International Journal of Physical Research, 11 (2) (2023) 31-35

International Journal of Physical Research

Website: www.sciencepubco.com/index.php/IJPR

Research paper

Flood exposure assessment in Rivers State, Nigeria

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Abstract

The primary procedure in emergency response and disaster risk management is identifying the scope of a natural hazard, such as determining regions at high risk. After this, exposure mapping helps estimate the disaster's potential impact - for instance, determining the number of possible people or facilities affected. Employing Earth Observation (EO) data gathered from satellites is commonly used to map areas with a high susceptibility to natural disasters. The purpose of this work was to evaluate flood exposure in Rivers State. The objectives included assessing the probable effects on local and urban settlement, and establishing the magnitude of damage on farmland. The research leverages multiple data sources, including Globalland 30, Global Human Settlement Population Layer. Quantum GIS played a significant role in assessing the vulnerability and exposure scale of both people and farmlands to flood risks. The primary analyses conducted involved zonal statistics and overlaps analysis. The study shows an estimated 161,537 people are impacted by this exposure. The flooding affects farmlands that cover approximately 5,591 hectares. Furthermore, estimated urban-rural area impacted by flooding is around 29,775,178 square meters, or 2,978 hectares This is executed largely for risk management or emergency response after events like floods, wind storms or landslides. For managing risks prior to a disaster, it's crucial to compare varying damage models with the corresponding exposure, delivering a comprehensive outlook on potential impacts.

Keywords: *Exposure Assessment; Flood; Rivers State; Population; Land Use.*

1. Introduction

The United Nations (UN) outlines exposure as the circumstance of individuals, infrastructure, residences, productive capabilities, and additional tangible human assets located in areas prone to dangers (UNISDR, 2017). The United Nations Office for Disaster Risk Reduction (UNISDR) specifies that exposure indicators can be measured and may include the number of people or variety of assets in a given region. This data can be matched with the distinct vulnerability and capability of the exposed factors to a specific hazard. This provides an estimated numerical risk associated with the turned out danger within the concerned zone (UNISDR, 2017). Pelling (2012), Cardona (2005), and Dilley et al. (2005) elaborate upon exposure as a terminology utilized for classifying elements at risk. According to Hagos et al. (2022), flood exposure is characterized as the existence of significant societal entities - such as people or buildings - within flood plains. Essential aspects of flood exposure analysis primarily include the measure of flood risk and the consolidated data of the population and constructed assets that may be affected (Aggarwal, 2016).
The conception of flood exposure is not universally clear-cut and can be scrutinized using diverse methodologies and techniques. Comprehensive analysis of flood exposure is feasible only when precise spatial data is at disposal. Therefore, the reliability of flood risk analysis is heavily contingent on the precision of the spatial data available.
A report by the UNDP named 'Diagnostics Analysis of Climate Change and Disaster Management in Relation to flood event' confirms that floods had the most significant impact on the population from 1980 to 2010. During this period, an equivalent of 90% of the population affected by disasters in Sierra Leone was due to floods. To further illustrate the extent of their impact, floods affected around 221,204 individuals and resulted in 145 fatalities, which is 11% of the total disaster-related deaths in the said period.
According to Lin et al. (2016), a flood can be defined as the temporary inundation of land due to the overflow of water. Although we can't completely prevent the event of a flood, its associated risks can be effectively minimized through careful planning and implementing appropriate mitigation strategies (Samu & Kentel, 2018).The pivotal role of spatial data gathering in relation to potential flood occurrences should not be overlooked. This data is crucial for flood planning, early warning systems, emergency response, and designing an effective flood risk reduction strategy (Esmaiel et al., 2022). Several research studies have explored various methodologies for evaluating and mapping elements present in areas susceptible to flooding (Hagos et al., 2022; Lekamlage et al., 2022; Pushpakumara & Isuru, 2018; Schelhorn et al., 2014). However, the quest for efficient flood risk reduction is often hampered by the lack of adequate spatial data.
In Nigeria, a severe flooding crisis struck the nation yearly, sweeping across key cities throughout roughly 14 states bordering the Niger-Benue River. The States most critically impacted were Adamawa, Taraba, Benue, Kogi, and Anambra, located in the east-central region of the country. The magnitude of this flood episode marks it as the most disastrous in the past four decades. As a consequence, properties

were submerged; transport networks were disrupted across the affected regions. It's estimated that this annual disaster usually forced around 1.3 million people to abandon their homes, and sadly resulted in the loss of approximately 431 lives. Furthermore, over 1525 square kilometers of agricultural land annihilated.

This study employs a Geospatial methodology to evaluate flood exposure in Rivers State, Nigeria, leveraging Google Earth Engine Flooded extent raster of Rivers state. The analysis focuses on the vulnerability of population and land use, conducted using the tool QGIS. The variables of interest in this risk assessment include population dynamics, and land cover using global land 30 data. The investigation is guided by a scenario modelled on significant historical flood events.

Considering the surge in flood incidents in past years, a precise assessment of flood risk constitutes a crucial part of urban flood mitigation (Daniela et al., 2010). To evaluate flood susceptibility, the team leverages data from the digital elevation model, census, streams, land usage, and soil types (Daniela et al., 2010). Recent findings by Mahsa et al., (2012) reveal that humans are frequently facing a growing number of natural calamities. Among these, floods are the most prevalent and widely occurring globally. For an efficient flood risk assessment, these authors utilize imaging and digital elevation model data collections in a Geographic Information System. Assessing exposure to flooding offers critical insights about the components and assets situated in areas susceptible to flood inundation, or regions prone to flood hazards. The resulting data from this evaluation carry significant relevance for decision-makers. It serves as the groundwork for the development of strategies and actions pertaining to readiness, advanced warnings, post-flood recovery response, and prevention measures.

1.1. Methodology for flood exposure assessment

Flood exposure is characterized using three selected indicators (Ziegelaar and Kuleshov, 2022). These include: Population, Type of Land Use and critical Infrastructure.

Exposure assessment is performed using population data acquired through remote sensing. (Ziegelaar and Kuleshov, 2022) The data set encompasses population categorization, done through zonal statistics in GIS software. A positive correlation is observed between population density and flood exposure meaning that a rise in population density inevitably culminates in higher numbers of people being affected during flood events (Ziegelaar and Kuleshov, 2022). This consequently translates to increased overall flood exposure.

Land use concept of Land Use type is frequently utilized as an indicator of flood exposure (Ziegelaar and Kuleshov, 2022). Essentially, Land Use type categorizes the various types of land within a specific area, based on their usage. These classifications generally have correlations with the community's valuation in relation to flood exposure. One can correlate Land Use type with flood exposure by allocating a value to each type. A higher value often implies a higher community value, leading to an increased flood exposure (Ziegelaar and Kuleshov, 2022). It's essential to appraise Land Use type since different types have varying degrees of contribution to flood exposure. Notably, this indicator can also exemplify flood vulnerability.

2. Study area

Fig. 1: Map of Africa with Location of Nigeria.

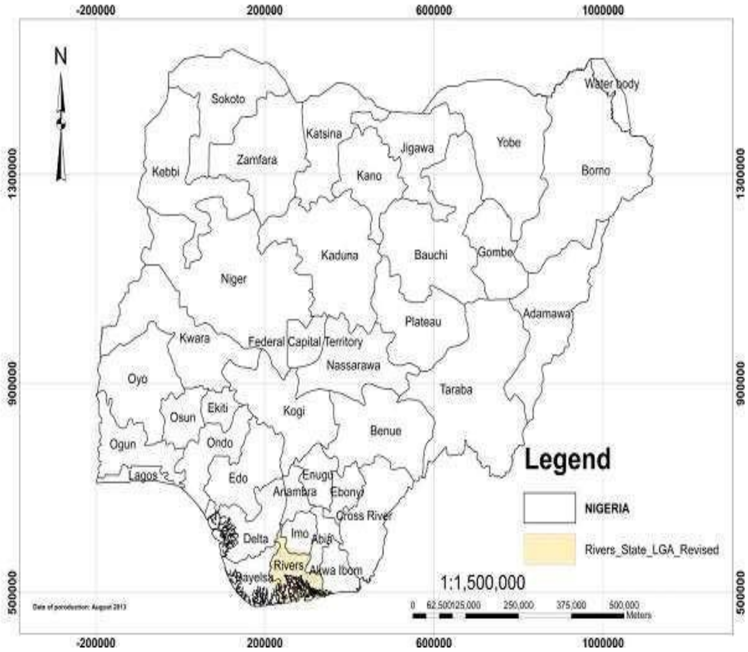

Fig. 2: Map of Nigeria with Location of Rivers State.

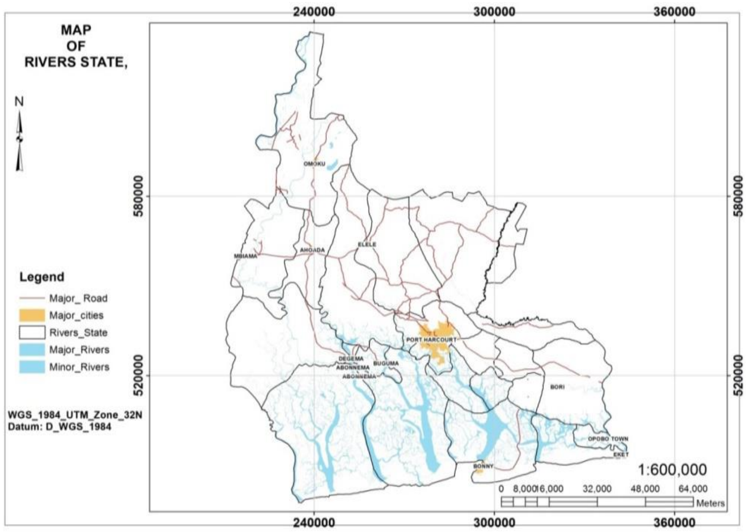

Fig. 3: Map of Rivers State.

Rivers State is home to over 23 Local Government Areas. The geographical coordinates of the state extend from 210590.00m to 344490.00m north, and 477432.00m to 634925.00m east, in relation to the UTM Zone 32N origin (See Fig 3 for reference). Borders of Rivers State include the Atlantic Ocean to the south, the states of Imo, Abia, and Anambra to the north, Akwa Ibom state to the east, and Bayelsa and Delta states towards the west. The state is recognized for its rich ethnic diversity, with ethnic groups including the Abua, Andoni, Ekpeye, Engenni, Etche, Ibali, Ikwerre, Kalabari, Ogba/Egbema/Ndoni, Okrika, and Ogoni residing there. As one travels towards the coastal regions of the state, there is a prominent change in landscape, marked by the widespread mangrove swamps. This is a unique characteristic of the Niger Delta. Rivers State, as an oil-rich region, has a high concentration of industrial facilities. These facilities, coupled with development works, mean significant infrastructure is at risk during a flood.

3. Methodology

The research employed multiple data layers, including Globeland 30 land cover data, population data, and administrative border data from the affected area, Rivers State. The flood mask dimension was created through Radar-based Flood Mapping via the Google Earth Engine platform. This flood mask was exported in two formats: a vector shapefile and a GeoTiff file for population data.

The study relied on the abilities of open-source tools, such as Google Earth Engine and QGIS. Furthermore, the processing used Quantum GIS overlap analysis and Zonal statistics. The study also utilizes the JRC Global Human Settlement Population Layer to evaluate the risk-prone population.

This information is accurate to a 250m spatial resolution. The newest update was in 2015. Flowchat of methodoogy as shown in Figure 4 below.

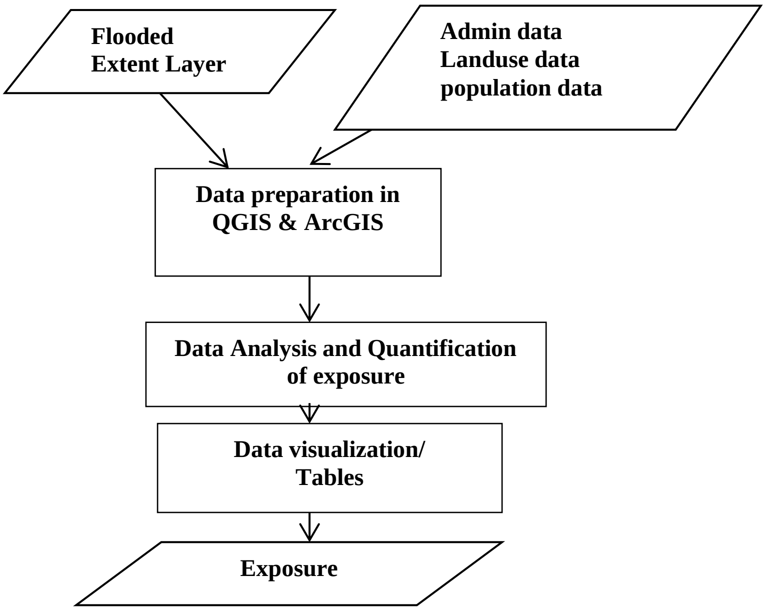

Fig. 3: Map of Rivers State.

4. Results and discussion

The GHSL 2015 data suggest that roughly 161,537 individuals are estimated to be at risk. Notably, within these, the Obio/Akpor Local Government Area (LGA) is reported to have the highest affected population, at an estimated 66,201 individual (see Table 1). s. On the contrary, the Asari-Toru LGA has the smallest estimated affected population with only 14 individuals according to the GHSL 2015 data. In order to evaluate the magnitude of the affected farming area, the Globalland 30 product was chosen for examination. The scope of the distressed zone in square meters was ascertained using the overlap analysis functionality present in QGIS. The Globalland 30 analysis puts the estimated size of endangered cropland at approximately 55,912,651 square meters, which is about 5,591 hectares (see Table 2).. An estimated size of the urban-rural area that is potentially impacted amounts to roughly 29,775,178 square meters, which equates to about 2,978 hectares.

Table 1: LGA Estimated Distributions of Exposed People: Based on GHSL 2015

Name of LGA	Population Sum
Ahoada West	16087
Emohua	1296
Ikwerre	3097
Abua/ Odual	0
Ahoada East	341
Omuma	0
Akuku-Toru	5989
Degema	11288
Asari-Toru	14
Bonny	0
Okrika	0
Obio/Akpor	66201
Port Harcourt	35131
Eleme	0
Khana	0
Tai	0
Gokana	0
Andoni	0
Opobo/ Nkoro	0
Ogba/ Egbema/ Ndoni	15936
Etche	4358
Oyigbo	0
Ogu/ Bolo	1840

Table 2: Estimated Exposed Croplands and Urban-Rural Areas Based on Globalland 30

Landuse	Area in m²	Affected Area in m²
Forest	4230202500	68572533
Shrubland	77616000	7540202
Grassland	876561300	50421355
Wetland	2556892800	73888426
Urban-rural	338642100	29775178
Bareland	104840100	8462161
Cropland	1582994700	55912651

5. Conclusion

The research assesses the risk of flooding in Rivers State, Nigeria, by examining a variety of influencing factors such as population and land usage patterns that could increase exposure levels. It is essential to address these aspects for the effective mitigation and management of possible flood-associated risks in Rivers State. The results of this investigation offer significant impressions that could guide decision-making procedures related to disaster readiness, land use planning and the execution of fitting risk reduction strategies. Using SAR satellite imagery is a practical method for quickly analysing images, thereby providing critical flood data to aid organizations in a timely manner. Moreover, the understanding of flooding boundaries can be essential for estimating damages and managing potential risks. This makes it easier to develop scenarios that pinpoint at-risk populations, economy, and environmental factors that are susceptible to potential issues related to flooding.

Acknowledgement

This work is part B of my PhD dissertation. Special words of thanks go to Engr. Edward K. Menegbo for his invaluable support. My supervisor (Co-Author), Prof. E. J. Emengini, deserves a distinctive acknowledgement. Her wealth of knowledge has enormously enhanced the quality of this dissertation.

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