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INTEGRATING A DECISION SUPPORT SYSTEM TO SOLVING AN ENVIRONMENTAL PROBLEM IN AN URBAN NIGERIA FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

This paper utilizes a decision support-based system for systematic management of disaster to enhance capacity building and sustainable development. Using setback and previous flood extent as the yardstick, the study area was divided into high, moderate and low vulnerable zones. Buffer analysis, overlay techniques, flow accumulation operation and spatial search were part of the geospatial analysis done using the ArcGIS10.5 software. The digital map depicted that the study area is situated on a uniform level ground with the vulnerable sections located on the deepest part of the plain which is the primary reason for the high flood events experienced in the study area. Flow accumulation zones, in addition with waste dumps which impede the free flow of water were noted as germane factors that amplified the rate of flood susceptibility. From the spatial search conducted, 211 buildings breach the setback rule and 10,820 people could be at risk of flooding.

Keywords: Environmental Problem, Flood, GIS, Support System, Sustainable Development, Ilorin Metropolis

INTRODUCTION

Floods, like drought, is one of the normally occurring range of streamflow conditions which occur when water bodies rise to land areas that are not formerly submerged. Flooding phenomena are considered the world's worst global threat in terms of magnitude, occurrence and geographical spread. It could result to deaths and lose of valuable properties, the displacement of people, and also hinder the socio-economic activities of the flooded area. Not less than one-third of losses being a direct result of nature's force can be attributed to flooding (Ayoade, 2003; Kwara State Environmental Protection Agency, 2010). Flooding is becoming more severe in Nigeria, especially in the urban areas. Unfortunately, the impact is more felt by the urban poor because most of them live in flood-prone areas.

The occurrence of flood has increased geometrically within Ilorin, Nigeria for some time. Increase in overland flow production in an urban area is a function among other factors to increase in percentage pared area caused by indiscriminate felling of trees and unhealthy environmental attitude of people (Jimoh, 2008). As observed by Action Aid (2006), there are four main forms of flooding and these include flooding caused by small streams, rivers, raining seasons flood events in the lowland, coastal cities and localized flooding. As observed by Faniran (1991) and Jimoh and Iroye (2009), the little concentration being paid to studies of runoffs in Nigeria are daily manifesting in water and water-related problems being experienced in the country. As human population to land area and land value increase in the urban centers, flood becomes a greater problem both economically and as a threat to safety as a result of increased runoff which is caused by felling of trees, increase in ratio of paved surfaces and blockage of canals, and other water ways among others, due to anthropogenic activities.

However, it has been reported that over ten thousand people have been displaced and a total of 200 people have died to cases of flood in Northern Nigeria. (Trevor and Johnson, 2000; Oriola, 2000; Ifabiyi, 2004). In Kano, 20 people died after cases of flood in the state, 48,800 people have been displaced in Jigawa State, a total of 180 bodies were counted, 800 people sustained injuries and 35,500 displaced (Nigeria Red Cross- World Disasters Report, 2010). Series of extreme climatic events which took place in Ibadan between 1960 and 1963 were related to the steep slope nature of the town (Onifeso and Akintola, 2012). Similar flood events took place in communities in Kastina, Sokoto and Kebbi States, the cause of which was traced to let out a large volume of water from Goroyo dam in Sokoto State (NEMA, 2008). The same situation operates in the southern part of Nigeria where the problem has degenerated into serious ecological problems (Harun, 1982). The trend of urban expansion has continued just as industrial activities have opened up new fields without critically considering the effects of this unchecked development on the environment.

The observed flood problem, therefore, calls for researches relating to flood risk mapping, as one of the major ways to combat flood incidence is to make reasonable efforts to predict cases of flood, make plans for it, train and engage in environmental education and identify areas which are flood prone. In Ilorin city Nigeria, flooding is a yearly occurrence especially along the flood zones/areas of Asa River.

Most floods are as an output of the accelerating rate of urbanization and the absence of well- pronounced and all-encompassing physical planning control. Refuse dumping over the years has led to the filling up of ponds, streams and the blockage of other natural aides to drainage so that when there is high-intensity of rainfall, there will be no room for water to drain, hence, excessive flooding (NEST, 1991).

Early warning systems and flood hazard mapping needs to be performed in an order to manage the disaster (World Disaster Report, 2005). However, sustainable flood management is still in its initial stage in Nigeria. Akintola and Ikwuyatum (2012), asserted that the policy, institutional and infrastructural instruments of flood management remain underdeveloped, inadequate and ineffective in Nigeria. Thus, virtually all levels of government in Nigeria are yet to see the essence of sustainability; hence they have not made it a cornerstone of development policy strategy. The threat to lives and properties along the Asa River being a function of flooding for many years, has been one of the major problems facing the city of Ilorin, Nigeria.

A huge sum of money is spent annually in solving the problem by the government and protection agencies. The problem rather than reducing is escalating due to insufficient of relevant information about the characteristics and nature of the flood plain. This work will, therefore, serve as a Spatial Decision Support System (SDSS) that will enhance effective management of the flood plain for sustainable development. Hence, this study examines flood risk mapping of the catchments of Asa River in Ilorin, Nigeria.

THE STUDY AREA

The Area of Study; Ilorin, the capital city of Kwara state, Nigeria (figure 1). It is sited between latitude 8^0 24' and 8^0 36' North of the Equator and longitude 4^0 10' and 4^0 36' East of the Greenwich meridian (Oyegun, 1983). The area occupied by the basin is about 731km^2. It transects three local government areas namely: Ilorin south, Ilorin east and Ilorin west. The basin stream rate is about 0.66 channels for every km^2 and the drainage density is 0.956. The dominant drainage systems are Asa River and close to the mouth of Asa River are two dams namely, Agba dam and Asa dam constructed in 1952 and 1978 respectively. Bode Moro, Asa, Ifelodun are the bordering LGA'S (Oloru, 1998).

Ilorin metropolis has a humid tropical atmospheric condition which is characterized by the wet and dry season. It possesses a tropical dry and wet climate, indicated as Aw in Koppen's classification. Wet season in the area begins towards the end of March and ends in October with 2 peak periods in June and September. Temperature range is warm to hot, due to high solar radiation throughout the year and open-air isolation can be very uncontrollable during the dry season (Oyegun, 2003). However, there are seasons of reduced temperatures during the harmattan period (November-February). The study area Ilorin is underlain by Precambrian igneous metamorphic rock of basement complex type, its characteristics neither permeable nor porous except in areas where they are deeply weathered or have a zone of weakness. A substantial area of the town is also laid by sedimentary rock, which contains both primary and secondary lateritic and alluvial deposit.

Figure 1: The Study Area

Source: Office of Surveyor General (2018)

The type of soil are sandy and clayey deposits lying over one another. Meanwhile, the sandy deposit is branded by low water holding, this encourages infiltration, and clayey deposit beneath outcome in water logging during the season, thus, encouraging overflow generation in the study area. It is located in the Guinea Savannah vegetation zone. Urbanization process is greatly replacing the Guinea Savannah flora type in Ilorin with anthropogenic (paved) surfaces with a resultant effect on run-off generation, hence, the frequent incidence of flooding (Enendu, 2001; Olaniran, 2003).

MATERIALS AND METHODS

In this study, both primary and secondary sources of data were exploited and employed. The data used are spatial and non-spatial (i.e. attribute). These include satellite images and topographic map of the area under study. The satellite images of Ilorin (One Square Meters Resolution) were processed using ArcGIS 10.5. For a successful implementation of this design, the hardware component includes: Garmin eTrex30x Handheld GPS receiver, a laptop Computer, and aCanon A0 Scanner. The

GIS analysis was processed using the following software: ArcGIS 10.5 and Microsoft Office 2016 (Microsoft Office Excel).

To create a database for Flood Risk Zones (FRZs), the map of Ilorin and its Environs was acquired and a map of river Asa was extracted, Geo-referenced and digitized from the 1:50,000 topographical map of Kwara State (Kwara State Ministry of Land and Housing, 1996). The complete electronic procedures of digitizing involved electronic scanning of the map, as they were converted into line, points, and polygons. Identities of the objects on the map and their spatial relations were well spelled out. The attributes of identified buildings around the river were linked to the georeferenced data using the software; ArcView GIS software.

RESULTS AND DISCUSSION

Conceptual Design

In Geographic Information System (GIS), database is design to facilitate the storage, organization and retrieval of information using a Database Management System (DBMS). Database design is however categorized into three stages, i.e. the conceptual design, logical design and the physical design phase. The conceptual design is a representation of human idealization of reality. At this stage of the database design, decisions were made on how the view of reality will be represented in a simplistic pattern and still satisfy the information needed from the users. For this study, points, line and polygon features, (vector data) model were utilized. The listed entities were observed; River, roads, and contour represented as line features, while the study area boundary, buildings, and dumpsite represented as a polygon features (See Fig.2).

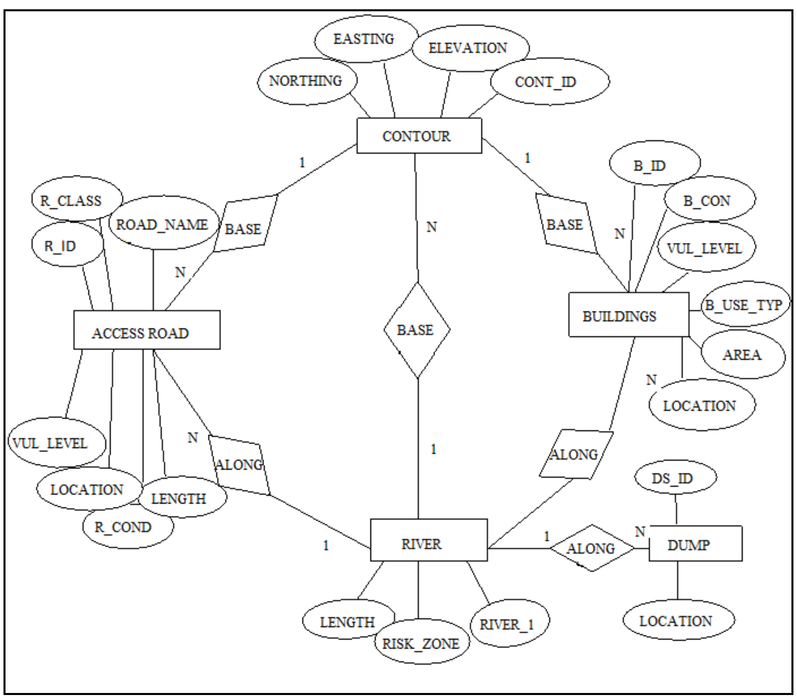

Figure 2: Entity Relationship

Source: Adapted and Modified from Sciencedirect.com, 2017

Assessing the Level of Vulnerability Using Flow Accumulation (Hydrological Function)

The Flow Accumulation Function was used to generate the convergence point for the surface run-off. The buildings and other functions concentrated around these areas are naturally more vulnerable to flood. To conduct Flow Accumulation Analysis, the contour layer was converted into raster which served as an input for the generation of Flow Direction necessary for the creation of Flow Accumulation Map under the Spatial Analyst Tool.

Table1: Different categories of buildings at risk of flood based on the buffered distance

Zone	Residential	Commercial	Educational	Religious	Total
High	170	26	1	14	211
Moderate	109	9	-	4	122
Low	112	5	1	2	120
Total	391	40	2	20	453

Source: Authors Survey 2018

Vulnerable zones within the Metropolis

The study observed that several buildings fall within the 3 vulnerable zones along the river but the following areas fall mostly within high, low and moderate vulnerability. The study further affirmed that about 10,820 people could be at risk of flooding

High: Taiwo Isale, Amilegbe, Unity area, Stadium road, Obbo Road etc

Moderate: Some part of Unity area, Coca Cola road, part of stadium road, Sabo-Oke, Ipata market, GSS Area etc

Low: Oja Oba, Post Office, GRA, Basin, Taiwo-Oke, Adewole etc.

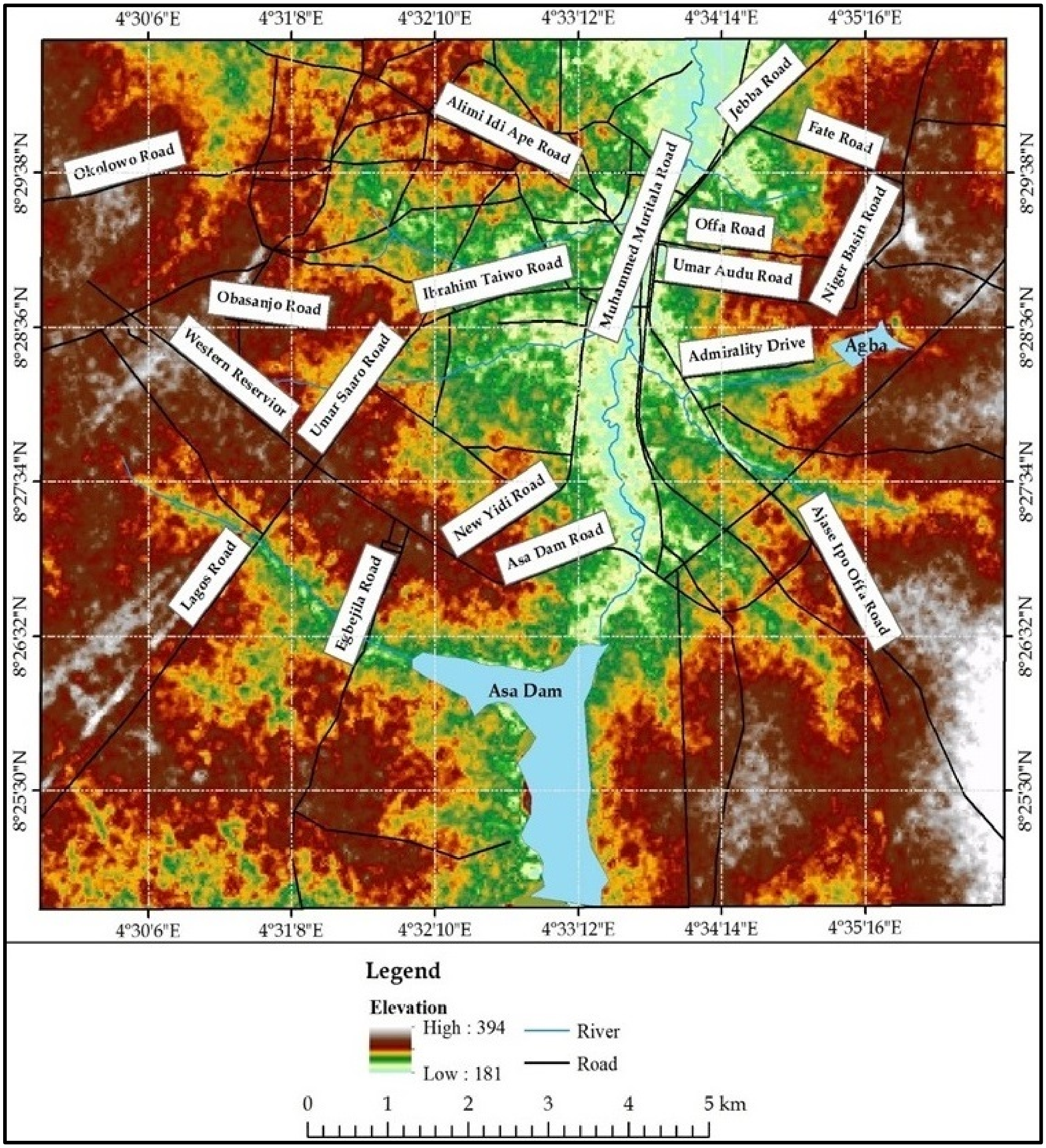

Figure 3: Study Area, Showing the Relief

Source: Generated from U.S. Geological Survey, 2016.

Implication for Planning and Development

Based on the study carried out, the following recommendations were considered to be useful in reducing the effect of flood hazard on the residents along the plain for sustainable development:

i. The government should embark on expansive channelization of Asa river basin. Proper channelization will provide a lasting solution to the problem since buildings are already situated along the plain.
ii. It is expected of the government through its agencies to strictly enforce all relevant laws and edicts that prohibit the erection of structures along the flood plain. Development can be permitted in areas beyond 30meters but quality building materials that can withstand the impact of flooding must be used.
iii. Relief materials and other compensation should not be given to new developments situated within the high vulnerable zone in case of flood occurrence as a penalty for violating planning regulations. Also, owners of buildings situated within the range of 30meters away from the river can be charged for the cost of a rescue mission in case of flooding. This will discourage further encroachment.
iv. Indiscriminate dumping of waste along the channel should be checked with a penalty to violators of such policy. Further, regular awareness programmes on the need to stop indiscriminate dumping of refuse and wastes on the river channels should be enhanced.
v. Regular mapping and updates should be carried out in the area and the country at large to help in disaster risk management.
vi. Concerned agencies should be well educated about the uses and how to use GIS tools in aiding and supporting their operations for capacity and sustainable development.

CONCLUSION

The integration of a decision support system to solve environmental problems is becoming more challenging and promising sustainable development. Consequently, the assessment and modelling of vulnerable areas within the catchment area appear to yield a more reliable result when approached from digital support services. The continuous threat to life and properties along the corridor of Asa River due to massive flooding needs urgent attention. Thus, the study concluded that GIS is a veritable tool for modelling vulnerable areas along the corridor of a river from a more familiar environment.

In as much as flood cannot be totally prevented, reduction of adverse effect can be done. Damage could be managed via effective and apt management and responsive measures and by giving adequate information to residents and land/estate developers. Geographic Information System is stocked with a well-structured analytical potentiality which can be utilized for proper decision-making processes for prevention, readiness, response, recovery and quick planning for flood and other hazard operational activities; for pre, during (taking initiative to rescue residents to save locations) and post the flood (reconstruction activities).

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