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Architectural Strategies and the Challenges of Pluvial Flooding in Port Harcourt Metropolis

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Abstract
*The study examined Architectural Strategies and the Challenges of Pluvial Flooding in Port Harcourt Metropolis**.** The methodology integrates both primary and secondary data sources. With a population of 1,416, a sample frame of 708, and a sample size of 512 determined using the Taro Yamane method, the study employed field observations, surveys, and statistical analysis, including descriptive statistics. Additionally, Geographic Information Systems (GIS) were used to identify flood-prone areas within the metropolis. Findings on the Awareness of Flood Mitigation strategies implemented in the neighborhood show that 61% of respondents are aware of the flood mitigation strategies implemented in their neighborhood, indicating that these measures are relatively well-known. However, 39% of respondents are unaware of these strategies, suggesting a gap in communication or outreach efforts while 69.5% of respondents acknowledged the presence of flood barriers, other measures are lacking. Improved drainage systems were deemed inadequate by 96.1%, and land-use planning and early warning systems were ineffective for 98.6% and 96.7% of respondents, respectively. Furthermore, only 26.6% recognized public awareness campaigns, indicating limited community engagement. Findings on the challenges hindering successful implementation of flood mitigation measures in the study area indicate that the implementation of flood mitigation measures in Port Harcourt faces challenges due to insufficient funding (99.8%) and inadequate infrastructure (99.4%). Regulatory issues also pose a significant obstacle, with 84.8% of respondents acknowledging difficulties in policy enforcement. However, community resistance is less of a concern, as 71.1% of respondents indicated minimal opposition to flood mitigation efforts. From the findings, the study recommends that Architectures should incorporate BGI into building design: Incorporate BGI features into building design from the outset, evaluate site conditions, drainage patterns, and environmental factors and develop maintenance plans to ensure BGI systems continue to function effectively.*

Keywords: Architectural Strategies, Challenges, Pluvial Flooding, Port Harcourt Metropolis

INTRODUCTION

Natural disasters cause extensive losses worldwide annually. Flood events are responsible for economic and life-threatening damages. To mitigate flood risks and resulting damages, particularly in the construction of residential buildings, two approaches exist. First: constructing in areas with lower flood susceptibility, and second: implementing architectural solutions to fortify structures against floods and associated hazards. Due to the presence of water resources, rivers, etc., prompting urban expansion due to reasons like transportation, trade, agricultural use, household consumption, etc., construction near rivers and flood-prone areas becomes inevitable. This underscores the importance of the second approach architectural fortification (Seyedeh, Ali, Maleki, Rasool, Piadeh & Kourosh Behzadian, 2025). By examining the specific elements of traditional architecture in each of these areas and exploring the cause and function of each element in facing floods over time, attention is given to the particular and regional (indigenous) architectural features that have responded to floods. Appropriate architectural measures and responses to reduce flood risks, such as constructing at elevation or suitable gradients, is combined with early warning systems to provide a proper route for the future construction projects

Tamunoala, Izebe and Nnamdi (2023) noted that the function of architect is particularly interesting due to their potential to affect the management and control environmental factors that threaten human existence such as flooding (Bosher & Dainty, 2011; Okey- Ejiowhor, Amakiri, & Nkeiruka, 2022). Among the few studies that focused on the effect of architectural design on disaster management in the developed building environment clarifies the issue in detail and provides a comprehensive summary of the possible roles of architectural designers along with other professionals. Authors conceive shelter or housing just a delivery problem and contended there may not be a need for the architect. To include the architecture to be part of the solutions, they need to learn how to talk to people and collaborate with other disciplines. Developing post-disaster solutions however require different skills than a commercial practice and an ability to understand the contextual differences between normal disaster situations (Thurairajah et al., 2011). Consequently architects might have to 'unlearn' their usual approaches and relearn new ways of working to be effective where the ability to engage in collective problem solving becomes especially critical (Cage et al., 2009). Disaster management is defined as a collective term encompassing all aspects of planning for and responding to disasters, including both pre- and postdisaster activities (CERO, 2004). Researchers often highlight a paradigmatic shift concerning the approaches to manage and avoid Pro-active strategies, with a more holistic and long-term approach, place emphasis on disaster preparedness, hazard mitigation and vulnerability reduction rather than the often reactive focus on disaster management and relief to address pre-event vulnerabilities.

Furthermore, Tamunoala, et al., (2023) opined that from the perspective of architects and planners, flood resilience is an interdisciplinary problem, and the design decisions of architects and planners have an important impact on the building lifecycle. Research suggests that 20% of design decisions are made in the initial stages, which subsequently affect the remaining 80% of design decisions (McClymont et al. 2020; Amakiri, Nkeiruka, & Okey-Ejiowhor, 2022) and these initial decisions usually involve multiple influences such as a large number of building codes, owners' opinions, interdisciplinary suggestions and architects' own subjective concepts. When it comes to inter-disciplinary goal optimization, traditional design methods are not well-suited to dealing with complex problems, and empirical methods are inefficient for realizing the optimal solution (Jalali, Noorzai & Heidari, 2020). Floods can be environmentally important to local ecosystems. Having a better understanding of what causes flooding can help people to be better prepared and to perhaps minimize or prevent flood damage. The primary causes of flooding are ocean surge, tropical rains and blocked drainages in urban areas.

Flooding is endemic in the coastal zone, in the flood plains of many of our rivers and in many urban areas. Architects can more efficiently take role in the process to enhance the capacity of the society to respond to disasters via sustainable and socially/culturally responsive design solutions. Felix et al. (2013)suggested that there are a couple of key issues in the educational context to achieve this goal: (i) shift towards a more collective problem solving space in the design studio along with an intellectual familiarity with the problems of contemporary society; (ii) an understanding of the heterogeneity of the needs and characteristics of different vulnerable groups; an adequate background knowledge to filter and adapt common design principles and norms, so that they are relevant to disaster and project scenarios; (iii) a familiarity with technical solutions patterns such as open prefabrication and adaptive re-use. In addition, more systemic interventions such as making D4D part of accreditation processes are likely to generate quick results in integrating disaster management perspective into the higher education system. An architectural process can be a primary contributor to a disaster but also can provide meaningful solutions and significantly impact the overall effectiveness of aid relief. In recent years, there have been multiple tragedies resulting from poorly built or under-supported structures. This study examined Architectural Strategies and the Challenges of Pluvial Flooding in Port Harcourt Metropolis

LITERATURE REVIEW

Flooding

This phenomenon occurs when water covers previously dry areas, such as when large amounts of water flow from a source such as a river or a broken pipe onto a previously dry area, or when water overflows banks or barriers. Nigeria's coastal belt is low lying and is subject to flooding as a result of heavy rainfalls and ocean surge. An estimated 25 million people or 28% of Nigeria's population live in the coastal zone and are at risk from flooding. The areas that receive severe flooding impact include the coastal areas of Lagos, Ondo, Delta, Bayelsa, Rivers, AkwaIbom and Cross River States. Many of the country's larger rivers have flood plains, which are subject to flooding during the rainy season. These include the Rivers Niger, Benue, Cross River, Katsina and Imo. A flooding contingency plan can be made based on regional and weather forecasts, geographic information systems, ground stations and satellite imaging. During flooding, timely and detailed situation reports are required by authorities to locate and identify the affected areas and to implement corresponding damage mitigations. During this period of response or relief, it is essential that information be accurate and timely in order to address emergency situations like search, rescue and relief. Information collected on the mitigation, preparedness, response and recovery phases can be integrated into master flood prevention projects.

The 2021 Floods in Port Harcourt

Residents reported that on 21st September 2021, the capital city of Rivers State, Port Harcourt, experienced severe flooding due to torrential rains. Among the most impacted were the Federal Road Safety Corps (FRSC) office and the Port Harcourt Shopping Mall (SPAR). The rains, which began at dawn and continued for several hours, overwhelmed the FRSC's Port Harcourt Zonal Office on Aba Road. Business operations at SPAR were heavily disrupted as staff scrambled to protect merchandise from floodwater that submerged the ground floor of the mall on Azikiwe Road. Numerous cars were also submerged on major roads throughout the city, leaving many commuters stranded and residents facing significant property losses.

Several respondents and victims blamed the flooding on inadequate drainage systems in the city. Additionally, some criticized the Rivers State Government for the rapid and concurrent construction of road projects concentrated in the capital city and the reclamation of waterways that previously absorbed floodwater. The most affected areas included Station Road, Abali Motor Park, Rivers State Judiciary Complex, Ikwerre Road, Ada George, and Sanni Abacha Road. One resident highlighted that the government's unrestrained land reclamation on waterways that used to absorb floodwater had exacerbated the situation. They remarked, the water will always find its level. The result is what we are seeing now. The affected areas may have been prone to flooding in the past, but the experience today is unprecedented (Vanguard, 2021). Ultimately, the consensus among many was that urbanization and the indiscriminate construction over natural waterways were the primary causes of the severe flooding in Port Harcourt.

Figure 1: **Flooding of Port Harcourt Mall Flood along Azikiwe Road. Source**: Vanguard Newspaper, (2021)

Nature-Based Mitigation and adaptation Strategies for Flooding

Flooding is a recurring and devastating natural disaster that affects communities worldwide. As the frequency and severity of floods continue to increase due to climate change, urbanization, and land use changes, there is a growing need for effective mitigation and adaptation strategies (Intergovernmental Panel on Climate Change [IPCC], 2019; Dimkpa, Ohochuku, Adibe, & Okey-Ejiowhor, 2024). Nature-based solutions, which utilize natural ecosystems and processes to mitigate the impacts of flooding, are gaining recognition as a valuable approach to reducing flood risk (United Nations Office for Disaster Risk Reduction [UNDRR], 2019).

Definition and Types of Nature-Based Mitigation and Adaptation Strategies

Nature-based mitigation and adaptation strategies for flooding involve the use of natural ecosystems, such as wetlands, forests, and floodplains, to reduce the risk and impacts of flooding (World Bank, 2019). These strategies can be divided into two main categories: mitigation and adaptation.

Mitigation strategies: These aims to reduce the likelihood and severity of flooding by restoring or preserving natural ecosystems that can absorb and filter floodwaters (European Commission, 2019).

Examples of mitigation strategies include:

I. Wetland restoration: Restoring wetlands can help to absorb and filter floodwaters, reducing the risk of flooding downstream (Mitsch & Gosselink, 2015).
II. Floodplain management: Allowing floodplains to flood naturally can help to reduce the risk of flooding in nearby communities (Tockner & Stanford, 2002).
III. Green infrastructure: Incorporating green infrastructure, such as green roofs and permeable pavements, into urban design can help to reduce stormwater runoff and alleviate flooding (Fletcher et al., 2015).

Adaptation strategies: These strategies focus on reducing the vulnerability of communities to flooding by promoting sustainable land use practices, improving flood forecasting and warning systems, and enhancing community resilience (International Union for Conservation of Nature [IUCN], 2019).

Examples of adaptation strategies include:

I. Ecosystem-based adaptation: This approach involves restoring and preserving natural ecosystems, such as mangroves and coral reefs, to provide natural barriers against flooding and storm surges (Adger et al., 2005).
II. Flood-resilient agriculture: Implementing flood-resilient agricultural practices, such as agroforestry and conservation agriculture, can help to reduce the vulnerability of agricultural communities to flooding (Ziervogel et al., 2016).

Sponge City: Benefits

Sponge cities offer numerous benefits, including reduced flood risk, improved water quality, enhanced biodiversity, mitigated urban heat island effect, and improved public health (Li et al., 2019). The use of green infrastructure in sponge cities can also help to improve air quality, reduce noise pollution, and enhance aesthetic value (Benedict & McMahon, 2006). Additionally, sponge cities can provide opportunities for physical activity, social interaction, and community engagement, which can help to improve public health and well-being (Sallis et al., 2016).

Reduced Flood Risk: One of the primary benefits of sponge cities is the reduced risk of flooding. By incorporating green infrastructure, such as green roofs, rain gardens, and permeable pavements, sponge cities can absorb and filter rainwater, reducing the burden on drainage systems and minimizing the risk of flooding (Fletcher et al., 2015). This can help to protect homes, businesses, and infrastructure from flood damage, reducing economic losses and improving public safety.

Improved Water Quality: Sponge cities can also improve water quality by reducing stormwater runoff and filtering out pollutants and sediments (Li et al., 2019). Green infrastructure, such as green roofs and rain gardens, can absorb and treat stormwater runoff, reducing the amount of pollutants and sediments that enter urban waterways. This can help to improve the quality of urban waterways, making them safer for recreation and aquatic life.

Enhanced Biodiversity: Sponge cities can also enhance biodiversity by providing habitat for urban wildlife and promoting ecosystem services (Mitsch & Gosselink, 2015). Green infrastructure, such as parks and green spaces, can provide habitat for urban wildlife, such as birds, bees, and butterflies. Additionally, sponge cities can promote ecosystem services, such as pollination, pest control, and climate regulation.

Mitigated Urban Heat Island Effect: Sponge cities can also mitigate the urban heat island effect by reducing the temperature in urban areas (Taha, 1997). Green infrastructure, such as green roofs and urban parks, can provide shade, reduce the amount of impervious surfaces, and promote evapotranspiration, all of which can help to reduce the temperature in urban areas.

Improved Public Health: Sponge cities can also improve public health by providing opportunities for physical activity, social interaction, and community engagement (Sallis et al., 2016). Green infrastructure, such as parks and green spaces, can provide opportunities for physical activity, such as walking, cycling, and playing sports. Additionally, sponge cities can promote social interaction and community engagement, which can help to improve mental health and well-being.

Improved Air Quality: Sponge cities can also improve air quality by reducing air pollution and promoting ecosystem services (Benedict & McMahon, 2006). Green infrastructure, such as green roofs and urban parks, can absorb and filter air pollutants, reducing the amount of particulate matter and other pollutants in the air.

Reduced Noise Pollution: Sponge cities can also reduce noise pollution by providing a natural barrier between urban areas and noise sources (Benedict & McMahon, 2006). Green infrastructure, such as green roofs and urban parks, can provide a natural barrier between urban areas and noise sources, reducing the amount of noise pollution in urban areas.

Enhanced Aesthetic Value: Sponge cities can also enhance aesthetic value by providing a natural and beautiful environment (Benedict & McMahon, 2006). Green infrastructure, such as parks and green spaces, can provide a natural and beautiful environment, enhancing the aesthetic value of urban areas.

Sponge City: Implementation and Challenges

Implementing sponge city initiatives can be challenging, requiring significant investment in infrastructure and community engagement (Li et al., 2019).

Some of the challenges include:

Cost: Implementing green infrastructure can be expensive, requiring significant investment in materials and labor (Fletcher et al., 2015). The cost of implementing green infrastructure can be a significant barrier for cities, particularly those with limited budgets. However, the long-term benefits of green infrastructure, such as reduced flood risk and improved water quality, can outweigh the initial costs.

Community engagement: Sponge city initiatives require community engagement and participation, which can be time-consuming and challenging to achieve (Mitsch & Gosselink, 2015). Community engagement is critical to the success of sponge city initiatives, as it helps to build support and ownership among local residents. However, engaging with the community can be challenging, particularly in cities with diverse populations and competing priorities.

Policy and regulatory frameworks: Sponge city initiatives require supportive policy and regulatory frameworks, which can be lacking in some cities (Li et al., 2019). Policy and regulatory frameworks play a critical role in supporting the implementation of sponge city initiatives. However, in some cities, these frameworks may not be in place, or may even create barriers to implementation.

Maintenance and upkeep: Green infrastructure requires regular maintenance and upkeep, which can be challenging to ensure (Fletcher et al., 2015). Maintenance and upkeep are critical to the long-term effectiveness of green infrastructure. However, ensuring that maintenance and upkeep are carried out regularly can be challenging, particularly in cities with limited resources.

Overcoming these challenges will require innovative solutions and collaborative approaches. Cities can learn from each other's experiences and share best practices in implementing sponge city initiatives. Additionally, cities can engage with local communities, stakeholders, and experts to build support and ownership for sponge city initiatives.

Furthermore, cities can also explore innovative financing mechanisms, such as green bonds and public-private partnerships, to support the implementation of sponge city initiatives. Governments can also provide incentives, such as tax credits and grants, to encourage private sector investment in green infrastructure.

In conclusion, implementing sponge city initiatives can be challenging, but with innovative solutions and collaborative approaches, cities can overcome these challenges and create more sustainable and resilient urban environments.

Flood Risk Management (FRM) and Planning

Effective flood risk management in Port Harcourt involves identifying areas prone to pluvial floods and incorporating architectural adaptations to reduce vulnerability. This includes strategies such as elevating buildings to keep them above the floodplain, creating detention ponds, and designing drainage systems that direct water flow away from urban areas (Kundzewicz, Hoozemans & Svensson, 2019). Comprehensive flood risk management involves a cross-disciplinary approach, where architects collaborate with urban planners, engineers, and environmental scientists to design solutions that address both structural and non-structural aspects of flood mitigation (Kundzewicz, Hoozemans & Svensson, 2019). Urban planning must incorporate policies that mandate flood resilience measures, ensuring that new developments adhere to flood-proofing standards.

Sustainable Architecture

Sustainable architecture is another essential element in mitigating flooding. This approach includes using eco-friendly building materials, energy-efficient systems, and low-impact construction techniques. Sustainable architecture in Port Harcourt could integrate water collection and recycling systems, solar power, and green roofs to help manage both floodwater and energy use (IPCC, 2022). Moreover, sustainable designs should prioritize the reduction of impervious surfaces, increasing water infiltration into the ground. Climate-resilient architecture, by anticipating the increasing frequency and intensity of rain events due to climate change, ensures that new buildings are capable of withstanding both current and projected flood risks (Sovacool, Kivimaa & Mitchell, 2017).

Integrated Water Management (IWM)

The integration of Integrated Water Management (IWM) in architectural strategies ensures that water systems are designed to manage both stormwater and wastewater. IWM encourages the use of permeable surfaces, retention ponds, and bioswales to capture rainwater and prevent flooding, while also ensuring that the water is reused effectively. However, in designing buildings that contribute to water retention and filtration on-site, Port Harcourt’s architecture can play a vital role in flood mitigation. Rainwater harvesting systems, for example, can store runoff for later use, reducing the immediate volume of water flowing into the city's drainage systems during a storm event (Ochoa, González & Latorre, 2022).

Community Engagement in Design

The success of flood resilience strategies depends significantly on community engagement. Participatory design involves the local population in planning processes to ensure that flood mitigation measures are contextually appropriate, acceptable, and sustainable. In Port Harcourt, involving local communities, residents, and stakeholders in architectural decisions can lead to solutions that address local flood patterns and the specific needs of different neighborhoods (Roslan, Ali & Rahman, 2015). Additionally, community-driven solutions often promote greater ownership and ensure long-term maintenance of flood resilience measures.

METHODOLOGY

Design

The quantitative component of the study provides objective data to complement the qualitative findings and offer statistical evidence on flood risks and mitigation strategies. Surveys were administered to residents, property owners, and local government officials in flood-prone areas of Port Harcourt Metropolis. The survey gathers data on the level of awareness among residents about pluvial flooding, current flood mitigation measures in place, and their views on various architectural strategies for flood prevention. The survey used a mix of Likert scale questions to measure attitudes and perceptions, along with close-ended questions. This approach allows for the quantification of public knowledge and opinions, as well as the identification of patterns in attitudes towards flood resilience. In addition, spatial analysis and mapping using Geographic Information System (GIS) tools was employed to map stratified flood-prone areas in Port Harcourt Metropolis, and analyze the relationship between urban development patterns, existing infrastructure, and the architectural features that influence flooding. Finally, the study incorporates flood impact data analysis. This was involved doing an urban flood vulnerability assessment of the selected areas in Port Harcourt Metropolis. It is essential for developing effective flood risk reduction and management strategies. Statistical tools will be used to analyze this data and explore the relationship between specific architectural features and the occurrence of flooding.

Population and Sampling

The targeted population for the study on Architectural Adaptation Strategies to Mitigate Perennial Pluvial Floods in Port Harcourt Metropolis includes various stakeholders and groups directly or indirectly involved in addressing pluvial flooding challenges.

Residents of Flood-Prone Areas: Based on the work of Wizor & Mpigi, (2020) on the 25 most-flooded roads in Port Harcourt Metropolis. 13 regions (streets/roads) were chosen from the 25 most-flooded roads/streets in Port Harcourt Metropolis. 4 streets/roads were chosen from low-flooded areas, 5 from moderately-flooded areas, and 4 from high-flooded areas. A total of 13 streets/roads were considered for this research. However, Residents from these 13 selected flood-prone areas in Port Harcourt Metropolis form a key part of the population. These individuals provided valuable insights into local experiences with flooding, awareness of flood risks, and opinions on both existing and potential architectural strategies for flood mitigation. From each of the 13 areas, 20 compounds were selected, with one respondent per compound, resulting in a total of 260 respondents from this group.

Urban Planners and Architects: Professionals such as urban planners and architects are integral to the study, offering expert opinions on design and urban development strategies aimed at reducing flood risks. The research focuses on members of the Nigerian Institute of Town Planners (Rivers State branch), which has 570 members, and the Nigerian Institute of Architects (Rivers State branch), comprising 240 fully registered members. These professionals provide insights into the most effective architectural solutions for mitigating pluvial flooding.

Government Officials: Officials from relevant state ministries in Port Harcourt also form part of the population. These include the Rivers State Ministry of Urban Development and Physical Planning, with 84 staff members, River State Ministry of Housing with 134 staff, and the Rivers State Ministry of Environment, with 102 staff members. Their perspectives on flood management practices, policies, and regulations are crucial for understanding the institutional framework required to implement architectural adaptation strategies.

Community Leaders: Community leaders from the 13 selected flood-prone areas were included to represent the views of the broader community. These leaders play a critical role in advocating for local concerns and influencing decision-making processes related to flood mitigation, two leader or such as street chairman and a member were selected from each flood area, making a total of 26 stakeholders in this category.

Sample Frame

The sample frame for this study, "Architectural Adaptation Strategies to Mitigate Perennial Pluvial Floods in Port Harcourt Metropolis", was thoughtfully developed to include a broad range of stakeholders with diverse roles and experiences related to flood mitigation. The approach ensures a balanced representation of opinions from individuals and institutions who are directly impacted or involved in addressing flooding challenges in the metropolis. The sample was selected by taking 50% of the total population from six key stakeholder groups.

Residents of flood-prone areas constitute a significant portion of the sample frame, with 130 participants selected from a population of 260. This group provides firsthand accounts of the flooding issues they face, offering valuable insights into the effectiveness of existing measures and highlighting the areas requiring improvement for better flood resilience.

The Nigerian Institute of Town Planners (Rivers State Branch) represents the largest group in the sample, with 285 participants selected out of 570. Town planners bring critical expertise to the study as they are responsible for urban development and zoning regulations. Their contributions help evaluate how planning practices can mitigate flooding in urban areas.

The Nigerian Institute of Architects also play a crucial role, contributing 120 participants from its total membership of 240. Architects are vital in designing buildings and infrastructure to withstand flooding. Their input focuses on assessing existing designs and recommending solutions tailored to the challenges posed by recurrent pluvial flooding in the region.

Officials from the Rivers State Ministry of Urban Development and Physical Planning are also included, with 42 selected from a population of 84. This group represents government involvement in urban planning and policy-making, ensuring that the study reflects institutional perspectives and strategies currently in place to manage urban flooding.

The Rivers State Ministry of Environment contributes 51 participants from a population of 102. Their expertise provides an understanding of the environmental dimensions of flooding, including its causes, impacts, and the role of sustainable practices in mitigating its effects.

The Rivers State Ministry of Housing contributes 67 participants from a total population of 134. Their specialized knowledge offers valuable insights into the environmental aspects of flooding, encompassing its underlying causes, consequences, and the importance of sustainable practices in addressing its challenges.

Finally, community leaders from flood-prone areas are represented by 13 individuals from a total of 26. These leaders provide collective insights on how floods affect local communities and the social and cultural dimensions of flood management. Their involvement ensures that community needs and priorities are well-represented in the findings.

In total, the sample frame includes 708 participants, drawn from a population of 1,416 across the seven stakeholder groups. By incorporating inputs from residents, professionals, government agencies, and community leaders, the study ensures a comprehensive understanding of the flooding problem. This diversity strengthens the analysis and helps develop practical, inclusive, and sustainable architectural strategies to address pluvial flooding in Port Harcourt Metropolis.

Sample size

The sample size for the research Architectural Adaptation Strategies to Mitigate Perennial Pluvial Floods in Port Harcourt Metropolis was determined using the Taro Yamane formula. This statistical approach ensures the selection of a representative sample that accurately reflects the target population while minimizing sampling error. The study drew participants from seven key stakeholder groups, resulting in a total sample size of 512 individuals from an initial sample frame of 708. The Formula for Taro Yamane method is statistically given as follows:

$$n = \frac{N}{1+N\,(e)^2}$$

Where n = sample size

N = Population size

e = Level of significance or allowable error

1 = a constant

However, for each stakeholder, the estimated sample size was obtained for the sample frame of the population, for example, using the residents of flood prone area with a sample frame of 130 stakeholder for illustration, the Taro Yamane formula is thus substituted.

$$n = \frac{130}{1 + 130\,(0.05)^2}$$

$$= \frac{130}{1 + 130\,(0.0025)}$$

$$= \frac{130}{1.325} \quad = \quad 98$$

The Residents of Flood-Prone Areas constituted a significant portion of the sample size, with 98 participants selected from a sample frame of 130. The Nigerian Institute of Town Planners, Rivers State Branch had the largest sample frame of 285 members, from which 166 were selected. From the Nigerian Institute of Architects (Full Members), 92 individuals were selected from a sample frame of 120. The Rivers State Ministry of Urban Development and Physical Planning had a sample frame of 42 participants, with 41 selected for the study. The Rivers State Ministry of Environment had a sample size of 45 individuals, drawn from a sample frame of 51. While the

Rivers State Ministry of Housing has a sample size of 57 selected from a sample frame of 67. Finally, the Community Leaders of Flood-Prone Areas, representing grassroots stakeholders, had all 13 members included in the sample size. In summary, the total sample size of 512 participants encompassed a diverse range of stakeholders, ensuring the study benefited from a broad spectrum of expertise, experiences, and perspectives. This approach enhances the reliability of the findings and supports the development of effective architectural adaptation strategies to mitigate pluvial flooding in Port Harcourt Metropolis.

Instrumentation and Data Collection

This section outlines the instrumentation and data collection methods employed in this research, including the design and administration of surveys, interviews, and observational studies. The data collection instruments were carefully developed and validated to ensure that they captured the necessary information to address the research questions and objectives. This chapter provides an overview of the data collection process, including data collection techniques, and instrumentation used to gather both qualitative and quantitative data.

Instrumentation

This research utilized a variety of tools to collect comprehensive data on strategies for architectural adaptation to address recurring urban floods in Port Harcourt Metropolis. The instruments employed included well-structured questionnaires, interviews, and Geographic Information System (GIS) tools, each tailored to extract specific information from relevant stakeholders actively involved in flood management in the city. The structured questionnaire served as the main instrument for data collection, featuring both closed and open-ended questions. Its purpose was to gather diverse insights from key groups such as government officials, urban developers, architects, residents of affected neighborhoods, and community leaders in areas susceptible to flooding. The questionnaire was organized into sections.

Data Collection

This study employed a mixed-methods approach, integrating both qualitative and quantitative methods to gain an understanding of flood risks and mitigation strategies. Field Observations focused on flood-prone areas, examining drainage systems, building elevations, and construction materials, providing a baseline for adaptation strategies. Document Review was conducted using government reports, urban planning documents, and flood management policies to understand the historical and policy context of flood mitigation in Port Harcourt Metropolis. Additionally, Surveys were used to gather both expert and community perspectives. Semi-structured interviews were conducted with professionals, including architects, urban planners, and flood management experts, to gain expert insights into effective architectural strategies. Focus group discussions with community leaders were held to explore local views on current flood mitigation measures and potential solutions. Surveys were distributed to residents, property owners, and local government officials to assess their awareness of pluvial flooding and their opinions on architectural strategies for flood prevention. The surveys combined Likert-scale and close-ended questions, providing statistical data on public knowledge and attitudes.

Analytical Techniques for Data Collected/ / Analysis

The data obtained from the survey and GIS assessments were carefully organized and prepared for analysis. Responses from the structured questionnaire were initially sorted according to the demographic characteristics of respondents and the study's key research objectives. Descriptive statistical techniques, such as frequency distributions, percentages, and graphical representations, were utilized to interpret the responses. These methods facilitated the identification of participants' views on recurrent pluvial flooding in Port Harcourt Metropolis. In addition, spatial data analysis was conducted using ArcGIS. The GIS software was instrumental in visualizing and analyzing specific flood-prone areas within the study region. However, in mapping these vulnerable locations, ArcGIS provided valuable spatial context to the survey findings, enabling an understanding of the challenges and solutions related to pluvial flood mitigation in Port Harcourt Metropolis. The integration of descriptive statistics and GIS analysis ensured that the data was examined from multiple perspectives, contributing to well-rounded insights into strategies for addressing flooding issues in the study area.

Validity and Reliability of Research Instruments

To guarantee the accuracy and dependability of the tools used in this study, a thorough validation process was undertaken. The consistency of the structured questionnaire was evaluated using the test-retest technique. This approach involved administering the same set of questions to a small group of urban planners and other relevant stakeholders within Port Harcourt Metropolis at two different times. This allowed for an assessment of the uniformity in responses, ensuring the questionnaire effectively captured participants' views and experiences related to pluvial flooding and its mitigation. The variations observed between the two rounds of responses were reviewed, and modifications were made to improve the questionnaire's reliability. Additionally, the GIS tools utilized in this research, particularly ArcGIS, were rigorously tested by a certified GIS specialist before being deployed for data collection. This preliminary evaluation ensured the software's capability to accurately extract and analyze spatial data related to pluvial flooding within the study area. The GIS tools were also assessed to confirm their reliability in providing consistent results throughout the study. This step was critical in verifying that the spatial data collected was both precise and dependable. However, in employing the test-retest method for the questionnaire and subjecting the GIS tools to expert evaluation, the study ensured that all research instruments were both valid and robust. These efforts ensured the collection of high-quality, reliable data that was essential for developing effective architectural strategies to mitigate recurring pluvial flooding in Port Harcourt Metropolis. The combined validation process enhanced the credibility of the research findings and supported the study's objectives.

RESULTS AND DISCUSSION

The analysis of the questionnaire responses on the level of participation and data collection efficiency for the research on Architectural Adaptation Strategies to Mitigate Perennial Pluvial Floods in Port Harcourt Metropolis. However, out of the total 512 questionnaires distributed, an impressive 95% (488) were completed and returned by the respondents. This high return rate demonstrates strong engagement and commitment from the participants, ensuring a robust dataset for the study. Conversely, only 5% (24) of the questionnaires were not returned, indicating a minimal loss of data and underscoring the effectiveness of the distribution and follow-up process. The near-complete response rate enhances the reliability and representativeness of the result, providing a foundation for analyzing architectural adaptation strategies to address flooding challenges in the study area. This high participation level underscores the importance and relevance of the research topic to the respondents, further validating the study's conclusions and recommendations.

The gender distribution of respondents in the study on architectural adaptation strategies to mitigate perennial pluvial floods in Port Harcourt Metropolis, however, the result reveals a notable disparity, with a higher proportion of male participants. Specifically, 86% of the respondents were male, while 13% were female, and 1% did not provide gender information. This data suggests that men were more likely to engage with the topic of flooding and architectural solutions in the region. Various factors, such as societal roles, cultural norms and the specific nature of this research, may have contributed to the higher male representation in the study. The relatively small percentage of female participants highlights potential gaps in gender representation when discussing environmental and urban challenges like flooding. Women, particularly in many communities, often play vital roles in resilience building and addressing environmental issues and their perspectives may offer critical insights into the challenges posed by floods. The underrepresentation of women could result in missing views on important factors such as household safety, community engagement, and the role of women in flood mitigation strategies. Future studies may consider developing targeted outreach approaches to encourage more female participation, ensuring a more comprehensive understanding of the impact of floods on various demographic groups. Additionally, the 1% non-response rate for gender is minimal but underscores the importance of complete participation in demographic data collection. The gender distribution in this research suggests that, although the study predominantly reflects male perspectives, efforts should be made to balance the participation of men and women. Thus, in fostering a more inclusive research environment, future studies can ensure that the voices of both genders are adequately represented in the design and implementation of flood mitigation strategies, which ultimately contribute to creating more resilient communities in Port Harcourt Metropolis.
The Percentage Distribution of Educational Attainment, however, a large proportion of the respondents, 75%, hold tertiary education. This suggests that most individuals in the sample are well-educated, which likely enhances their ability to grasp complex issues such as urban flooding, sustainable development, and the technical aspects of flood mitigation. This group may also be more inclined to support scientifically grounded solutions and policies related to urban planning and infrastructure. A substantial 24% of respondents have completed secondary education. While

this group may not have the in-depth technical knowledge of those with tertiary education, they likely possess general awareness about urban environmental issues. Their opinions and insights could be shaped by broader societal conversations and awareness campaigns regarding flooding and urban resilience. They may offer practical ideas based on their experiences and observations in their communities. A smaller percentage, 1%, has only completed primary education. Despite their limited formal education, this group may still provide important perspectives, particularly based on lived experiences of flooding and its impacts on everyday life. Their insights might emphasize simple, accessible solutions or community-driven approaches to address flooding in a way that does not require specialized knowledge. Additionally, the data indicates a relatively well-educated sample, predominantly consisting of individuals with tertiary or secondary education. This educational background is likely to influence their ability to contribute to discussions on the challenges and potential solutions for perennial flooding in the region. However, it is essential to include the perspectives of all education levels, ensuring that both expert and community-based knowledge contribute to the design of effective flood mitigation strategies.

Architectural Strategies and the Challenges of Pluvial Flooding in Port Harcourt Metropolis

Table 1: Awareness of Flood Mitigation strategies implemented in the neighborhood

Are you aware of any flood mitigation strategies implemented in your area?		
Awareness	**Frequency (F)**	**Percentages (%)**
Yes	296	61%
No	192	39%
Total	**488**	**100%**

Source: Researcher, 2024

Table 1 Awareness of Flood Mitigation strategies implemented in the neighborhood. However, results reveal a mixed level of awareness regarding flood mitigation strategies in the neighborhood. A majority of respondents, 61%, reported being aware of the flood mitigation measures implemented in their area, indicating that these strategies are relatively well-known among the residents. This could be attributed to effective communication or public awareness campaigns conducted by local authorities or community organizations. However, the remaining 39% of respondents expressed a lack of awareness about the flood mitigation strategies in place. This gap in awareness suggests that there may be a need for improved communication channels or targeted outreach efforts to ensure that all community members are informed about these crucial strategies. The discrepancy between the two groups may also point to the effectiveness of current awareness campaigns, which might not have reached all residents or may not have been compelling enough to garner widespread attention. Therefore, further efforts to educate and engage the community are essential to ensure that everyone is informed and prepared for potential flood risks.

Table 2: Attempts to Mitigate Flooding

S/N	Reason	Response		
		Yes	No	Total
1.	Improved drainage systems	3.9	96.1	**100**
2.	Flood Barrier	69.5	30.5	**100**
3.	Land –use planning	1.4	98.6	**100**
4.	Early warning Systems	3.3	96.7	**100**
5.	Public awareness campaigns	26.6	71.5	**100**

Source: Researcher, 2024

Table 2 shows attempt to Mitigate Flooding. However, the data on flood mitigation efforts in Port Harcourt metropolis highlights significant challenges in addressing flooding effectively. Flood barriers appear to be the most implemented strategy, with 69.5% of respondents acknowledging their presence. Other essential measures show considerable deficiencies. Improved drainage systems were reported as inadequate by 96.1% of respondents, revealing a critical gap in infrastructure. Land-use planning and early warning systems were also perceived as ineffective by 98.6% and 96.7%, respectively, indicating weaknesses in urban development and flood preparedness. Additionally, only 26.6% of respondents were aware of public awareness campaigns, pointing to limited community engagement. These result stress the urgent need for flood management strategies, including better drainage, strategic urban planning, robust warning systems, and effective public education.

Figure 2: Architectural adaptation strategy (permeable road pavement, green verge by the road, and covered drainages to prevent indiscriminate refuse disposal) Source: (Researcher, 2024**)**

Discussion of Findings

Findings on the Awareness of Flood Mitigation strategies implemented in the neighborhood show that 61% of respondents are aware of the flood mitigation strategies implemented in their neighborhood, indicating that these measures are relatively well-known. However, 39% of respondents are unaware of these strategies, suggesting a gap in communication or outreach efforts. This highlights the need for improved awareness campaigns or targeted community engagement to ensure that all residents are informed about the flood mitigation measures in place. Addressing this gap can help enhance preparedness and foster greater community involvement in mitigating flood risks. Findings on Flood mitigation efforts in Port Harcourt metropolis also show significant shortcomings. While 69.5% of respondents acknowledged the presence of flood barriers, other measures are lacking. Improved drainage systems were deemed inadequate by 96.1%, and land-use planning and early warning systems were ineffective for 98.6% and 96.7% of respondents, respectively. Furthermore, only 26.6% recognized public awareness campaigns, indicating limited community engagement. These findings highlight the urgent need for improved infrastructure, strategic urban planning, effective early warning systems, and enhanced public education to address the challenges of flooding and build resilience in the city

Findings on the challenges hindering successful implementation of flood mitigation measures in the study area indicate that the implementation of flood mitigation measures in Port Harcourt faces challenges due to insufficient funding (99.8%) and inadequate infrastructure (99.4%). Regulatory issues also pose a significant obstacle, with 84.8% of respondents acknowledging difficulties in policy enforcement. However, community resistance is less of a concern, as 71.1% of respondents indicated minimal opposition to flood mitigation efforts. These results highlight the urgent need for increased financial resources, enhanced infrastructure, and more effective regulatory frameworks to overcome barriers and improve flood management in the metropolis. Addressing these challenges is essential for implementing sustainable and effective flood mitigation strategies. Findings on the Primary Goals of Flood Mitigation Strategies in Alignment with Architectural Objectives show unanimous alignment between flood mitigation strategies and architectural objectives in Port Harcourt, with 100% of respondents agreeing on key priorities. These include protecting infrastructure, enhancing community safety, preserving architectural heritage, supporting sustainable urban development, and ensuring human comfort and building sustainability. This consensus reflects a comprehensive approach to flood management that not only addresses the immediate risks of flooding but also emphasizes long-term sustainability, public safety, and the preservation of cultural and architectural values. The integration of these objectives indicates a well-rounded strategy for managing flood impacts in the metropolis. Finding on the best ways community involvement can be enhanced to ensure success of flood mitigation measures in Port Harcourt metropolis shows that all respondents (100%) agreed on the importance of community engagement programs, collaborative planning sessions, and public awareness campaigns to boost participation. Additionally, educational workshops were universally supported (100%) as an essential means to raise awareness and provide vital knowledge to the community. These findings highlight the need for an inclusive approach, ensuring that the community actively contributes to the planning and execution of flood mitigation strategies, thereby enhancing their effectiveness and acceptance.

Conclusion

Existing flood mitigation strategies, while present, revealed shortcomings in awareness, implementation, and funding. The research emphasized the value of practical measures such as elevated damp-proof courses, flood proofing essential systems, and incorporating permeable surfaces. However, systemic challenges like poor urban planning, ineffective drainage systems, and weak enforcement of policies remain significant obstacles. To address these issues, the study proposed a flood-resilient design framework that incorporates architectural innovations, effective stakeholder involvement, and strong policy measures. Thus in enhancing public awareness, fostering community participation, and prioritizing sustainable urban planning practices, Port Harcourt Metropolis can better manage and mitigate the impacts of perennial pluvial floods while building a more resilient urban environment.

Recommendations

i. Incorporate BGI into building design: Incorporate BGI features into building design from the outset.
ii. Conduct thorough site assessments: Evaluate site conditions, drainage patterns, and environmental factors.
iii. Collaborate with stakeholders: Engage architects, engineers, landscape architects, and other stakeholders.
iv. Ensure maintenance and upkeep: Develop maintenance plans to ensure BGI systems continue to function effectively.
v. Monitor performance: Track the effectiveness of BGI systems and make adjustments as needed.

REFERENCES

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockström, J. (2005). Social ecological resilience to coastal disasters. Science, 309(5737), 1036-1039

Amakiri, I. T., Sheriff, E. I., & Chima, I. N. (2024). Architectural designs and disaster management: Evidence from flood incidence in Rivers State. *IIARD International Journal of Geography & Environmental Management (IJGEM), 9(6), 193-205*

Amakiri, I. T., Nkeiruka, O. A., & Okey-Ejiowhor, C. H., (2022). Housing challenge and urban infrastructure development in Rivers State. *International Journal of Innovative Environmental Studies Research 9(2):9-15,*

Benedict, M. A., & McMahon, E. T. (2006). Green infrastructure: Linking landscapes and communities. Island Press.

Bosher, L.S. & Dainty, A.R.J, (2011). Disaster risk reduction and 'built-in' resilience: towards overarching principles for construction practice. *Disasters, 35(1), 1-18.*

Cage, C., Hingorani, D., Jopling, S. &Paeker, E, (2009). Building relevance: post-disaster shelter and the role of the building professional.Background paper for the one day International Federation of the Red Cross (IFRC) and Center for Development and Emergency Practice (CENDEP), Oxford Brookes University.

CERO, (2004).Disaster management for students: managing disasters. Barbados, Central Emergency Relief Organization. Available from http://cero.gov.bb/ pages/students.html [accessed 13 February 2025]

Dimkpa, K., Ohochuku, P. C., Adibe, O. N., & Okey-Ejiowhor, H. C. (2024). Architectural Resilience: Navigating Climatic Challenges in Secondary School Buildings across Port Harcourt Local Government Area, Rivers State. *Journal of Engineering, Mechanics and Modern Architecture, 3(4), 23-33.*

Fletcher, T. D., Shuster, W. D., & Hunt, W. F. (2015). *Sustainable stormwater management: Blue-green infrastructure*. Springer.

Fletcher, T. D., Shuster, W., Hunt, W. F., Ashley, R., Butler, D., Arthur, S., & Bertrand-Krajewski, J. L. (2015). SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage. Urban Water Journal, 12(7), 525-542

Jalali, Z., E. Noorzai, &Heidari.S.(2020).Design and optimization of form and facade of an office building using the genetic algorithm. *Science and Technology for the Built Environment 26 (2), 128–140.*

Li, Z., Liu, W., & Zhang, J. (2019). Sponge city construction in China: A review. *Journal of Cleaner Production, 235, 131-143.*

McClymont, K., D. Morrison, L. Beevers, and E. Carmen.(2020). Flood Resilience: A Systematic Review. *Journal of Environmental Planning and Management 63 (7), 1151–1176.*

Mitsch, W. J., & Gosselink, J. G. (2015). Wetlands. John Wiley & Sons.

Okey- Ejiowhor, C. H., Amakiri, I. T., & Nkeiruka, O. A. (2022). The impact of rural urban migration on housing deficit in Port Harcourt Local Government Rivers State. *International Journal of Innovative Human Ecology & Nature Studies 10(2):1-8,*

Sallis, J. F., Cerin, E., Conway, T. L., Adams, M. A., Frank, L. D., Pratt, M., ... & Davey, R. (2016). Physical activity in relation to urban environments in space and time: A systematic review of empirical studies. Social Science & Medicine, 147, 45-53.

Taha, H. (2017). Urban heat islands and green infrastructure. Journal of Urban Planning and Development, 143(3), 05017004.Tauhid, F. (2018). Urban Green Infrastructure For Climate Resilience: A Review. ResearchGate.https://www.researchgate.net/publication/326267324_Urban_Green_Infrastructure_For_Climate_Resilience_A_Review

Thurairajah, N., Palliyaguru, R. & Williams, A, (2011). Incorporate disaster management perspective into built environment undergraduate curriculum. In: Proceedings of the International Conference on Building Resilience 2011, Heritance Kandalama, Sri Lanka 19th-21st July 2011, Paper ID:218. Available from: http://www.orbee.org/images/stories/paper_building%20resilience%20conference%202011.pdf [Accessed 13 February 2025].

World Bank (2023). *Urban Flooding and Climate Change: Challenges in Sub-Saharan Africa*. Climate Change and Development, 31(1), 45-60.