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Research Paper

An Assessment of Flood Vulnerability Areas in ETI-OSA Local Government Area, Lagos State, Nigeria

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ABSTRACT
There has been a significant increase in flood occurrence with their devastating impacts leaving lasting imprints in the coastal areas especially. To this end, the study assessed flood vulnerability areas in the Eti-Osa area of Lagos. The application of Geographical Information System (GIS) and remote sensing are used in pre-processing and processing acquired spatial information. Five flood vulnerable zones are identified from the analysis. They are very highly vulnerable zone (23.59%), highly vulnerable zone (12.23%), moderately vulnerable zone (10.04%), less vulnerable zone (9.52%), and none-vulnerable zone (44.62). The residential area is vulnerable to socio-economic development because of loss and damages to the properties of residents. The study concludes with the recommended management strategies to mitigate the adverse effects in the study area
KEYWORDS: ***Vulnerability, Flood, Assessment, Geographical information system, Risk***

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I. INTRODUCTION

Flood is one of the major environmental disasters that often pose dangers to people situating in flood vulnerable areas such as riverine and waterlogged areas. Flood vulnerability is the degree of damages to the lives and property of people in a flood-prone area. It increases in severity and frequency, specifically through the effect of climate change, the forceful weather condition in the form of heavy rainfalls, tidal waves, melting of oceans, and river discharge. Flood vulnerability assessment imperatively reveals the level of economic, social, and physical assets vulnerability and the measures in assisting people to withstand the effects of flood hazards (Dinh *et al.*,2012).

Over decades, there are so many causal factors of flooding all over the globe, varying homogeneously from one place to the other. Apart from the nature of land terrain, Urbanisation is a prime cause and indicator of city development contributing to flooding as a result of change-in-use of land, conversion of natural vegetation, agricultural land, riverbanks, and wetland to built-up settlements, and the construction of natural drainage due to poor urban development and management policies. Poor implementation of urban development and management policies has led to the thoughtless development of buildings in floodplains without the advice of an appropriate development agency. Building development in riverine areas causes flooding when building close to river banks and water slips into adjacent low-lying areas (Ijigah and Akinyemi, 2015).

Low-lying coastal Cities are highly susceptible to flood risks owing to their relatively low terrain of land, assets, and populations drawing attention to the need and importance of flood risk preparedness in these areas (Pelling and Blackburn, 2013). Many areas of the coastal cities have suffered losses of lives and properties which attributed to economic, social, and physical damages owing to the catastrophic incidents of flooding in the area. This necessitates the management of flood risks to mitigate the effect of flooding (Olayinka and Irivbogbe, 2017).

The management of flood risks area is characterised by structural and non-structural measures. And these are generally set up to protect lives and properties from the effect of calamitous floods. Flood risk preparedness is a subset concept of flood risk management that clamourfor natural and technical cost-effective defenses that are infallible and long-lasting remedying flood hazards. However, flood risks scenarios demand appropriate spatial and geographical information on the potential hazards of floods, and determination of the areas vulnerable to flood hazards is needed to prepare for disasters. The application of GIS has made it possible to produce flood-risk mapping and flood simulation models of flood-prone areas. It is an essential component of flood risk preparedness usually carried out before, during, and after flood occurrences (Olayinka and Irivbogbe, 2017).

Flood risk preparedness is a critical activity in managing flood events because the flood risk maps show the exact locations to experience the hazards of floods. With the knowledge of flood vulnerable areas, measures such as flood forecasting, early warning system, relocation scheme, construction of drainage channels, public sensitization on waste disposal, etc. could be carried out in helping to mitigate the possible hazards of the flood before its occurrences. Flood-risk mapping allows effective communication of risks and what is threatened (Edwards, Martin and Näslund-Landenmark, 2007).

All over the world, different methods are used by several researchers to process flood vulnerability mapping and analyses. With the advent of GIS, Global Positioning Systems (GPS), and remote sensing techniques, maps can be prepared to inform decision-making and planning for flood-risk preparedness in flood susceptible areas (Olayinka *etal.*, 2017). The provision of flood risk maps usually serves as spatial information which is the key measure to be taken to mitigate and prevent the effects of flooding in flood vulnerable areas. However, flood-risk mapping requires adequate spatial information and the required spatial information for flood mapping in Nigeria is expensive and inadequately available. However, this information is essential to determine the extent of floods and their effects on the lives and properties of people, hence the use of the online dataset. Inadequacy and high cost of spatial information for flood mapping in Nigeria has been making it difficult for some researchers to adeptly provide appropriate long-term solutions to flood hazards using flood maps despite the obvious effect of flooding in some Nigeria major cities of which Lagos state is one of them. Over time, some major urban areas of Lagos state have been battling with the incidents of floods which have been having a tremendous effect on the lives and properties of people (Ishaya, 2009).

This research assesses flood vulnerable areas and measures for flood risk preparedness in the low-lying coastal areas in Eti-Osa, Local Government Area of Lagos State. Specifically, Eti-Osa Local Government Area is one of the Local Government Areas frequently experiencing flooding owing to its low-lying area and boundary sharing with the Atlantic Ocean and Lagos Lagoon. The application of GIS and remote sensing is useful in pre-processing and processing acquired spatial information to produce flood vulnerability maps which could be useful to government agencies or authorities in charge of flood risk management to perform their responsibilities adeptly in managing floods incidents to protect lives and properties of people. However, a holistic perspective of the factors contributing to flood will be determined, in as much as the flood cannot be eradicated but its effects can be mitigated.

II. LITERATURE REVIEW

Flood occurs in different locations and magnitudes posing detrimental effects on the environment. Some of the causes of flood in Nigeria are lack of drainage network, indiscriminate disposal of wastes leading to the blockage of drainage channels, climate change, heavy rainfall, melting of glacial and ice sheet, tidal wave, population increases in urban coaster areas, etc. and the combination of these factors cause flood disaster (Adeoye, Ayanlade and Babatimehin, 2009). Moreover, urbanisation results in change-in-use and conversion of natural vegetation, agricultural land, riverbanks, and wetland to built-up settlements. Likewise, the construction of natural drainage increases the number of people living in flood susceptibility areas (Adeoye *et al.*, 2009). However, Alaghmand, Abustan, Bin-Abdullah and Vosoogh (2010) opined that there is a synergy between hydrological characteristics and urbanisation; which tends to decrease infiltration, increase run-off, flood height, and frequency in the urban coastal area which eventually affects the lives and properties of people living in such an area.

Over time, there has been an increase in the damages of properties and lives of people as a result of flood occurrences especially in coastal areas of the urban environment. As a result of these incessant challenges, there have been some attempts through empirical studies to understand the causes of flooding majorly in flood vulnerable areas, and its effects on the lives and properties of people. Evidence from the literature of those empirical studies suggests interest in the development towards the management and preparedness against flood hazards is growing. For instance, those of Adelekan

(2015); Oyinloye, Ajayi and Olanibi (2016); Ugoyibo, Enyinnay and Souleman (2017); Olayinka *et al.* (2017), Wahab and Ojolowo (2018).

Adelekan (2015) examined the current approach to flood risk management by private and public agents in the context of international practices of flood risk management. The study revealed that the state government has been taking primary responsibility for flood management of which includes both structural and non-structural measures. The structural measure involves the construction of the channel, the ongoing construction of revetment to protect cities from coastal flooding. The demolition of buildings along the coastline has been embarked upon by the state government. For example, the demolition exercise that took place in flood vulnerable areas of Ijeshatedo, Ijora-Badia, and Agege (2010, 2011, 2012, 2013) in Lagos, Nigeria. The non-structural measure is been administered by the state government through the urban development framework guided by land-use and zoning regulation, regulation on the minimum setback to the Lagoon, ocean, and the enforcement exercise to ensure that developers obtain a building permit before the construction of any building to safeguard against flood hazard. The study investigates extensively the existing measures of flood management in the city by both public and private agents and suggested briefly additional management measures. However, the study was limited in scope as it does not consider the scientific aspect of flood management in terms of the technical analysis of flood risk thereby only employing different existing measures of floods management in the City.

Other studies were carried out to assess the extent of spatial development in flood-prone areas. Wahab *et al.* (2018) examined the factors influencing spatial development in the floodplain. The study revealed that the proximity to the place of work, proximity to children's schools, proximity to the market, low income, ineffective development control, and poor compliance with building regulations and planning standards among others are the factors that influenced the spatial development in flood-prone of Lagos metropolis. However, the study shows that development in flood-prone areas in Lagos increased from 9.3 km2 in 1990 to 10.50 km2 in 2000 and 17.80 km2 in 2014. The study suggests recommendations to include strict enforcement of planning standards by an appropriate agency, flood-prone areas should be acquired to serve as a sink for stormwater and discourage continuity of physical development. However, the research focused on factors influencing development in the floodplain area. This study would, however, focus on the delineation of flood-prone areas, areas to be affected if planning standard is adequately observed, and establish preparedness measures before flood hazard occurrence.

Furthermore, Oyinloye *et al.* (2016) examined the effect of shorelines changes on Victoria Island of Eti-Osa Local Government Area, Lagos State, Nigeria. The study revealed that there was a loss of landmass between 1962 and 1984. And between 1984 and 2011 there was an increase in land gain over time using land-use and land cover change analysis. Ugoyibo, Enyinnay and Souleman (2017) examined Flood susceptibility in Anambra East Local Government, Anambra State, Nigeria. The study identified flood vulnerability areas using Boolean operation (ArcGIS raster calculator tool) and accounted that 76.24% of the total land area is prone to flood and most of the flood-prone area is for agricultural purposes. The studies were limited in scope as they only identified flood-prone areas and the extent of spatial development in those identified areas.

In terms of the effect of flooding in flood-prone areas, Olayinka *et al.* (2017) assessed flood vulnerable areas of Lagos Island and Eti-Osa Local Government Areas of Lagos State. The study revealed the use of HEC-HMS (Hydrological Engineering Centre-Hydrologic Model System), HEC-RAS (Hydrological Engineering Centre-River Analysis System), and Analytical Hierarchy Process (Pairwise Comparison Approach) in determining flood vulnerable areas. Moreover, the study accounted for the number of buildings to be affected by flooding in flood-prone areas. The scope of the study was limited as it did not address the issue of planning standards and regulations in floodplains of the study areas.

Preparedness for flood disasters is imperative to get ready for flood disaster occurrences as this underscores the need for GIS for flood-risk and flood vulnerability mapping. Flood risk and flood vulnerability mapping are usually deemed as one of the major steps in flood risk mitigation to help identify areas susceptible to flood disaster to plan adequately ahead of flood occurrence. GIS, remote sensing and photogrammetric imagery (satellite imagery, Digital Elevation Model [DEM], etc.) are important and effective in identifying flood-prone areas and mechanisms for flood preparedness. Application of GIS and remote sensing offers a synoptic view of spatial flow, distribution, and state of hydrological components (erosion and flood), and they are used frequently to measure, monitor, and estimate the extent of land area and facilities to be affected by flood (Izinyon and Ehiorobo, 2011).

In conclusion, the above underscores the need for this study to make use of suitability analysis (spatial decision support system) with the use of Boolean operation (raster calculation), weight overlay(multi-criteria approach), and weight determination to identify flood-prone areas to produce flood vulnerability maps and flood simulation model to serves as a mechanism for flood-risk preparedness which would help in finding appropriate solutions, prevention and mitigation strategies to address this incessant menace. Moreover, the technical exercise of planning standards and regulations will be conducted along coastal areas to ascertain the level of compliance and to checkmate the activities of the planning authority in the study area.

THE SETTING

Eti-Osa is one of the 20 Local Government Areas of Lagos State, Nigeria. It is within Latitude 6026'34" N and Longitude 3024'30" E on the left and Latitude 6029' 04" N and Longitude 3039'09" E on the right covering a land area of approximately 174.067 square kilometers. Eti-Osa Local Government Area shares boundaries on the North with Lagos Lagoon (largest coastal lagoon in Western Africa). It also shares boundaries on the south with the Atlantic Ocean. It consists of three (3) council areas which are Eti-Osa East LCDA, Ikoyi-Obalende, and Iru Victoria Island LCDA. Like other areas of Lagos State, Eti-Osa Local Government Area is home to a diverse ethnicity across the whole country. Eti-Osa people are primarily from the Awori Yoruba sub-group and Edo sub-group (Eti-Osa L.G.A, 2011).

The rainy season in Eti-Osa Local Government Area is usually between March and early November. By early November, rainfall is often at its maximum at night and very early in the morning hours. Hence, the quantity of rainfall varies from 1980mm to 2200mm from year to year (Adeoye, Ayanlade and Babatimehin, 2009). Moreover, the temperatures hottest months are between late January and late March. It has an average annual temperature above 20 Celsius, with a mean annual humidity of about 75%. However, the humidity rises to about 90% during the rainy season. The state has an Ozone of about 258.95 Dobson units, precipitation likelihood of 1%, precipitation intensity of 0.0008in /hr., Wind Directive of about 314o, and wind speed of about 2.78mph. (Adeoye *et al.*, 2009). However, Eti-Osa is one of the Local Government Areas in the state faced with flooding. There have been different cases of economic losses as a result of the effect of flooding, yearly. Lagos state has a low-lying topography, and areas like Eti-Osa, Lagos Island, Festac are some major urban and commercial areas of the state usually flooded due to excessive rainfall resulting in the loss of lives and damaging of properties. The ceaseless occurrence of flood, especially during the rainy season, underscores the urgent need for this study to proffer adequate measures for flood-risk preparedness in the study area.

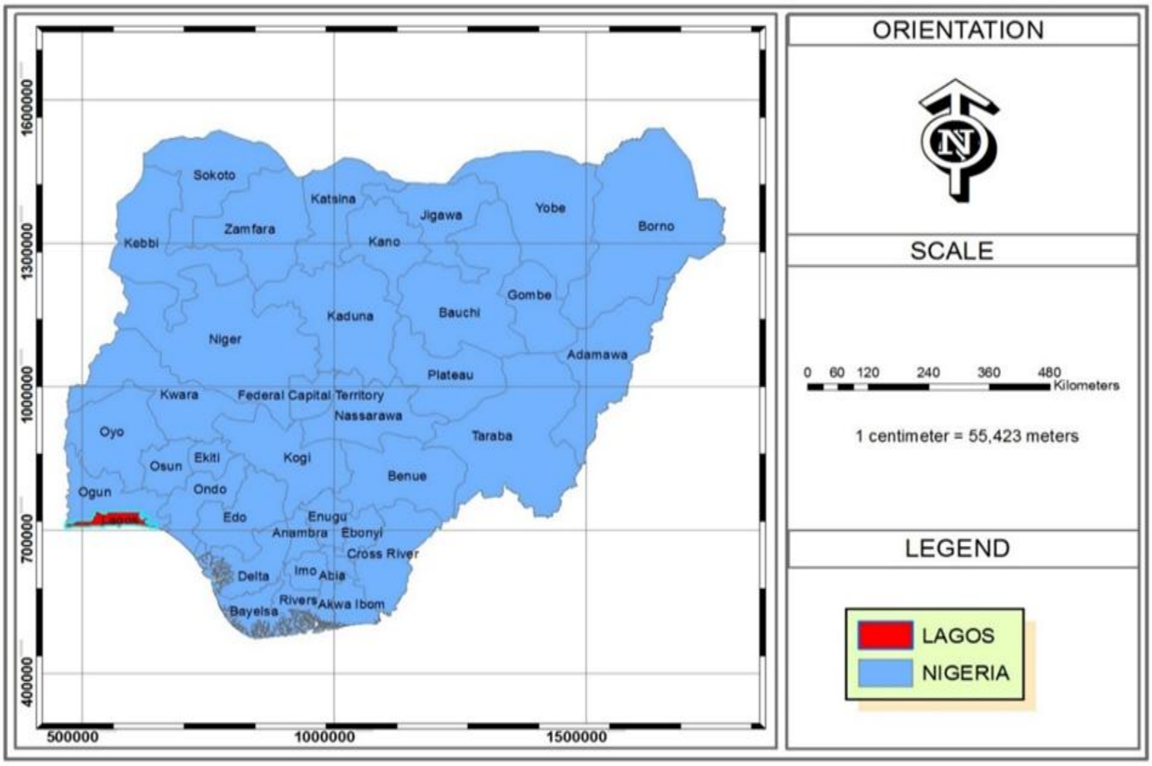


Figure 1: Lagos State within the context of Nigeria

Source: Author's Field Survey, 2020

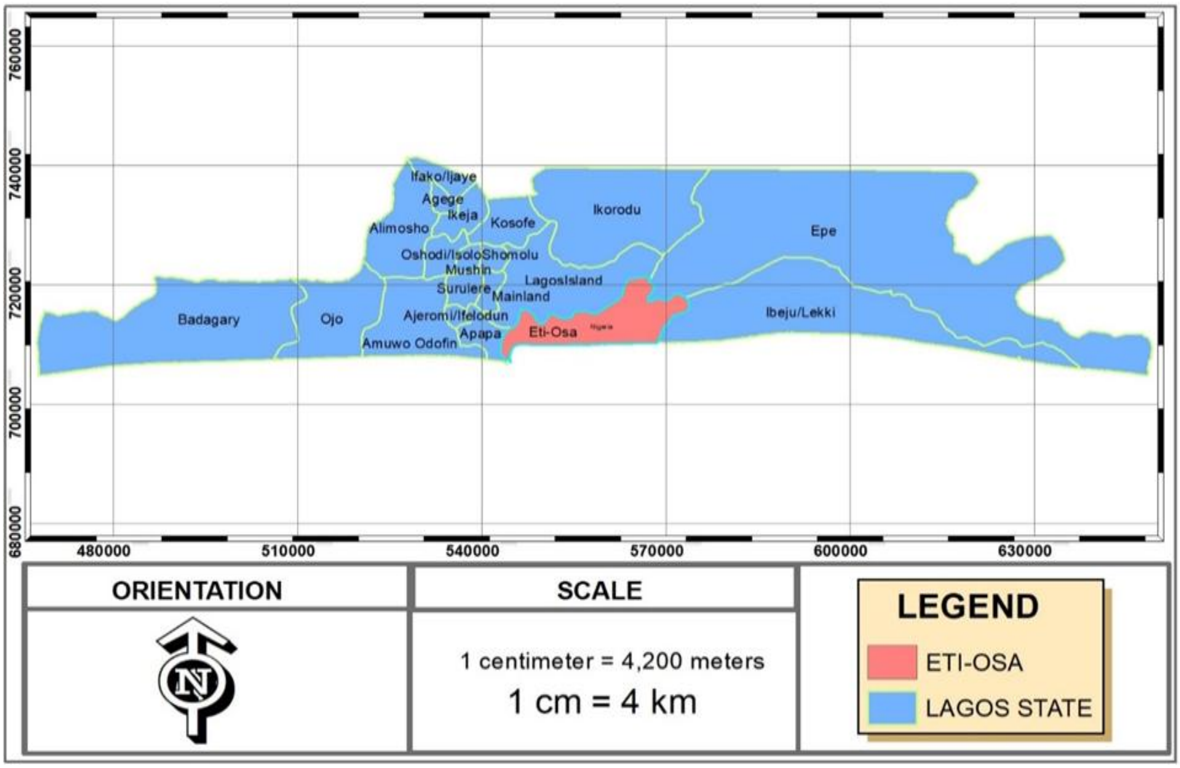


Figure 2: Eti-Osa within the context of Lagos State

Source: Author's Field Survey, 2021

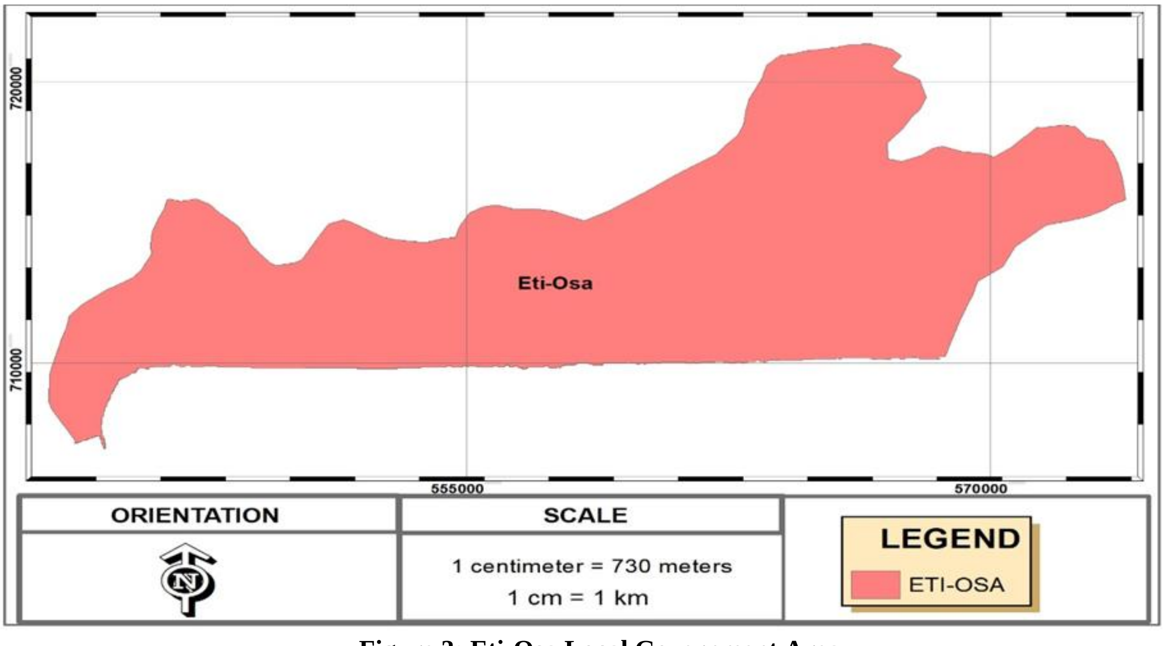


Figure 3: Eti-Osa Local Government Area

Source: Author's Field Survey, 2021

III. RESEARCH METHODOLOGY

The research design for this study relied on a mixed approach (quantitative and qualitative). For the quantitative analysis, the use of questionnaire administration to obtain information from the residents living in prone areas about the existing measures of flood management put in place by them and the government in the area. Also, the causes of flood, and its effects of flooding on residents' lives and properties. The total number of houses (1,521) in the prone areas was the sampling frame for the study. Khotari's formula was used to determine the sample size for the study which is as follows

$$n = \frac{z^2 * p * q * N}{e^2(N-1) + z^2 * p * q}$$

Where, n= sample size
Z= the value of standard variate at a given confidence level (1.96)
p= sample proportion (0.5)
q= 1-p (0.5)
e= given precision rate or acceptable error (0.07)

$$n = \frac{1.96^2 * 0.5 * 0.5 * 1521}{0.07^2(1521 - 1) + 1.96^2 * 0.5 * 0.5}$$

$$n = \frac{1460.768}{8.413}$$

$n = 173.63$ = 174 household questionnaires were administered

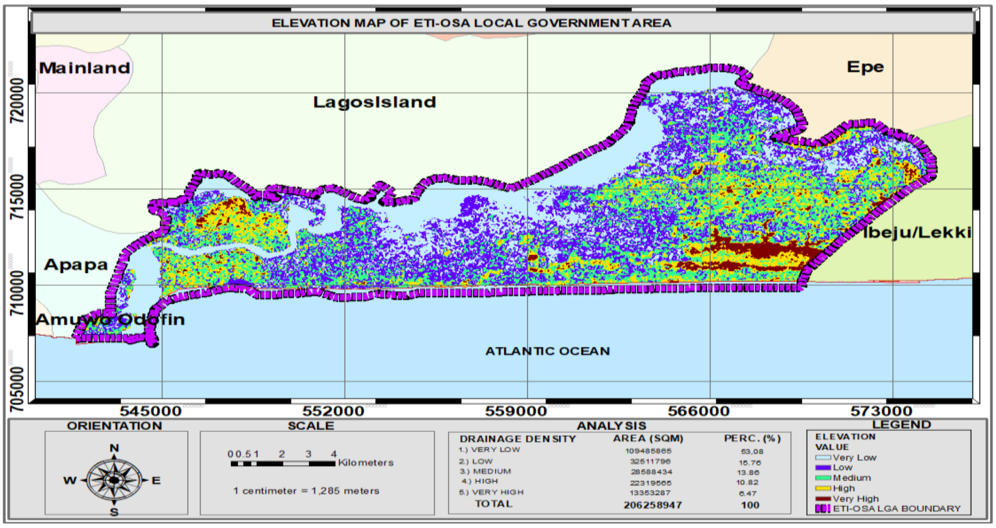
Questionnaires were administered using a systematic sampling method, on the principle that the first building in every selected street was selected randomly and subsequent selections will be made at an interval of three (3) buildings along the selected streets. The respondent was the available oldest person in the house. Also is the administration of questionnaires for the institutions to consolidate findings from the households.

IV. DATA ANALYSIS AND INTERPRETATION

The questionnaire was analysed using descriptive statistics on the platform of Statistical Package for Social Sciences (SPSS 26) and the result was displayed using frequency tables and charts. For the qualitative analysis, the photogrammetric imagery and Digital Elevation Model (DEM) of the study area were obtained from United States Geological Survey (i.e., USGS Earth Explorer). The Geographic Information Systems (using ArcGIS and Surfer) were used to analyse the data obtained for this study. To identify the floodplain areas and the extent of spatial development in the floodplain areas, the following dataset as Satellite Imagery, Advanced Spaceborne Thermal Emission and Reflection Radiation (ASTER Data), Soil Data, and Landsat-8 which were used to produce flood vulnerability maps. Application of GIS and Remote Sensing was employed on the platform of ArcGIS. However, suitability analysis i.e., the use of Analytical Hierarchical Process and pairwise comparison approach were used in weighing geographical-based flood influencing factors to determine flood-prone areas and the extent of spatial development in the study area. However, flood influencing factors such as elevation, drainage density, land-use land cover, slope, and soil type data were classified and reclassified in raster format and then weighted overlay using ArcGIS 10.2 to generate the final flood vulnerability map.

Elevation Map

Elevation is the geographical height of a place above sea level. It is the most critical factor determining flood vulnerability area as it makes analysis easy for other factors. Moreso, it is essential because the water flows from highlands to lowland areas. Hence, areas of lower elevations have a higher probability of getting flooded than areas of higher elevations. The elevation of the study area is between 13metres below sea level and 35meter above sea level. The major area below the sea level (Figure 4. below refers) is more prone to flood. The analysis revealed that very low and low areas are between 13meters below the sea level and approximately 5meter above sea level making them much more prone to flooding than any other area.

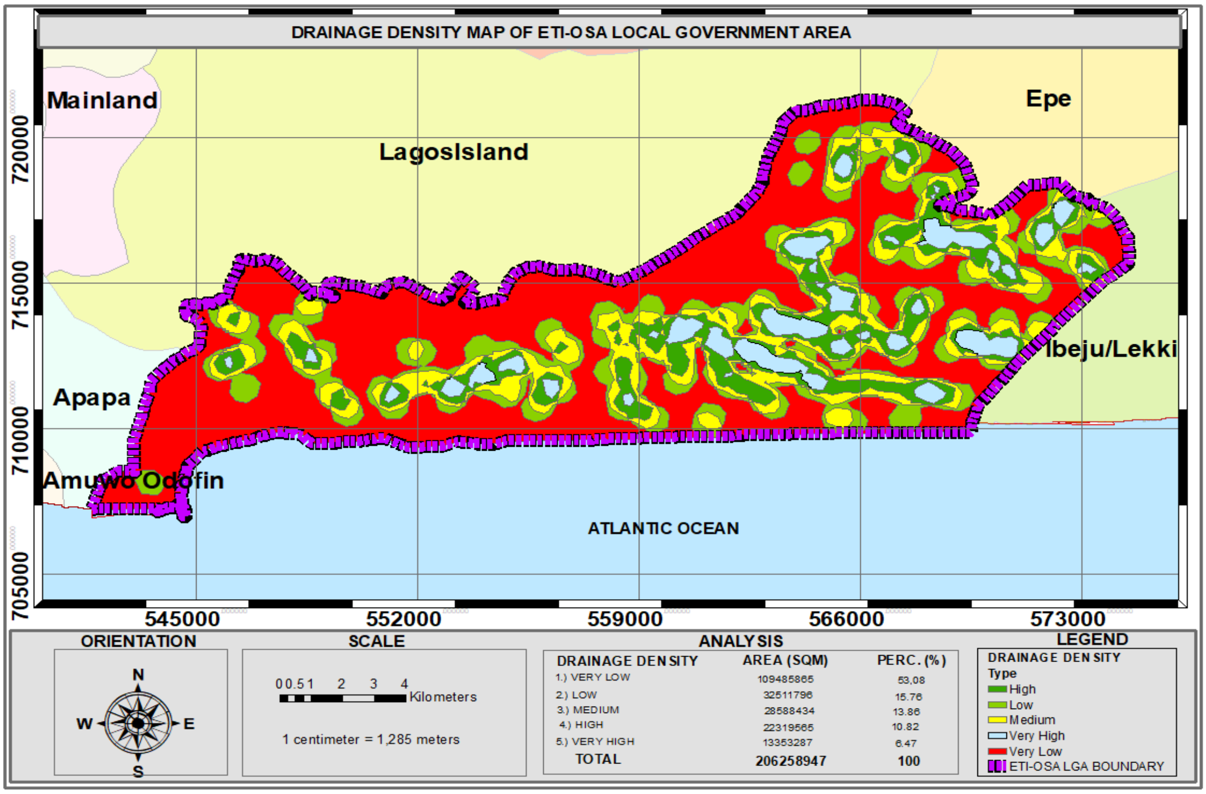


Source: United State Geological Survey (USGS Earth Explorer), 2021.

Figure 4. Elevation Map

Drainage Density Map

Drainage density is the total length of stream channels per unit area. It is significant to flood vulnerability mapping because of Its geotechnical properties such as infiltration capacity and permeability. Areas of higher drainage density (indicated with deep green (Fig. 5. refers) have high tendencies of been flooded because high drainage density indicates sizeable surface runoff and vice versa.

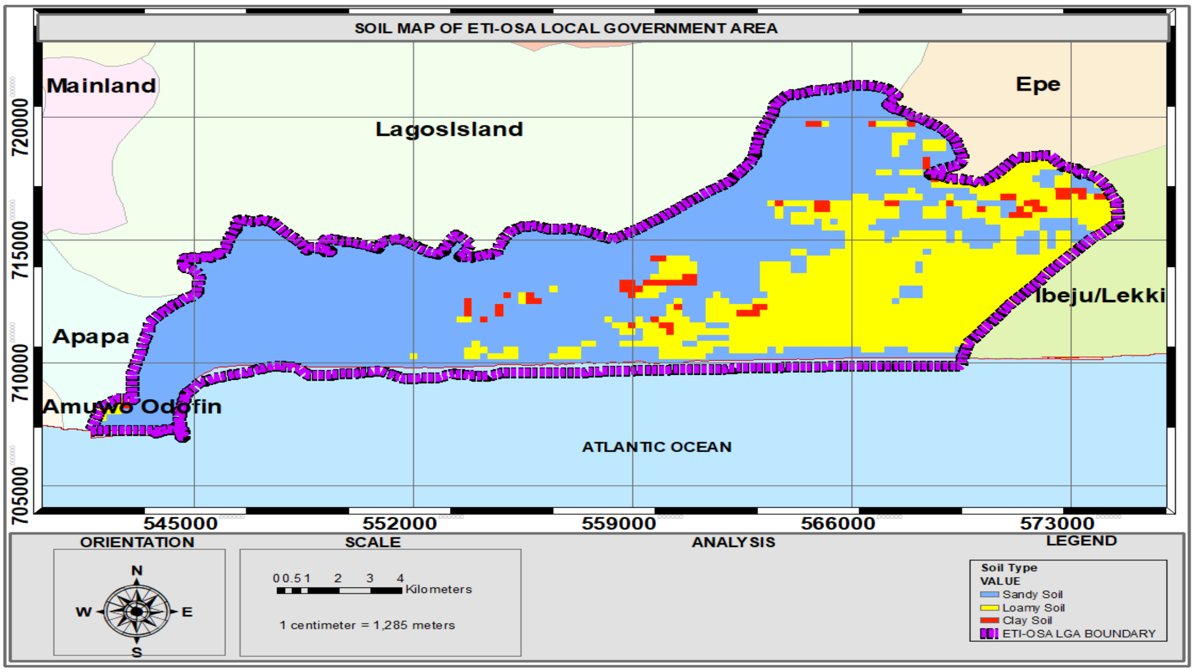


Source: United State Geological Survey (USGS Earth Explorer), 2021

Figure 5: Drainage Density Map

Soil Analysis Map

Soil map identified types of soil present in the study area. The type of soil in the study area consists of Sandy soil, loamy soil, and clay soil (Fig. 6. refers). About 75% consist of Sandy soil (indicated with blue colour below) which is instability and can easily allow infiltration of water. They contribute to the incident of flood in some areas such Ogombo 2, Peninsula II, Alasia, etc

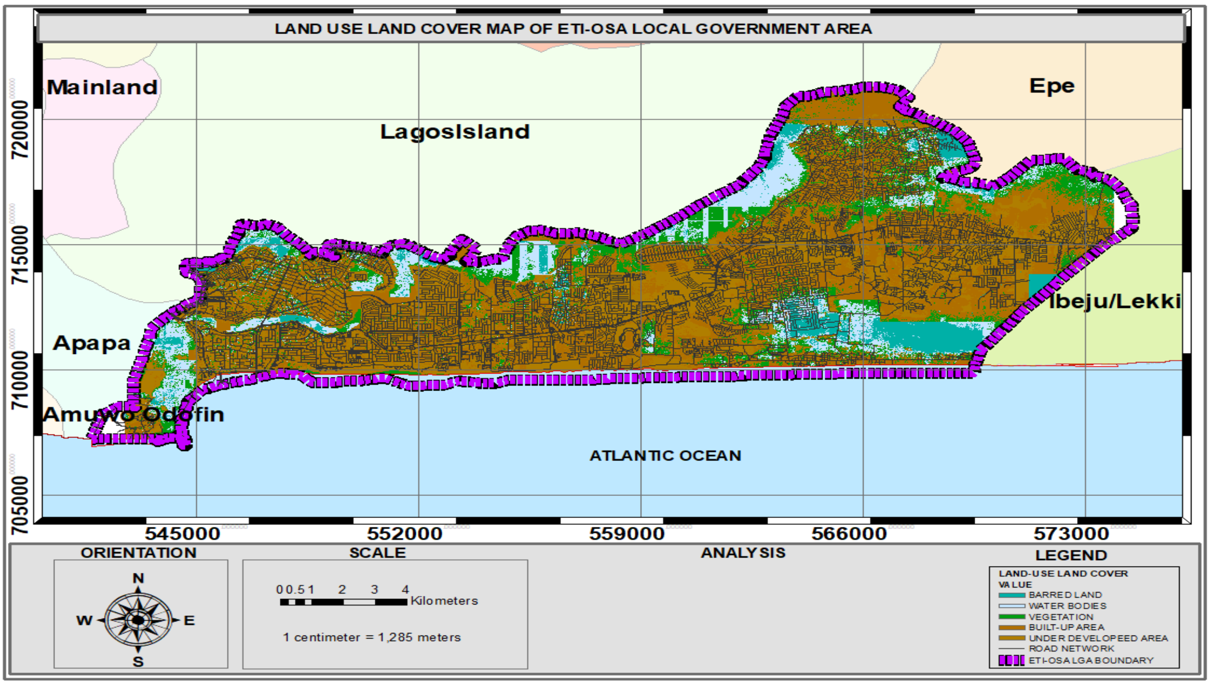


Source: United State Geological Survey (USGS Earth Explorer), 2021

Figure 6.: Soil Map

Land Use Land Cover (LULC) Map

Land use map identifies the present use to which land is put (Fig 7. refers). It is an integral factor in flood risk mapping because of its importance to soil stability and infiltration. Impermeable surfaces such as buildings, roads, and parking lots reduce infiltration capacity and increase runoff while vegetated surfaces enhance the percolation and infiltration of raindrops into the soil which prevents runoff. From the false colour composite of the study area, four landcover classes namely built up, waterbody, vegetation, road, bare land, and undisturbed forest were identified. Most vulnerable areas are along the coastal line, built-up area, and vegetation.

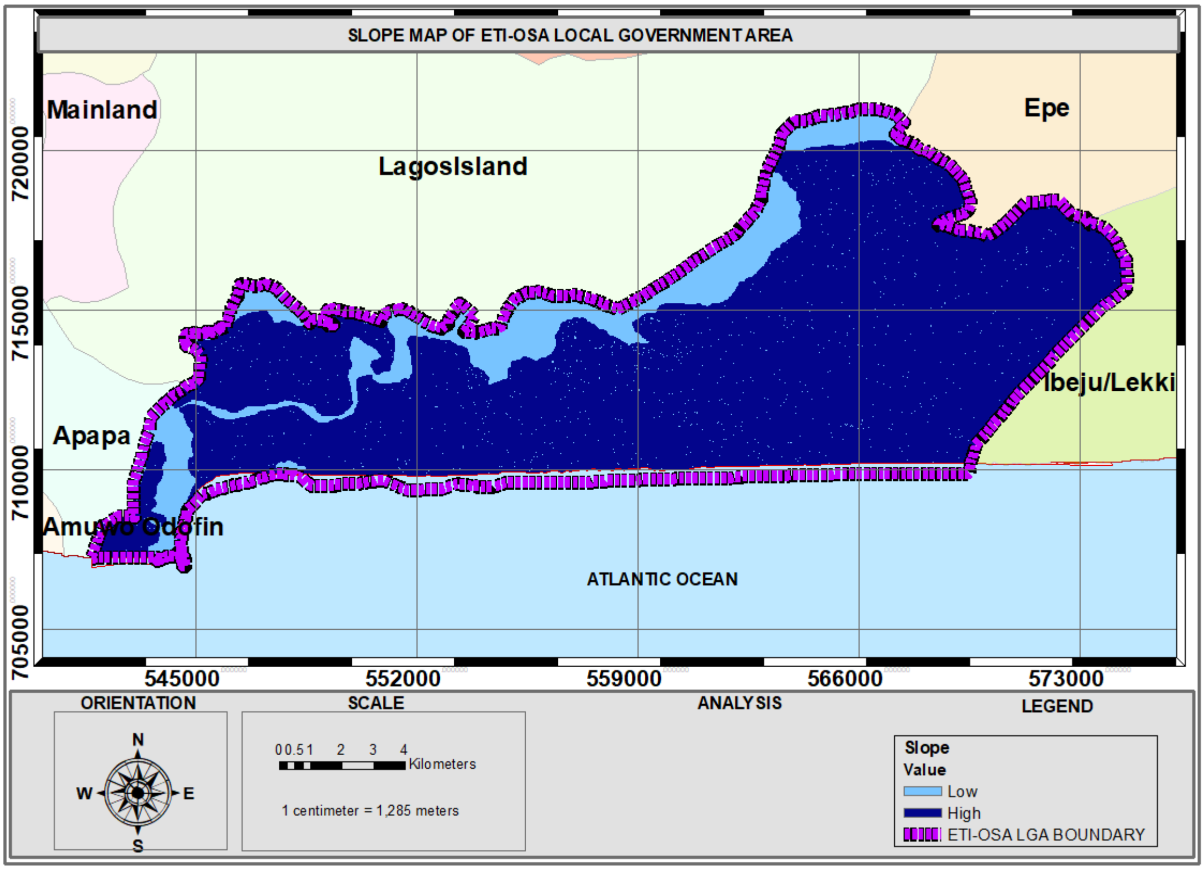


Source: United State Geological Survey (USGS Earth Explorer), 2021.

Figure 7: Land use land cover Map

Slope Analysis Map

Slope is the rate of steepness or the degree of inclination of a feature with the horizontal surface. Gently sloped areas have a higher probability of being flooded than areas with steep slopes. It is because, on gentle slopes, surface runoff is usually slow and encourages ponding, whereas, on steep slopes, the rate of runoff is often very high. Most areas in the study (Fig. 8. refers) are low slope angles having high flood risk while areas with high slope angles have a low flood risk.



Source: United State Geological Survey (USGS Earth Explorer), 2021.

Figure 8.: Slope Analysis Map

The Fundamental Scale of Absolute Numbers

It explains the intensity of importance to assign value for one variable (i.e., flood influencing factor) over the other. The exercise was carefully carried out by critically comparing one factor against others according to their level of importance.

Table 1: The Fundamental Scale of Absolute Numbers

Intensity of importance	Definition Explanation
1	Requirement A and B are of equal value or importance
3	Requirement A has a slightly higher value than B
5	Requirement A has a strongly higher value than B
7	Requirement A has a very strongly higher value than B
9	Requirement A has an absolutely higher value than B
2, 4, 6, 8	These are intermediate scales between two adjacent judgements
Reciprocals/Transpose Value	If Requirement A has a lower value than B

Source: Thomas Saaty, 2008

4. Analytical Hierarchical Process to Determine Weight for Each of the Factors

The pairwise approach helps compare the level of importance among factors that influence flood in the study area as every location is different. It was approached by using a fundamental scale of absolute numbers (see Table 1).

Table 2 : Analytical Hierarchical Process to Determine Weight for Each of the Factors

Factors	Elevation	Soil	DD	LULC	Slope
Elevation	1	2	3	2	3
Soil	0.5	1	2	2	0.5
Drainage Density	0.33	0.5	1	3	3
LULC	0.5	0.5	0.33	1	2
Slope	0.33	2	0.33	0.5	1
Total	**2.66**	**6.0**	**6.66**	**8.5**	**9.5**

Source: Author's Computation, 2021

Normalisation of values of the pairwise factors

The values in Table 1 must be normalised. And to normalise the values, the value of each cell was divided by the summation of the values of the respective column. The normalisation results obtained gives us average weight scores for each factor. More importantly, the summation of all average weight scores must be equal to 1 (See Table 3).

Table 3: Normalisation of Values of the Pairwise Factors

Factors	Elevation	Soil	D.D	LULC	Slope	Sum of Score	Avg. Score Weighted
Elevation	0.3759	0.3333	0.4505	0.2353	0.3158	1.7108	0.3422
Soil	0.1880	0.1667	0.3003	0.2353	0.0526	0.9429	0.1886
Drainage Density	0.1241	0.0833	0.1502	0.3529	0.3158	1.0263	0.2053
LULC	0.1880	0.0833	0.0496	0.1177	0.2105	0.6491	0.1298
Slope	0.1241	0.3333	0.0496	0.0588	0.1053	0.6711	0.1342
Total							1.00

Source: Author's Computation, 2021

Assigning Weight for the Contents of each of the Factor to produce Flood vulnerability map

It would be so biased to conclude that all content of flood influencing factors maintained the same rank. Hence, each of the factor contents was ranked and assigned value according to their weight and level of importance for the final output of the flood vulnerability map. The contents were ranked and the value assigned to determine the weight for each of those contents and average weighted score for the factors were used to produce a flood vulnerability map of Eti-Osa Local Government Area.

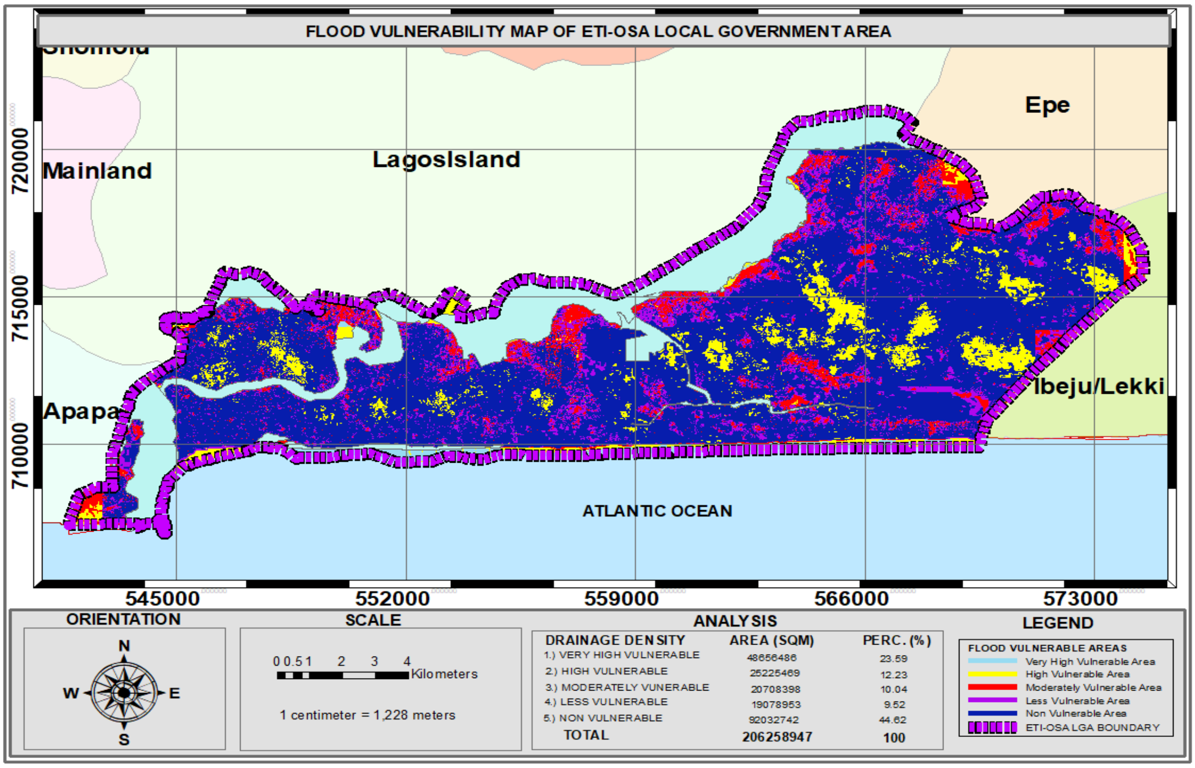
Table 4: Assigning Weight for the Contents of Each of the Factor to Produce Flood Vulnerability Map

Factors	Weight (100%)	Rank	Over All
	Elevation		
Very High		5	171.10
High		4	136.88
Medium		3	102.66
Low	34.22	2	68.44
Very Low		1	34.22
	Soil		
Sandy Soil		5	94.30
Loamy Soil	18.86	3	56.58
Clay Soil		1	18.86
	Drainage Density		
Very High		1	20.53
High		2	41.06
Medium		3	61.59
Low	20.53	4	82.12
Very Low		5	102.65
	Land Use Land Cover		
Built-Up Area		5	64.90
Underdeveloped Area		4	51.92
Water Bodies		5	64.90
Vegetation	12.98	4	51.92
Land		3	12.98
Road		4	51.92
	Slope		
High	13.42	2	26.84
Low		1	13.42

Source: Author's Computation, 2021

Flood Vulnerability Map of Eti-Osa Local Government Area

After determining the overall weights for each of the content of flood influencing factors, the overall weighted value was assigned for each of those contents on the ArcGIS 10.5 platform was used to produce a final flood vulnerability raster map which were then converted to polygonal features for analyses purposes. The flood vulnerability map was created in five different zones or areas i.e. (very highly vulnerable, highly vulnerable area, moderately vulnerable area, less vulnerable area, and non-vulnerable area. The difference in the area was the alteration of the elevation ranges in each of the areas, flood vulnerability map shows a more précised illustration to reality giving that flood vulnerability factors were critically considered for mapping.



Source: United State Geological Survey (USGS Earth Explorer), 2021

Figure 9: Flood Vulnerability Map of Eti-Osa Local Government Area

Table 5:Percentage of Flood Vulnerable Zones

Zone	Area Covered (km^2)	Percentage (%)
Very Highly Vulnerable	48.66	23.59
Highly Vulnerable	25.23	12.23
Moderately Vulnerable	20.71	10.04
Less Vulnerable	19.08	9.52
Non-Vulnerable	92.03	44.62

Source: Author's Findings, 2021

The result (*Table 5 refers*) indicated that 48.66km2 (23.59%) of the study area falls into the very highly vulnerable to flood category while about 25.23 km2 (12.23%) lies within the highly vulnerable zone. The very highly vulnerable zone lies mostly in the very low land of Langbasa, Oke-Iranla, Badore, Okun Ajah, Ijeh, Okun alfa, Maroko, Ikota, etc also close to the banks of Lagos Lagoon and Some Creeks. More so, due to the land use/land cover along this area, soil, and topography of the area, it is most liable to flooding once it's raining. The Highly vulnerable areas lie in the low land of Lekki, Agungi, Alaguntan, Chevron, Peninsula II, Abraham Adesanya, Ogombo. Flood is often experienced in these areas in the period of heavy rainfall i.e. (August to November), This is always a problem because of the number of Creeks populated in the area, low terrain of the land, and very low degree of slope in those areas. About 10.04 km2 lies moderately vulnerable zones, moderate not because the effect of the flood is not usually felt but because when it is experienced, no much time for it to be departed. As indicated also with the flood vulnerable map, some areas Eleganza, Maruwa, Olokonla, VGC, etc, are areas non-floodable due to their high elevation, good natural drainage, and soil type. It was observed during the study that incessant floods in these areas "mostly very highly, highly and moderately vulnerable zones" may cause destruction and demolition of some not structurally balanced structures which would amount to economic loss. More so, it is most worthy to note that Flood inundation in this study area causes loss of lives, economic loss, and causes water-related diseases, etc.

Possible Effects of Flood on Land-Use in the Flood-Prone Area

This section deals with the possible effects of the flood on land use in the study area. The questions formulated reflect the views of the surveyed respondents based on their flooding experience in the study area.

Flood Experience

Information on floods as experienced in the study area is depicted in Table 6 It revealed that 150(86.2%) of the respondents claimed they had experienced flooding. Few, 18(10.3%) claimed they have not experienced flooding. The insight to be gleaned from this finding is that those who experienced flood maybe those who have been living in the study area for a very long time while those that have not experienced flood may be those who just moved to the study area. The table also revealed that 97(54.8%) of the surveyed respondents claimed they often experience flooding, 67(37.5%) claimed their experience flooding is not often and 10(4.6%) claimed their experience of flooding is very often.

Flood Experience	**Frequency**	**Percentage**
Experienced	150	86.2
Experienced Not	18	10.3
Neutral	6	3.4
Total	174	100
Frequency of Experience	**Frequency**	**Percentage**
Very Often	10	4.6
Often	97	54.8
Not Often	67	37..5
Total	**174**	**100.0**

Table 6: Flooding as Experienced by Respondents

Source: Field Work, 2021

Effects of Flooding

The surveyed respondents were of different views concerning the effects of flooding in the study area. As depicted in Table 7, more than half of the surveyed respondents 110(63.2%) opined that the effects of flood led to the destruction of properties in the study area, 35 (20.1%) opined that it led to displacement 10(5.7%) opined that it led to disease, and 10(5.7%) opined that it led to land dereliction.

There exists a variation in the stance of the surveyed respondents concerning the effects of the flood on building and infrastructure. As contained in Table 7, it was shown that more than two-third 123(70.6%) of the interviewed respondents agreed that flood had effects on building and infrastructure, 29(16.6%) were neutral, 13(7.5%) strongly disagreed, 5(2.8%) disagreed, and 3(1.7%) strongly disagreed. The respondents' opinion on the effects of the flood on economic and human activities indicated that close to two-thirds 109(62.6%) of them agreed that floodaffected economic and human activities, 31(17.8%) strongly agreed, 24(13.8%) were neutral, 5(2.9%) disagreed, and 3(1.7%) strongly disagreed.

Table 7: Effects of Flooding

Effects of Flooding	**Frequency**	**Percent**
Destruction of Properties	110	63.2
Disease	10	5.7
Displacement	35	20.1
Land Dereliction	10	5.7
No Response	3	1.7
Total	**174**	**100**
Effect of Flood on Building and Infrastructure	**Frequency**	**Percent**
Agree	123	70.6
Disagree	5	2.9
Neutral	29	16.6
Strongly Agree	13	7.5
Strongly disagree	3	1.7
No Response	1	1
Total	**174**	**100**
Effects of Flood on Economic and Human Activities	**Frequency**	**Percent**
Agree	109	62.6
Disagree	5	2.9
Neutral	24	13.8

Strongly Agree	31	17.8
Strongly disagree	3	1.7
No Response	2	1.1
Total	174	100

Source: Field Work, 2021

Compliance Level of Building Activities to Planning Standards and Regulations
This section focuses on the compliance level of building activities in the study area to planning standards and regulations.

Building Type

Although there is a variety of building typologies in the study area**,** the finding reveals that the majority 101(58%) of the respondents opined that the dominant building type in the study area was bungalow (Table 7). Conversely, 41(23.6%) of the respondents' said duplex was the dominant building type in the study area, 28(16.1%) claimed storey building was the dominant building type, and 1(0.6%) claimed it was shopping complex. More than two-third 148 (85%) of the respondents claimed that buildings in the study area are used for residential purposes, 23(13.2%) claimed they were used for commercial purposes, and 2(1.1%) claimed they were used for administrative purposes. Findings indicate that more than half 100 (57.5%) of the surveyed respondents said the age of their building is between 11 and 20yrs, 44(25.3%) said it is between 21 and 30yrs, 22 (12.6%) said it is less than 10yrs, 6(3.4%) said it is between 31 and 40yrs, and 1(0.6%) said it is 40yrs and above. As displayed in Table 7, it was discovered that 146(84.0%) of the respondents claimed they got the building permit approval from the planning authority while 24(13.8%) claimed they did not get building permit approval from the planning authority.

Table 8: Building Type

Type	**Frequency**	**Percent**
Bungalow	101	8
Duplex	41	23.6
Shopping complex	1	0.6
Storey Building	28	16.1
Building Use	**Frequency**	**Percentage**
Administrative	2	1.1
Commercial	23	13.2
Residential	148	85.7
Building Age	**Frequency**	**Percentage**
Less than 10yrs	22	12.6
Above 40yrs	1	0.6
31-40	6	3.4
21-30	44	25.3
11-20	100	57.5
Building permit approval	**Frequency**	**Percentage**
Approved	146	84.0
Not Approved	24	13.8
Neutral	4	2.3

Source: Field Work, 2021

V. SUMMARY OF FINDINGS

Floodplain Areas and the Extent of Spatial Development in the Floodplain Areas

The result indicated that 23.59 km2, 12.23 km2, and 10.04 km2 of land falls under very highly vulnerable, highly vulnerable, and moderate vulnerable to flood respectively in the study area. It means about 45.86% of land in the study area is prone to flooding. The very highly vulnerable zone lies majorly in the very low land of Langbasa, Oke-Iranla, Badore, Okun Ajah, Ijeh, Okun alfa, Maroko, Ikota. These locations are also close to the banks of Lagos Lagoon and Some Creeks. More so, the land use/land cover along this area, the soil, and the topography make it most liable to flooding once it's raining. The Highly vulnerable areas lie in the low land of Lekki, Agungi, Alaguntan, Chevron, Peninsula II, Abraham Adesanya, Ogombo 2, etc. Flood is usually experienced in these areas when there is heavy rainfall. The period of heavy rain (August to November) is always a problem because of the number of creeks in the area, low land terrain, and very low degree of slope in those areas.

Possible Effects of Flood on Land-Use in the Flood-Prone Areas

Findings revealed that the majority of the respondents claimed they had experienced flooding in their area. The study also distinguishes that most of the surveyed respondents claimed they often experience flooding. More than two-thirds of the surveyed respondents attributed the cause of floods to climate change. More than half of the surveyed respondents opined that the drainage system is available, the condition of which most them opined was poor. More than half of the surveyed respondents opined that the effects of flood led to the destruction of properties in the study area. Furthermore, over two-thirds of the respondents agreed that floods had effects on building and infrastructure.

Compliance Level of Building Activities to Planning Standards and Regulations

Although there is a variety of building typologies in the study area**,** the finding reveals that the dominant building type was bungalow and are used for residential purposes. Findings indicate that more than half of the surveyed respondents reasoned that the age of their buildings is between 11 and 20yrs. The tenurial status of the surveyed respondents showed that most of the respondents were tenants. It was discovered that most of the respondents claimed they got the building permit approval from the planning authority. Gaining approval before building construction is critically important, however, findings revealed that the majority of the respondents got planning approval during the construction process. Less than one-third of the surveyed respondents were skeptical about site inspection by town planners when their buildings are under construction. Although the residents live in flood-prone areas, they live in proximity to different water bodies. The study observed that most of the respondents live in proximity to Lagoon.

Building setbacks are a necessity for safety, privacy, and environmental protection. Most of the interviewed respondents said that the setbacks from their houses to the waterbody are above 51m. The low-risk awareness of the residents living in flood-prone areas is often highlighted among the principal causes of their low preparedness, which sequentially generates an inadequate response to natural disasters. Findings revealed that a significant percentage of the respondents were unaware of the flood before its occurrence. The situation of flood occurrence according to the views of the respondents is bad. While the occurrence of flood makes affected people vacate their residences to secure places, finding shows that a sizeable percentage of the respondents did not vacate their residences. It is common for the occurrence of floods to lead to the loss of lives and properties. While it is conventional, findings revealed that most of the respondents claimed that flood occurrence had led to the loss of lives and properties.

Floods lead to tremendous losses of property, infrastructure, business, increased risk of diseases etc. More than two-thirds of the respondents opined that the kind of flood experienced is the damage of property. Regarding public education on the control and mitigation of flooding, findings indicate that a significant percentage of the interviewed respondents have had public education on flooding.

VI. CONCLUSION AND RECOMMENDATION

Due to the effects of floods, there is a need to look for ways to mitigate them. Some strategies must be developed and evaluated to deal with the problems. Hence, the following recommendations are made to tackle the problem of flood and for further studies:

Urbanization is a principal reason people build in flood-prone areas, to the point that some people have to go the extra miles to purchase swampy land and sand-fill it. This contributes to the extent of physical developmental projects in flood-prone areas. And as such no specific agency is saddle with the responsibility of monitoring spatial development in Lagos State. Even though people could build in flood-prone areas, they must be prepared to build by following laid down procedures given by such an agency. However, this study recommends the establishment of multi-disciplinary flood-prone monitoring and Management Agency (MDMMA) or Multi-Disciplinary Hydrological Agency (MDHA) in the study area and all other parts of the state. For the most part, the agency should be equipped with GIS, Urban Planners, Meteorologists, Structural Engineers, Hydraulic Engineers, Quantity Surveyors, etc. GIS analysts need to be furnished with the necessary tools to produce a flood simulation model. There is need also to develop a robust GIS web application and mobile application that people can access and see the propensity of the flood before its occurrence using rainfall data forecasted by meteorologists. Urban planners should be charged with the duty of developing a flood-prone area developmental plan that would give a guide to road construction, drainage construction, and the type of foundation for the building to be constructed in those areas. More importantly,for the most part, charting should be mandated for any developer seeking planning approval to know if the land is in a prone area or not. If the land is in a prone area, a flood-prone area development plan becomes a relevant tool for proper guidance.

So far, the main effect of flooding is experienced by people living in very low terrain and along the coastal line. And its causes cannot be either eradicated or avoided but can be minimized. This study recommends the construction of revetments were necessary along the coastline. Moreover, the study discovered there is no well functional internal displaced persons camp for less privileged people who got displaced by flood incidents in the study area. The study recommends the development of well-functional IDP camps by the Government at a good location

According to the findings, the majority of the residents have planning permits from the district planning authority even though most of them acquired them during the construction which shows they collected the planning permit after the planning authority would have served notice of "stop work order". The study recommends the need for proactive approach from the part of government that will make development without prior planning approval unnecessary and undesirable.

REFERENCES

[1]. Adelekan, I. O. (2015). Flood risk management in the coastal city of Lagos, Nigeria. J Flood Risk Management, 9(2016), 255–264. http://dx.doi.org/10.1111/jfr3.12179

[2]. Adeoye, N. O., Ayanlade, A., & Babatimehin, O. (2009). Climate change and menace of floods in Nigerian Cities: Socio-economic implications. Advances in Natural and Applied Sciences, 3(3), 369-377. http://dx.doi.org/10.12691/jgg-5-5-2

[3]. Alaghmand, S., Bin-Abdullah, R., Abustan, I., & Vosoogh, B. (2010). GIS-based river flood vulnerability mapping in urban area: a case study in KayuAra river basin, Malaysia. International Journal of Engineering Technology, 2(6), 488–500.

[4]. Burningham, K., Fielding, J., & Thrush, D. (2008). "It'll never happen to me": understanding public

[5]. awareness of local flood risk. Disasters, 32(2), 216–238. https://doi.org/10.1111/j.1467- 7717.2007.01036.x

[6]. Calvert, k., Pearce, J. M., & Mabee, W. E. (2013). Application of GI Science and remote sensing that can build institutional capacity: toward renewable energy geo-information infrastructure. Renewable and Sustainable Energy Reviews, 18(C), 416-429. https://doi.org/10.1016/J.RSER.2012.10.024

[7]. Demeritt, D., Nobert, S., & Buchecker, M. (2011). Models of "good" risk communication for flooding and other water related hazards: a critical review, Report for WP5 od KULTURisk, EN. V.2010.1.3.2. http://www.kulturisk.eu/

[8]. Clark, K. C. (1986). Advances in geographic information systems. Computers, Environment and Urban Systems,10(3-4), 175 – 184. https://doi.org/10.1016/0198-9715(86)90006-2

[9]. Dinh, N.Q., Balica, S., Popescu, I., & Jonoski, A. (2012). Climate change impact on flood hazard, vulnerability and risk of the Long Xuyen Quadrangle in the Mekong Delta. International Journal of River Basin Management, 10(1), 103-120. https://doi.org/10.1080/15715124.2012.663383

[10]. Edwards J., Martin G., & Näslund-Landenmark, B. (2007). Handbook for vulnerability mapping. EU Asia Pro Eco project, disaster reduction through awareness, preparedness and prevention mechanisms in coastal settlements in Asia, demonstration in tourism destinations (pp.1-18).

[11]. Environment Agency (2009). Desktop review of 2D hydraulic modelling packages. Environment Agency, Bristol. Flood risk management. Http

[12]. Etuonovbe, A. K. (2011). The devastating effect of flooding in Nigeria. Paper presented at FIG Working Week. Bridging the gap between Cultures, Marrakech, Morocco, 18-22 May 2011.

[13]. European Parliament Council (2007). Directive 2007/60/EC of the European Parliament and of the Council of 23 October on the Assessment and Management of Flood Risks. Journal of the European Union, 288, 27 – 34. http://ec.europa.eu/environment/water/floodrisk/index

[14]. Evans, S.Y., Gunn, N., & Williams, D. (2007). Use of GIS in flood risk mapping. Environment Agency, Orchard House Endeavour Park, London Road, Addington, Kent.

[15]. Heywood, I., Cornelius, S., & Carver, S. (2006). An introduction to geographical information systems. (3rd edition). Essex, Prentice Hall.

[16]. Höppner, C., Buchecker, M., & Frick, J. (2000). What drives people's willingness to discuss local landscape development? Lands Res, 33, 605-622. https://doi.org/10.1080/0142639082013549

[17]. Ijigah, E. A., & Akinyemi, A. T. (2015). Flood disaster: an empirical survey of causative factors and preventive measures in Kaduna, Nigeria. International Journal of Environment and Pollution Research, 3(3), 53-66

[18]. Ishaya S., Ifatimehin, O.O., & Abaje, I.B. (2009). Mapping flood vulnerable areas in a developing urban centre of Nigeria. J. Sust. Dev. Afr, 11(4), 180-194.

[19]. Izinyon, O. & Ehiorobo, J. (2011). Measurements and documentation for flood and erosion monitoring and control in the Niger Delta states of Nigeria, Engineering Survey, Marrakech, Morocco 18- 22 May 2011.

[20]. Jeb, D. N. & Aggarwal, S. P. (2008). Flood inundation hazard modeling of the River Kaduna using remote sensing and geographic information systems. Journal of applied sciences research, 4(12), 1822-1833.

[21]. Jha, A., Watkins, S. C., & Traub, L. M. (2012). Maximum flood prone area mapping using RADARSAT images and geographic information system: A case study of Kelantan River Basin. International Journal of Geoinformatics, 5(2), 11 – 23.

[22]. Jonkman, S. N. & Dawson, R.J. (2012). Issues and challenges in flood risk management. Editorial for the Special Issue on Flood Risk Management, 4, 785–792. https://doi.org/10.3390/w4040785

[23]. Kenneth, E. F. & Margaret, L. (2015). Geographic information system as an integrating technology: Context, concepts and definitions. The Geographer's Craft Project, Department of Geography. The University of Colorado at Boulder.

[24]. Khan, S. I., Hong, Y., Wang, J., Yilmaz, K. K., Gourley, J. J., Adler, R.F., & Irwin, D. (2011). Satellite remote sensing and hydrologic modelling for flood inundation mapping in Lake Victoria basin: Implications for hydrologic prediction in ungagged basins. IEEE Transportation Geoscience Remote Sensing, 49(1), 85–95. http://doi.org/10.1109/tgrs.2010.2057513

[25]. Krasovskaia, I., Gottschalk, L., Skiple Ibrekk, A., & Berg, H. (2007). Perceptionof flood hazard in countries of the North Sea region ofEurope, Nord. Hydrol., 38, 387–399. http://doi.org/10.2166/nh.2007.019

[26]. Lagos State Environmental Protection Agency [LASEPA] (2019). Flood Vulnerability Assessment and Mapping of Lagos State using GIS Techniques

[27]. Merz, B., Hall. J., Disse. M., & Schumann. A. (2010). Fluvial flood risk management in a changing world. Natural Hazards and Earth System Science, 10(3), 509-527. http://doi.org/10.5194/nhess-10-509-2010

[28]. Mmom, P. C. & Ayakpo, A. (2014). Spatial analysis of flood vulnerability levels in Sagbama Local Government Area using geographic information systems (GIS). International Journal of Research in Environmental Studies, 1(2014), 1-8. http://dx.doi.org/10.13140/RG.2.2.21791.41128

[29]. National Population Commission (2006). National Population Census figure 2006.

[30]. Olayinka, D.N. & Irivbogbe, H.E. (2017). Flood modelling and risk assessment of Lagos Island and part of Eti-Osa Local Government Areas in Lagos state. Journal of Civil and Environmental Systems Engineering – UNIBEN, 15(1), 106- 121

[31]. The Office of Public Works [OPW] (2009). The planning system and flood risk management; guidelines for Planning Authorities (pp.1-40). http://www.flooding.ie/en/Planningguidelines.

[32]. Oyinloye, M.A., Ajayi. G.G., Olanibi. J.A., (2016). Assessment of shoreline changes on Victoria Island in Eti-Osa Local Government Area, Lagos State, Nigeria. Journal of Earth Sciences and Geotechnical Engineering, (6)1, 47-62.

[33]. Pelling, M. & Blackburn, S. (2013). Megacities and the coast: risk, resilience and transformation (pp.1-245). Oxon: Routledge.

[34]. Prinos, P. (2008). Review of flood hazard mapping. Hazard Mapping, 4(1),1-54). http://www.Floodsite.net/html/partner-area/project=docs/T030701

[35]. Saaty, T.L., (2008). Decision making with the analytic hierarchy process. International Journal Services Sciences, 1(1), 83–98.

[36]. Tobin G.A. (1995). The Leve love affair: a stormy relationship. Water Resource Bull, 31(4), 359-367

[37]. Ugoyibo. O.V., Enyinnaya. O.C., & Souleman. L. (2017). Spatial assessment of flood vulnerability in Anambra East Local Government Area, Nigeria using GIS and remote sensing. British Journal of Applied Science & Technology, 19(5), 1-11. https://doi.org/10.9734/BJAST/2017/29378

[38]. Veland, H. & Aven, T. (2013). Risk communication in the light of different risk perspectives. Reliability engineering and system safety, 110(C), 34–40. http://doi.org/10.1016/j.ress.2012.09.007

[39]. Wahab, B. & Ojolowo, S. (2018). Drivers and spatial extent of urban development in flood- prone areas in metropolitan Lagos. Journal of Sustainable Development; 11(2), 98-111. http://dx.doi.org/10.5539/jsd.v11n2p98