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A Geospatial Expose of Flood-Risk and Vulnerable Areas in Nigeria

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ABSTRACT

Flooding is recurrent in Nigeria, occurring yearly at different scales. This geared the need for a study to reveal local government areas (LGAs) that are at risk and vulnerable to flooding. The multi-criteria approach was adopted, using geospatial techniques and data. Factors considered were elevation, slope, rainfall intensity, and distance to river. The factors were classified, reclassified, rated, and weighed in a systematic process. Nineteen states and 114 LGAs face high risks, especially communities in the Niger Delta, around the lagoons of Lagos, along River Niger, Benue, and the Cross-River. Also, 125 LGAs in 18 states face medium flood-risk vulnerability. Consideration the population density of communities, Lagos State is the most vulnerable because of LGAs with high population densities within high flood-risk zones. Other states with communities exposed to high flood-risk vulnerability include Rivers, Kogi, Cross River, Akwa Ibom, Anambra, and Delta. The study provides information key to proactive policy formulation, mitigation, and adaptation to flood risk in Nigeria.

KEYWORDS

Flooding, Flood-Risk Zones, Geographic Information Systems, Multi-Criteria Analysis, Vulnerability

BACKGROUND TO THE STUDY

The past two decades have seen a significant upsurge in the frequency of flooding on a global scale (Najibi & Devineni, 2017). The Intergovernmental Panel on Climate Change (IPCC) confirmed that flood vulnerability would most likely increase in line with increasing rainfall events (Conix & Bachus, 2007). The occurrence of flooding around the world is fast becoming a normality (Thomalla, Downing, Spanger-Siegfried, Han & Rockström, 2006) with about 70 million people exposed to flood risk and at least 800 million people susceptible (Peduzzi, Dao, Herold & Mouton, 2009). Its impacts are as well immeasurable. For example, in the United States, floods destroy property worth US$6 billion and kill 140 people annually (National Geographic, 2018).

In Nigeria, flooding is a recurrent phenomenon which could be coastal, fluvial or pluvial (Aderogba, 2012). Coastal and fluvial flooding in Nigeria affects coastal and riverine environments and are due to seasonal water upsurge from large rivers such as the Niger, Benue, Cross River, Kaduna,

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and others. On the other hand, pluvial floods are yearly occurrences during the rainy season (from July to October) and are more eminent in the cities (Nkwunonwo, Malcolm & Brian, 2015). Recent flood occurrences in Nigeria have been particularly, among other factors, geared by the release of water from the Lagdo Dam in Cameroon (Udo, Ojinnaka, Baywood & Gift, 2015), the high intensity of rainfall in some regions (Eagle Online, 2018) and the haphazard development of land on flood prone areas (Atufu & Holt, 2018).

Flooding is the most occurring natural hazard in Nigeria and the situation is dire (Aderogba, 2012). An early account of flooding in Nigeria is the Ogunpa River flooding of Ibadan in 1963, 1978, 1980 and 2011, which led to an estimated property loss of at least 30 billion naira and 100 fatalities. In Lagos, there were at least 8 flood events that killed at least 30 people between 2011 and 2012 (Komolafe, Adegboyega & Akinluyi, 2015). Whereas flooding has been a recurrent occurrence in Nigeria, the year 2012 event was a striking one, superseding previous flood events in the last 40 years. The National Emergency Management Agency (NEMA) reported that it affected 7 million people in 30 states, displaced 2.3 million people, killed 363 and cost Nigeria's economy an estimated loss of US$ 9.6 billion (Amangabara & Obenade, 2015).

Earlier studies have examined flooding and flood-risk in Nigeria as a whole (Nkwunonwo, Malcolm & Brian, 2015; Komolafe, Adegboyega & Akinluyi, 2015), while others assessed the problem at a regional or state level (Amangabara & Obenade, 2015; Udo, Ojinnaka, Baywood & Gift, 2015; Udo & Eyoh, 2017, Efiong & Hogan, 2017). The question of "which Local Government Areas (LGAs) in Nigeria are most at risk to flooding and which are more vulnerable?" has however received no empirical attention. Providing answers to these questions are key to flood mitigation and adaptation in Nigeria and elsewhere. The geospatial technologies of remote sensing and geographic information systems (GIS) have proven to be of immense value in this regard.

GIS and remote sensing techniques have become indispensable tools for mapping flood-risk vulnerability (Karmakar, Simonovic, Peck & Black, 2010, Wicht & Osinska-Skotak, 2016; Das, Chattopadhya & Basu, 2017; Gandini, Prieto, Garmendia, San-Jose & Egusquiza, 2018), providing evidence for early warning and emergency response systems.

GIS tools in a multi-criteria approach (MCA) combines causative natural factors to derive flood vulnerability classes that support flood risk mitigation (Daneshbod, 2014; Elsheikh, 2015; Blistanova, Zelenakova, Blistan & Ferencz, 2016). In this vein, Meena & Gupta (2017) integrated multiple parameters such as rainfall, slope, drainage density, land use, building density and so on to make deductions. Similarly, Danumah, *et al.* (2016) integrated parameters such as slope, drainage density, type of soil, isohyet, population density, land use and sewer system density. Njoku, Efiong, Uzoezie, Okeniyi & Alagbe (2018) also combined independent parameters (distance from river, rainfall intensity, elevation, land use, slope and soil- "DRELSS") to evaluate flood-risk vulnerability.

These parameters in the MCA are usually assigned different weights, based on the influence of the variable on flood occurrence. This weighting process, termed the weighted overlay analysis has gained popularity in the spatial flood risk-vulnerability mapping process (Liu, 2013; Mokarram & Hojati, 2017). The selection of appropriate weights and ranks in the MCA process is fundamental in the vulnerability assessment (Hoque, Pradhan & Ahmed, 2019). Some authors have depended on the situation in the field, backed by literature (Udani & Mathur, 2016; Ajjur & Mogheir, 2020), while some others have adopted the Analytical Hierarchy Process (AHP) to compute the priority weights of factors (Umar, Abdullahi & Usman, 2019; Hoque, Pradhan & Ahmed, 2019; Fadhil, Ristya, Oktaviani & Kusratmoko, 2019). Despite these differences, there is a consensus that the MCA is most suitable for decisions on flood mitigation and land use planning (Ogato, Bantider, Abebe & Geneletti, 2020).

Notably, tackling flooding and reducing its associated risks in Nigeria has been an uphill task because of some cardinal gaps highlighted by Nkwunonwo, Malcolm & Brian (2015). Even when flood vulnerability is modeled, a major gap still exists between what the