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Geospatial Mapping of Urban Flood-Prone Areas in Port Harcourt Metropolis: Implications for Effective Urban Physical Planning in Nigeria

Collins H. Wizor, Gbenekanu L. Mpigi

***Abstract*— This study demonstrates the capability of geographic information system technology in the identification and mapping of urban flood-prone areas in Port Harcourt metropolis, Nigeria. The primary source of data for the study is the use of Global Positioning System (GPS) to generate coordinates for the urban flood-prone areas in the study area. ArcGIS software and Kenson electronic measuring wheel were used to determine the extent of the various urban flood-prone areas while the standard height meter rule was used to determine the depth of the flood in the identified urban areas. The reconnaissance survey was done in June 2019 while the actual study was carried out between July and September 2019. Based on the depths and extent of floodwater in the identified urban flood-prone areas, three (3) different areas in the metropolis were classified into lowly, moderately and highly flooded areas. The study revealed Twenty-five (25) urban flood-prone areas in the metropolis, out of which eight (8) are lowly flooded, nine (9) are moderately flooded and eight (8) are highly flooded. The results show details of geographic coordinates of the lowly, moderately and highly flooded areas and three (3) geo-referenced maps showing the three categories of urban flood-prone areas in Port Harcourt metropolis. The results of the study revealed that all the identified lowly flooded, moderately flooded and highly flooded areas of Port Harcourt metropolis are completely built up with high population concentration which brings to the fore, the need for effective urban physical planning in Port Harcourt metropolis and other high-density cities of the global south. The study further recommends that present and future urban developers in the metropolis should adhere strictly to municipal development control decisions as regards plans and site approval. It also suggests the demolition of properties on natural and man-made drainage channels in the study area.**

***Index Terms*— Geospatial, Mapping, Urban, Flood, Planning, Nigeria.**

I. INTRODUCTION

Flooding is an overflow of a body of water that inundates land. This usually occurs due to the volume of water within a body of water, such as a lake or river, exceeding the total capacity of the body, resulting in some water flowing outside of the normal boundaries of the body. It can also occur in rivers. When the strength of the river is so high, it flows right out of the river channel. Flooding is an anticipated hazard in the coastal regions and when it occurs, it leaves loss and damage at its wake giving rise to disasters. The need for investing in mitigative measures can never be over-emphasized as the presence and adherence to control measures, both structural and non-structural is key in avoiding loss and damage of properties. Between June and September 2012, Cameroun experienced heavy rainfall which led to excessive flooding around the Ledja Dam such that the dam's carrying capacity was exhausted, consequently there was a release of the dam walls between July 2nd and September 17th 2012 [1].

The fallout out was a flow of water to Nigeria through Benue Rivers and into the Seas through the Niger River. Several Nigerian states including Rivers State were flooded. This led to public awareness of flood and how destructive it could be. Before the year 2012, Port Harcourt metropolis has always experienced urban flood incidences because of its location in the coastal region of the country. Smith and Ward [2] and Mwape [3] argued that direct losses to floods occur immediately after the event as a resultof the physical contact of the floodwaters with humans and with the damageable property. However, indirect losses which are less easily connected to the flood disaster and often operate on long-time scales may be equally, or even more important. Depending on whether or not losses are capable of assessment in monetary values, they are termed tangible and intangible. Some of the most important direct consequences of flooding such as loss of human life or the consequent ill health of the survivors are intangible. Indirect and intangible consequences of flooding are probably greatest in the least Developed Countries (LDCs), especially where frequent and devastating floods create special impacts for the survivors. In addition to economic loss and loss of life and injury, there may be an irreversible loss of land, of historical and cultural valuables and loss of nature or ecological valuables.

Mark et al [4] further opined that considerable economic and infrastructural losses arise from urban flooding. Kang et al,[5]; Parker [6; Ranzi et al [7] insisted that there is an interrelationship between urbanization and flooding in developing countries and developed countries as population explosion and continued urban expansion has led to a reduction in the permeability of soil, thus leading to increased surface runoff in the absence of alleviating urban drainage design.

Urban flooding remains the most frequently reported and

Collins H. Wizor (PhD), Department of Geography and Environmental Management, University of Port Harcourt, P.M.B 5323, Port Harcourt, Nigeria.
Gbenekanu L. Mpigi, Development Planning Unit, University of London, United Kingdom.

costliest disaster as over 40% of natural worldwide disaster are reported as a flood [8]. According to the National Environmental Survey/Action Team (NEST), flooding is a body of water which rises to overflow land which is normally submerged. Urban flooding is environmental hazards that occur regularly every year in different parts of the country, especially during rainy seasons. Urban flood occurrence is usually due to the increase in the volume of water within the body such as rivers and lakes. This causes water to exceed the drainage channel capacity and overflows its boundaries.

The holistic consequence of urban flooding is very intense both in impact and magnitude. Its occurrence has constantly caused a reduction in land use and the value of the property while the cost of living remains on the increase. The impact of urban flooding in our environment can be seen from two different angles; the first impact is on the natural environment while the second impact is on the built environment. The brunt on the built environment is far more destructive due to the presence of human activities and continuously increased populace. Resonzweig[9] has observed that urban flood occurrence is majorly triggered by several factors which include, high tides, rapid runoff, paved surfaces and heavy rainfall. Burrus (1990) stated that urban floods occur when drainage channels experience a surge. The excess overflow from the drainage channels spread out to the surrounding lands, producing the flood condition known as flooding. Urban flood is any overland flow over urban land, severe enough to cause significant damage to property and also lead to traffic congestion creating nuisance and health hazards.

Urban flood generally occurs as a result of compound conditions working sometimes in isolation or synergy. These conditions are mostly natural and anthropogenic at the same time. The natural causes of flooding are increased mostly by landscape and nature of weather while anthropogenic causes of flooding are propelled by human activities. Though man does not by default create a flood, however, his activities of deforestation and urbanization especially in flood-prone areas increase the probability of occurrence and severity of flood on the earth. Wright [10] opined that the problem of an urban flood is made worse by man's activities giving rise to synthetic situations that lead to an excessive runoff as this scenario is the most common cause of the flood.

Urbanization aggravates flooding by restricting where floodwaters can go. In an urban area, large parts of the ground are covered with roofs, tarred roads and pavements. These obstruct sections of natural channels and built drains that ensure water movement to rivers faster than it could under the natural conditions (Ojigi et al, [11]. Another factor in an urban setting is the population density. As more people crowd into the cities, so the effects of the flood intensify. Consequently, even quite moderate storm could produce high flows in rivers because there are more hard surfaces and drains. In extreme cases, urban floods can result in disasters that setback urban development by years or even decades. Given the high spatial concentration of people and values in the cities, even small-scale floods may lead to considerable damages. Recent statistics indicate that economic damages caused by urban floods are rising [12]; [13]; [14]. The frequency of events and the number of people affected have increased steadily as human-related activities such as deforestation, overgrazing and urbanization aggravate environmental conditions, making communities more vulnerable [15]; [16].

There are numerous kinds of flooding, and each one has a different impact as regards how it occurs, damage caused, and how it is projected. Port Harcourt metropolis experiences a combination of pluvial and fluvial flooding. Pluvial or surface water flood occurs when there is heavy rainfall; it usually occurs without depending on an overflowing body of water. It is usually misconstrued to assert that flood occurs only when land is situated close to a body of water. Pluvial flooding rebuffs the assertion, as it can occur in any urban area - even higher elevation areas that lie above coastal and river floodplains. Pluvial flooding is commonly found in urban areas, where there is an inundation of land and property in a built environment caused by rainfall overwhelming the capacity of drainage systems. Two common types of pluvial flooding can be distinguished. The most common is a situation where intense rain saturates municipal drainage channels. The channels become besieged and water flows out into streets and close by buildings. This is a typical urban scenario found in many big cities in Nigeria, Port Harcourt metropolis inclusive.

Fluvial flooding, on the other hand, happens when too much rainfall over an extensive phase of time causes a river to surpass its capacity. It can also be caused by heavy snowmelt and ice jams. The harm from a river flood can be widespread as the overflow affects smaller rivers downstream, often causing dams and dykes to break and swamp nearby areas. Flash flooding is a typical example of fluvial flooding. It is characterized by an intense, high-velocity torrent of water that occurs in an existing river channel with little to no notice. Flash floods are usually very dangerous and destructive not only because of the water force but also due to the continuous gathering of debris that is often swept up in the flow. This type of fluvial flood is also a common occurrence in the city of Port Harcourt.

The urban surface is a contributory factor to urban flood as permeability is greatly reduced with urban growth. According to Zabbey[17], there was an unprecedented flood which submerged houses, rendering residents of Mgbouba, Diobu, Nkpolu areas displaced. He further stated that the excessive rainfall associated with climate change was the cause of the flood in Port Harcourt. However, further, observation shows that increasing build-up areas lack proper urban planning control.

According to observation results released at the First National Communication on Climate in Nigeria, under the United Nations Framework Convention on Climate Change, the period 2010-2039 is projected to experience low rainfall in Port Harcourt Metropolis, and suggest an increasing trend of rainfall by 2039 [18]. This implies that flooding would

increase in the future especially with the rate of increasing urban expansion. It, therefore, means that although in Port Harcourt, flooding is primarily climatic; the flat land topography, inflow from surrounding water bodies, inadequate urban planning and blocked drainages due to poor waste management are all determinants of urban flooding.

This study aims to identify and map the various flood-prone areas in Port Harcourt metropolis using geospatial techniques. The use of Geographic Information Systems (GIS) in flooding and disaster management studies cannot be overemphasized. The role of GIS in disasters analysis and management is typically important in critical life-saving measures and has been used in developed and developing countries in the last two decades. Advancements in remote sensing (RS) technology and GIS help in real-time monitoring, early warning system and quick damage assessment of flood and drought disasters [19]. A Geographic Information System is a tool that can assist floodplain managers in identifying urban flood-prone areas in metropolitan areas. With GIS, geographical information is stored in a database that can be queried and graphically displayed for analysis. By overlaying or intersecting different geographical layers, flood-prone areas can be identified and targeted for mitigation or stricter floodplain management practices.

Various researches have been carried out on flooding over time, the rental value of properties as it affects property, the comparisons in the valuation of properties in flood-prone areas and the need for revaluation of damaged properties arising from urban flood disasters, no known conscious effort has been made in mapping flood-prone areas in Port Harcourt metropolis. Hence, the researchers in this study identified and geospatially mapped flood-prone areas in the metropolis to fill the obvious gap in knowledge. For ease of identification by all stakeholders in the metropolis, particularly urban planners, urban flood-prone areas were further classified into highly, moderately and lowly flooded areas.

II. STUDY AREA

This study is limited to two Local Government Areas (LGA) of Rivers State, Nigeria, which make up the Port Harcourt metropolis. These LGAs are:

- Port Harcourt City local government area (Figure 1).
- Obio/Akpor local government area (Figure 2).

Eleme LGA which is currently part of the metropolis was not considered in this present study. Port Harcourt city is one of the major capital cities of Nigeria. It is the capital of Rivers state, lying along Bonny River, an eastern tributary of the Niger River, 66km upstream from the Gulf of Guinea, located at the coastal region of Nigeria. Its geographical coordinates are 4o47‟ 21” north, 6o 59‟ 55” east with 15.83 meters elevation above sea level.

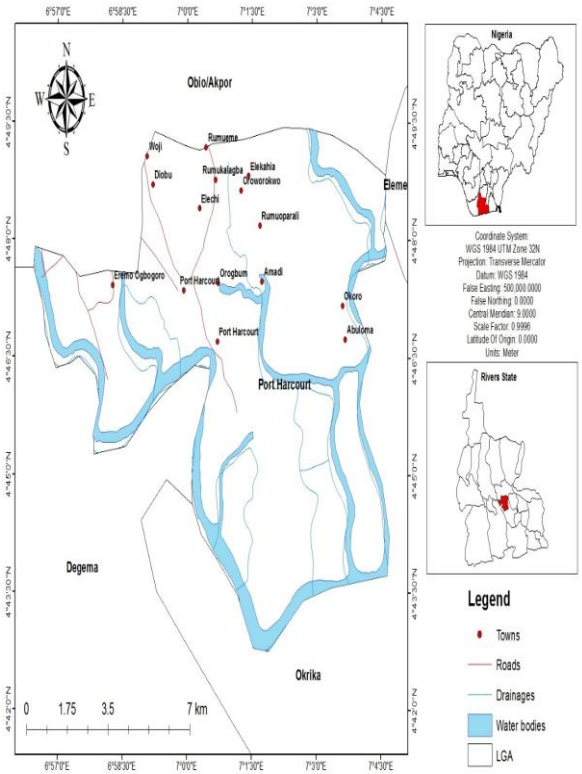

Figure 1: Port Harcourt LGA

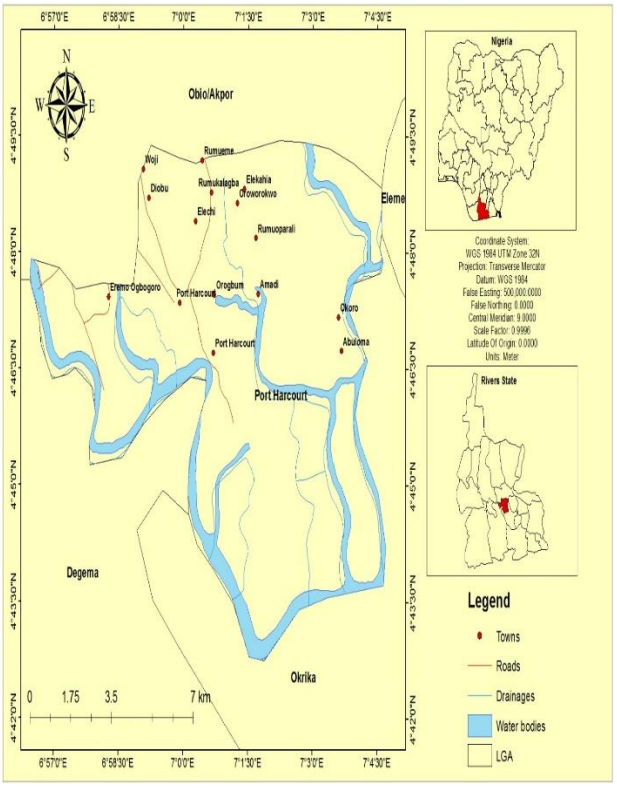

Figure 2: ObioAkpor LGA

The climate of Port Harcourt features a tropical monsoon climate with long and heavy rainy seasons and very short dry seasons. Only the months of December and January can be said to be truly the period of the dry season. Harmattan is less pronounced in Port Harcourt. By observation over time, the heaviest rainfall in the city occurs during the month of September. The temperature throughout the year in the city is relatively constant, showing little variation throughout the

course of the year. The average temperature in the study area is typically between 25oC – 28oC. The vegetation in Port Harcourt is sparse. In places that are not yet overcome by infrastructural development, the vegetation is majorly swampy. The proximity of Port Harcourt to the ocean makes available a lot of freshwater vegetation.

The relief of Port Harcourt metropolis is a low-lying plane with tidal variations that influences the numerous rivers, creeks, swamps and the Atlantic Ocean serving as a unique drainage surface, though with a poor network essentially due to low relief, high water table and high rainfall (Figure 3). The land surface slope gently (30m to 50m on the average) in an NW-SE direction [20]. The dry land area of the region is characterized by an equal thickness of the upper soil layer of silt and sand. The entire topography is made up of low-lying planes generally less than 20m above sea level and sloping gently in a north-south direction to the sea. It is relative, a flat terrain with a gradient of not more than 3%.

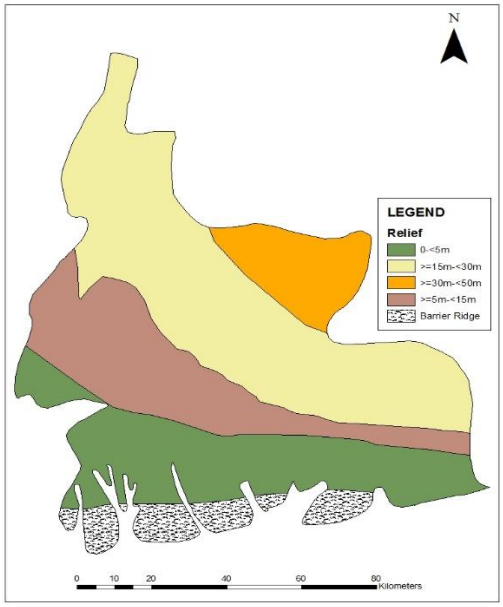

Figure 3: Relief Map of Port Harcourt Metropolis

The issue of flooding is a reoccurring decimal in the city. Port Harcourt has been expanding physically at a fast rate. It has grown from 15.34 square meters in 1914 to a metropolis covering an area of about 360 square kilometres in the 1980s. The growth of Port Harcourt and its fringe areas has been phenomenal since its inception in 1913. Growth has been experienced in terms of population and space. Two years after its founding, the population was 5,000. Census figures for the city through its history are 7,185 in 1921; 15,201 in 1932 and 71,634 in 1953 [21]. The 1963 census gave the city's population as 179,563 and in 1973 it was 213,443 [22]. The 1991 census fixed the population of Port Harcourt and Obio/Akpor LGAs alone at 645,883. The projection for 1996 by the National Population Commission (NPC) is 832,471 for the two local governments and the interim figures for the 2006 national census is over one million. The total population was estimated at two million as of 2009, making it one of the largest metropolitan areas in Nigeria and covered about 360km2 [23].

Spatially too, Port Harcourt city has grown to cover much of the Upper Bonny River Basin. Originally the city covered a 25 km2 area between the UTC junction and the New Layout Market. In the land use and vegetation map of Nigeria (1975/76), the built-up area of Port Harcourt covered 17.4km2. Twenty years later, a similar map showed the extent of the city as 89.4km2. This is a five-fold increase (Figure 4). As an urban area, Port Harcourt metropolis has so many economic opportunities for residents and guests, hence the need to map urban flood-prone areas in the metropolis using geospatial techniques becomes very imperative.

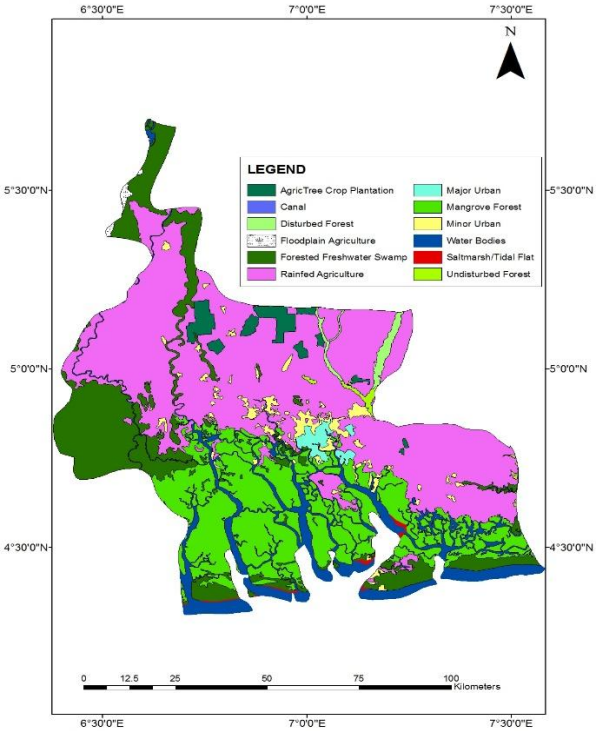

Figure 4: Port Harcourt Metropolis showing Landuse

III. MATERIALS AND METHODS

A reconnaissance survey and physical field observation of the study area was carried out to familiarize the researchers with the study area and the subject of enquiry. This assisted the researchers immensely in planning the acquisition of the various coordinates and actual measurement of flood extent and depth in the study area.

The sources of data used in this research were primary and secondary. The primary source of data is the use of GPS to generate coordinates for the urban flood-prone areas (highly, moderately and lowly) in the study area. ArcGIS software and Kenson electronic measuring wheel were used to determine the extent of the various urban flood-prone areas while the standard height meter rule was used to determine the depth of the various urban flood-prone areas. The secondary sources include:

- Topographical map of the study area.
- Landsat imagery of the study area at 5m resolution.

Based on the depths and extent of floodwater in the

identified urban flood-prone areas, three (3) different areas were classified in the metropolis. They are:

- Lowly flooded areas
- Moderately flooded areas
- Highly flooded areas

Criteria for Classification

Depth of Floodwater	Extentof Floodwater	Classification
20 - 40 cm	200 – 400 m	Lowly Flooded
41- 80 cm	401 – 600 m	Moderately Flooded
Above 80 cm	Above 600 m	Highly Flooded

Source: (Authors' Field Survey, 2019)

The GPS coordinates for the identified urban flood-prone areas (lowly, moderately and highly) was later shown in tables and maps.

IV. RESULTS AND DISCUSSION

Table 1 shows the GPS coordinates (Northings and Eastings) of all the identified urban flood-prone areas in the study area. Twenty-five (25) urban flood-prone areas were identified across the study area.

Table 1: GPS Coordinates of Identified Urban Flood-prone Areas in Port Harcourt Metropolis

S/ No	Name of Street/Area	Northings	Eastings
1	Salem Close, Off Ada George Road	4.855444	6.979556
2	Omachi Road, Rumuodomaya	4.875247	6.999777
3	Abanna Street, Old GRA	4.785583	7.022028
4	Hon. Attah Close, Peter Odili Road	4.793833	7.05075
5	Nkpolu Road 1, Rumuigbo	4.853346	6.986527
6	Eneka Town	4.878167	7.029514
7	Horsefall Street, Old GRA	4.786917	7.021222
8	Evelyn's Close, GRA Phase 11	4.8195	7.006917
9	Omerelu Street, GRA Phase 11	4.839583	7.005639
10	Abacha Road, GRA Phase 11	4.823778	7.003361
11	Orubo Close, Peter Odili Road	4.797111	7.052361
12	NTA/Apara Link Road	4.854637	6.983774
13	Obiwali Road, Rumuigbo	4.858639	6.986944
14	L.K. Anga Road, Off Peter Odili Road	4.801917	7.047389
15	Uyo Street, Rumumasi	4.838444	7.017583
16	Odani Road, Elelenwo	4.840208	7.073506
17	Diamond Valley Estate	4.796222	7.046083
18	Amaechi Drive, GRA Phase 11	4.821278	6.000972
19	BuePearl Street, Peter Odili Road	4.794083	7.019917
20	Hilltop Road, Amadi-Kalagbo	4.823806	7.023444
21	Kenka Road, Off Mgbuoba Road	4.856194	6.980361
22	Akwaka Street, Rumuodomaya	4.880281	6.994285
23	Peter Odili Road	4.804861	7.045556
24	Alalibo Road, Old GRA	4.794083	7.019917
25	Zion Street, Rumuodomaya	4.881607	6.993837

Source: (Authors' Field Survey, 2019)

Findings of this study with regards to the depth and extent of the floodwater in the identified urban flood-prone areas of the metropolis were used to classify the study area into highly, moderately and lowly flooded areas. Table 2 shows the GPS coordinates of the lowly flooded areas of the metropolis. Eight (8) urban flood-prone areas were identified.

Table 2: Lowly Flooded Areas in Port Harcourt Metropolis

S/ No	Name of Street/Area	Northings	Eastings
1	Abanna Street, Old GRA	4.785583	7.022028
2	Hon. Attah Close, Peter Odili Road	4.793833	7.05075
3	L.K. Anga Road, Off Peter Odili Road	4.801917	7.047389
4	Hilltop Road, Amadi-Kalagbo	4.823806	7.023444
5	Uyo Street, Rumumasi	4.838444	7.017583
6	Omerelu Street, GRA Phase 11	4.839583	7.005639
7	Akwaka Street, Rumuodomaya	4.880281	6.994285
8	Peter Odili Road	4.804861	7.045556

Source: (Authors' Field Survey, 2019)

Figure 5 depicts the lowly flooded areas in the metropolis.

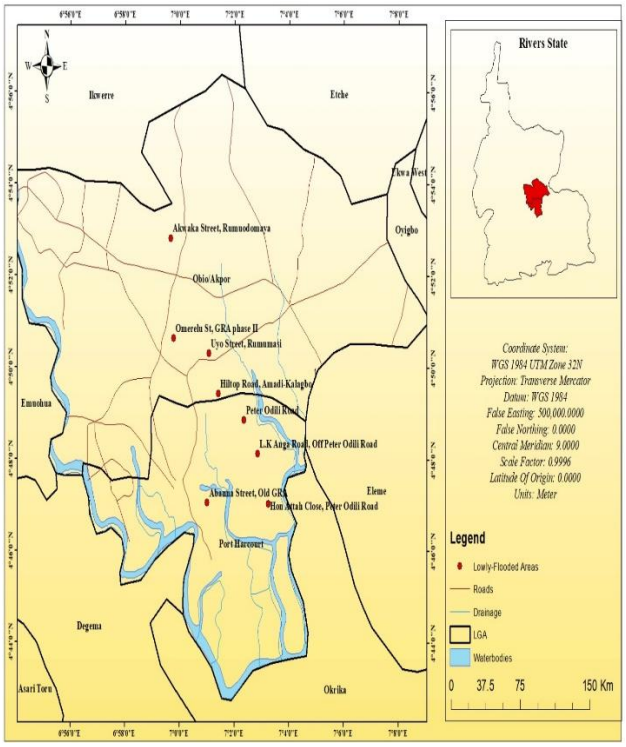

Figure 5: Lowly Flooded Areas in Port Harcourt Metropolis

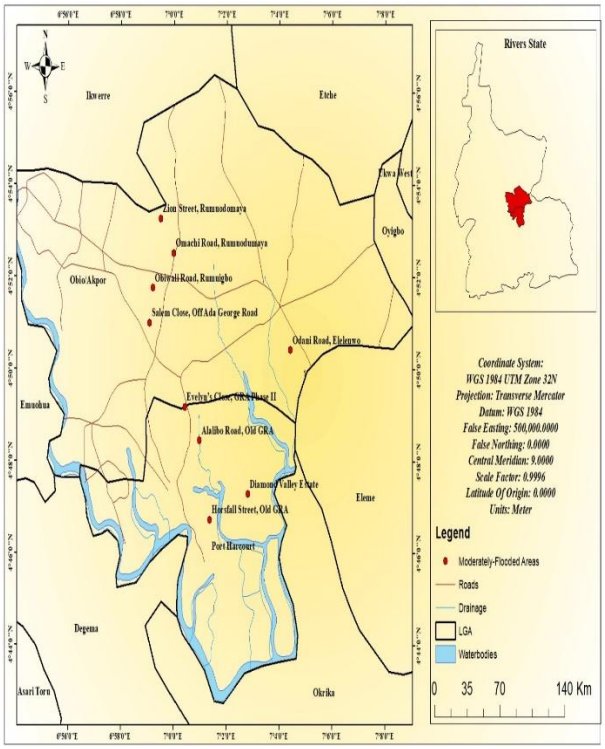

Figure 6: Moderately Flooded Areas in Port Harcourt Metropolis

Table 3 shows the details of the geographic coordinates of the moderately flooded areas in the metropolis. The result shows that nine (9) urban flood-prone areas in the metropolis fell into this category.

Table 3: Moderately Flooded Areas in Port Harcourt Metropolis

S/No	Name of Street/Area	Northings	Eastings
1	Omachi Road, Rumuodomaya	4.875247	6.999777
2	Salem Close, Off Ada George Road	4.855444	6.979556
3	Obiwali Road, Rumuigbo	4.858639	6.986944
4	Diamond Valley Estate	4.796222	7.046083
5	Zion Street, Rumuodomaya	4.881607	6.993837
6	Odani Road, Elelenwo	4.840208	7.073506
7	Evelyn's Close, GRA Phase 11	4.8195	7.006917
8	Horsefall Street, Old GRA	4.786017	7.001000
9	Alalibo Road, Old GRA	4.794083	7.019917

Source: (Authors' Field Survey, 2019)

Figure 6 is a geo-referenced map of the moderately flooded areas of Port Harcourt metropolis while plate 1 shows Obiwali road in Rumuigbo (moderately flooded)

Plate 1: Obiwali Road, Rumuigbo

Findings of this study as revealed in table 4 show that there are eight (8) highly flooded areas in the metropolis. The results were used to produce a geo-referenced map (Figure 7). All these areas are completely built up with very high population concentration. Nkpolu road 1, Rumuigbo for instance, is a major hub in the metropolis linking Rumuokoro, Rumuodara and Eleme junction along the very busy east/west expressway. It also links the University of Port Harcourt and other peri urban areas of Rivers state. Real estate development, movement and the livelihood of the residents of these highly flooded areas have been negatively affected. BluePearl street, on the other hand, is located around one of the highbrow residential areas of the metropolis. The flooding in this area has also negatively impacted the urban dwellers in

this neighbourhood. (See plates 2 and 3).

Plate 2**:** Nkpolu Road 1, Rumuigbo

Table 4: Highly Flooded Areas in Port Harcourt Metropolis

S/ No	Name of Street/Area	Northings	Easthings
1	Nkpolu Road 1, Rumuigbo	4.853346	6.986527
2	Eneka Town	4.878167	7.029514
3	NTA/Apara Link Road	4.854637	6.983774
4	Rotimi Amaechi Drive, GRA Phase 11	4.821278	6.000972
5	Kenka Road, Off Mgbuoba Road	4.856194	6.980361
6	Abacha Road, GRA Phase 11	4.823778	7.003361
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8	BuePearl Street, Peter Odili Road	4.794083	7.019917

Source: (Authors' Field Survey, 2019)

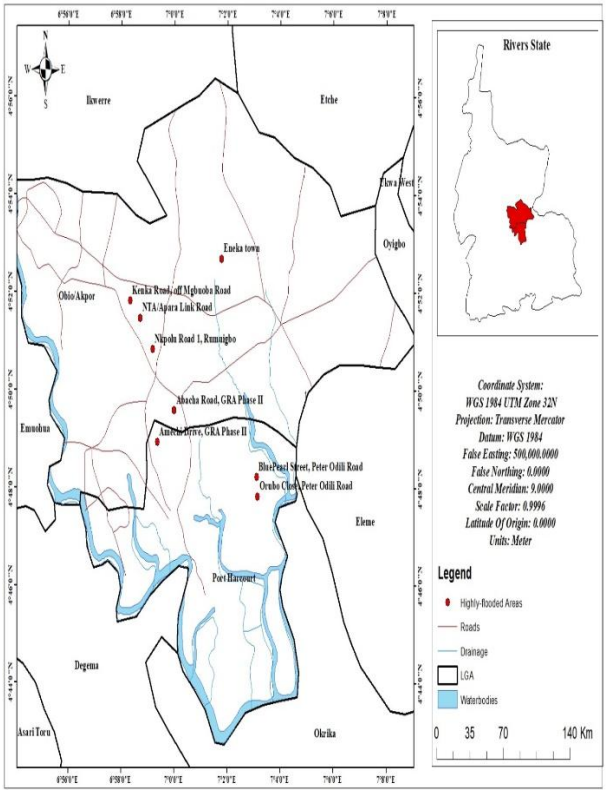

Figure 7: Highly Flooded Areas of Port Harcourt Metropolis

Plate 3: Blue Pearl Street, off Peter Odili Road, Port Harcourt

V. RESEARCH IMPLICATIONS AND CONCLUSIONS

This study has demonstrated the holistic nature of urban flood-prone areas in Port Harcourt metropolis. In the global south with particular reference to sub-Sahara Africa, adequate knowledge of urban flood-prone areas is expected to help in the efficient planning of the city and mitigation of flood impacts. This study thus becomes vital for urban physical planners in the area of conducting field investigations to analyze factors affecting land use, review of site plans submitted by developers, assessment of the

feasibility of proposals, identification of needed changes and recommendations as to whether proposals should be approved or denied, staying current on zoning or building codes, environmental regulations, and other legal issues, identification of community needs and development of short- and long-term plans to create, grow, or revitalize an urban area or city.

Accordingly, Blong[24] and Barroca[25] affirms that flood vulnerability mapping indeed offers a hundred per cent security against floods. Flood disaster management just as other disaster risk management in urban areas is very vital since it helps in ensuring preparedness, prevention and mitigation of urban flood disasters. Good knowledge of urban flood-prone areas in metropolitan cities will lead to a robust city planning and preservation of real properties and lives, ordering and regulation of land use efficiently and ethically, thus preventing conflicts in urban land use.

The results of this study have shown that all the identified lowly flooded, moderately flooded and highly flooded areas of Port Harcourt metropolis are completely built up with high population concentration. The rapid rate of urbanization in the metropolis has over time exacerbated the urban flood menace in the city leading to perennial flooding. The obvious implications of the findings of this study are the failure of urban planning authorities to regulate and control real property development and other urban land uses. This result is consistent with the study of Aluko [26] which maintains that despite the existence of Local Planning Authorities in every Nigerian city whose portfolio includes development control of urban land use, many buildings have been and are being constructed without approved layouts, illegal structures springing up arbitrarily, open spaces are disappearing fast and many parts of Nigerian cities lacking access.

Interestingly, building on natural and man-made drainage channels has continued unabated in most of the mapped areas of Port Harcourt metropolis leading to blockage of flows with its disastrous consequences. In all the highly flooded areas of the metropolis, the researchers observed the obvious lack of political will to enforce development control by the Directorate in charge of development control in the Ministry of Urban Development. Development control is an integral and vital aspect of urban physical planning and is very important to the success of every government. Ratcliffe [27] sees it as the formal voice of the planning authority regarding such matters as the permitted density, height limitations, user restrictions, access, and outstanding preservation or conservation orders of one kind or another. Agbola[28 on the other hand defines development control or land use control as a collection of interrelated para-legal and administrative techniques and instruments designed to safeguard, regulate, conserve and disburse land or part thereof in the interest of the overall community.

Findings of this study have also brought to the fore, the need for effective urban physical planning in Port Harcourt metropolis and other high-density cities of the global south. According to Aluko [26], Physical Planning arose from the realization that certain land uses should be separated from one another because of their incompatibility. Hence, the need for effective development control is to prevent abuse and misuse of land and to ensure compatible use of land as stipulated in the master plan. Development control also ensures that real estate developers or owners of landed property use their lands and buildings in conformity with approved town planning schemes or master plans for the town; for if development control is not enforced, landowners and estate developers will build anywhere and anyhow, causing the chaotic and disorderly growth of the town concerned.

Finally, the findings of this study have revealed the importance of geospatial techniques in urban flood studies. Thus, with the systematic geospatial mapping of urban flood-prone areas in the metropolis, policymakers, land speculators, prospective residents, architects, builders and the general public can at a glance see the various lowly-flooded, moderately-flooded, highly-flooded areas in Port Harcourt metropolis and take appropriate decisions. From the foregoing, it is now imperative that present and future urban developers in the metropolis should adhere strictly to municipal development control decisions as regards plans and site approval. This study also suggests the demolition of properties on natural and man-made drainage channels in the study area.

In conclusion, it is believed that urban development control will make the best use of urban lands in the best interest of the urban societies in Nigeria and other countries of the global south. With proper urban physical planning, the perennial flooding experienced in Port Harcourt metropolis will be adequately mitigated for the benefit of all stakeholders and livable urban environment.

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