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SOCIO-ECONOMIC AND ENVIRONMENTAL DETERMINANTS OF FLOOD VULNERABILITY IN THE OGUN RIVER BASIN, NIGERIA

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ABSTRACT

Flooding remains one of the most devastating natural hazards globally, causing severe socio-economic and environmental impacts, particularly in developing nations such as Nigeria. This study evaluates the socio-economic and environmental determinants of flood vulnerability in the Ogun River Basin using a GIS-based Flood Vulnerability Index (FVI) approach. Primary data were collected through structured questionnaires administered to 316 respondents in flood-prone communities, complemented by spatial and environmental datasets. Indicators representing exposure, susceptibility, and resilience were standardized using Min–Max normalization and equally weighted to compute the FVI. Results showed FVI values ranging from 0.14 to 0.21, indicating low to moderate vulnerability across the basin. Despite these values, field evidence revealed significant flood impacts, including structural damage, livelihood disruption, and environmental degradation, especially in downstream areas such as Ikorodu, Kosofe, and Lagos Mainland. Socio-economic factors: income, education, gender, and housing quality alongside environmental variables such as elevation, land use, and proximity to rivers, were key determinants of vulnerability. The study concludes that flood risk reduction in the Ogun River Basin requires integrated management strategies combining improved infrastructure, enhanced community awareness, and strengthened institutional structures.

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1.0 INTRODUCTION

Flooding is one of the most devastating and recurrent natural disasters affecting societies worldwide. It disrupts lives, livelihoods, and economic activities, while imposing severe environmental and infrastructural damage. Globally, floods are responsible for more losses than any other natural hazard, with both their frequency and intensity increasing in recent decades (Vojinovic et al., 2012). The impacts are particularly severe in developing countries, where limited infrastructure, weak institutional capacity, and inadequate planning exacerbate vulnerability (Tran et al., 2023). Floods result not only in loss of life and destruction of property but also in the irreversible loss of agricultural land, cultural heritage, and ecological resources (Yang and Liu, 2020).

The United Nations (2002) reported that floods are the most widespread and frequent natural hazard, affecting more than two billion people between 1988 and 2017. Their growing impacts on human settlements underscore the urgent need to understand the multiple factors that shape vulnerability. Floods occur when water levels in rivers, streams, or drainage channels exceed their carrying capacities, leading to overflow into adjacent lands. While climatic factors such as heavy rainfall, snowmelt, and storm surges are common triggers, human-induced factors—including unplanned urbanization, deforestation, poor drainage, and land degradation—play a crucial role in intensifying flood risk.

In Nigeria, flooding has become a recurring environmental crisis and one of the most serious natural hazards affecting communities and the national economy. Over the last three decades, rapid urban expansion, population growth, and inadequate drainage infrastructure have heightened flood exposure in many cities (Eguaroje et al., 2015). The 2012 nationwide flood disaster exemplifies this problem: it affected 30 of Nigeria's 36 states, displaced about 1.3 million people, claimed over 431 lives, and caused economic losses exceeding US$16.9 billion (Agada and Nirupama, 2015). Similarly, in 2024, heavy rainfall and catchment overflow resulted in catastrophic flooding across 31 states, leading to over 1,200 deaths, 2,712 injuries, and mass displacement, particularly in Lagos, Abuja, Bauchi, and Borno. Such frequent and severe flood events reveal the persistent vulnerability of Nigerian communities and the need to understand its underlying socio-economic and environmental determinants.

Vulnerability is a central concept in flood risk assessment. The United Nations Office for Disaster Risk Reduction (UNISDR, 2015) defines vulnerability as the conditions determined by physical, social, economic, and environmental factors that increase the susceptibility of individuals or systems to the impacts of hazards. Similarly, the Intergovernmental Panel on Climate Change (IPCC, 2014) conceptualizes vulnerability as the predisposition to be adversely affected, encompassing sensitivity and limited adaptive capacity. Birkmann (2011) further explains it as a dynamic interaction among exposure, sensitivity, and the ability to cope or recover from hazards. In the context of flooding, vulnerability extends beyond physical exposure; it reflects how socio-economic conditions, environmental degradation, and institutional weaknesses combine to amplify risks.

Flood vulnerability has multiple dimensions. Physical vulnerability depends on the structural characteristics and resilience of buildings, infrastructure, and the built environment (Nasiri et al., 2016). Social vulnerability reflects the demographic and socio-economic traitssuch as income level, education, age, and health status that shape a community's ability to anticipate, cope with, and recover from flooding (Tate et al., 2021). Economic vulnerability relates to the potential

impact of floods on livelihoods, employment, and financial stability, particularly among low-income households and small enterprises (Balica, 2007). Environmental vulnerability, meanwhile, pertains to the sensitivity of ecosystems to flood-related damage, such as soil erosion, biodiversity loss, and water quality degradation (Cutter et al., 2003). Understanding these interlinked dimensions is critical for identifying the determinants of flood vulnerability and designing effective adaptation and mitigation strategies.

The Ogun River Basin, located in southwestern Nigeria, exemplifies the growing challenge of flood vulnerability driven by socio-economic and environmental change. The basin supports a mix of urban, industrial, and agricultural activities, and is home to rapidly expanding cities such as Abeokuta, Ifo, and Lagos peri-urban areas. Over the past few decades, unregulated land development, deforestation, and the conversion of wetlands have increased surface runoff and reduced the basin's natural flood retention capacity. These environmental pressures are compounded by socio-economic challenges, including poverty, inadequate planning, weak enforcement of land-use regulations, and limited access to coping resources. Consequently, the basin experiences recurrent floods that threaten lives, property, and livelihoods.

Assessing the socio-economic and environmental determinants of flood vulnerability is vital for understanding why some communities are more severely affected than others. Such an assessment enables policymakers and planners to prioritize interventions, strengthen community resilience, and integrate risk reduction into sustainable development frameworks. Geographic Information Systems (GIS) and remote sensing offer valuable tools for spatially analyzing the relationships between environmental conditions, land-use dynamics, and social vulnerability. By integrating spatial data with field-based socio-economic information, flood-prone zones can be mapped and analyzed to identify the most critical vulnerability drivers.

This study therefore investigates the socio-economic and environmental determinants of flood vulnerability in the Ogun River Basin, Nigeria. It seeks to identify how land-use changes, population growth, urbanization, and environmental degradation interact with social and economic factors to shape flood risk. The findings will provide insights into spatial patterns of vulnerability, highlight the underlying drivers of flood exposure, and support the development of evidence-based strategies for disaster risk reduction and sustainable floodplain management. Ultimately, the study aims to contribute to national and international efforts, including the Sendai Framework for Disaster Risk Reduction, by promoting a more resilient and adaptive approach to flood management in Nigeria

2. MATERIALS AND METHODS

2.1 Study Area

The Ogun River Basin is in southwestern Nigeria, spanning between longitudes 3º22′E and 3º39′E, and latitudes 6º3′N and 6º39′N, covering an estimated area of approximately 361.02 km² (Raji et al., 2014). The Ogun River originates from the Igaran Hills at an elevation of about 530 meters above sea level and flows southward for roughly 480 kilometers before emptying into the Lagos Lagoon (Areola et al., 1985). Its major tributaries include the Ofiki and Opeki rivers.

The basin experiences two distinct seasons: a dry season from November to March, and a wet season from April to October. Annual rainfall varies across the basin, ranging from about 1,250 mm in the northern region to 2,000 mm in the southern part (Raji et al., 2014). The river maintains a substantial flow rate, averaging around 393 m³/s (Dimowo, 2013), while the total annual potential evapotranspiration is estimated between 1,600

mm and 1,900 mm. According to Adeaga (2006), the basin falls within a tropical rainy climate zone influenced by both tropical continental and tropical maritime air masses.The downstream portion of the basin includes Lagos State, which hosts over 2,000 industries and accounts for approximately 65% of Nigeria's commercial activities.

Climatically, the basin is influenced by the Maritime South-West Monsoon winds and the Dry North-East Trade Winds. The mean annual temperature is around 30°C, although it varies with location and season (Ifabiyi, 2005). The hottest months are typically February and March, during which high temperatures are recorded throughout the basin.

Water resources in the Ogun River Basin consist of both surface and groundwater systems. The underlying geology includes sedimentary rock sequences dating from the Cretaceous to recent periods. The oldest formation, the Abeokuta Formation, comprises grey sandstones interbedded with clay layers (Oke et al., 2015). The Ogun River Basin is underlain by two distinct geological formations: the ancient Precambrian Basement Complex in its upper reaches and the younger sedimentary rocks of the Dahomey Basin in the lower section, which include the Ewekoro, Ilaro, and Coastal Plain Sands formations. This geological transition creates a shift from a steep, basement-dominated upper zone to a flatter, sedimentary-dominated lower zone that drains into the Lagos Lagoon. Consequently, the river's morphology varies along its course, with fast-flowing sections upstream and slower flows with substantial alluvial deposits downstream (Fashae and Faniran, 2015).

Topographically, the basin features extensive low-lying floodplains with poor drainage, particularly around Abeokuta and Lagos, where the river empties into the lagoon. The flat terrain in these areas slows runoff, resulting in ponding and recurrent flooding during heavy rainfall (Aderoju et al., 2014; Adeaga, 2008).

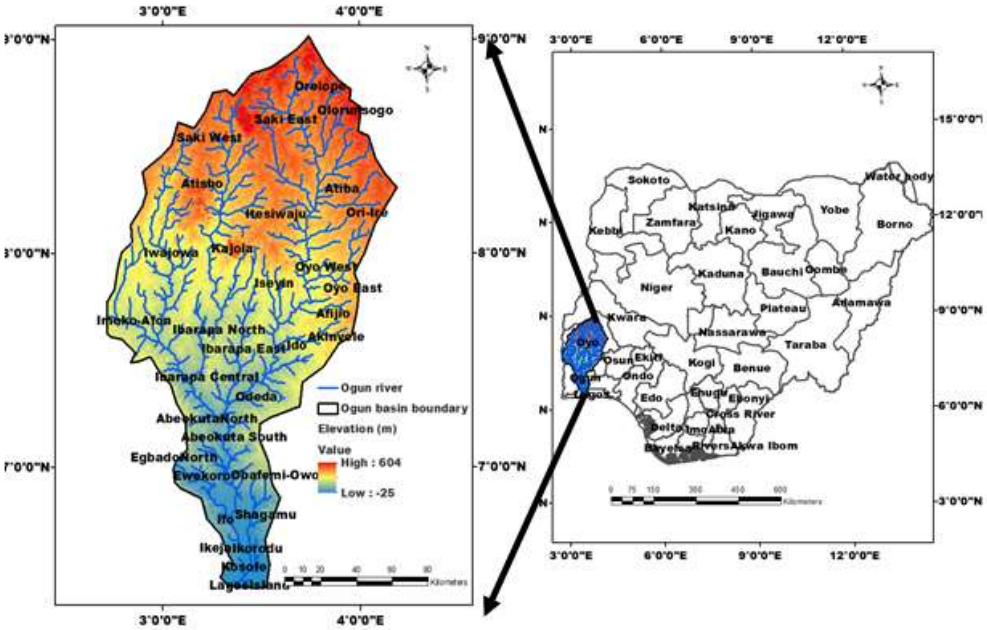


Figure 1: Map of the study area - Ogun River Basin

Source: Authors work

The basin's soils, predominantly sandy loam and lateritic types, have moderate infiltration capacity but quickly become saturated during prolonged rainfall, leading to increased runoff and localized flooding (Adeaga, 2008). Moreover, a significant share of the basin's population and infrastructure including settlements in Abeokuta, Ifo, and Lagos suburbs are concentrated along riverbanks and low-lying floodplains. These locations are regularly inundated during seasonal floods, heightening exposure and overall vulnerability (Komolafe et al., 2014).

2.2 Data Collection, Sampling, and Questionnaire Design

Relevant information was gathered using questionnaire survey to get response from over 300 respondents around different communities within the flood zone of Ogun River Basin which was distributed through Kobo Toolbox and made available on mobile devices by means of the URL that was supplied: https://ee.kobotoolbox.org/x/0YxgllXe. The survey captured socio-demographic details, flood history, environmental conditions, and coping strategies. Purposive sampling was used to identify households in flood-prone areas because it is a non-probability sampling techniques that allows selection based on predetermined criteria that align with the study's goal. Data were cleaned and analysed using descriptive statistics and thematic grouping. The significance of the questionnaire data to this research is outlined in Table 1.

Table 1: Significance of questionnaire data

Data Group	Data Sub-Group	Significance
Location	Coordinates Elevation Name of community	This allows for precise location identification that will enable spatial analysis
	Type of settlement Terrain of the area Land use patterns	This helps to determine exposure of assets and people, land use indicates where people live, work, and build infrastructure. Densely populated residential or commercial areas in hazard-prone zones increase vulnerability.
Personal information	Sex Marital status Education level Profession Monthly income Source of income House ownership Duration of stay Household members	This helps in having a comprehensive understanding of the affected community. This includes demographic profiling, enabling the identification of vulnerable groups for targeted assistance and customized communication strategies. The data aids in fostering community engagement by acknowledging individual needs, understanding social structures, and assessing the risk profile of residents. Personal information is crucial for public health planning, tailored relief and recovery programs, and developing informed policies. It contributes to data accuracy and analysis, providing deeper insights into the impact of flooding on diverse demographic groups

Data Group	Data Sub-Group	Significance
Infrastructure and housing information	Type of house House ownership Construction material Presence of flood barrier Presence of drainage system Distance from nearest river	This is vital for understanding vulnerability, informing planning and mitigation efforts, enhancing resilience, and promoting community awareness and engagement in flood-prone areas, Assessing the construction materials, elevation, and structural integrity of buildings helps identify high-risk areas, inform future infrastructure planning, and optimize evacuation plans
Exposure to flood hazard	Flood experience Flood frequency Causes of flood Duration of flood Natural flood barrier Flood severity Flood impact	Detailed information about people's exposure to hazard helps to assess risk and vulnerability. By understanding the causes and duration of flood, it assists to target interventions to reduce flood vulnerability. The data gathered can be integrated with spatial analysis to identify high risks areas.
Coping mechanism and adaptation measures	Measures taken to prevent flooding and its effectiveness Government awareness and intervention Willingness to relocate	To provides essential information for risk assessment, emergency planning, infrastructure development, and community engagement. It enables a comprehensive understanding of the community's ability to cope with and recover from flooding events.
Impacts on the environment	Environmental impacts noticed during flood Vulnerability of the natural environment to flooding	Environmental impact in vulnerability assessment helps to understand how environmental conditions and degradation affect a system's ability to withstand and recover from hazards. Vulnerability is not only a function of exposure and sensitivity but also of environmental resilience, which is heavily influenced by the state of the natural environment.
Flooddamage assessment	Flood assessment Last flood event Sustained damage % of property damaged Loss or damage to flood	Helps to determine how the flooding starts and know the months in which flooding occurs. It also helps to determine when and how management plans can be implemented.
Flood characteristics	Flood depth recorded Flood water duration Speed of water during flood Damage experienced Estimated cost of damage	The understanding of flood characteristics helps to access risk and inform decision making. It assists to inform designs and implementation of flood mitigation measures.

2.3 Vulnerability Indicators

The development of flood-vulnerability indicators in this study draws on earlier study that formulated flood-vulnerability indices, largely following the Organization for Economic Cooperation and Development (OECD) framework.

Indicators were organized into socio-economic, environmental, and physical categories. These indicators were then converted into numeric values, normalized, and assigned equal weights to produce aggregate component scores, which were subsequently combined to calculate the overall flood-vulnerability index.The equal weighting was assigned because all the indicators have the same level of significance and it helps to simplify the calculation to achieve useful results.

2.3.1 Grouping of Indicators

The flood vulnerability index is designed to capture three core components socio-economic, environmental, and physical each represented by exposure, susceptibility, and resilience indicators, respectively. The socio-economic component reflects how social and economic conditions influence the vulnerability of elements within the area to flooding. The key vulnerability indicators assessed include: educational level, level of income, experience of flooding, sex, education, marital status, duration of stay in an area, household dependent, and access to flood warning. Physical components include physical condition, both natural and artificial, which affects flood vulnerability of the area. The vulnerability indicators are: type of house, house ownership, flood water duration, natural barriers, flood depth, flood water retention, construction materials and distance to the river.

Environmental components consist of indicators which mention the environmental damage caused by flood hazard on the exposed elements in the area. The indicators are: elevation, distance to the river, land use, soil type, water level that surrounds the building, flood experience, vegetation type, terrain of the area, flood occurrence, environmental impacts during floods, vulnerability of the natural environment, natural flood buffers, type of infrastructure in the area and changes in rainfall patterns.

Table 2: Description of key indicators from household survey

Vulnerability Factors	Vulnerability Components	Indicators	Justification	Reference
Exposure	Social-economic	Number of dependents	Households with more dependents are more vulnerable to flooding	Deepak et al., 2020
Exposure	Social-economic	Educational level	The higher the literacy rate, the more their capacity to anticipate, hence the lower people's vulnerability	Müller et al., 2011
Exposure	Social-economic	Level of income	The households that have low income are more vulnerable to flooding	Cutter et al., 2003
Exposure	Social-economic	Experience of flooding	The less flood experience people have, the more they are susceptible to becoming affected and the higher the vulnerability	Balica and Wright, 2009a

Vulnerability Factors	Vulnerability Components	Indicators	Justification	Reference
Exposure	Social-economic	Gender	Women are more vulnerable than men, because recovery may be more difficult for women than for men	Nazeer et. al., 2019
Exposure	Social-economic	Marital status	Single parents and widows are more susceptible than married couple.	Balica and Wright, 2009b
Exposure	Social-economic	Duration of stay	The longer a household stays in a flood prone area, the higher their experience to cope and lower their vulnerability	Kissi et.al.,2015
Resilience	Physical	Construction materials	The more the number of houses with poor building materials, the higher the susceptibility, hence the higher the vulnerability	Cutter et.al.,2003
Resilience	Physical	Type of house	Houses with flood-proof barriers can protect against flooding and reduce flood vulnerability	Balica and Wright. 2009a
Resilience	Physical	Flood water retention	Areas with a high-water retention are more vulnerable because the land surface will not be able to absorb water and reduce water flow.	Fernandez et al.,2016
Resilience	Physical	Flood water duration	The longer the floodwater persists, the higher the vulnerability	Fernandez et al.,2016
Resilience	Physical	Distance to river	The shorter the distance to the river, the more vulnerable the area	Entin et. al., 2021
Resilience	Physical	Flood depth	Buildings with higher flood depth are more likely to experience flood damage which increase their exposure and hence higher vulnerability during flood	Balica and Wright, 2009b
Susceptibility	Environmental	Elevation	Flood exposure increases as elevation decreases, hence the higher the vulnerability	Entin et. al., 2021

Vulnerability Factors	Vulnerability Components	Indicators	Justification	Reference
Susceptibility	Environmental	Land use	High building density means high vulnerability	Balica and Wright, 2009b
Susceptibility	Environmental	Soil type	The lower the soil permeability, the more vulnerable the soil.	Murali et al. 2013
Susceptibility	Environmental	Flood experience	The less flood experience people have, the more they are susceptible to becoming affected and the higher the vulnerability	Balica and Wright, 2009a
Susceptibility	Environmental	Vegetation type	Vegetation like wetlands act as natural buffers which absorb excess water and thus reduce flood vulnerability	Murali et al. 2013
Susceptibility	Environmental	Terrain of the area	Urban areas with impervious surfaces like pavements and buildings can increase runoff and increase vulnerability	Entin et. al., 2021

Source: Field survey 2025

2.4 Data analysis

2.4.1 Conversion to numeric scores

The responses from the questionnaire were converted to numeric scores using data codification. For Yes/No a binary value of 1 was assigned to Yes while 0 was assigned to No. This was applied to all the indicators of different vulnerability components.

2.4.2 Normalization of numeric scores

To maintain consistency and allow for comparison, all responses were standardized using Min–Max normalization, following the approach of Nazeer et al. (2019). This method converts indicator values to a linear scale ranging from 0 to 1, where 0 represents the minimum and 1 represents the maximum value. Indicators directly associated with vulnerability were adjusted using Equation 1.

$Xi = (Xa - Xmin)/(Xmax - Xmin)$ …Eq. 1

Where:

X_i = the normalized value,

X_a is the actual value,

X_{Max} is the maximum value, and

X_{Min} is the minimum value for an indicator i. (1,2,3……n)

2.4.3 Weighting of Indicators

Equal weighing was assigned to the indicators; this is because the survey questionnaires are all important and all factors are all equally relevant. Equal weighting is represented by:

$$\text{Weight} = 1/n \quad \text{……. Eq. 2}$$

Where n is the no of indicators in a vulnerability component.

2.4.4 Aggregate to component scores

To get the aggregate component scores for each component, the product of the weighted indicators and normalized scores was calculated using equation 3.

$$\sum \llbracket W_i.Xi \rrbracket \quad \text{…….. Eq. 3}$$

Where: W_i = Equal Weighting

Xi = Normalized scores

2.4.5 Compute Flood Vulnerability Index

The computation of robust flood vulnerability indices begins with systematic indicator selection that adequately captures the multiple dimensions of vulnerability while maintaining practical feasibility in data collection and analysis. Contemporary approaches typically organize indicators according to the exposure-sensitivity-adaptive capacity framework, though specific indicator selection varies considerably across different studies and contexts.

The overall food vulnerability index was calculated through Eq. 4 based on IPCC 2014 framework.

$$FVI = 1/3(EI + SI + RI) \ldots. \quad \text{Eq. 4}$$

Where: EI means Exposure Index

: SI means susceptibility Index,

: RI means Resilience Index

The average value of the index indicators gives the overall flood vulnerability index.

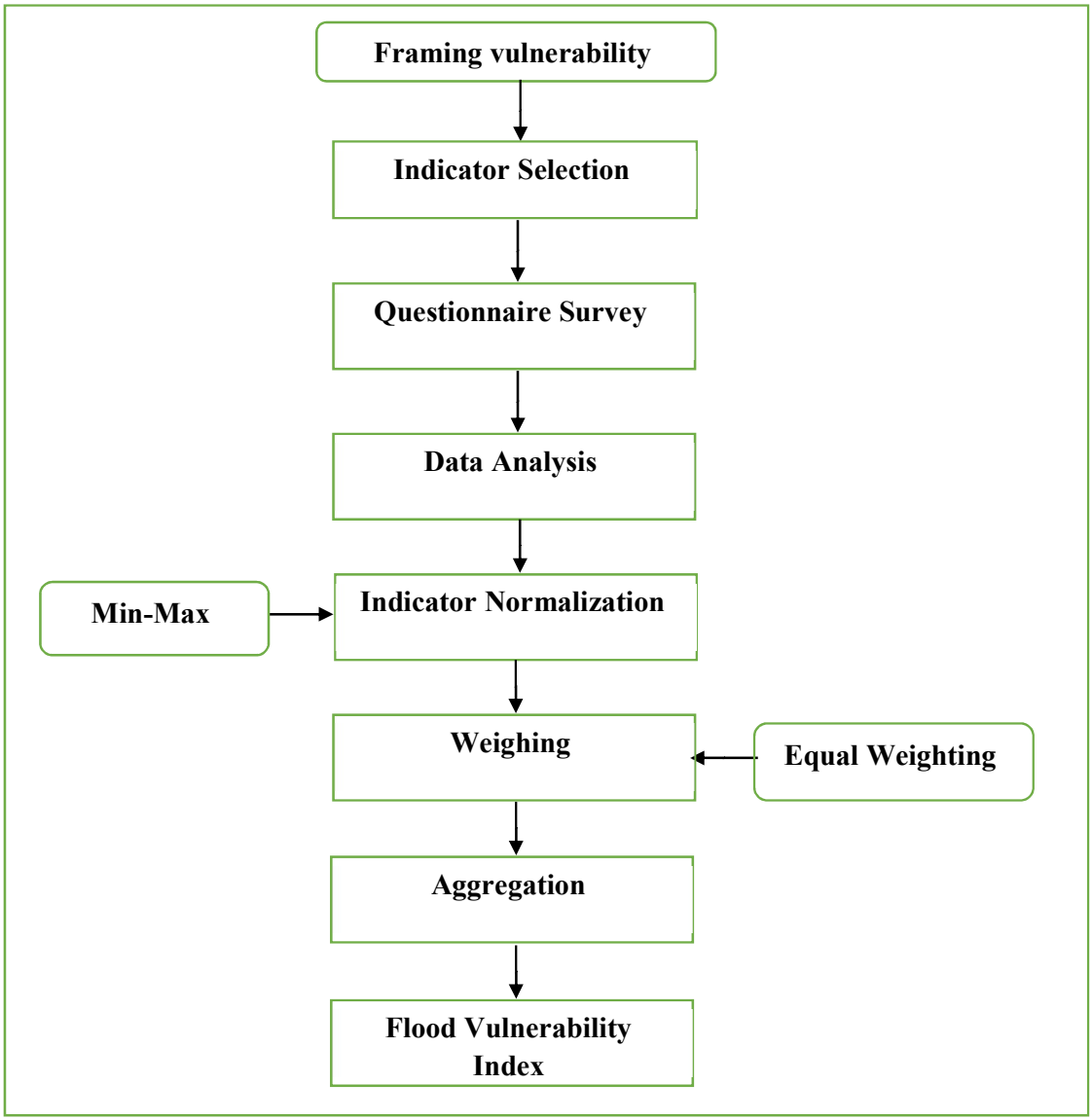


Figure 2: Flood vulnerability workflow used in this work

3.0 RESULTS

3.1 Flood Vulnerability Index

The computed flood vulnerability index (FVI) for the selected area in the river basin ranged between 0.14 and 0.21 as shown in table 3 on a normalized scale of 0 – 1 (Balica et. al., 2013). These values fall within the low to moderate vulnerability category which indicates relatively limited exposure and sensitivity to flooding. The FVI scores was lowered due to residents strong coping strategies put in place against flood risks such as use of sandbags, elevated housing, improved drainage system, building of flood barriers and relocation during flood.

Table 3: Flood Vulnerability Indices (FVI) of selected location in Ogun River Basin

Selected Location	Exposure index (EI)	Susceptibility index (SI)	Resilience index (RI)	Flood vulnerability index (FVI)
Audu Baale (Yaba)	0.22	0.08	0.20	0.16
Berger	0.23	0.09	0.23	0.18
Church street	0.28	0.08	0.25	0.20
Garuba Musa	0.23	0.08	0.21	0.17
Iyaomolere	0.22	0.07	0.23	0.17
Tunde Ajaga	0.23	0.10	0.22	0.18
Abubakar street	0.23	0.10	0.26	0.19
Adedoyin Osinbanjo	0.24	0.09	0.26	0.19
Adeleye Street	0.29	0.09	0.22	0.20
Maryland	0.26	0.11	0.22	0.20
Adeniji	0.25	0.09	0.20	0.18
Adiyan	0.27	0.10	0.24	0.20
Afa Yahaya	0.18	0.08	0.20	0.15
Agbede Ikorodu	0.32	0.10	0.20	0.21
Agboyi Street (Ketu)	0.29	0.10	0.24	0.21
Ajebo Ikorodu	0.19	0.08	0.22	0.16
Ajibola Crescent	0.23	0.08	0.16	0.16
Aladin Close	0.25	0.09	0.16	0.17
Alhaji Alimi	0.24	0.09	0.20	0.17
Anike Abu	0.25	0.07	0.14	0.15
Animasahun	0.34	0.09	0.21	0.21
Araromi (Shomolu)	0.29	0.08	0.19	0.19
Ayenero Street	0.27	0.09	0.20	0.19
Bakare Faro	0.26	0.09	0.16	0.17
Balogun Market	0.19	0.07	0.27	0.17
Basswood Street	0.20	0.09	0.15	0.15
Bells street	0.23	0.08	0.16	0.16
Coachwood Street	0.31	0.10	0.16	0.19
Comfort Avenue	0.25	0.09	0.16	0.17
Cowrie creek	0.26	0.09	0.16	0.17
Adeleye Street	0.24	0.09	0.16	0.17
Dendenke street	0.32	0.09	0.16	0.19
Disu Adeigbe (Ikorodu)	0.31	0.10	0.18	0.20
Elm street	0.25	0.11	0.18	0.18
Erunkan, Melidan	0.27	0.09	0.20	0.19
Eshinlokun Street	0.20	0.09	0.20	0.16
Majidun Ikorodu	0.26	0.09	0.18	0.18
Franklin Street	0.22	0.09	0.16	0.16
Gbayesola	0.23	0.10	0.20	0.17
Ibrahim Odofin	0.28	0.08	0.20	0.18
Idenu Close	0.28	0.09	0.20	0.19
Idumagbo	0.25	0.09	0.26	0.20

Selected Location	Exposure index (EI)	Susceptibility index (SI)	Resilience index (RI)	Flood vulnerability index (FVI)
Ifelodun	0.23	0.09	0.17	0.16
Igadungan	0.30	0.08	0.20	0.20
Igbogbo	0.26	0.09	0.17	0.18
Igbopa	0.26	0.08	0.20	0.18
Ikenne Ikorodu	0.28	0.08	0.18	0.18
Ilaje Ikorodu	0.18	0.08	0.21	0.16
Ilemere	0.20	0.08	0.20	0.16
Isasi Ikorodu	0.29	0.09	0.16	0.18
Isawo Ikorodu	0.28	0.08	0.20	0.19
Isheri Olofin	0.26	0.09	0.18	0.18
Iwaya	0.25	0.09	0.17	0.17
Jankara	0.24	0.08	0.21	0.18
Jarkata	0.27	0.11	0.20	0.19
Jenjeke Martins	0.23	0.10	0.21	0.18
Jimoh Ibrahim	0.19	0.10	0.20	0.16
Jones Street	0.25	0.10	0.23	0.20
Labule	0.25	0.10	0.16	0.17
Lagos mainland	0.25	0.10	0.20	0.19
Magodo Phase 2	0.29	0.09	0.19	0.19
Orile	0.28	0.08	0.20	0.19
Mile 12	0.20	0.08	0.21	0.16
Ofin	0.29	0.10	0.23	0.21
Ogbe Close	0.26	0.11	0.18	0.18
Ogunyemi street	0.29	0.09	0.23	0.21
Ojodu area	0.21	0.08	0.23	0.17
Ojogiwa	0.23	0.09	0.21	0.18
Ojokoro Ikorodu	0.26	0.11	0.22	0.20
Ojuodo	0.29	0.11	0.20	0.20
Ojuoro Ikorodu	0.27	0.09	0.16	0.17
Ojurin	0.30	0.08	0.23	0.20
Oke Olu	0.29	0.08	0.20	0.19
Okoya	0.25	0.09	0.16	0.16
Olaitan	0.18	0.09	0.20	0.16
Olatunji	0.21	0.10	0.13	0.15
Olatokunbo	0.30	0.07	0.16	0.18
Olatunji Street	0.29	0.09	0.21	0.20
Oloyinyin	0.25	0.09	0.24	0.20
Omologede	0.30	0.10	0.18	0.19
Opebi Ikeja	0.25	0.06	0.21	0.18
Opeoluwa	0.28	0.09	0.16	0.18
Oroyin	0.09	0.09	0.25	0.14
Oruba Agbonyi	0.28	0.09	0.15	0.17
Orunyinyin	0.27	0.10	0.20	0.19
Oshogunle	0.28	0.11	0.14	0.18
Osolonge Whisky	0.23	0.10	0.18	0.17
Owutu Ikorodu	0.25	0.10	0.21	0.19
Pams dr Avenue	0.23	0.10	0.19	0.17
Pinewood Street	0.27	0.11	0.18	0.19
Primerio	0.25	0.09	0.14	0.16
Makoko	0.26	0.09	0.17	0.17
Ramotu street	0.24	0.08	0.20	0.17
River Valley Estate	0.29	0.08	0.16	0.18
Sari Iganmu	0.22	0.09	0.23	0.18
Shomolu	0.21	0.08	0.22	0.17

Selected Location	Exposure index (EI)	Susceptibility index (SI)	Resilience index (RI)	Flood vulnerability index (FVI)
Shobodu	0.25	0.09	0.27	0.20
Maidan Orile	0.25	0.10	0.18	0.18
Temple street	0.31	0.09	0.20	0.20
Tony Omoregie	0.25	0.10	0.13	0.16
Yellow wood street	0.27	0.09	0.18	0.18

Source: Field survey 2025

Despite the relatively narrow range, spatial differences in vulnerability are evident, reflecting varying degrees of exposure, susceptibility, and resilience among the communities. Locations such as Agbede Ikorodu (0.21), Agboyi Street, Ketu (0.21), Animasahun (0.21), Ofin (0.21), and Ogunyemi Street (0.21) recorded the highest FVI values, signifying areas with higher flood risk. These areas are predominantly characterized by high exposure indices (EI = 0.29–0.34) and moderate to high susceptibility (SI = 0.09–0.10), often coupled with relatively low resilience levels (RI = 0.20–0.23). The high exposure values suggest proximity to floodplains and built-up zones that experience frequent inundation due to uncontrolled urban expansion, poor drainage, and impervious surface development.

In contrast, communities such as Oroyin (0.14), Afa Yahaya (0.15), Anike Abu (0.15), Basswood Street (0.15), and Olatunji (0.15) exhibited lower FVI values, reflecting comparatively lower exposure and higher resilience. These locations may benefit from elevated terrain, better drainage infrastructure, or reduced density of vulnerable physical assets. Moreover, the resilience index (RI) in these areas ranges between 0.20 and 0.25, suggesting stronger adaptive capacities and community-based coping mechanisms against flood impacts.

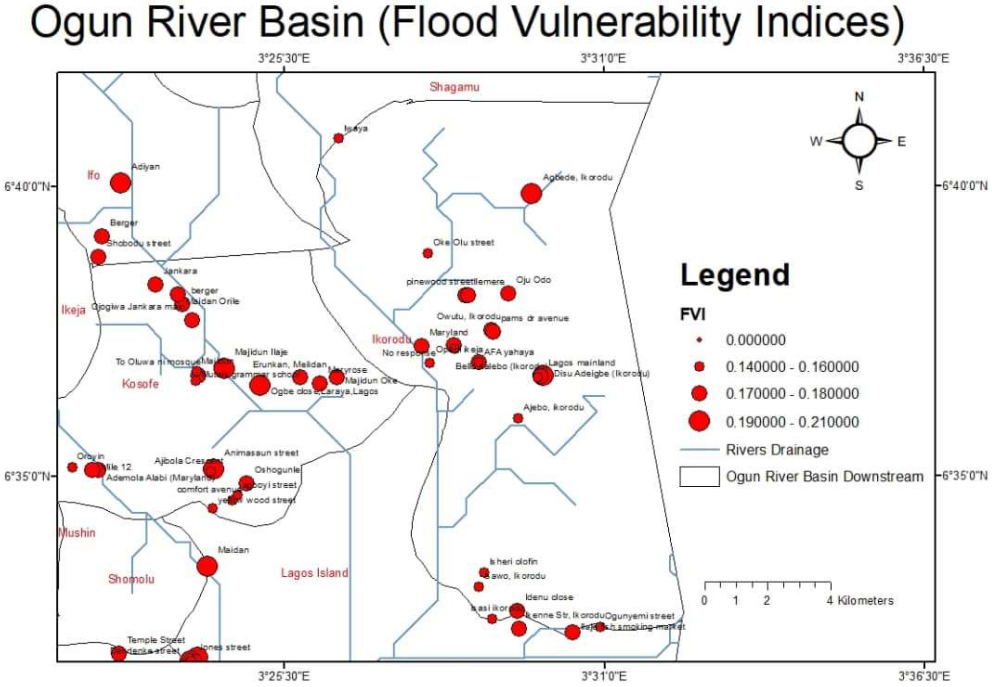


Figure 3: Map showing FVI of the selected area within the Ogun River Basin

3.2 Overview of the Flood Vulnerability areas in the Map

The map titled in fig 3 above presents the spatial distribution of flood vulnerability across various communities located in the downstream of the Ogun River Basin, in southwestern Nigeria. The map uses graduated symbols (red circles) to represent varying levels of the Flood Vulnerability Index (FVI) at different locations. The legend classifies FVI values into four ranges:

- 0.00 – No vulnerability (represented by very small dots)
- 0.14 – 0.16 → Low vulnerability
- 0.17 – 0.18→ Moderate vulnerability
- 0.19 – 0.21→ High vulnerability

The size of the red circle increases with higher FVI values while the larger circles indicate greater vulnerability to flooding. The map covers several Local Government Areas (LGAs) along the downstream reach of the Ogun River, including Ikorodu, Kosofe, Ikeja, Mushin, Shomolu, Lagos Mainland, and Lagos Island.The river drainage network is overlaid in blue, showing how settlements are distributed along flood-prone channels.

High FVI Zones (0.19 – 0.21): These are found in densely populated urban centres such as:Lagos Mainland (Maryland, Oyingbo), Ikorodu (Majidun, Ajebo, Disu Adejibe, Awo, Idenu Close), Kosofe and Ikeja (Berger, Ojogbo, Shangisha, Ogudu). These areas exhibit high exposure and sensitivity due to:

i. Proximity to river channels and low-lying floodplains
ii. High population density and unregulated urban expansion
iii. Inadequate drainage infrastructure

Moderate FVI Zones (0.17 – 0.18): Theses are found in midstream areas such as Maryland, Erunkan, and Ojodu, which are semi-urban with mixed land uses and moderate infrastructural resilience.

Low FVI Zones (0.14 – 0.16). These are found in slightly elevated or less densely populated areas such as Shagamu and some parts of Ifo and Kosofe, where flood risk is lower due to better drainage or distance from main river channels.

Zero or Minimal FVI: These are Very few or no data points that indicate negligible vulnerability in likely areas with minimal flood exposure or strong adaptive measures.

It can be inferred that the downstream segment of the Ogun River Basin, especially around Lagos State, is characterized by intense human settlement, high impervious surface coverage, and encroachment on floodplains. Consequently, the FVI values range between 0.14 and 0.21, showing that even the lowest vulnerability areas remain moderately at risk. This distribution indicates that flood vulnerability is spatially clustered around urbanized corridors, a reflection of anthropogenic pressures and poor land-use management.

The Ikorodu–Kosofe–Lagos Mainland axis stands out as the most vulnerable stretch due to:

- Low elevation (near sea level)
- Rapid urbanization without adequate drainage infrastructure
- Channel blockage and encroachment on wetlands
- Socio-economic sensitivity (dense population and informal settlements)

This implies that the downstream communities are highly vulnerable to flood hazards, requiring urgent structural (engineering) and non-structural (policy, education) interventions.

3.3 Socio-Economic Determinants of Flood Vulnerability

3.3.1 Gender

It is of importance to investigate the gender distribution in the study area and the result of the analysis of responses of respondents as regards their gender. The survey shows that 108 persons representing 34.2% of the population sampled in the project area are female, while the remaining 205 (64.9%) persons are male. The difference is significant, but it is important to point out that the male gender in the project area exceed the female counterparts in the project area numerically. However, it was believed that female gender is more vulnerable than their male counterpart because of their social roles and responsibilities which can increase their vulnerability especially when caring for children or elderly. Women have limited access to resources compared to men such as education, employment and property ownership which can affect their ability to prepare for and respond to flood. In terms of mobility and communication, women may face restrictions on mobility or access to information which can make it difficult for them to evacuate or receive early warnings.

3.3.2 Marital Status

The analysis from the survey explains the marital distribution among the respondents within the study area. Single people have higher vulnerability, especially elderly or single parents, these set of people may lack support systems during evacuation or recovery. Their level of income may be limited, especially if they live alone. Married couples constitute 71.8% of the respondents in the study area. They typically have lower vulnerability due to shared responsibilities during evacuation and decision-making. They have more financial resilience due to combining income and emotional support during disaster. Divorced and Separated Individuals often have weaker support networks and may have custody of children which will increase their responsibility and exposure and thereby make them vulnerable to disaster. The widowed individuals are often older adults, these raises their vulnerability due to reduced mobility and health challenges, emotional isolation and lack of help during evacuation or property protection.

3.3.3 Education level

To measure the degree of susceptibility of respondents to flood hazards, education background is significantly important as it influences people's vulnerability to floods in several ways. The survey showed that 57.3% of the respondents have a higher level of education. The education background affects not just their ability to understand and respond to flood risks, but also their long-term capacity to recover and prepare for future events. In terms of risk awareness and preparedness, educated individuals are generally better informed about natural hazards, including floods. They are more likely to understand flood warnings and evacuation orders, follow weather forecasts and emergency instructions and participate in disaster preparedness programs**.** Less educated populations may not fully grasp the severity of risks or may rely more on informal knowledge. People that are educated have access to information which increases their access to digital tools (apps and online resources), institutional information such as government programs. The less educated populace may face challenges in accessing or understanding the information due to language or literacy barriers.

Higher education often correlates with higher income and stable employment. Educated individuals are more likely to live in better-constructed homes. Safer geographic areas and not in floodplains or informal settlements. In contrast, lower-educated people may live in high-risk zones due to economic constraints. In terms of response and recovery, education improves decision-making during emergencies as when to evacuate

and how to protect assets. Less educated people might find it difficult to navigate which increases their vulnerability.

3.3.4 Profession

The respondents within the study area are majorly 62% self-employed while 18% are government workers. Profession plays a critical role in determining flood vulnerability, both directly and indirectly. It influences exposure, sensitivity, and adaptive capacity, which are the three core dimensions of vulnerability in disaster risk frameworks. People's profession affects flood vulnerability in terms of their work location (Exposure). Professions that are outdoor like farmers, street workers are more exposed to flood impacts especially if they work in flood-prone areas. Indoor professions like teachers and IT workers can often work remotely or in safer environments.

In terms of economic stability and recovery (Sensitivity), Professions with daily wages or informal contracts (e.g., construction laborers, cleaners, vendors) suffer immediate income loss during floods and take longer to recover unlike stable salaried jobs (e.g., government employees, engineers, doctors) that usually provide better financial ability to recover or relocate.

3.3.5 Monthly Income

Monthly income is one of the strongest and most direct indicators of measuring socio-economic susceptibility of people to flood hazard. It affects every stage of the disaster cycle: preparedness, impact, response, and recovery. People with lower monthly incomes tend to be more vulnerable for structural, economic, and social reasons. From the survey conducted within the river basin, 44.3% of the respondents interviewed earn between N84,000 and above while 43% earn between N42,000 and N83,000. Low-income individuals are more likely to live or settle in flood-prone areas (near rivers, in low-lying zones) and poorly constructed housing with weak flood resistance. Higher-income individuals can afford safe, elevated housing with better construction materials and flood-resilient designs and neighbourhoods with drainage, levees, or flood infrastructure. In terms of Preparedness and Risk Reduction, People with higher monthly income can install flood barriers or raise floor levels, insured homes, vehicles, and belongings. Those with lower income may lack funds to prepare for floods and access to early-warning systems.

During the Flood, higher-income families can afford temporary relocation (e.g., hotels, relatives' homes), transportation during evacuation and medical treatment for injuries or illness. Low-income households often had the issue of relocating due to cost and limited mobility and they usually rely on government shelters, which may be overcrowded or inadequate or in some cases not available.

3.3.6 Source of Income

The source of income among the respondents correlates with their profession, as explained previously that majority are self-employed, source of income is majorly business profit, which is 56.6% of the respondents surveyed, while 30.4% are salary earners from government work and private work. Source of income is one of the indicators to measure degree of socio-economic susceptibility of people to flood hazard. Individuals whose livelihoods depend on land or natural resources such as farmers, are often located in flood-prone areas because such environments provide fertile soil, access to water, or cheaper land. These groups are highly exposed to flood hazards. Flooding can destroy crops, wash away topsoil, and damage irrigation infrastructure, leading to severe income loss. Studies have shown that smallholder farmers are disproportionately affected by floods due to limited resources for adaptation (Adger et al., 2001; FAO, 2015).

People working in informal markets or as day labourer may lose income during flood events due to market closures, damage to infrastructure, or illness. Since informal employment often lacks social protection, the recovery period can be prolonged (UNISDR, 2015).

The stability and nature of income determine the ability of individuals to prepare for, respond to, and recover from flood events. People with formal jobs are more likely to have savings, insurance, and access to credit, which enhances their adaptive capacity. Conversely, those with irregular or insecure incomes often lack financial buffers, increasing their vulnerability (Cutter et al., 2003). Poorer households typically cannot afford to invest in flood defenses, relocate to safer areas, or take preventive health measures, such as purchasing clean water or avoiding contamination (Birkmann et al., 2010). Low-income earners are more likely to reside in informal settlements or marginalized urban areas that are more exposed to floods and have weaker infrastructure (Douglas et al., 2008). People with limited income options may be forced to live in high-risk flood zones due to cheaper housing or proximity to livelihood sources, compounding both physical and socio-economic vulnerability.

3.3.7 Property ownership

From the survey and interview conducted, majority of the respondents do not own the property, they are rented. Its only 35.1% that own their property. Property ownership significantly affects people's vulnerability to floods, it influences where individuals reside, the quality of their housing, their capacity to prepare for and recover from flood events, and their long-term resilience. The relationship between property ownership and flood vulnerability is shaped by factors such as socio-economic status, access to resources, and land-use governance. Property ownership can reduce or increase exposure depending on where the property is located. Homeowners may reside in high-risk flood zones because of affordability, historical settlement patterns, or limited availability of safer land.

According to Adelekan (2010), in many urban areas, especially in developing countries, low-income households often own or occupy properties in informal settlements along floodplains or near rivers. These locations tend to lack adequate drainage, sanitation, and flood defense infrastructure, increasing flood exposure. Home owners typically have greater incentives to invest in flood-resilient construction, maintenance, and protective measures compared to renters. Stronger housing structures reduce physical vulnerability to floods. Studies showed that people who own their homes are more likely to adopt flood mitigation strategies, such as raising building foundations, installing barriers, or using flood-resistant materials (Grothmann and Reusswig, 2006). In contrast, tenants often lack the authority or financial motivation to make such improvements.

Property ownership also facilitates faster recovery after flood events. Owners have an asset that may retain value and can be repaired, rebuilt, or used as collateral for loans. Renters, in contrast, may be displaced without compensation and lack legal protection or eligibility for recovery assistance. Kuhlicke et al. (2011) argue that property owners often have access to insurance or governmental aid, especially in countries with structured disaster response systems. However, those without formal titles may be excluded from compensation or relocation programs. Informal or undocumented landholders may be more vulnerable due to legal insecurity, eviction risk, and lack of state support. In cities like Jakarta and Lagos, people with informal tenure often face heightened vulnerability because their land is not officially recognized, making them ineligible for infrastructure upgrades or disaster aid (Di Baldassarre et al., 2019).

3.3.8 Duration of Stay

The duration of stay in an area significantly affects people's vulnerability to flooding, it shapes their exposure, risk perception, coping capacity, and access to social networks and institutional support. People who have lived in a flood-prone area for extended periods may develop adaptive knowledge and community ties, but may also face heightened risks due to age, complacency, or attachment to place. So also, longer residence in a flood-prone area can lead to greater familiarity with local flood patterns and foster experiential knowledge that enhances preparedness. Residents with past flood experience are more likely to perceive flood risks accurately and take preventive measures (Terpstra, 2011). However, repeated exposure without severe consequences may also lead to underestimation of future risks. For example, Grothmann and Reusswig (2006) found that individuals who had experienced previous flooding but suffered minimal damage were less likely to adopt new protective behaviours.

Long-term residents often develop strong emotional and cultural attachments to their homes and communities. This place attachment can make them less willing to relocate or accept government resettlement programs, even in high-risk zones (Adger et al., 2011). Consequently, these individuals may remain exposed to recurrent flooding. (Devine-Wright, 2009, Aldrich and Meyer, 2015).

Communities with a high proportion of long-term residents often demonstrate stronger recovery capacity after flooding due to local knowledge and neighbourly cooperation (Cutter et al., 2003).

3.3.9 Household size of respondents

Household size is a critical social determinant of vulnerability to flood hazards. It influences a household's capacity to prepare for, respond to, and recover from flood events. Larger households may benefit from increased labour and social support, they also face heightened challenges related to dependency ratios, resource constraints, and evacuation logistics.

Larger households generally require more financial, food, and housing resources, which can strain the ability to invest in flood preparedness or recovery efforts. When household income is limited, supporting more members can divert available funds for flood-proofing homes, or replacing lost belongings (Cutter et al., 2003).

For low-income families, large household sizes may exacerbate poverty, thereby increasing vulnerability to flood impacts (Birkmann, 2011). Paul and Routray (2010) found that families with more dependents in flood-prone regions usually had higher difficulty evacuating and experienced greater physical and psychological impacts during flood events.

During flooding, evacuating larger households poses logistical challenges, particularly when transportation and shelter space are limited. Accommodating more people in evacuation centres may also be more difficult, increasing the likelihood of exposure to overcrowded or unsanitary conditions (UNISDR, 2015).

3.4 Environmental Determinants of Flood Vulnerability

3.4.1 Impacts on the environment

Floods are among the most frequent and devastating natural disasters, with profound consequences on human societies and the natural environment. While the socio-economic impacts of floods are well-documented, their environmental consequences warrant equally significant attention.

3.4.2 Damage to vegetation

One of the most immediate environmental impacts of flooding is soil erosion. As floodwaters move across landscapes, they often strip away topsoil,

which is rich in nutrients and vital for plant growth. This loss not only reduces agricultural productivity but also contributes to land degradation and damage to vegetation. Pimentel (2006) emphasizes that soil erosion during floods poses a major threat to food security and environmental sustainability, particularly in regions lacking adequate vegetation cover.

3.4.3 Water Pollution

Floods can significantly deteriorate water quality by introducing pollutants into freshwater systems. Contaminants such as sewage, industrial waste, agricultural runoff, and hazardous chemicals are often carried by floodwater into rivers, and groundwater supplies. According to Few et al. (2004), the mixing of these pollutants during floods poses severe health risks to both humans and wildlife, highlighting the intersection between environmental and public health challenges.

3.4.4 Loss of Ecosystems and biodiversity

Flooding alters ecosystems by disrupting the habitats of terrestrial and aquatic species. Many organisms are forced to relocate, and breeding patterns may be disturbed. While some ecosystems, such as floodplains, are adapted to periodic flooding, extreme or irregular events can be destructive. Junk et.al., (1989) discuss the "flood pulse concept," noting that while natural flood cycles can support biodiversity, human-induced changes to flood regimes often lead to ecological harm.

4.0 DISCUSSION

4.1 Implication of FVI on the Study Area

A review of the indices shows that exposure and susceptibility are positively correlated with flood vulnerability, while resilience is inversely related. Communities with higher exposure (≥ 0.28) and susceptibility (≥ 0.10) generally exhibit higher FVI scores. For instance, Agbede Ikorodu and Animasahun both recorded high exposure and susceptibility levels and correspondingly high vulnerability. Conversely, Anike Abu and Oroyin, with low exposure (0.09–0.25) and moderate susceptibility (0.07–0.09), have lower FVI, implying that flood risk can be effectively mitigated through resilience-enhancing measures even in moderately exposed areas.

Spatially, the downstream sections of the Ogun River Basin, particularly within the Ikorodu–Ketu axis, display relatively higher FVI values. This pattern can be attributed to the flat terrain, inadequate drainage systems, unplanned urban growth, and encroachment on floodplains. The concentration of commercial and residential developments near waterways increases the exposure of assets to flood events. On the other hand, upland or moderately elevated areas such as Oroyin, Afa Yahaya, and Basswood Street show lower vulnerability due to reduced flood exposure and higher adaptive capacity.

Although the values are below 0.3, they still indicate a noticeable flood vulnerability. Low absolute values resulted from the normalization process in FVI calculation, but relative differences between communities are important for prioritization.

Communities closer to the river channel, with lower elevation, and poor drainage infrastructure recorded slightly higher FVI values. This means flood risk is not evenly distributed and localized interventions are necessary.Even with “low” numeric FVI values, field evidence shows that real-life impacts are high. This suggests the FVI may be underestimating vulnerability numerically, but relative rankings are still useful. The low FVI values should not be interpreted as low risk, but rather as a reflection of relative vulnerability within the basin. Communities with values above 0.18 (e.g.,Church Street, Berger, Agboyiketu and others) should be prioritized for flood preparedness, drainage management, and livelihood support programs.The results highlight

the need for integrated flood management that addresses not only physical exposure but also socio-economic resilience. Balica and Wright (2009a)

4.2 Exposure to flood hazard

The concept of exposure is fundamental to understanding flood risk, as it reflects the presence of people, infrastructure, housing, economic assets, or other elements in locations that may be adversely affected by flooding (UNDRR, 2020). Recognizing the drivers and patterns of exposure is critical for effective disaster risk reduction and urban planning.

The Intergovernmental Panel on Climate Change (IPCC, 2014) defines exposure as *"the presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected."*

In practice, exposure is often measured spatially for example; by determining how many people or assets are situated in flood-prone zones and how long they remain at risk.

Survey results from this study revealed that 70% of the 316 respondents live less than 500 m from the river, placing them in a high-exposure category. Proximity to rivers naturally heightens spatial exposure, as these communities are located within the floodplain where inundation depth and velocity are greatest during peak flows. Using GIS analysis, Jongman et al. (2012) demonstrated that populations residing within 1 km of major rivers face disproportionately high exposure to flooding. When asked about their experiences, 96% of respondents reported previous flooding in their area, some experiencing frequent events and others occasional ones. Recurrent flooding increases temporal exposure, leading to cumulative damage. Adger et al. (2001) described how repeated flooding in Vietnam entrenched exposure through the combined effects of geography and limited relocation options. Similarly, Paul and Routray (2010) found that in Bangladesh, households in regularly flooded villages suffered greater losses and long-term vulnerability due to repeated economic shocks.
Interviews further confirmed that 94% of participants acknowledged living in flood-prone zones, underscoring the high level of both spatial and temporal exposure among the surveyed communities.

4.4 Coping mechanism and adaptation measures

Floods rank among the world's most destructive natural hazards, with low-income and developing nations experiencing the greatest impacts, communities have adopted a mix of coping strategies, short-term actions and adaptation measures, long-term approaches to reduce vulnerability and enhance resilience (Adelekan and Fregene, 2021).

Interviews with residents provided insight into the specific steps households have taken to deal with recurring floods in the study area. The coping mechanism engaged includes temporary barriers like sandbags to minimize damage, construction of elevated housing known as flood barriers, flood embankments, improved drainage systems and sometimes relocation during flood. Adelekan, (2010) explained that in Lagos, Nigeria, flood-prone communities have adopted housing designs that incorporate stilts and raised platforms to cope with flood disasters. 70% of the respondents stated that the measures are effective and that account for their survival in the area. 55% of the respondents said they are not willing to move out of the area.

5.0 CONCLUSION

This study has shown that flood vulnerability in the Ogun River Basin is influenced by a complex interaction of socio-economic and environmental factors. Although the computed Flood

Vulnerability Index (FVI) values (0.14–0.21) fall within the low to moderate range, the physical and economic realities in the field reveal that communities within the downstream section of the basin remain significantly at risk. Densely populated areas such as Ikorodu, Kosofe, and Lagos Mainland exhibit heightened vulnerability due to their proximity to river channels, poor drainage infrastructure, and unregulated urban expansion. The results further indicate that socio-economic characteristics such as income level, education, gender, and property ownership play critical roles in shaping community resilience and adaptive capacity. The study underscores that flood vulnerability is not merely a function of natural exposure but also of social inequality, weak planning enforcement, and environmental degradation. Therefore, reducing vulnerability requires coordinated actions that integrate scientific assessment, community participation, and sustainable development policies. There should be enforcement of strict buffer zones along rivers that will prohibit construction within floodplains. So also, wetlands should be protected and restored to enhance natural floodwater retention and mitigate runoff. Government should upgrade and maintain drainage systems, culverts, and embankments, particularly in downstream urban areas and encourage the use of flood-resilient materials and designs for new buildings. So also, Government through Ministry of environments should establish localized flood early warning systems, community-based alert networks and also promote education and awareness campaigns to enhance preparedness and adaptive behaviour. Reforestation and soil conservation in upstream areas should be promoted to reduce runoff and sedimentation.

Clinical Trial Number:
Not applicable.'

Ethics approval
The study involving human participants was reviewed and approved by the Ethics Committee of Federal University of Technology, Akure (FUTA). Approval number: FUTA/ETH/25/275. Written informed consent to participate in this study was provided by the participants.

Accordance statement
This study was conducted in accordance with the ethical standards of Federal University of Technology Akure Research Ethics Committee. Informed consent was obtained from all participants involved in the survey prior to data collection. Participation was entirely voluntary, and respondents were assured of confidentiality and anonymity. All methods were carried out in accordance with relevant institutional and national guidelines and regulations.

Data Availability declaration
Data for this research are available upon request

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Competing Interest declaration
Authors declare that there is no conflicting of interest

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Consent to Publish declaration:
All authors have approved the manuscript and consent to its publication including any accompanying images or data contained within the manuscript. In addition, informed consent was obtained from all individual participants involved in the study, and they agreed that anonymized data could be published for research purposes.

REFERENCE

Adeaga O. (2006). Multi-decadal variability of rainfall and water resources in Nigeria, Climate Variability and Change - Hydrological Impacts, *Proceedings of the Fifth Friend World Conference held at Havana*, Cuba, November 2006, p.294-299

Adeaga, O. (2008). Flood hazard mapping and risk management in parts of Lagos Lagoon area, Nigeria. *African Journal of Environmental Science and Technology,* vol. 2(1), p.22–33

Adelekan, I. O. (2010). Vulnerability of poor urban coastal communities to climate change in Lagos, Nigeria. *Environment and Urbanization*, vol. 22(2), p.433–450. https://doi.org/10.1177/0956247810380141

Adelekan, I. O., and Fregene, A. A. (2021). Flood risk management strategies in Nigerian coastal cities. *Urban Climate*, vol. 38, p.100886. https://doi.org/10.1016/j.uclim.2021.100886

Aderoju, O. M., Odufuwa, B. O., and Balogun, I. A. (2014). Building urban resilience: Assessing flood risk and adaptation options in Abeokuta, Nigeria. *International Journal of Disaster Risk Reduction, vol.* 10, p.1–9. https://doi.org/10.1016/j.ijdrr.2014.06.002

Adger, W. N., Kelly, P. M., and Ninh, N. H. (2001). Living with environmental change: social vulnerability, adaptation and resilience in Vietnam. Routledge. Pg 314, *The Journal of Asian Studies*, vol. 62(2), p.691-693.

Adger, W. N., Barnett, J., Brown, K., Marshall, N., and O'Brien, K. (2011). Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change*, vol. 1(2), p.112–117. https://doi.org/10.1038/nclimate995

Agada, S., and Nirupama, N (2015). A serious flooding event in Nigeria in 2012 with specific focus on Benue State: a brief review. Natural Hazards, vol. 77(2), p.1405-1414

Aldrich, D. P., and Meyer, M. A. (2015). Social capital and community resilience. *American Behavioral Scientist*, vol. 59(2), p.254–269. https://doi.org/10.1177/0002764214550299

Areola, O. O., Ojo, O., and Adedoyin, R. S. (1985). The Ogun River Basin: A study in environmental management. *Environmental Management*, vol. 9(3), p.235–245

Balica, S. (2007) Development and Application of Flood Vulnerability Indices for Various Spatial Scales. Master's Thesis, UNESCO-IHE Institute for Water Education, Delft, Australia, 2007, p.1 - 157

Balica S. F, Wright N.G (2009a) A network of knowledge on applying an indicator-based methodology for minimizing flood vulnerability. *Hydrol Process*vol. 23(20), p.2983– 2986

Balica S. F, Wright NG (2009b) Reducing the complexity of Flood Vulnerability Index. *Environ Hazard J (EHJ)* vol. 9(4). p.321–339,

Balica, S. F., Douben, N., and Wright, N. G. (2009). Flood vulnerability indices at varying spatial scales. *Water science and Technology*, vol. 60(10), p.2571-2580

Balica, S. F., Popescu, I., Beevers, L, and Wright N. G. (2013) Parametric and physically based modelling techniques for flood risk and vulnerability assessment: A comparison, *Environmental modelling and software*, vol. 41, p.84-92.

Birkmann, J. (2011). First- and second-order adaptation to natural hazards and extreme events in the context of climate change. *Natural Hazards*, vol. 58(2), p.811–840. https://doi.org/10.1007/s11069-011-9806-8

Birkmann, J., Cardona, O. D., Carreño, M. L., et al. (2010). Framing vulnerability, risk and societal responses: the MOVE framework. *Natural Hazards*, vol. 67(2), p.193–211. https://doi.org/10.1007/s11069-013-0558-5

Cutter, S. L., Boruff, B. J., and Shirley, W. L. (2003). Social vulnerability to environmental hazards. *Social Science Quarterly*, vol. 84(2), p.242–261

Deepak S., Rajan G., Jairaj P.G. 2020. Geospatial approach for assessment of vulnerability to flood in local self governments. Geoenvironmental Disasters, 7(1), 35. https://doi.org/10.21203rs.3.rs-22816v1

Devine-Wright, P. (2009). Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. *Journal of Community and Applied Social Psychology*, vol. 19(6), p.426–441. https://doi.org/10.1002/casp.1004

Di Baldassarre, G., Martinez, F., Kalantari, Z., and Viglione, A. (2019). More than floods: Valuing the costs and benefits of green infrastructure in floodplains. *Earth's Future*, vol. 7(9), p.1068–1080. https://doi.org/10.1029/2019EF001311

Douglas, I., Alam, K., Maghenda, M., Mcdonnell, Y., McLean, L., and Campbell, J. (2008). Unjust waters: climate change, flooding and the urban poor in Africa. *Environment and Urbanization*, vol. 20(1), p.187–205.

Eguaroje O. E., Alaga T. A., Ogbole J. O., Omolere S., Alwadood J., Kolawole I. S., Muibi K. H., Nnaemeka D., Popoola D. S., Samson S. A., Adewoyin J. E., Jesuleye I., Badru R. Atijosan A., Ajileye O. O (2015), 'Flood vulnerability assessment of Ibadan City, Oyo State, Nigeria'. *World Environment,* vol. 2015, 5(4), p.149-159 https://doi.org/10.5923/j.env.20150504.03

Entin H., Retno U. Agung W., Ageng D. W. 2021 Development of the flood vulnerability index using a multi-element approach. *Journal of Water and Land Development*. Vol. 50, p. 255–264. https://doi.org/10.24425/jwld.2021.138181

Food and Agriculture Organization (2015). The impact of disasters on agriculture and food security. Food and Agriculture Organization of the United Nations. http://www.fao.org/3/a-i5128e.pdf

Fashae O. A., Faniran A. (2015), Downstream Morphologic Characteristics of the Alluvial Section of Lower River Ogun, Nigeria. *Journal of Environmental Geography Journal of Environmental Geograph,y* vol. 8 (1–2), p.1–10. https://doi.org/10.1515/jengeo-2015-0001

Fernandez D. S, Lutz M. A (2010) Urban food hazard zoning in Tucumán Province, Argentina, using GIS and multicriteria decision analysis. *Eng Geol*., vol. 111, p.90–98. https://doi.org/10.1016/j.enggeo.2009.12.006

Few, R., Ahern, M., Matthies, F., and Kovats, S. (2004). Floods, health and climate change: a strategic review. *Tyndall Centre Working Paper* No. 63

Grothmann, T., and Reusswig, F. (2006). People at risk of flooding: Why some residents take precautionary action while others do not. *Natural Hazards*, vol. 38(1-2), p.101–120. https://doi.org/10.1007/s11069-005-8604-6

Ifabiyi, I. P. (2005) Construction versus yield of deep wells in the regolith aquifer of Osun River basin, Nigeria. *Water Resources,* vol. 16, p.1–16

Intergovernmental Panel on climate change (2014). IPCC, 2014: impacts, adaptation, and vulnerability. Part B: regional aspects. Contribution of working Group II to the fifth assessment report of the Intergovernmental Panel on climate change (688p.). Tech. rep.

Jongman, B., Ward, P. J., and Aerts, J. C. J. H. (2012). Global exposure to river and coastal flooding: Long term trends and changes.

Global Environmental Change, vol. 22(4), p.823–835. https://doi.org/10.1016/j.gloenvcha.2012.07.004

Junk, W. J., Bayley, P. B., and Sparks, R. E. (1989). The flood pulse concept in river-floodplain systems. *Canadian Special Publication of Fisheries and Aquatic Sciences*, vol. 106, p.110–127

Kissi, A. E., Abbey G. A., Agboka K., Egbendewe A., (2015) Quantitative assessment of vulnerability to flood hazards in downstream area of Mono Basin, South-Eastern Togo: Yoto District. *Journal of Geographic Information System,* vol. 7, p.607-619

Komolafe, A. A., Adegboyega, S. A. A., and Akinluyi, F. O. (2014). A review of flood risk analysis in Nigeria. *American Journal of Environmental Sciences, vol.* 11(3), p.157-166

Kuhlicke, C., Scolobig, A., Tapsell, S., Steinführer, A., and De Marchi, B. (2011). Contextualizing social vulnerability: Findings from case studies across Europe. *Natural Hazards*, vol. 58(2), p.789–810. https://doi.org/10.1007/s11069-

Müller A., Reiter J., Weiland U. (2011). Assessment of urban vulnerability towards floods using an indicator-based approacha case study for Santiago de Chile. *Natural Hazards and Earth System Sciences*. vol. 11(8), p.207–2123. https://doi.org/10.5194/nhess11-210

Murali R.M., Ankita M., Amrita S., Vethamony P. (2013). Coastal vulnerability assessment of Puducherry coast, India, using the analytical hierarchical process. *Natural Hazards and Earth System Sciences*. vol. 13, p.3291–3311. https://doi.org/10.5194/nhess-13- 3291-2013

Nasiri H., Yusof, M.J.M., Ali T.A.M., Hussein M.K.B. (2016) District flood vulnerability index: urban decision-making tool. *International Journal of Environmental Science and Technology,* vol. 16, p.2249–2258 https://doi.org/10.1007/s13762-018-1797-5

Nazeer, M.; Bork, H.R. (2019) Flood Vulnerability Assessment through Different Methodological Approaches in the Context of North-West Khyber Pakhtunwa, *Pakistan. Sustainability*, vol. 11(23), p.6695. https://www.mdpi.com/2071-1050/11/23/6695

Oke, M. O., Martins, O., Idowu, O. A. and Aiyelokun, O. (2015). Comparative analysis of groundwater recharge estimation value obtained using empirical methods in Ogun and Osun River basins. *Ife Journal of Science,* vol.17(1), p.53-63

Pimentel, D. (2006). Soil erosion: A food and environmental threats. *Environment, Development and Sustainability*, vol. 8(1), p.119–137

Raji, B. A., Olaniran, O. O., and Olaniran, O. J. (2014). Hydrological modeling of Ogun River Basin, Nigeria. *Journal of Water Resource and Protection*, vol. 6(10), p.1001– 1010

Tate, E., Rahman, M. A., Emrich, C. T., and Sampson, C. C. (2021). Flood exposure and social vulnerability in the United States. *Natural Hazards,* vol. 106(2), p.435-457

Terpstra, T. (2011). Emotions, trust, and perceived risk: Affective and cognitive routes to flood preparedness behavior. *Risk Analysis*, vol. 31(10), p.1658–1675. https://doi.org/10.1111/j.15396924.2011.01616.x

The United Nations (2002) Floods Affected Over 17 Million People Worldwide. *UN Meetings Coverage and Press Releases* ENV/DEV/679 29 August 2002, 54p.

Tran M. Q., Sousa H. S., Texeira E. and Matos J. C. (2023). Flood Vulnerability Index (FVI) of infrastructures for reducing adverse flood events Lifecycle of Structures and Infrastructure Systems – *Biondini and Frangopol* (Eds), 512p https://doi.org/10.1201/9781003323020

United Nations Office for Disaster Risk Reduction (UNISDR) (2015). Global Assessment Report on Disaster Risk Reduction, vol.3(1), p.417-428

United Nations Office for Disaster Risk Reduction UNDRR. (2020). Terminology on Disaster Risk Reduction. United Nations Office for Disaster Risk Reduction. Retrieved from https://www.undrr.org/terminology.

Vojinovic Z., Abbott M. B (2012). From Quantitative to Qualitative Flood Risk Assessment and Mitigation. Available at:https://www.iwapublishing.com/books/9781843393870/flood-risk-and-social-justice

Yang T.H., Liu W.C. (2020). A general overview of the risk-reduction strategies for floods and droughts. Sustainability. vol. 12(7), p.1–20. https://doi.org/10.3390/su12072687