before, during and after a disaster event, particularly among developing countries. Improper information due to methods, low technological development and lack of integrated database, have been identified by previous studies (Wirtz, Kron, Löw & Steuer, 2012; Fiala, 2017; Osuteye et al, 2017; Usuda, 2017) as the bane of successful disaster management in developing countries.

The Potentials of Web-GIS for Critical Information Flow for Disaster Management, using LACRIDS as a Case Study

Information flow in disaster management have been identified as major determinant in the battle against disaster (Sharma, Misra & Singh, 2019; Li & Ji, 2020; Sadeghi, Struckell, Ojha & Nowicki, 2020). Yap (2011) and Kapucu and Garayev (2011), affirmed that effective disaster management requires inter-agency collaboration. The breakdown of this critical component of disaster management was identified by Yap (2011) as contributing to setbacks in effective disaster management in most developing countries. In the same vein, studies like Liu, Duffy, Whitfield and Boyle (2010) as well as Manfre et al., (2012) proposed integration of data from various sources into a stand-alone database and web technology for supporting decision.

Arising from the analyses of the responses of the KII with heads of the disaster management agencies in the study area, a GIS driven web-based platform referred to as LACRIDS was designed for this study. Findings from the content analyses of the KII revealed the generic

advantages of web-based databases over the current method of access to and sharing of critical disaster information (see Table 8). The design of the LACRIDS is discussed in the methods section of this paper.

Table 8: Potentials of Web-GIS Website

Potential	Areas of Deficiency of Existing Methods	Strength of Web-GIS
Data sourcing	Inefficient because it relies on phone call	Uses database management system designed in mySQL
Data sharing	Through control room	Via the use of internet
Data accessibility	Data are not readily accessible	Easy access to data
Data management	Paper based data management system	Uses database management system designed in mySQL
Work load	Increases work load	Reduces work load through accessibility and flexibility
Data updating	Cumbersome	Easy for data updating
Decision making	Ineffective for decision making	Informed decision making

Source: Author's Analysis, 2018

Figures 6 (a-b) show the LACRIDS web interface (a), login page (b) and the welcome page of the LACRIDS. The registration portal of LACRIDS was designed with a unique gateway for user who wants to consult the disaster database. It creates a platform for users to register their personal information into the website before consulting the database. It also provides background check for monitoring the number of users that consult the database.

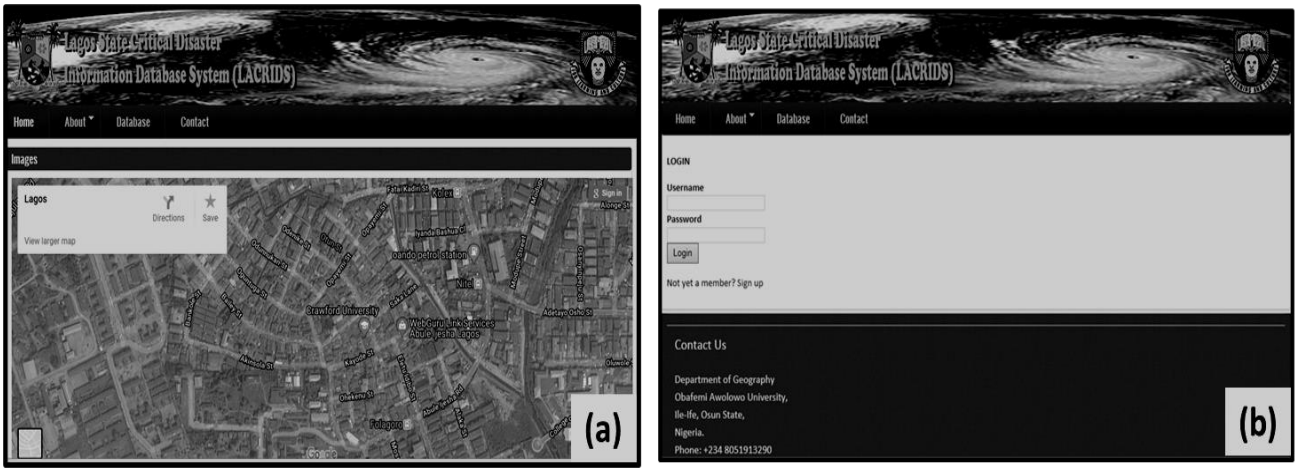


Figure 6: (a) Web interface and (b) Login page of the LACRIDS

Figures 7 (a)-(c) show the interface for relational databases that drives LACRIDS. Data on disasters are made accessible not only for the agencies but also researchers. In all, the LACRIDS website was designed to improve the existing method of accessing, disseminating and sharing of disaster data among the coordinating agencies in disaster management. It also provides the opportunity for time-to-time updating of the database and also make disaster data accessible at any time which is very essential at the preparedness phase of disaster management.

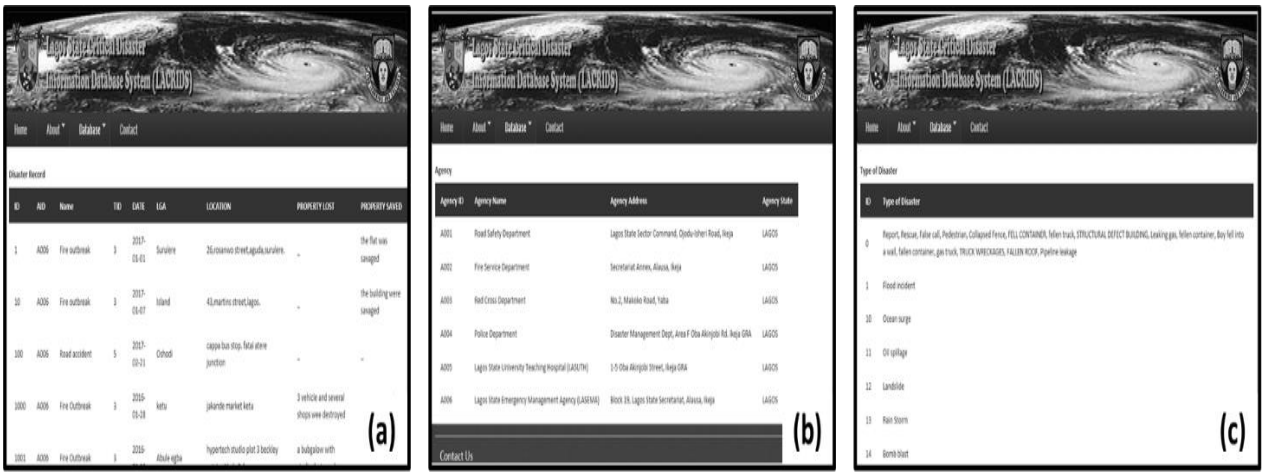
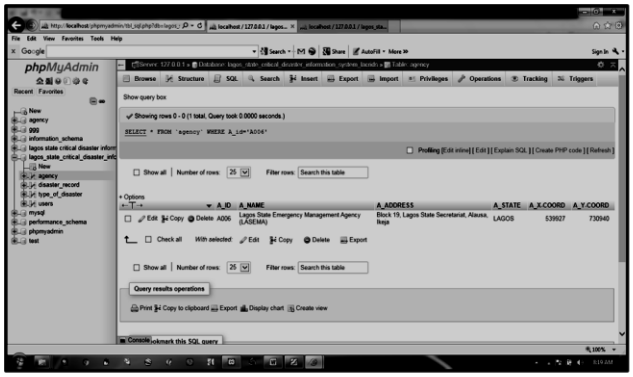


Figure 7: Interface of the Database of (a) Disaster records, (b) Agencies and (c) Type of Disasters

The developed LACRIDS is expected to serve as spatial decision support system (SDSS) for decision making in disaster management in Lagos State. It integrates data from 6 different agencies and provide the opportunity to query any data of interest. The designed LACRIDS platform was tested by subjecting it to a number of queries. Both single and multiple queries were issued on the database. Figure 8 shows the retrieval of data from a single query performed with the intent of showing agency with identification number A006. Figure 9 on the other hand shows events of building collapse recorded in the state within the years under consideration. 2 relations, Agency and Disaster Record were used in this query. The result shows 88 data entry were captured under building collapse.



Query Syntax:

```
SELECT *
FROM `agency`
WHERE A_id='A006'
```

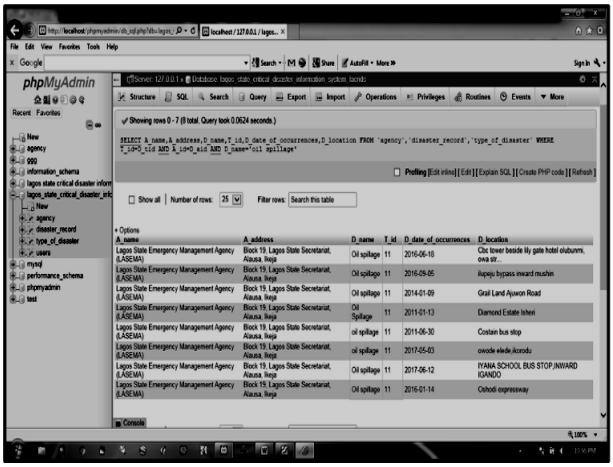
Figure 8: Query for Agency Identification Number 'A006'

Query syntax:

```
SELECT:
A_id,A_name,D_name,D_date_of_occurrences,D_location
FROM `agency`,`disaster_record`
WHERE A_id=D_aid AND D_name='building collapse'
```

Figure 9: Result of the Query for collapsed building LACRIDS database

Figure 10 shows the result of query performed from the three relations in the LACRIDS specifying two conditions. The query syntax uniquely selected seven columns from the agency, disaster record and type of disaster tables. The condition specified in the query was to find records from agency, disaster record and type of disaster where agency identification number is 'A002' and type of disaster identification number is 2. The result shows that 21 records, assigned as oil spillage, were retrieved.



Query syntax:

```
SELECT
A_id,A_name,A_address,T_id,T_name,D_date_of_occurrences,D_locat
ion
FROM `agency`,`disaster_record`,`type_of_disaster`
WHERE T_id=D_tid AND A_id=D_aid AND A_id='A002' AND
t_id='2'
```

Figure 10: Results of the Disaster Name Oil Spillage from the LACRIDS

The LACRIDS was developed to facilitate critical disaster information flow among first responder and coordinating agencies, by providing a better way of disaster data accessibility, dissemination and management. The LACRIDS share similar characteristics with existing platforms (Mobaraki, Mansourian, Malek & Mohammadi, 2006; Yan-xi, Gang-jun, Er-jiang & Ke-fei, 2009) designed to overcome loss of critical disaster information flow, particularly in developing countries, where disaster management is more reactive than proactive.

CONCLUSION

This study characterized the critical disaster information flow among the coordinating agencies in Lagos State using Key Informant Interview (KII) approach and geospatial techniques. The study further designed the LACRIDS as a decision support system for managing disaster information among coordinating agencies in disaster management in Lagos State. The study concludes that the creation of a geospatial decision support system and web user interface are very essential framework for disaster management as it tends to promote interoperability and partnership in disaster management. Also, it eliminates data duplicity and aid data accessibility, dissemination and sharing among wide range of spatial information producers, users and stakeholders for improved disaster management since disaster management requires timely and up-to-date information. The study however recommends further improvement on the current method such that it will enhance the ability of the disaster management agencies to formulate effective proactive measures to ameliorate the potential effect of any disaster.

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