Drivers and Spatial extent of Urban Development in Flood-prone Areas in Metropolitan Lagos

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Abstract

Urban development in flood-prone areas has created many environmental challenges in many cities in Nigeria. This survey-based study examined the drivers and spatial extent of development in floodplains in metropolitan Lagos. A total of 1,031 (7.2%) buildings out of 14,273 were systematically selected along 211 streets out of 1,403 prone to flood, and a structured questionnaire was administered to heads of households to determine the factors influencing development in floodplains. A Thematic Mapper of 1990, Enhanced Thematic Mapper of 2000 and the Google Earth Landsat of 2014 were also analysed in ILWIS 3.3 Academic and Arc-GIs 10.2 to determine the extent of development in floodplains. The study revealed, in order of significance, closeness to place of work, nearness to market, closeness to children's schools, low rent, low income, and family affinity as factors that influenced the development in floodplains in the Lagos metropolis. Ineffective control of development and inadequate compliance with planning and building regulations were additional factors. Urban development in flood-prone areas in Lagos increased from 9.3 km^2 in 1990 to 10.50 km^2 in 2000 and 17.80 km^2 in 2014. The study recommends that floodplains should be acquired and effectively protected to prevent any form of physical development; they should serve as natural sink for storm water and urban green for passive recreation. Urban development regulations should be strictly enforced by the relevant government agencies, such as the Lagos State Building Control Agency in the Ministry of Physical Planning and Urban Development.

Keywords: drivers, urban development, floodplains, Lagos metropolis

1. Introduction

It is estimated that the urban population will rise from 3.57 billion in 2010 to 6.34 billion in 2050, with almost 70 per cent of the world population is expected to live in cities (United Nations, 2014). This growth is as a result of migration from rural to urban areas in search of better quality of life generated by urban activities and services (Deng, Wang, Hong, & Qi, 2009). The increasing population of urban dwellers is one of the causes and indicators of urban development. Urban development is the development or improvement of an urban area in terms of number of building constructions (*Collins English Dictionary*, 2014). It occurs by expansion into unpopulated areas and/or the renovation of decaying regions (Brooks, 2014). For most cities, the transformation of land use is required to meet the needs of life and economic development (Hsiang-Leng, Hsing-Fu, & Ko-Wan, 2013). However, lack of or inadequate implementation of urban development policies and regulations has led to the indiscriminate development of buildings (such as residential, industrial, recreational, commercial, religious, public and semi-public) in floodplains without recourse to urban development regulations. Development in floodplains is one of the causes of flooding in coastal cities. Flood usually occurs when a river or lagoon spills its excess water over the banks and runs into adjoining low-lying lands (Ijigah & Akinyemi, 2015).

The severity of the impact of flood is compounded by sea level rise, rapid population growth, urbanization and increased rainfall intensity and frequency related to alterations in climate distribution (Nkwunonwo, 2017). As the coastal cities of Africa expand, many of their residents are pushed to the edges of available land space and

some into the most hazardous zones (Boamah *et al*., 2015). Concentration of human population in urban settlements, without considering salient and relevant ecological factors aggravates flooding. Construction of buildings restricts runoffs, by covering large parts of the ground with roofs, roads and pavements, and obstructing sections of natural channels and drains that ensure that water moves to rivers faster than it does under natural conditions (Action Aid, 2006). Oni (2003) asserts that, when rainfall intensity exceeds the infiltration capacity of the soil, excess water is generated. The impervious human-made surfaces that make up the urban fabric ensure that little of the falling rain infiltrates into the ground (Ayoade, 2006). When it rains, some of the water is supposed to be retained in ponds or soil, by grass and vegetation, while the rest travels over the land as surface runoff. The removal of these water-retaining features, owing to urban development, increases impermeable surfaces that facilitate excessive runoff, causing siltation and blockage of hydraulic facilities, which eventually leads to flooding.

From 2010 to 2015, 57 disastrous flood events were recorded in West Africa with 1,169 fatalities Africa (Ouikotan, *et al.*, 2017). From the early 1970s and possibly to date, floods have been responsible for building collapse, destroying property, and affecting more than 300,000 people in Lagos (Etuonovbe, 2011). Akanni and Bilesanmi (2011) report how a Lagos flood forced communities in Lagos to relocate because of heavy torrential downpour of 7th and 8th of July, 2011. Yet, residents continue to develop and live in flood-prone areas. So the areas are experiencing continuous flooding like that of July, 2017, which ravaged high-brow areas of Ikoyi, Lekki and Victoria Island. Previous studies (Taiwo, 2009; Etuonovbe, 2011; Adelekan, 2012; Aderogba, 2012) examined the overall spatial development of Lagos, without providing information about the characteristics of structures and factors influencing development within floodplains. This prompted the search for possible drivers, and also the spatial extent of development within floodplains in metropolitan Lagos, with a view to identifying sustainable solutions.

2. Locational, Demographic and Spatial Traits of Lagos State

Lagos State was created on May 27, 1967 when Nigeria was restructured into 12 states. Before this period, Lagos municipality was under the administration of the Federal Government, through the Federal Ministry of Lagos Affairs, as the regional authority. The city of Lagos was then under the Lagos City Council. The regions of Ikeja, Agege, Mushin, Ikorodu were under the former Western Region. Lagos State lies approximately between longitude $2^0$42'E and $3^0$42'E and latitude $6^0$22'N and $6^0$52'N. The state is located on the south-western part of Nigeria, with the southern boundary of the state framed by about 180 kilometres of stretch of land along the Atlantic coastline, while the northern and eastern boundaries are framed by Ogun State. Republic of Benin formed the western boundary. The state is the smallest state in Nigeria in land area, covering about 358,861 hectares or 3577sq.km (Odumosu, 1999). This represents only 0.4% of the entire area of the country. The state is also the most urbanised in Nigeria (UN-HABITAT, 2015). Only about 5.0% of the state total population is of rural areas. This has serious consequences on land use planning in the state, especially in urban areas, where residents continue to build on floodplains. The implications and consequences of this practice manifest in incessant environmental challenges, such as flooding, coastal erosion, improper waste management, insufficient storm drainage, housing collapse and land subsidence.

The Lagos metropolis had about 25,000 people in 1866 (Ayeni, 1981). The population grew to 40,000 in 1901 owing to the arrival of earlier refugees from slavery and war in the interior, freed slaves from Brazil, and later colonial administrators and traders who settled in the port. It reached 74,000 by 1911; and by 1963, it was 665,000 (Abiodun, 1997). The provisional results of the 1991 and 2006 population censuses gave the Lagos metropolis a population of 5,294,774 million (or 93.0% of the total population of Lagos State) and 8,048,430 million, respectively (NPC, 1991; 2006). According to United Nations Department of Economic and Social Affairs, Population Division (2006), the population of Lagos State was 1.9 million in 1975; 8.4 million in the year 2000; 10.9 million in 2005; and 16.1 million in 2006. It projected the population to 20,662,902 and 21,324,114 in 2014 and 2015, respectively. Spatially, while the metropolis occupies 1,171.28 km^2 only about 0.4% of the Nigerian land area, it harbours 6.43% of the nation's population. Also, while it occupies 40.0% of the land area of Lagos State, about 91.5% of the population of the state resides in it (The Lagos State Government, 2014). Metropolitan Lagos is located in a lowland, and about 220.6 km^2 (23.2%) of the metropolis is made up of water bodies, wetlands and mangrove swamps (Lagos State Government, 2014). These traits have exposed the population and assets to the risks of flooding in Lagos City.

Spatially, Lagos City grew from a traditional core settlement of about 3.85 km^2 in 1881to 46.6 km^2 in 1911 (Okude & Ademiluyi, 2006). The city covered 52.3 km^2 in 1921, 66.3 km^2 in 1931, and 69.9 km^2 in 1952 (Abiodun, 1997). By 1984, Lagos City had engulfed neighbouring towns and villages, and metropolitan Lagos encompassed about 85.44 km^2 in 1986, 96.53 km^2 in 1990 (Abiodun, 1997), and 950.72 km^2 in 2006 (NPC, 2010;

Lagos State Government, 2014). The spatial growth of Lagos State from 1984 to 2010 is presented in Figure 1 (Adelekan, 2012).
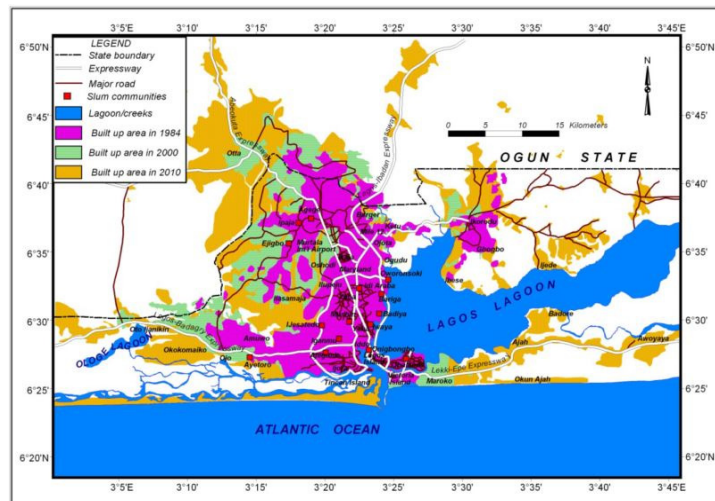

Figure 1. Urban development (1984-2010) in Lagos State

Source: Adelekan (2012)

3. Methodology

Primary and secondary data were employed to analyse the factors responsible for continual development and the extent of spatial development in flood-prone areas in metropolitan Lagos. Cross-sectional survey research approaches were adopted to obtain primary data sourced through the use of a structured questionnaire and physical observations. The questionnaire covered socio-economic and demographic characteristics of households, housing characteristics and reasons for building in flood-prone areas. The simple random technique was employed to select 211 of the 1,403 streets prone to flooding in the Lagos metropolis (Table 1). Yamane's (1967) model with the desired level of precision of 0.03 was used to calculate the number of sampled buildings, 1,031 (7.2%) out of 14,273 buildings found in the study area. The systematic random sampling technique was used to select the 1,031 buildings where a structured questionnaire was administered to heads of households. Out of the 1,031 copies of the questionnaire administered, only 1,025 were adequate for analysis.

Table 1. Sample frame and size

S/No.	LGAs	*No. of streets	*No. of streets prone to flooding	*No. of selected streets prone to flooding	*No. of houses on selected streets	**No. of houses sampled
1	Agege	1095	196	14	587	42
2	Ajeromi-Ifelodun	391	70	11	620	45
3	Alimosho	890	159	13	1121	81
4	Amuwo-Odofin	119	21	10	860	62
5	Apapa	191	34	14	656	47
6	Eti-Osa	275	49	13	582	42
7	Ifako-Ijaye	133	24	17	994	72
8	Ikeja	419	75	13	525	38
9	Kosofe	181	32	10	528	38
10	Lagos Island	279	50	10	676	49
11	Lagos Mainland	301	54	14	813	59
12	Mushin	719	129	17	691	50
13	Ojo	242	43	10	4177	302
14	Oshodi-Isolo	1054	187	17	381	28
15	Shomolu	1065	190	17	601	43
16	Surulere	503	90	11	461	33
	Total	7857	1403	*211	*14,273	**1,031

Source: *Drainage Department, Lagos State Ministry of Environment, Alausa Ikeja   **Authors

The starting point was randomly selected by using the table of random numbers. To determine the sampling interval, the number to be sampled was divided by the number of houses in each street. The primary data obtained were analyzed with descriptive statistical models, while frequencies and percentages were used to present the data. Ethical issues were given due consideration, with regard to the purpose of the study, contents of the research instrument, acceptance of respondents' right to privacy, and confidentiality of the data; and the informed consent and willingness of the respondents to answer questions was obtained.

To analyse development in floodplain in the Lagos metropolis, three sets of images were used for this study: the Thematic Mapper of 1990, Enhanced Thematic Mapper of 2000 and the Google Earth Landsat of 2014. The images of 1990 and 2000 were downloaded from two different paths and rows (p190r056 and p191r055). The properties of the images are shown in Table 2. Bands 4,3,2, were used to form the false colour composite for this study. In these bands combination (4,3,2) vegetation appeared in shades of red, urban areas in cyan blue and water surfaces appeared in blue. The images from the two different paths and rows (p190r056 and 191r055) were glued using the "Glue Raster Map Tool" on the operation list of ILWIS Academic 3.3 and the Area of interest (the Lagos metropolis) was "clipped out" using the X,Y Coordinates on the top right corner and X,Y Coordinates on the lower left corner. This task was also performed on ILWIS 3.3 Academic. The image of 2014 was downloaded on Google Application. Segments for water body, built-up area and vegetation were created on these images and each of these features (water body, vegetation and built-up area) was digitized on ILWIS 3.3 Academic. After the digitization of these features, their "segments" were polygonized so as to determine the area coverage of each of these features.

To ascertain the built-up area vulnerable to flooding, all the polygonized features were exported from ILWIS 3.3 Academic to Arc-GIs 10.2 software. A buffer of 50 metres (the designated setback for canals/lagoon) was created along the water ways. This operation was executed using the "Analysis Tool" on "Arc toolbox" and the option of proximity was selected. The built-up areas that fell within the buffer area were digitized, and areas of the vulnerable development were calculated.

Table 2. Properties of images

S/No.	Image Year	Path and Row	Sensor
1	1990	P190 R056 and P191 R055	TM
2	2000	P190 R056 and P191 R055	ETM$^+$
3	2014	------	Google Earth

4. Results and Discussions

4.1 Gender, Age Structure, Marital Status and Household Size of the Respondents

Sixty-three per cent of the respondents were males, while 36.6% were females. The classification of age, as presented in Table 3, showed that 68.4% of the respondents were in the age group 30-39 years, 16.4% were 40-49 years, 4.1% were 50-59 years, 7.6% were 20-29 years, while 3.5% were 60 years and above. This implies that the majority (84.9%) of the people inhabiting the sampled flood-prone areas were within the age bracket 30-49 years, who were assumed to be contributing significantly to continuous development of flood-prone areas owing to their increasing demand for housing and associated infrastructure. The majority of the respondents (87.4%) were married. The high percentage of married residents implies that the population of residents in flood-prone communities will continue to rise through birth and migration (couples attract more squatting families), leading to increasing demand for and construction of houses in more fragile parts of wetlands in the face of laxity in development control. On the size of households, the majority (72.0%) had 3-6 members, 11.3% had more than 10, 9.7% had 7-9 members, while 7.0% had 1-2 members. By implication, the size of the households facilitated the trampling of the floodplains and subsequent hardened land surface made infiltration of water difficult and led to excessive surface runoff and then caused flooding.

4.2 Educational Status, Occupation and Income Distribution

The educational status of the respondents reflected the metropolitan nature of Lagos State, as all of them attended school. While 1.0% of the respondents indicated that they had primary school education, 71.9% had secondary school, and 27.1% had tertiary education, as shown in Table 3. These qualifications are expected to facilitate their knowledge and understanding of the implications of all forms of development in flood-plains and

wetlands in their communities.

The various occupations indicated by the respondents are also presented in Table 3. The study revealed that 39.5% were traders, 34.1% were artisans, while 15.3% were civil servants. About 4.8% engaged in farming, 3.0% mined sand, 1.4% engaged in fishing, 0.9% were retirees, while 1.0% were commercial bus-drivers. This indicates that the majority (84.7%) of the inhabitants of the flood-prone areas were in the informal sector of the economy. More than half (51.4%) earned ₦18,000 and below monthly, 16.8% earned ₦40,000-₦59,000; 15.2% earned ₦80,000-₦99,000, 11.7% earned ₦20,000-₦39,000, 3.7% earned ₦100,000 and above, while 1.2% earned ₦60,000-₦79,000 per month. This information showed that the majority (51.4%) of the people living in flood-prone areas earned below the national minimum wage of ₦18, 000 per month (at the time of survey).

Table 3. Socio-economic and demographic characteristics of the respondents

Socio-economic variables	Number of respondents	Percentage
Highest Educational Status		
Primary	10	1.0
Secondary	737	71.9
Tertiary	278	27.1
Total	**1025**	**100.0**
Occupation		
Trading	405	39.5
Fishing	14	1.4
Farming	49	4.8
Sand mining	31	3.0
Civil service	157	15.3
Artisan	350	34.1
Retiree	9	0.9
Commercial Bus Driving	10	1.0
Total	**1025**	**100.0**
Income range per month		
< ₦ 18,000	527	51.4
₦ 19,000 - ₦ 39,000	120	11.7
₦ 40,000 - ₦ 59,000	172	16.8
₦ 60,000 - ₦ 79,000	12	1.2
₦ 80,000 - ₦ 99,000	156	15.2
₦ 100,000 & Above	38	3.7
Total	**1025**	**100.0**

4.3 Residential Tenure and Structural Condition of Buildings

The level of income of the respondents was reflected in the totality of their environment, particularly in the types of materials used for constructing houses, household facilities, and general conditions of the compounds. Of the respondents presented in Table 4, 23.7% owned the buildings, 69.4% were tenants, while 6.9% were living with relations. The majority (60.6%) of the buildings were Brazilian bungalows (90.9%), followed by Brazilian storey (17.2%); detached self-contained bungalows (11.3%) and block of flats (10.9%). The building types reported reflected the findings on household size and number of rooms. The buildings with 5-10 rooms were 71.4%; 10.4% had 11-15 rooms; while those with less than 5 rooms were 10.8%; and only 7.4% had 16-20 rooms (Table 5).

Information obtained about the age of the buildings indicated that people began to occupy the flood-prone areas since the last 50 years, and that occupation was more pronounced about the last 20 years, as indicated by 52.7%

of the buildings (Table 4). This coincided with the period when the population of Lagos State grew from 5.3 to 7.9 million (67.9%) in 1991 and 2006, respectively (NPC, 1991 and 2006). Those buildings that were constructed 20-29 years ago were 43.7%; 2.4% were built 30-39 years ago, while only 1.2% was developed 40-49 years ago. The information obtained revealed that the occupation of flood-prone areas was an old, unabated phenomenon that continued into the present time, and was aggravating the exposure of the inhabitants of the Lagos metropolis to the risks of flood, as postulated by Hallegatte, Green, Nicholls, & Corfee-Morlot (2013). The materials used to construct these buildings were also captured; they were indicative of poor earnings, as revealed in the residents' monthly income. For the walls, 2.2% were made of plank (Plate 1), 12.4% of concrete, 1.9% of wattle, 1.5% of corrugated iron sheets (Plate 2), and 80.2% of sandcrete blocks (Table 4).

Out of 15 (100.0%) buildings whose walls were made of corrugated iron sheets, 80.0% were suspended in the lagoon, canal or wetland and had their floors made of plank, as illustrated in Plate 2. About 64.7% of the buildings had their floors made of mud with cement, while 34.1% had their floors made of cement concrete. Expectedly, the common roofing material was corrugated iron sheets, with 80.2% frequency, implying that almost all the buildings had corrugated iron sheet for their roof. About 12.2% of the buildings had their roofs made of slate; 2.5% had concrete roofs in anticipation of mounting another floor, while 5.1% had roofs made of sheet metal (Table 4).

Plate 1. Residential buildings made of planks and corrugated iron sheets with the drainage blocked by solid waste at Ugbewankwo Lane, Ajeromi-Ifelodun LGA, Lagos State, Nigeria

(Note the building constructed with sandcrete blocks at the background)

Plate 2. A typical residential building on stilt in a flood-prone area at Otto, Lagos Mainland LGA, Lagos State, Nigeria

Table 4. Residential tenure and characteristics of buildings

Characteristics	No. of buildings	Percentage
Residential Tenure		
Owned	243	23.7
Tenant	711	69.4
Living with relations	71	6.9
Total	**1025**	**100.0**
Building type		
Detached Self-contained Bungalow	116	11.3
Brazilian Bungalow	621	60.6
Brazilian Storey	176	17.2
Block of Flats	112	10.9
Total	**1025**	**100.0**
Age of building (year)		
< 20	540	52.7
20-29	448	43.7
30-39	25	2.4
40-49	12	1.2
Total	**1025**	**100.0**
Materials used in constructing wall		
Plank	23	2.2
Wattle	19	1.9
Concrete	127	12.4
Sandcrete blocks	841	82.0
Corrugated iron sheet	15	1.5
Total	**1025**	**100.0**

The study also revealed that, in spite of the appalling conditions of the floodplains, the respondents had long years of residency. For instance, while only 3.2% of the sampled residents had been residing in the areas for more than 25 years, 0.6% had resided there for 21 to 25 years; 12.6% had lived in flood-prone areas for 16-20 years; and 14.0% had been residing in the areas for between 11 and 15 years (Table 5). Surprisingly, 66.5% of the respondents moved into the flood-prone areas in the last ten years, out of which only 3.1% of them moved into the areas in the last five years. This is an indication that the floodplains had continued to attract more residents notwithstanding the obvious high-level risks and the hazardous nature. It also suggests the general massive population inflow into Lagos for employment opportunities and social and infrastructural facilities available in the city. The unavailability of suitable, accessible and affordable plots of land close enough to areas of employment opportunities also contributed to the development of "shanty" structures for housing in areas that are prone to flooding in the metropolis of Lagos.

Table 5. Duration of living in the sampled communities

S/No.	Duration (years)	Number of respondents	Percentage
1	< 5	32	3.1
2	6-10	682	66.5
3	11-15	143	14.0
4	16-20	129	12.6
5	21-25	6	0.6
6	>25	33	3.2
Total		**1025**	**100.0**

4.4 Reasons for Residing in Floodplains

Furthermore, the reasons for residing in the floodplains in metropolitan Lagos were investigated. Table 6 shows that the most prominent factor in eight of the 16 LGAs was "closeness to place of work", ranked highest in Agege (21.5%), Ajeromi-Ifelodun (18.8%), Alimosho (16.8%), Apapa (22.4%), Eti-Osa (26.8%), Ifako-Ijaiye (20.5%), Lagos Island (22.9%) and Lagos Mainland LGAs (17.8%). Other factors that were ranked highest as influencing residents' choice of their residential areas were "closeness to children's school", in Lagos Mainland (17.8%); "low rent", in Agege (21.5%), Ajeromi-Ifelodun (18.8%), Ifako-Ijaye (20.5%), and Surulere LGAs (19.9%); "nearness to market", in Amuwo-Odofin (42.0%), Ikeja (27.3%), Ojo (27.7%) and Oshodi-Isolo LGAs (20.0%); and "low income", in Apapa (22.4%), Ifako-Ijaye (20.5%), Kosofe (30.0%), Mushin (19.3%), and Shomolu LGAs (17.9%).

The second most prominent factor identified by the respondents for their choice of residential location was still "closeness to place of work", as claimed by respondents in six of the sixteen LGAs: Amuwo-Odofin (30.8%), Ikeja (19.1%), Mushin (17.2%), Ojo (20.7%), Shomolu (17.5%) and Surulere (18.5%). Other factors ranked second in the various LGAs were "closeness to children's school", indicated by the respondents in Alimosho (14.7%), Eti-Osa (25.5%) and Oshodi-Isolo LGAs (19.6%); "low rent", in Lagos Island (21.4%), Mushin (17.2%), Ojo (20.7%) and Shomolu LGAs (17.5%); "nearness to market", in Kosofe LGA (18.3%); and "low income", in Oshodi-Isolo LGA (19.6%).

Factors that were ranked the least as influencing respondents' residential choice in the study area, where they were rated at all, were "portion of family land", rated in Agege (4.0%), Ajeromi-Ifelodun (1.6%), Alimosho (2.2%), Eti-Osa (2.2%), Ifako-Ijaye (1.3%), Lagos Island (4.0%), Ojo (0.8%), Shomolu (1.2%) and Surulere LGAs (1.1%); and, "well planned community" was rated in Apapa (1.4%), Ikeja (1.5%), Lagos Island (1.4%), and Lagos Mainland LGAs (2.2%) (Table 6).

The study has thus revealed the prominence of "proximity to work", "proximity to children schools", "proximity to market", and "economic situation" in that order as determinants of residential choice in flood-prone communities in the Lagos metropolis. The findings, especially in relation to proximity to place of work, was in conformity with earlier studies on the City of Chicago by Burgess (1923) and Harris and Ullman (1945), which observed the tendency of low-income earners to cluster in residence close to the central business district at the city centre where many of them work. Generally, significant factors, without considering the environmental conditions, before the decision to reside in floodplains were closeness to place of work (317.4%), nearness to

market (285.4%), closeness to children's schools (270.4%), low rent (258.4%), low income (251.0%), family affinity (196.1%), and portion of family land (18.4%).

Table 6. Reasons for living in flood-prone areas in Metropolitan Lagos

S/N	LGA	Closeness to place of work %(Rank)	Nearness to market %(Rank)	Closeness to children school %(Rank)	Low rent % (Rank)	Low Income %(Rank)	Family affinity %(Rank)	Well planned community %(Rank)	Portion of family land % (Rank)
1	Agege	21.5 (1)	17.0 (4)	17.0 (4)	21.5 (1)	1.0 (7)	18.0 (3)	-	4.0 (6)
2	Ajeromi-Ifelodun	18.8 (1)	14.1 (5)	13.5 (6)	18.8 (1)	15.7 (4)	17.6 (3)	-	1.6 (7)
3	Alimosho	16.8 (1)	14.4 (3)	14.7 (2)	4.4 (6)	11.7 (2)	6.0 (5)	-	2.2 (7)
4	Amuwo-Odofin	30.8 (2)	42.0 (1)	26.9 (3)	8.0 (6)	21.4 (4)	10.9 (5)	-	-
5	Apapa	22.4 (1)	10.7 (5)	20.1 (4)	20.6 (3)	22.4 (1)	2.3 (6)	1.4 (7)	-
6	Eti-Osa	26.8 (1)	7.8 (6)	25.5 (2)	9.8 (5)	5.9 (7)	13.7 (3)	10.5 (4)	2.2 (8)
7	Ifako-Ijaiye	20.5 (1)	7.8 (6)	15.3 (4)	20.5 (1)	20.5 (1)	14.0 (5)	-	1.3 (7)
8	Ikeja	19.1 (2)	27.3 (1)	13.4 (5)	16.0 (4)	16.5 (3)	6.2 (6)	1.5 (7)	-
9	Kosofe	13.9 (4)	18.3 (2)	16.1 (3)	13.9 (4)	30.0 (1)	7.8 (6)	-	-
10	Lagos Island	22.9 (1)	20.5 (3)	16.2 (4)	21.4 (2)	1.4 (7)	16.2 (4)	1.4 (7)	4.0 (6)
11	Lagos Mainland	17.8 (1)	16.8 (3)	17.8 (1)	16.2 (4)	15.9 (5)	13.4 (6)	2.2 (7)	-
12	Mushin	17.2 (2)	16.9 (4)	14.9 (5)	17.2 (2)	19.3 (1)	14.5 (6)	-	-
13	Ojo	20.7 (2)	27.7 (1)	19.9 (4)	20.7 (2)	15.9 (5)	14.1 (6)	-	0.8 (7)
14	Oshodi-Isolo	12.2 (5)	20.0 (1)	19.6 (2)	12.2 (5)	19.6 (2)	16.5 (4)	-	-
15	Shomolu	17.5 (2)	13.5 (6)	16.3 (4)	17.5 (2)	17.9 (1)	16.3 (4)	-	1.2 (7)
16	Surulere	18.5 (2)	10.6 (4)	3.2 (7)	19.9 (1)	15.9 (3)	8.6 (5)	3.3 (6)	1.1 (8)
	Total	**317.4**	**285.4**	**270.4**	**258.6**	**251.0**	**196.1**	**20.3**	**18.4**

4.5 Urban Development in Flood-Prone Areas

The nature of development in flood-prone areas in the Lagos metropolis revealed contiguous buildings with inadequate setbacks among them and between adjoining roads/streets, canals and lagoons. Most disturbing were developments in wetlands, gorges, canals and lagoons. These water bodies naturally connected with one another, such that disturbance in one affects the others. There is disruption or disturbance to the free flow of stream water each time there is rainfall, thereby causing inundation in the metropolis. Therefore, this study investigated whether or not development was continuing or had seized in flood-prone communities and also analysed the extent of urban development within floodplains in Lagos metropolis.

Table 7 presents the statuses of urban development across the LGAs, as obtained through checklist during the field survey. Development was ongoing in 10 out of the 16 metropolitan LGAs, as shown in Plate 3, where building foundations were being laid in flood-prone areas at Muwo, in Ojo LGA. Flood-prone areas were fully developed in Lagos Island, Lagos Mainland, Mushin, Oshodi-Isolo, Shomolu and Surulere LGAs. This corroborated the status of development in wetlands reported in Taiwo (2009).

Remote sensing and GIS analysis carried out revealed (Table 7) that urban development in flood-prone areas in the metropolis of Lagos in 1990 was 9.3 km^2 (0.7%), development in non-flood-prone areas was 359.05 km^2 (30.7%), and vegetation cover was 802.93 km^2 (68.6%) (Figure 2). In the year 2000, vegetation cover reduced to 618.68 km^2 (52.8%), while development in flood-prone and non-flood-prone areas increased to 10.50 km^2 (0.9%) and 542.10 km^2 (46.3%), respectively (Figure 3). The trend continued in the year 2014, as development in flood-prone and non-flood prone areas increased to 17.80 km^2 (1.6%) and 892.90 km^2 (76.2%), while vegetation cover reduced to 260.58 (22.2%) km^2 (Figure 4). The results showed the trend in continuous development of flood-prone and vegetated areas in utter disregard for urban development regulations. Participant observation

revealed that development in floodplains clogged stormwater drainage channels and other hydraulic infrastructures each time there was precipitation and caused flooding in metropolitan Lagos.

Table 7. Nature of development in flood-prone areas in the Lagos Metropolis, Nigeria

Development in 1990	Area (Km^2)	% of development of total land area
Development in flood-prone area	9.30	0.7
Development in non-flood-prone area	359.05	30.7
Vegetation cover	802.93	68.6
Total land area	1171.28	100.0
Development in 2000		
Development in flood-prone area	10.50	0.9
Development in non-flood-prone area	542.10	46.3
Vegetation cover	618.68	52.8
Total land area	1171.28	100.0
Development in 2014		
Development in flood-prone area	17.80	1.6
Development in non-flood-prone area	892.90	76.2
Vegetation cover	260.58	22.2
Total land area	1171.28	100.0

Plate 3. Reinforced columns for residential development erected in flood-prone area at Muwo, Ojo LGA
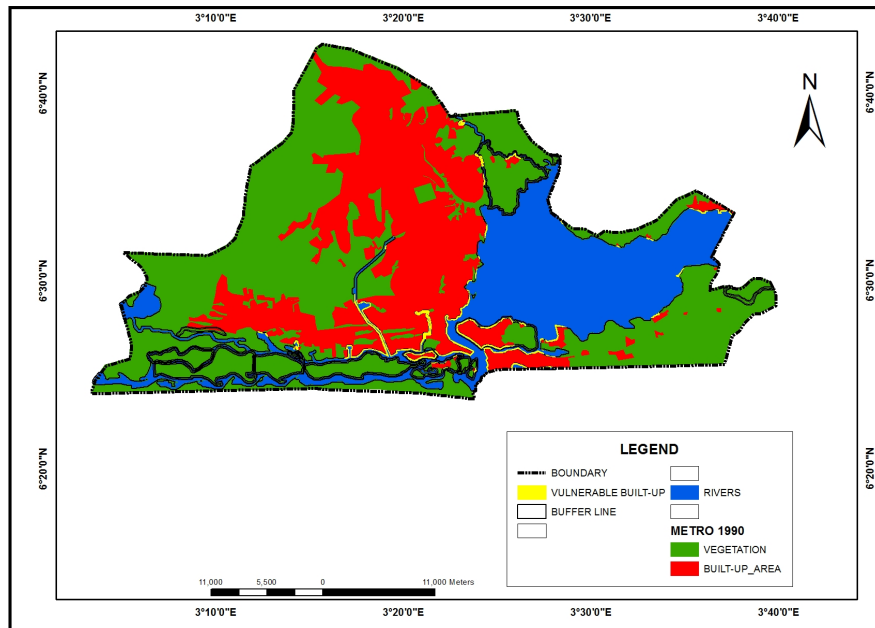
Figure 2. Urban Development in 1990
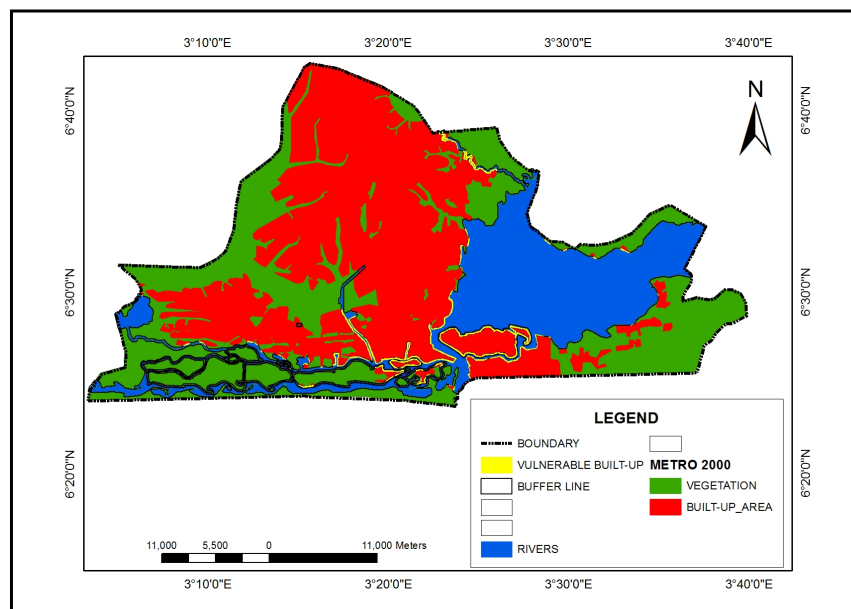
Source: Authors' analysis, 2014

Figure 3. Urban Development in 2000

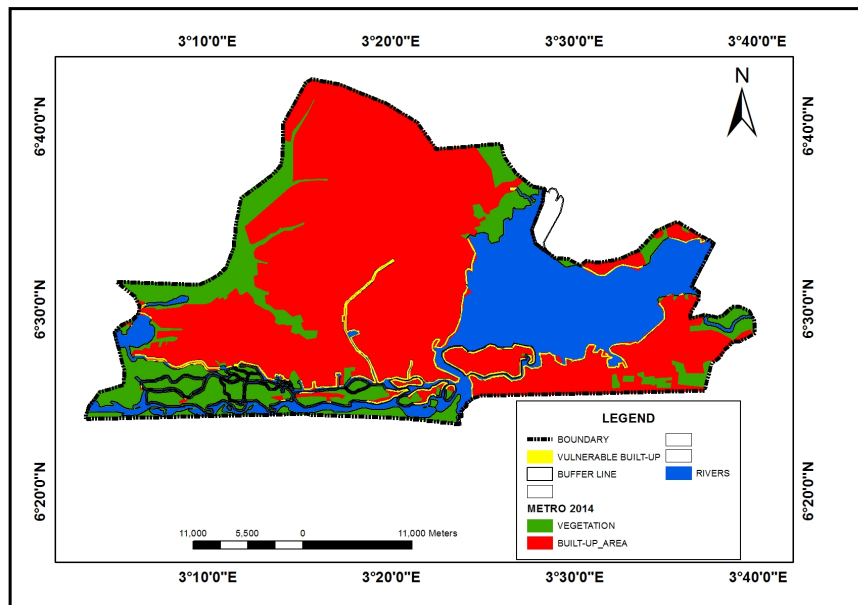Source: Authors' analysis, 2014

Figure 4. Urban Development in 2014

Source: Authors' analysis, 2014

5. Summary and Conclusion

The majority of the people inhabiting floodplains in metropolitan Lagos was poor, earning below ₦18, 000 per month, had secondary school education, and were into trading. These made them to occupy poor-low-rent buildings, with inferior materials, erected in the most precarious portions (floodplains) close to city centres since the late 1980s. The predominant reasons for living in floodplains in metropolitan Lagos in order of significance were closeness to place of work, nearness to market, closeness to children's schools, low rent, low income, and family affinity. Urban development in flood-prone areas increased from 9.3 km^2 in 1990 to 10.50 km^2 in 2000 and 17.80 km^2 in 2014. The flooding of 2011, that killed 25 people displaced 5,393 households and destroyed an estimated ₦100 billion worth of property, coincided with the period when physical development in flood-prone areas covered about 15.50 km^2. The continuous physical development in flood-prone areas in metropolitan Lagos exposed residents to flood risks. The trend will not only increase the frequency of flooding and associated loss, but also make flood control and management difficult. The development of floodplains in violation of physical development control regulations is one of the causative factors of perennial flooding in metropolitan Lagos.

5.1 Recommendations

The Office of the Surveyor General of Lagos State should produce flood-risk maps indicating areas vulnerable to flood in the Lagos metropolis and make the maps readily available to the public for their information and necessary actions against physical developments in flood-prone areas.

Owing to the metropolitan nature of Lagos, that is associated with increasing population and housing shortages, the floodplains should be redesigned by the Ministry of Physical Planning and Urban Development (MPPUD) to accommodate adequate stormwater sewer and low-cost buildings that are flood-resistant. The building code for the flood-prone areas should be reviewed by the MPPUD to encourage and facilitate the development of flood-resistant buildings with consideration for appropriate construction materials and techniques that can prevent flood damage. The "houses living with floods" designed by the UN-HABITAT (~~Jah~~ Jha, Bloch~~,~~ & Lamond, 2012) is suitable for the flood-hazard areas of the Lagos metropolis. Appropriate guidelines for integrating flood-risk into landuse planning, building construction and related physical development should be enacted and diligently implemented.

The low-income status of the majority of residents in the flood-prone areas requires that the Lagos State Government should assist in the provision of subsidies to facilitate their access to low-cost flood-resistant buildings that are raised above the regular flood level. This will enable the poor to continue to play active roles

in the informal sectors of the city economies, enjoy easy access to their places of work, be close to their children's schools, and maintain unflinching affinity with their relations. To achieve this, partnership should be made with private developers who could finance the low-cost housing and let them to the poor at affordable rates. Enumeration of the people currently residing in the floodplains should be undertaken by the Lagos State Government in order not to exclude them in the implementation process. In the interim, the MPPUD should identify suitable areas that can be used for temporary shelters (camps) during flooding in the metropolis and communicate such to the people inhabiting the floodplains. This will go a long way in saving lives and reducing exposure to risks of flood in metropolitan Lagos.

Acknowledgements

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