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URBAN GROWTH AND FLOOD VULNERABILITY IN ASABA, DELTA STATE

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Abstract:

This study investigated the relationship between urban development and flood susceptibility in Asaba. A survey research design was employed, with questionnaires serving as the primary tool for data collection from heads of households in the study area. This was supplemented by interviews and direct observations. Using William's model for sample size determination, a sample size of 300 was drawn from Asaba's population. Stratified and simple random sampling techniques were used to select the participants. Landsat imagery from 1987 and 2023 was analyzed using remote sensing and ArcGIS 10.1 software. The data was analyzed using percentages, frequency counts, and summary tables. The results indicated that Asaba experienced a 23.9% increase in built-up areas between 1987 and 2023, alongside notable changes in other land uses. Flooding was found to be a widespread issue in the low-lying Niger Delta, with flash floods being the most common in Asaba. Interviews with state officials revealed that Asaba lacks an urban master plan to guide its physical development. The study also highlighted how unregulated and haphazard urban development has worsened flooding in the city. The study concluded that the absence of a master plan and the lack of proactive urban planning by relevant authorities have significantly contributed to flooding issues in Asaba. Based on these findings, it is recommended that urban development in Asaba and other cities in the Niger Delta be guided by a master plan and proactive planning strategies to mitigate flooding and other hazards.

Keywords: Built environment, coastal cities, flooding, physical development, susceptibility.

Introduction

Flooding and its associated hardships have become increasingly common and severe, particularly in low-lying towns and cities worldwide. This growing susceptibility to recurrent floods has raised significant concerns among urban planners, geographers, civil engineers, hydrologists, municipal authorities, environmentalists, and other stakeholders at both local and international levels. Various technology-driven solutions for flood prediction, mitigation, and management have been developed in response to the escalating threat. Despite these efforts, urban flooding continues to occur, becoming even more destructive in recent decades.

In Nigeria, flooding has emerged as the most frequent natural disaster. Media reports have highlighted the worsening situation with headlines such as "Residents Groan as Flood Wreaks Havoc in Asaba" (Awanyai, 2018, Oracle News), "Floods: Federal Government to Relocate 10,000 Persons in Kogi" (Guardian, March 14, 2023), and "Preparing for the Impending Flood" (The Sun, March 10, 2023). These reports underscore the devastating impacts of floods, including damage to personal property and public infrastructure. Flooding has also inundated roads, cutting off access to certain areas of affected cities.

Studies suggest that urban flooding is driven in part by climate change, particularly rising sea levels, while uncontrolled human activities encroaching into flood-prone areas exacerbate the problem. This is especially true in rapidly growing, unregulated coastal settlements and low-lying towns like those in the Niger Delta, where annual flooding hampers both physical and economic development. According to research by Douglas et al. (2008) and Adelekan (2010), the vulnerability of coastal cities is heightened by population growth and unplanned urban expansion. Li (2003) and Few (2003) also note that coastal cities in developing countries, recognized globally for rapid urbanization, face increased environmental risks, especially from flooding. Currently, flooding in many Nigerian cities has become more severe, frequent, and destructive. Asaba, a city in the low-lying Niger Delta region, is among the worst affected by this environmental hazard.

The built environment characteristics of urban areas such as form and development footprint, to a great extent, determines the environmental and social conditions in which the urban dwellers live (Brody, et al., 2012). However, several studies have equally revealed that the catastrophes emanating from climate-related menace like flooding in most emerging towns and cities in the world are driven by rapid growth in population, urbanization, and unregulated physical developmental activities in at-risk areas (Action Aid, 2006; Brody, Highfield &

Kang, 2011; Agbonkhese, Agbonkhese, Aka, Joe-Abaya, Ocholi & Adekunle, 2014). Urban flooding and its resultant adverse effects on humans and the environment are often times attributed to topography, rainfall, soil and other geophysical characteristics. The role of the built environment as an essential element that greatly influences flood hazards has to a great extent been neglected or not given adequate consideration.

Prior to 1991 when Asaba became the state capital, it was only known for river flooding resulting from seasonal tide from River Niger. From 1991, the new status changed the socioeconomic and physical landscape, thus encouraging a rapid increase in population and urban expansion. Eventually, its marginal lands that used to serve as natural sinks for runoff water became easy target for unregulated development. Without guidance unregulated and haphazard urban physical activities and land uses without commensurate physical planning became the order. As a result of this phenomenon, the city residents are now exposed to urban deluges of different duration and magnitudes in recent times. Successive state administrations, local communities, individuals and other concerned stakeholders have made concerted attempts geared towards mitigating the ravaging floods in the city. These attempts however tend to be ad hoc and not too successful as the underlying factors responsible for the perennial urban flooding plaguing the city have not been properly investigated and identified. This stud therefore, explored the urban built environment and its relationship with urban flooding in Asaba, exploring the major underlying factors of urban development responsible for the perennial flood.

Literature Review

Flooding from the Built Environment Perspective

Flooding, particularly in the built environment is a major global plague in contemporary times. Increasingly, many cities and towns across the global north and south are continuously being ravaged by this environmental hazard with displacements and heavy casualties. Severely affected by this hazard are a number of coastal areas, surrounding cities and river basins that are witnessing rapid population growth in the absence analogous infrastructure and planning arrangements (Whitworth & Baily, 2016). Over the decades, the reason why flooding occurs in the built environment have attracted attention and this has been ascribed to a number of factors based on the knowledge of the hazard. Liao (2012) highlighted that flooding is most often times attributed to heavy rainfall, but deluges however can be triggered in various ways that are not directly related to ongoing weather conditions. He further argued that a

comprehensive account of flooding must take into account processes that may possibly have little or nothing to do with weather-related happenings. Similarly, Okon, Ogba, Idoko, Eni & Sule (2015) pointed out that deluges in most cities, particularly in the developing nations are not in essence initiated by high intensity precipitation, rather it is a function of physical development which is a consequence of urbanisation process.

A significant characteristic of the built environment is the application of impervious surfaces. The transformation of natural landscapes to urban areas compromises the capability of hydrological systems to absorb, store, and gradually release water. However, empirical and observational evidences have shown those extensive hardened surfaces which are a product of physical development increases deluge intensity (Carter, 1961; Tourbier & Westmacott, 1981) and subsequently its scope and associated negative impact on the environment. According to Paul & Meyer (2001) larger areas of impervious surface decreases rainfall infiltration and increase surface runoff. For instance, examining impervious surface coverage emergence as a key environmental indicator, Arnold and Gibbons (1996) revealed that storm-water runoff within a drainage basin will nearly double with a 10 to 20 percent increase in impervious surfaces. While White and Greer (2006) on the other hand highlighted that as urbanization in the Penasquitos Creek watershed in southern California grew from 9 to 37 percent, total runoff over the study period of 1973 to 2000 was amplified to approximately 200 percent.

A number of researchers have correspondingly argued that urban physical developmental activities are responsible for environmental hazard such as flooding that is being experienced in most towns and cities across the globe. For instance, Brody et al. (2011b) argued that increased surface runoff consequential from additional impermeable surfaces is a very important predictor of deluge since it can translate into increased frequency and severity of flooding in at risk areas. Examining the incidence of flooding in coastal Texas from the perceptive of the built environment of the period 1997 to 2001, Brody et al. (2007b)observed that every square metre of additional impermeable surface translated into approximately $3,602 of added property destruction caused by deluges per year over thirty-seven counties including Harris and Galveston counties. Kousky & Zeckhauser (2006) on the other hand also asserted that expanding the amount of impervious surface cover in a region increases the speed of runoff, prevents infiltration and consequently leads to flooding.

Lund (2012) contended that in Europe 40 percent of the flood-related casualties witnessed in the period 1950–2006 were due to flash floods. He further maintained that the potentials for

flash flood casualties and damages were correspondingly on the increase in many areas due to physical developments which were wielding pressure on land uses. Similarly, Barredo & Engelen (2010) affirmed that in the flood prone zones of Pordenone province in northern Italy, the main driving force of increased flood risk was physical development activities. Douglas, Alam, Maghenda, Mcdonnell, Mclean&Campbell (2008), observed that the land cover throughout London city continues to be greatly modified by urban physical development and the changes in response to rainfall and flood peaks and the extents are becoming higher. Investigating the nature of flooding in the urban areas of Accra in Ghana, Karley (2009) asserted that there was no indication that unusual precipitation had been occurring lately that could justify the increased incidences of flooding being witnessed in the city of Accra. Rather the fundamental cause of the deluges could in turn be ascribed to unregulated physical development activities on floodplains. Ologunorisa, (2009) equally observed that in Trinidad flooding had become a legacy of unregulated physical development and it was impacting negatively on the environment. He further asserted that rapid growth in physical development without corresponding physical planning strategies had contributed immensely to flood disasters as various surfaces and buildings are flooded, with existing drainage facilities equally overwhelmed.

In Nigeria, flooding in many of its cities has become more recurring, severe and worrisome in recent decades (Agbonkhese et al., 2014). Severely affected by this menace are towns and cities in the Niger Delta region. The Niger Delta region constitutes one of the most ecologically delicate area in the country where deluges of diverse scope and magnitude are witnessed. Flood incidences in most towns and cities in the region are increasingly recurring and affecting human activities and livelihood in diverse ramifications (Agbonkhese et al., 2014). The increasing rate and severity of incidence of deluge in coastal cities in the region are not just as a result of increasing precipitation, but a direct consequence of alteration of the natural landscape in the absence of effective and comprehensive physical planning. Urban flooding and its associated negative effects are commonly labelled a function of soil, topography, rainfall, and other geophysical characteristics. The role of the built environment in this regard as an important predictor of flood menace has not been given adequate attention (Odemerho, 2014; Okon, Ogba, Idoko, Eni &Sule, 2015). The circumstance in Asaba city is a case in point.

Research Methods

This study adopted the survey research design. Residents of Asaba constituted the target population for the study. This consists of about 250,096 persons being the 2023 projected population of Asaba. Household heads/residents in Asaba were the units of analysis. With the aid of Williams' 1978 formula for sample size determination as adopted by Kerlinger and Lee (2000), 300 persons were selected. Data for this study were collected from secondary and primary sources. Data sourced from secondary sources included amongst others, the 2023 and 1987 Landsat imagery of Asaba city. Questionnaire was used in collecting primary data on the nature of flooding in Asaba city as well as Personal interviews with some professionals (Town Planners, Surveyors, Architects and Geographers). Validation of the instruments was done by a statistician and two Senior Research Fellows. To test the reliability of the instruments, Cronbach alpha was used and it yielded a correlation coefficient of 0.91. Two weeks fact-finding survey was carried out prior to the actual field survey, with a view to having a comprehensive knowledge of the phenomenon under investigation as well as identifies notable flood hotspots. The field survey took place between the months of July and September, 2023.The stratified random and simple random sampling methods were adopted in drawing samples (household heads) from the population under study, in proportion to the percentage that make up each strata in the study area; and 282 questionnaires out of the 300 copies that were administered in the field survey were duly completed and used for analysis. GIS software was used for the image capture and analysis. The field data were analysed using tables, percentages, and frequency counts. Remote sensing and ArcGIS 10.1 software were used in the data analysis and for generation of maps.

Results

Land Use Changes in Asaba

The findings of this study in the light of the urban built environment and the susceptibility of the city of Asaba to flooding are presented here. In order to explore the perennial deluge devastating Asaba in contemporary times from the built environment perspective, 1987 and 2023 Landsat imageries of Asaba were captured and analysed using remote sensing and ArcGIS 10.1 software. Based on this analysis, built-up areas were specifically extracted from the 1987 and 2023 land use/land cover map that was generated. The analysis revealed that built-up area as at 1987 was 23.64km^2, while in 2023 it was 29.29 km^2. This result signifies 23.9 percent change in terms of built-up area (physical development) between the year 1987 and 2023 (see Table 1). In the study the land use land cover was classified into 7. They are built up

area, farmland, swamp, water body, sand dome, forest and Savannah. The study showed changes in other areas and land uses such as swamps and area covered by water which increased by 12.16% and 1.71% respectively during the period. The areas occupied by farmland decreased from 70.94km^2 to 10.33km^{2}indicating a change by 60.61%, while area covered by forest decreased from 108.08km^{2}to 79.78km^2 signifying a change by 28.30% during the same period. Moreover, Savannah which was not in existence in the area in 1987 emerged within the period and had covered an area of 76.09km^2. In addition to the above analysis, maps of Asaba showing the extent of built-up area in 1987 and 2023 were equally produced as presented in Figures 1 and 2.

Table 1: Summary of Land use//land cover Change of Asaba for 1987 and 2023

No	Classes	1987 Built-up Area (km^2)	2023 Built-up Area (km^2)	Rate of Change	Percentage of Change
1	Built up area	23.64	29.29	5.65	23.9
2	Farm Land	70.94	10.33	-60.61	-85.44
3	Swamp	9.00	21.16	12.16	135.11
4	Sand Dune	8.57	1.87	-6.7	-78.18
5	Water Body	12.65	14.36	1.71	13.52
6	Savannah	0.00	76.09	76.09	100
7	Forest	108.08	79.78	-28.3	-26.18
	Total	**232.88**	**232.88**		

Source: Field Study (2023)

Changes in Built-up Area and vulnerability to Flooding

In order to explore the relationship between the incidence of flooding ravaging Asaba and the nature of urban physical development activities, the notable flash flood hotspots in the study area were identified and the coordinates of their respective geographical locations were equally taken as well (see Table 2). Furthermore, an overlay of 1987 and 2023 built-up area respectively on the major flash flood hotspots was performed using Arc GIS 10.1 spatial analysis tool (see Figure 3). The result reveals that all the identified flash flood hotspots are within the gamut of the 2023 built-up area (see Figure 2). However, the result also revealed that some of the flash flood hotspots are outside the scope of the 1987 built-up area (see Figure 1). What can be inferred from this analysis is that there is a corresponding relationship between the nature of urban physical development activities in Asaba and the perennial deluge plaguing

the city residents. As more areas are subjected to urban development in terms of housing development and other uses, there is a correspondent increase in areas susceptible to flooding. The above affirmation was equally substantiated by personal interviews among some professionals which revealed that in the early 90s, urban flooding was not really a menace in the city. The major type of flooding that was of concern then was river flood, and it was restricted to the peripheral areas (Cable Point and Otuogu neighbourhoods) that are very close to the bank of River Niger.

Table 2: Major Flash Flood Hotspots in Asaba

No	Flash Flood Hotspots	Geographical Coordinates
1	New State Secretariat	LAT 6^0 12^{l} 57.36^{ll} LONG 6^0 41^{l} 5.75^{ll}
2	Federal Secretariat	LAT 6^0 13^{l} 12.9^{ll} LONG 6^0 41^{l} 17.95^{ll}
3	Police Headquarters	LAT 6^0 13^{l} 3.25^{ll} LONG 6^0 41^{l} 35.85^{ll}
4	Women Affairs Primary School	LAT 6^0 12^{l} 35.05^{ll} LONG 6^0 41^{l} 56.55^{ll}
5	Briscoe Motors	LAT 6^0 12^{l} 23.81^{ll} LONG 6^0 41^{l} 51.82^{ll}
6	Waste Management Board office	LAT 6^0 12^{l} 0.00^{ll} LONG 6^0 42^{l} 45.06^{ll}
7	Standard Life (Vital Okakwu)	LAT 6^0 12^{l} 1^{ll} LONG 6^0 42^{l} 33^{ll}
8	Umudaike Junction	LAT 6^0 12^{l} 3^{ll} LONG 6^0 43^{l} 41^{ll}
9	Ogbeosowe	LAT 6^0 12^{l} 1^{ll} LONG 6^0 43^{l} 46^{ll}
10	Umuaji/Umuekwo	LAT 6^0 11^{l} 45^{ll} LONG 6^0 43^{l} 56^{ll}
11	Jesus Saves Road	LAT 6^0 12^{l} 19^{ll} LONG 6^0 42^{l} 31^{ll}
12	BioseAmantu Street	LAT 6^0 12^{l} 15^{ll} LONG 6^0 42^{l} 28^{ll}
13	Agric Road (ChineduEzenyili)	LAT 6^0 12^{l} 24^{ll} LONG 6^0 42^{l} 30^{ll}
14	Interbau Roundabout	LAT 6^0 12^{l} 54^{ll} LONG 6^0 42^{l} 5^{ll}
15	Eagle Square Junction (Okpanam Road)	LAT 6^0 12^{l} 3^{ll} LONG 6^0 43^{l} 41^{ll}
16	Mozia (By New General Hospital)	LAT 6^0 14^{l} 3^{ll} LONG 6^0 41^{l} 13^{ll}
17	DBS Junction	LAT 6^0 13^{l} 10^{ll} LONG 6^0 41^{l} 23^{ll}

Source: Researchers Survey (2023)

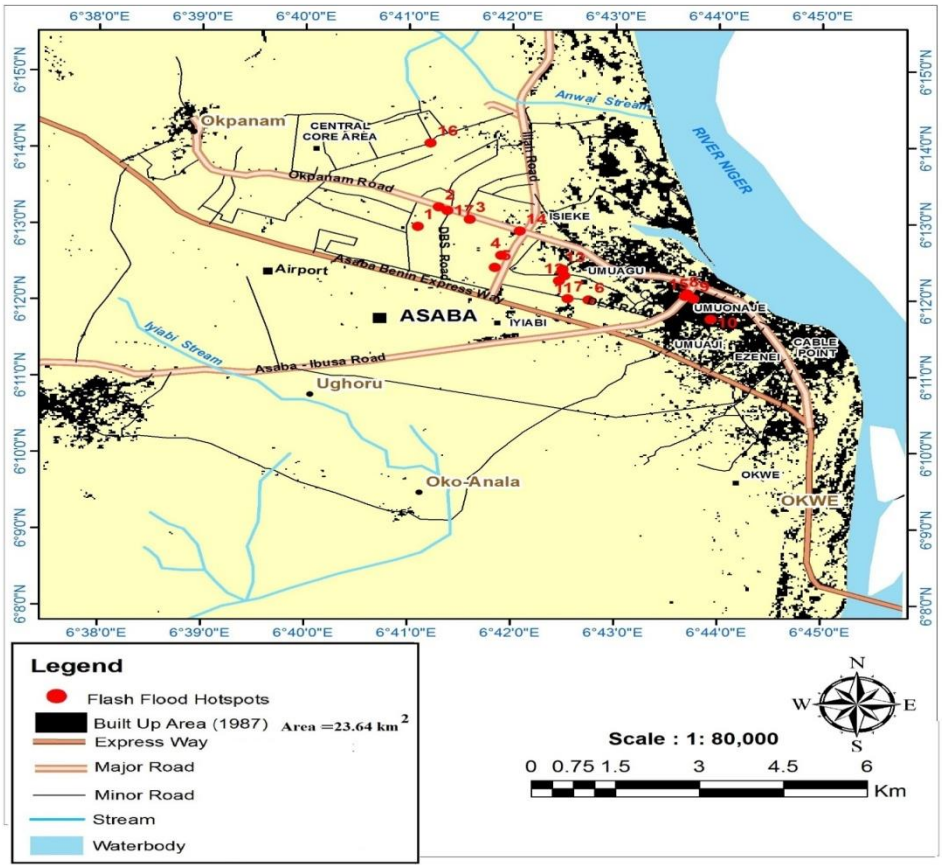


Figure 1: Flood vulnerability Map of Asaba Showing the Extent of Built-up Area in 1987 (Researchers Analysis, 2023).

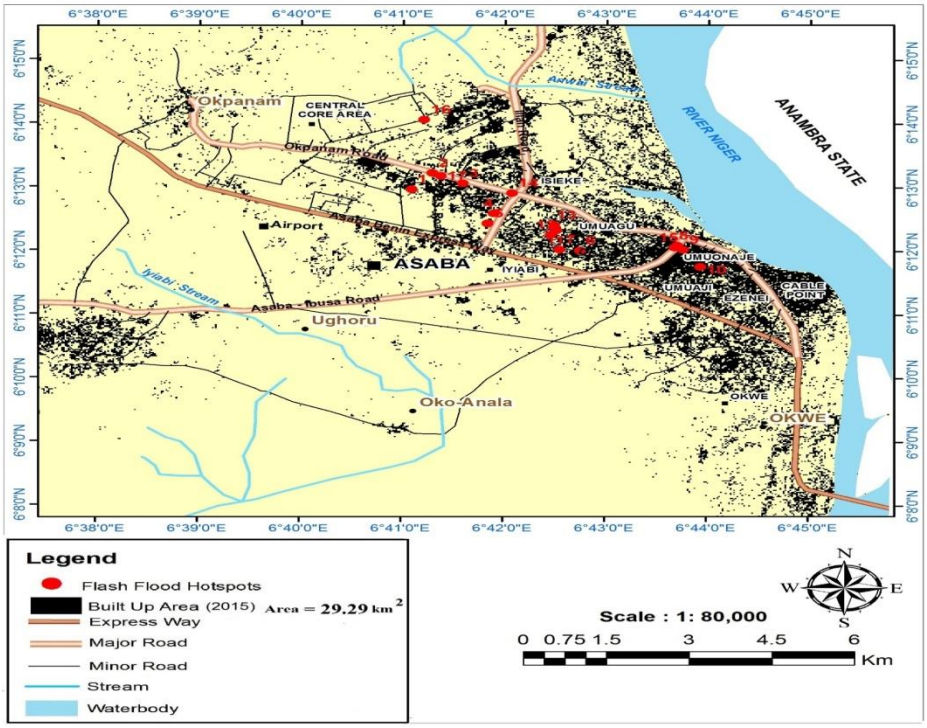


Figure 2: Flood Susceptibility Map of Asaba Showing the Extent of Built-up Area in 2023 (Researchers Analysis, 2023).

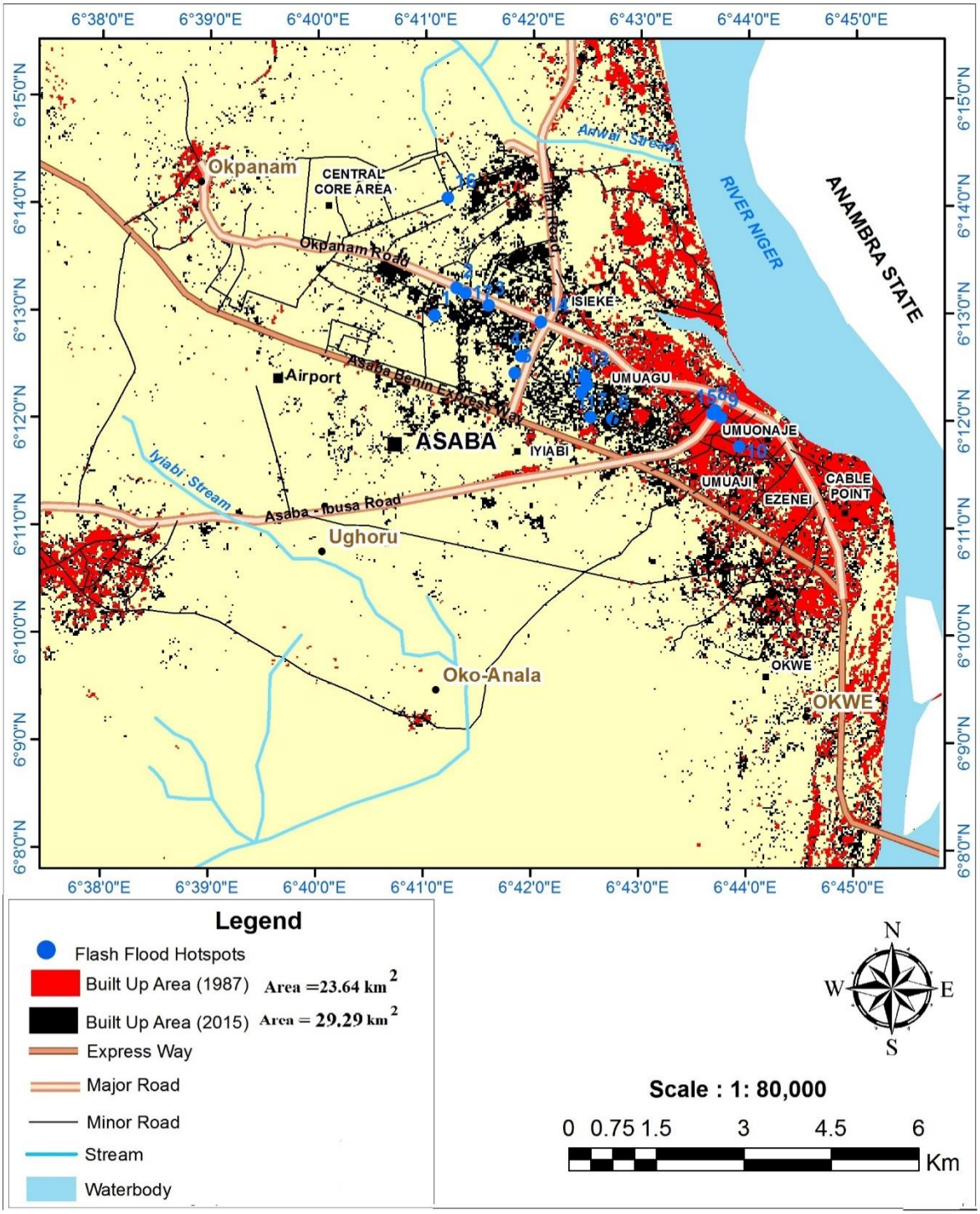


Figure 3: Flood vulnerability Map of Asaba Showing an Overlay of Built-up in 1987 and 2023 respectively (Researchers Analysis, 2023).

Table 3 provides a profile of respondent's awareness and the nature flood menace devastating the city of Asaba. The statistics indicate that although there is the problem of flooding in Asaba, 47.2 percent of the respondents however testified to the fact that they are not aware of flooding as a menace in their neighbourhood. More so, 78.7 percent of the respondents agree to the fact

that physical development activities have significant influence on the perennial deluge in the area. The above affirmation is equally substantiated by the responses of the majority of the respondents (76.6 percent) who admitted that the flood events in their neighbourhoods became of serious concern as the city began to experience proliferation of unregulated urban physical development activities.

Table 3: Awareness and the Nature Flood Menace Devastating the City of Asaba

Knowledge of Flood Menace in their Neighbourhood in Asaba		
Awareness of Flood Menace	Frequency	Percent
Yes	149	52.8
No	133	47.2
Total	282	100.0
Knowledge of if Physical Development is Responsible for the Usual Flooding in Asaba		
Influence of Physical Development on Flooding	Frequency	Percent
Strongly disagree	12	4.3
Disagree	48	17.0
Agree	159	56.4
Strongly agree	63	22.3
Total	282	100.0
Knowledge of the Nature of Flood Menace Ravaging Asaba		
Nature Flood Menace	Frequency	Percent
Do not know	6	2.1
Flood has been a problem when the area was undeveloped	12	4.3
Flooding has been a problem when the area was sparsely developed	48	17.0
Flooding became a problem due to intensity of urban physical development in the area	216	76.6
Total	282	100.0

Source: Field study (2023).

Table 4 provides a statistics of respondents' knowledge of the main type of flooding experienced, and a comparison of 2023 flood events with previous years in Asaba. The data indicates that among the main types of deluge experienced in Asaba, flash flood tends to be the dominant flood type experienced by the city residents as affirmed by the majority (91.8 percent) of the respondents. In addition, a comparison of the flood scenarios in 2023 with erstwhile years in Asaba equally revealed that the flood events in 2023 have been more devastating as acknowledged by 94 percent of the respondents. The most notable experience was the 2012 floods which sacked many communities in the city from their homes. While many people were relocated to Internally Displaced Persons (IDP) Camps during the period, huge damages to houses, household properties, farms and public infrastructures were recorded. Since then

creation of IDP camps has been an annual activity by the state government to accommodate victims of flood disaster in Asaba and the neighbouring communities. Other measures taken by the government to address flooding include construction of drainages in some major roads and occasional evacuation of debris in the blocked drainages. But many parts of the city have no good drainage channels and this account largely for the perennial flooding in such areas. Where drainages are provided, either they are not properly connected and built with good gradients to allow easy flow or they are blocked by indiscriminately disposed solid wastes.

However, a master plan for the physical development of Asaba tend to be lacking as 90.4 percent of the respondents attested to the fact that they are not aware of an extant master plan for the physical development of the city of Asaba. Table 4 provides also a statistics of respondents' knowledge of the extant master plan for physical development in Asaba. While many of them are aware of the Town Planning Agency responsible for granting approval for building of houses they are not familiar with the laws and regulations as well as any plan that should determine the pattern of development of the city.

Table 4: Knowledge of an Extant Master Plan for Physical Development and the Type of Flooding Experienced in Asaba

Knowledge of an Extant Master Plan for the Physical Development of Asaba		
Extant Master Plan	Frequency	Percent
Yes	27	9.6
No	255	90.4
Total	282	100.0
Knowledge of the Main Type of Deluge Experienced in Asaba		
Main Type of Deluge	Frequency	Percent
Flash flood	259	91.8
River flood	6	2.1
Local flood	17	6.0
Coastal flood	-	-
Total	282	100.0
Comparison of 2023 Flood Events with Previous Years in Asaba		
Flood Comparison	Frequency	Percent
Do not know	5	1.8
More Severe	60	21.3
Severe	205	72.7
Less severe	12	4.3
Total	282	100.0

Source: Field Study (2023).

Discussion

The perennial deluge devastating Asaba city was explored from the built environment perspective. In this light however, the 1987 and 2023 Landsat imageries of Asaba were captured and analysed using remote sensing and ArcGIS 10.1 software, with a view to ascertaining the relationship between urban physical development and the ravaging floods in Asaba. Based on the analysis carried out, built-up area was specifically extracted from the 1987 and 2023 land use/land cover maps of Asaba that was generated. The result shows that there is a 23.9 percent change in terms of built-up area (physical development) between the year 1987 and 2023, for built-up area as at 1987 is 23.64km2, while in 2023 it was 29.29km2 (Table 1). In addition to the above analysis, map of Asaba showing the extent of built-up area in 1987 and 2023 was equally produced as presented in Figure 1 and 2.

In other to ascertain the relationship between the incidence of flooding desolating Asaba and urban physical developmental activities place, the notable flash flood hotspots in the study area overlaid on the 1987 and 2023 built-up area respectively using ArcGIS 10.1 spatial analysis tool (See Figure 2). The result indicates that all the identified flash flood hotspots are within the gamut of the 2023 built-up area (Figure 2). However, the result also revealed that some of the flash flood hotspots are outside the scope of the 1987 built-up area (See Figure 1). Given the stride and scale of population expansion, and associated urban physical developmental activities in Asaba in recent time, we can infer from the above result that there is a corresponding relationship between incidences of flooding and urban physical developmental activities in Asaba, This affirmation is equally substantiated by studies carried out by Ran & Nedovic-Budic (2016), Brody et al. (2007a), and Odemerho (2014). These authors argued that wetland modification by human activities mainly in coastal areas and river basins is a major variable that influences flooding and flood risk. This finding is equally corroborated by the attestation of majority of the respondents (76.6 percent) who affirmed that the flood events in their neighbourhoods became of serious concern due to proliferation of unregulated and haphazard physical developmental activities in the study area. Although, flooding as a menace in Asaba was acknowledged, 47.2 percent of the respondents however testified to the fact that they are not aware of flooding risk in their neighbourhood before moving in. This affirmation can be attributed to the fact that the configuration of the natural topography of some neighbourhoods has not been greatly altered by human physical developmental activities. In addition, 78.7 percent of the respondents equally agree to the fact that physical developmental activities have significantly influenced the recurring floods in the city.

The study also revealed that flash flood is the dominant flood type experienced by the city residents in recent times. Furthermore, an appraisal of the flood events in 2023 with erstwhile years in Asaba shows that the flood events in 2023 have been more devastating as testified by majority of the respondents. However, findings equally revealed that a master plan for the physical development of Asaba is lacking as buttressed by the affirmation of majority of the respondents (90.4 percent) who attested to the fact that they are not aware of an extant master plan for the physical development of Asaba. Personal observations and interviews conducted in the course of field survey also revealed that Asaba was not known for urban deluge in the early 90s when most parts of the city have not been altered by human activities. Findings also revealed that government have made concerted effort in bringing endearing solution to the devastating deluge in Asaba, but these efforts tends to be ad hoc and futile. This is as a result of the fact that lack of drainage system was often time implicated as the major problem of flooding in the study, while neglecting the role of unregulated and haphazard developmental activities that is being witnessed at a tremendous rate in contemporary time.

Conclusion

Successive governments and other stakeholders have implemented various policy actions to address the persistent flooding in Asaba. However, these efforts have been largely ad hoc and unsustainable, providing little relief to residents. A critical issue is the failure to accurately identify the root causes of the recurring urban flooding, resulting in ineffective solutions. The role of physical development, specifically the urban built environment, in predicting and managing flood hazards has been largely overlooked. Based on the findings of this study and successful flood risk management practices worldwide, several fundamental steps are necessary to implement long-lasting flood mitigation measures in Asaba. A key element in promoting sustainable urban growth is the development of an urban master plan. There is an urgent need to revive the abandoned Asaba Master Plan. The state government should prioritize the preparation of a comprehensive master plan to guide future physical development and land use in the city.

Equally important is the immediate implementation of the proposed Asaba urban drainage master plan, which should incorporate both indigenous knowledge and contemporary technologies. This drainage plan must be fully integrated into the overall urban master plan. Additionally, an urban renewal program targeting parts of the city affected by unregulated and haphazard development would help manage flood risks more effectively.

The "sponge city" initiative, successfully adopted in China, presents a scientifically grounded approach to flood risk management. It addresses urban flooding holistically, promoting sustainable physical development while minimizing environmental impact. This initiative is highly recommended for Asaba. The study's findings provide valuable insights into mitigating the recurrent flooding in Asaba. Future research should focus on flood modelling from the perspective of the built environment in Asaba and other vulnerable cities across Nigeria.

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