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FLOOD VULNERABILITY ASSESSEMENT USING FIELD OBSERVATION AND GEOSPATIAL TECHNIQUES; A CASE STUDY OF MAKURDI, BENUE STATE, NIGERIA

*A.Mamodu [1], J.D.Kor[1], N.J. Chukwu[1], S.H.Waziri, [1], N.P.Ofor [2,] D .U.Alhassan [2]

1. *Department of Geology, Federal University of Technology, Minna, Niger state, Nigeria*
2. *Department of Physics, Federal University of Technology, Minna, Niger state, Nigeria.*

**Department of Geology, School of Physical Sciences, Federal University of Technology, Minna, Niger State, Nigeria*

Correspondent author: adegbemamodu@futminna.edu.ng
Phone number: +2347030496207

ABSTRACT: Flooding is a global phenomenon and one of the most damaging and destructive natural hazards. It has become an annual occurrence in many States, towns and villages in Nigeria. In Makurdi, it occurs along the River Benue because of many factors interplaying together. Worst still, a greater proportion of the populace have little or no knowledge about the risk of living in flood prone zone. Therefore, are not aware of their vulnerability to such hazard. In order to bridge this gap and also, for flood prevention, flood mitigation, flood risk assessment and flood risk management reasons, there is the need for flood vulnerability assessment, so as to generate flood hazard map for the area. Flood vulnerability assessment was therefore, carried out using an integrated field observation and geo-spatial techniques. The research found that, flooding events are mainly caused by multiple factors interplaying together to increases the vulnerability of the study area to flood hazard. These factors were validated by field observation. The factors are , heavy rainfall, raising level of population in the study area, poverty, lack of education and sensitization on the danger of living along flood plains, growth in urbanization, improper disposal of refuse dumps which inturn clogs the drainage channel, inadequate drainage systems and lack of maintenance of existing ones, building of houses along flood plains, sedimentation of the river channel and excessive rainfall and lack of political will on the government to providing basic housing infrastructure. Thus, the research has demonstrated that integrating rainfall data, fieldwork, image interpretation and GIS are very important in flood vulnerability mapping and characterization.

KEYWORDS: Flood, hazard vulnerability, GIS, buffer, rainfall

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1. INTRODUCTION: Flooding is one of the most damaging and destructive natural hazards. It may cause tremendous damages and loss of lives in the world (1). Ajaya (1) reported that, about 196 million people in more than 90 countries are affected by disastrous flooding each year. South Asian countries with China and India are top of the list of absolute exposure of flooding indicating around 150 million victims each. Besides, Africa countries, being less developed are also among the worst hit countries of flood related disasters. Aysan (2) reported that most of the flood disasters are manifested in some physical losses.

According to Azad (3), flooding is attributed to lack of well-attributed plan and consideration of various aspect of plan such as the waste generation and disposal, traffic and population. Birkmann (4) supported this assertion and further added that inadequate drainage is one of the peculiar planning problems that causes flood. Blaikie et al (5) attributed flooding to heavy rains, melting of ice or snow, or the bursting of dams and sea banks. Flooding is one of the world's greatest environmental problems and this is because of the devastating effect it has on lives and property [(4), (6)] enumerated three factors that caused Floods. Viz: Anthropogenic factor; rainfall excesses; snow and ice (which usually include damaging flood due to thawing condition and coastal factors) and among the three factors, excessive rainfall is the

most prominent cause of flooding. They are environmental hazards of meteorological phenomena but very often induced by man's improper utilization or abuse of the physical environment. CSE (7) related the causes to excessively heavy and prolonged rainfall is the commonest universal cause of floods.

The type of relief in a place can also be a contributory factor to the occurrence of floods (8). The Benue Valley is low and broad swamps can be found there thus, may contribute to flooding in Makurdi town. In addition, some socio-economic and anthropogenic activities have been found to intensify flood conditions in the environment. Among these is urban land use particularly in the floodplains of stream traversing cities The occurrence of floods in flood plains is perceived to be natural phenomena. But the encroachment of urban areas onto flood plains has brought about damage to property and sometimes loss of human lives in cases of floods (9).

In addition, the worst condition happens when the physical vulnerability occurs when people have lack of resources, awareness, knowledge and capacity to deal with the hazard (2). Nigeria as a country, has suffered from flood events in various parts of the country. It is therefore, important to know that in year 2012 alone in Nigeria, about 7 million people were affected, 2.3 million people were displaced, 597,476 houses destroyed or damaged, over 363 people killed and an estimate of 2.6 trillion naira were lost to flood disaster (8) . Most of the affected areas belonged to the flood plains and flood hazard zones, especially in Makurdi metropolis.

Griacela (10) carried out a research on the flood risk perception and coping mechanism of a local community in Surakarta City, Central Java province, Indonesia, based on field observation and participation of the local community to elicit knowledge. He concluded that, people living near the embankments or the flood plains are usually more vulnerable to flood than those living in other areas.

Oluwole & Olugbenga *(11)* carried out a research on integrating local knowledge into GIS-based flood risk assessment, a case study of Triangulo and Mabolo communities in Phillipines. Her studies, presents an approach for integration local knowledge into GIS-supported flood risk assessment. The work demonstrated how spatial and non-spatial components of local knowledge are turn into information ready for integration with other formalized means of analysis. The studies, incorporated open interview, filed observation and group discussion into information for flood risk management. The peoples experiences with water depth, duration and flood perception was captured. The data generated were used for spatially reconstructing and analyzing the hazard events. She further pointed out that, it was possible to convert hazard parameters in classes based on the community's point of view. This became the primary input combined with the outputs of flood modeling using hydrodynamic software (SOBEK). By so doing, past, present and future scenarios were modeled to reveal the influence of landscape transformation in aggravating the threat to flooding for communities in the study area. The study concludes that, community knowledge is not homogenous through space and time. Hence, community knowledge is dynamic and sometimes very difficult to collect. In addition, memory of a specific event decays after a certain period of time. Finally, she also, concluded that, local knowledge stored in a GIS cab is a very good source of validating information derived from other sources.

Just like in many cities of the world, majority of the population in Makurdi live in urban and semi-urban areas, and the percentage of these city dwellers continue to grow year in year out [(2), (9)] With escalating influx of people from the rural regions in search of better life's opportunities such as white collar jobs and businesses in Makurdi being the Benue State capital, A greater proportion of this populace have little or no knowledge about the risk of living in flood prone zone. In Makurdi, seasonal flood disaster occur annually causing massive destruction of lives and property, a good example is the 2012 flood disaster that claimed many lives and property. Flooding in Makurdi area occur along the river Benue has become an annual occurrence because of heavy rainfall and some geologic conditions present in the area such as its impervious soils and relief. This area has become an issue of serious concern as many lives and properties worth millions of naira are lost annually to floods.

Considering the frequency of flood events in the study area, inadequate forecasting techniques and lack of emplaced early warning system, coping with flood disaster has been traditionally treated as a question of donations of relief materials to victims after the event has occurred rather than as a risk that should be anticipated [(7)- (11)]. Hence, this brings into focus the need to assess the vulnerability of the habitant to flood hazard by carrying out field observation integrated in a GIS.

Furthermore, for the purpose of physical planning, decision making, reconstruction, flood prevention, flood mitigation, flood risk assessment and flood risk management reasons, there is the need for flood vulnerability assessment, so as to generate flood hazard map for the area. To this end, the aim of this research is to delineate flood hazard areas and determine the level of vulnerability or susceptible to flood in study area (Fig.l). The study will further provide data for input into flood risk studies as most of the Benue State agencies have inadequate information about flood hazard, hence the need for a research work to complement existing data.

In addition, geospatial techniques was employed for mapping the flood-prone areas because of it provides practical and cost-effective way to identify flood plains, hazard zones and other susceptible areas (9).

2. RESEARCH AREA: Fig. l is map of Nigeria showing the research area in green (in the legend). Makurdi, is the Benue state capital is located in the central part of Nigeria and lies between latitude 7°40’00’’N of the equator to 7°50’00’’N and longitude 8°20’00’’E to 8°40’00’’E of the Greenwich meridian. The study area is accessible through Roads, Air, Rail and the river Benue. By road, the following roads connect Makurdi town with the rest of other Nigerian.

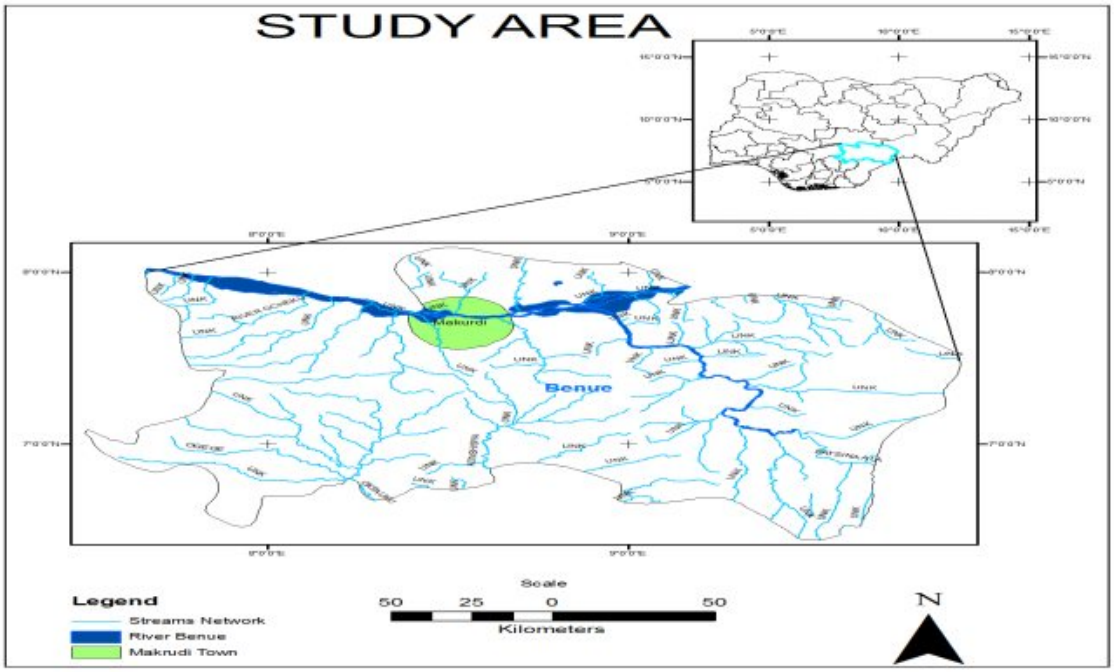

Fig. l: is map of Nigeria showing the research (study) area in green (in the legend).

3. METHODOLOGY:

3.1. MATERIALS: The lists of materials used for this research are Global Positioning System, Satellite images; The satellite imagery used for this research included; Nigeria Sat-1, Nigeria Sat-X, SPOT imagery and Shuttle Radar Topography Mission (SRTM) Digital elevation model (DEM) data, all gotten from National space research and development agency (NASRDA), Abuja, Nigeria. The software component used for this project work included the following: ILWIS 3.3 (for image classification and interpretation), Arc map (for buffering clipping, masking, and other analysis). ArcGIS 9.3 (for digitizing and performing spatial operations). Photographic camera was used to take pictures.

3.2. METHODS : The methods employed in this research are fieldwork, image interpretation and buffering in ArcGIS.

3.2.1. FIELDWORK: Fieldwork was carried out to map current flood inventory for the study area. During this period, efforts was made to study drainage condition, refuse dump pattern, map last flood levels and ascertain the level of physical flood imprint on buildings .The flood imprint is very pertinent because, it will reveal the level of flood intensity , thus, measure flood severity. During the fieldwork, secondary data like rainfall pattern was collected from Nigerian Metrological Agency.

3.2.2. IMAGE INTERPRETATION AND BUFFERING IN ARCGIS: Image interpretation was carried out to identify and map the various landuse patterns for the study area. This may have a connection to the flooding in the area. Buffering analysis was done for proximity Analysis. The Buffer was used to delineate zones of influence and characterization of the flood hazard. It is a spatial analysis for generating zones of a given distance around a feature on the earth surface. This forms a polygon around a point, line or polygon feature by locating its boundaries at a specific distance. Buffer zones were created around selected features using ArcGIS software at specified distances of 1000m (1km), 3000m (3km), 5000m (5km) and 7000m (7km) respectively for the identification of areas that are highly prone, less prone or not prone to flood hazards. Based on the above criteria and information, a flood hazard map was produced to show areas susceptible to flood hazards. They include:

- Very low hazard free zone.
- Low flood hazard zone.
- High flood hazard zone.
- Very high flood hazard zone.

  The zones were characterized mostly based on their proximity to the river Benue, wetlands and major drainage channels.

4. RESULTS:

4.1. FIELDWORK RESULTS: The fieldwork shows that dumping of refuse, mostly solid waste into drainage system is rampart in the study area. Therefore, clogging them (Fig. II a, II b). The clogging of the existing drainage system contributed to the high level of flooding in the area. This will narrow the channels were water is supposed to flow through. Thus, forcing water to overflow its banks and subsequently leading to flooding

Fig. II a and II b: showing the dumping of solid waste into the drainage system/channels in the study area. (Source, fieldwork*)*

Furthermore, from field observations, it was discovered that most houses, business premises, schools and commercial centers were built on drainage channels and on the floodplains of the river Benue, and in water logged areas (Fig. III a, III b and IV). These areas are usually inundated yearly and are hotspots for flood disaster in times of heavy rainfall.

Fig. III a and III b: showing building along the River Benue floodplain. These are highly vulnerable to flooding during high rainfall. (Source fieldwork)

Fig. IV: shows an ongoing construction on the bank of River Benue (source fieldwork)

During the fieldwork, the level of flood imprints on building was observed (Fig.V)

Fig. V: imprint of flood on building's wall, signifying the level or height of flood waters at the time of impact. (Source fieldwork)

Looking critical at the mean monthly rainfall information from 2002-2012 collected during the fieldwork (Fig. VI).

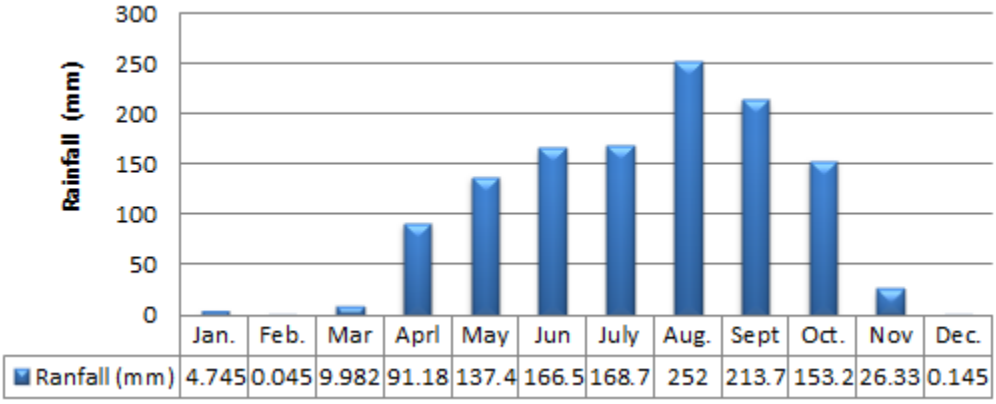

Fig. VI: shows graphical representation of the mean monthly rainfall distribution in Makurdi from 2002-2012.
From figure 6, it is clearly seen that the highest rainfall for the period under review occurs in August with rainfall value of 252mm while it is zero in February. This indicates that flooding in the study area is usually around August and September where the rainfalls are generally heavy.

4.2. IMAGE INTERPRETATION AND BUFFERING RESULTS:

4.2.1. IMAGE INTERPRETATION BASED ON LANDUSE: Image interpretation based on landuse/landcover and subsequent classification of the Landsat 2010 image led to six classes of landuse viz: settlement areas, vegetation, water bodies, mudflats or sediment and bare ground (Fig. VII)

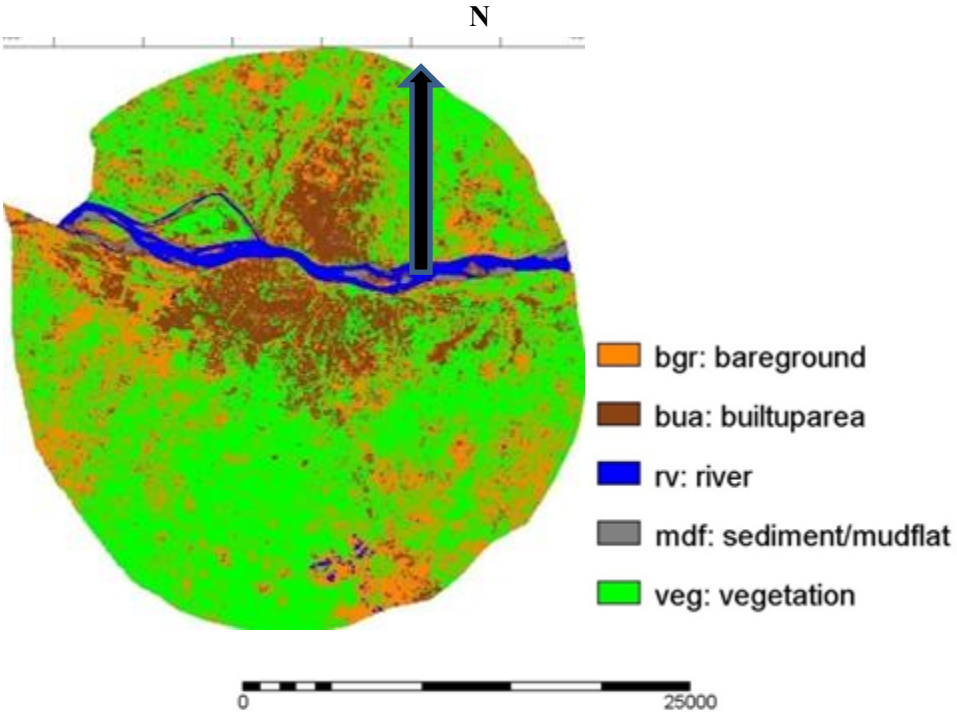

Fig. VII shows Land use and Land cover Map of Makurdi-2010

4.2.2. BUFFERING: The buffer was used to characterize flood vulnerability for the study area and the result is shown in Fig. VIII

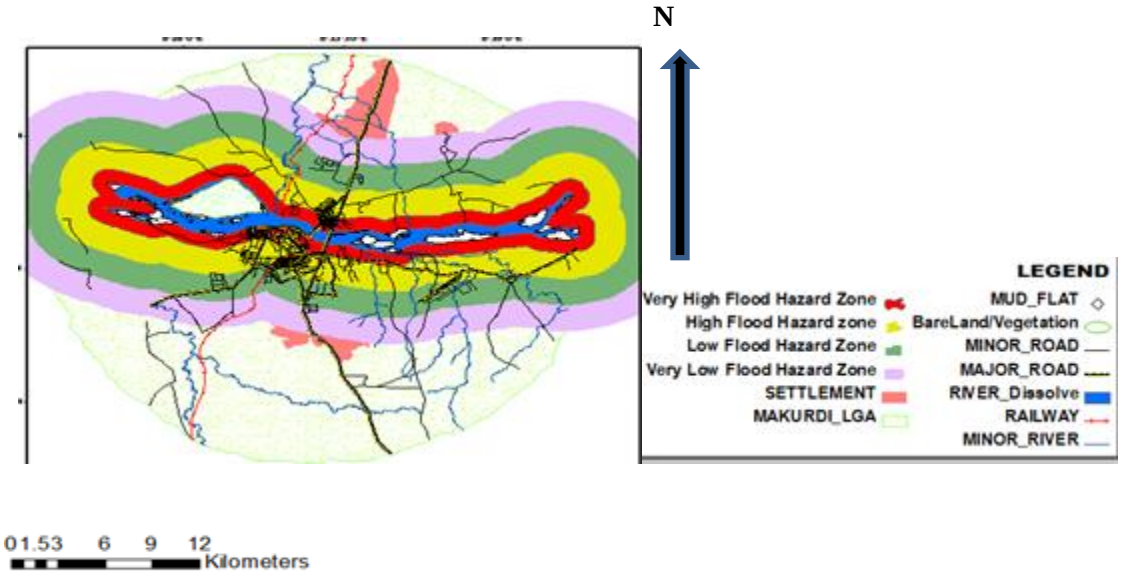

Fig. VIII: Map of Makurdi showing the Flood vulnerable zones

As can be seen, the areas in red are the most vulnerable to flooding in the study area. This is because; such areas are closer to the river. However, the farther one moves away from the river, the less vulnerable to flooding.

5. CONCLUSION: The research has demonstrated that integrating rainfall data, fieldwork, image interpretation and GIS are very important in flood vulnerability mapping and characterization. The research further concludes that, the flooding events are mainly caused by multiple factors interplaying together to increases the vulnerability of the study area to flood hazard. These factors as validated by field observation are , heavy rainfall, raising level of population in the study area, poverty, lack of education and sensitization on the danger of living along flood plains, growth in urbanization, improper disposal of refuse dumps which inturn clogs the drainage channel, inadequate drainage systems and lack of maintenance of existing ones, building of houses along flood plains, sedimentation of the river channel and excessive rainfall and lack of political will on the government to providing basic housing infrastructure for the lower class of the society. All these mentioned factors have cumulative effect on the exacerbated flood hazard in the study area.

6. REFRENCES:

1. Ajaya.D.2002. *Flood and vulnerability: need to Rethink flood management*. Natural hazards.28:155-179.
2. Aysan, A.K.1993. *Vulnerability assessment, Natural Disaster; Protecting vulnerable communities*, Editor: Merriman, P.A. and Browitt, C.W.A., International Decades for Natural Disaster Reduction, Proceedings on the conference Held in London, 13-15th October 1993, Published by Thomas Telford Services Ltd, London.
3. Azad,A.K (2008). *Urban Flood Risk Assessment Using Community's perception and flood propagation model*. ITC, International Institute of Geoscinece and Earth Observation, Msc Thesis, Enschede, Netherlands.
4. Birkmann, J. 2006. *Measuring vulnerability to Natural Hazards: Towards Disaster Resilient Societies,* United Nation University Press, Tokyo, New York, Paris.
5. Blaikie, P., Cannon, T., Davis, I., And Wisner, B.:1994, *At Risk: Natural Hazards, People's Vulnerability, and Disasters,* Routledge, London.
6. Chitkara, S. C. and Mukhopadhyaya, T. K.: 1999, *Flood forecasting: A non structural measure or flood management*, Himganga 1(3), April–May–June Patna, India.
7. CSE: 1991, *Floods*, *Flood Plains and Environment Myths*, State of India's Environment A Citizen's Report, Centre for Science and Environment, New Delhi.
8. Chhetri, M. B. P. and Bhattarai, D.: 2001, *Mitigation and Management of Floods in Nepal*, Ministry of Home Affairs, His Majesty's Government of Nepal, Kathmandu.
9. Fetty Febrianti, 2010*. Flood risk perception and coping mechanism of a local community in Surakarta City, Central Java province, Indonesia.* ITC, International Institute of Geoscinece and Earth Observation, Msc Thesis, Enschede, Netherlands.
10. Griacela Peters Guarin 2008. *Integrating local knowledge into GIS-based flood risk assessment, a case study of Triangulo and Mabolo communities in Phillipines.* ITC, International Institute of Geoscinece and Earth Observation, Ph.D Thesis, Enschede, Netherlands.
11. Oluwole A., Adedayo A. &Olugbenga A.2013.*Delineation of flood vulnerable zones and Disaster Risk Management along Asa River;* A GIS Approach.