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Factors Affecting the Application of Flood-Resilient Techniques in the Design and Construction of Buildings in Anambra East Local Government Area, Anambra State, Nigeria

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Abstract: **Flooding is one of the most devastating natural disasters in Nigeria, causing significant damage to lives, property, and infrastructure, particularly in riverine and low-lying areas. Anambra East Local Government Area of Anambra State, situated within the lower Niger River Basin, has experienced recurrent severe flood disasters, notably in 2012 and 2022, which resulted in widespread submergence of homes, displacement of residents, and long-term socio-economic disruptions. This study investigated the factors affecting the application of flood-resilient techniques in the design and construction of buildings in the area, with the aim of providing context-specific recommendations for improving resilience. A survey research design was adopted, targeting homeowners and building professionals, including Architects, Builders, and Engineers (Civil, Electrical, and Mechanical) within Anambra State. A sample size of 398 homeowners and 310 building professionals was selected using systematic and random sampling techniques, respectively. Data were collected using structured questionnaires and analysed using the Statistical Package for Social Sciences (SPSS) version 22. Descriptive statistics were employed to summarise responses, while the Relative Importance Index (RII) was used to rank the factors influencing resilience. Findings revealed unanimous agreement among respondents on the significance of various factors in improving flood resilience. Access to early warning information systems ranked highest (RII = 0.76), followed by government support and flood education (RII = 0.74), and proper flood management, infrastructure development, and urban planning (RII = 0.73). Financial constraints, weak policy implementation, and inadequate spatial planning were also identified as key barriers. The study concludes that improving resilience requires an integrated approach involving governance, infrastructure, community engagement, and technology. Strengthening early warning information systems is recommended as the most critical priority to enable proactive response and minimise the impacts of flooding in Anambra East L.G.A.**

Keywords: **Flooding, Building Resilience, Early Warning Systems, Flood-Resilient Techniques, Anambra East.**

I. INTRODUCTION

The built environment remains one of the most vulnerable sectors to the destructive impacts of natural disasters due to the physical characteristics and fixed nature of constructed facilities, even when such disasters are accurately predicted (Ezeokoli, Okoye, & Ugochukwu, 2015). Among the various natural hazards, floods constitute a particularly devastating phenomenon, defined as water-induced disasters that lead to the temporary overflow of dry land, causing severe damage to lives, properties, and infrastructure (Ijigah & Akinyemi, 2015). In Nigeria, recurrent flooding has resulted in widespread destruction, including the collapse of buildings, loss of human lives, displacement of communities, and the destruction of agricultural produce.

The incidence of flooding in recent years has intensified, largely attributed to global warming and climate change, which have increased the frequency and intensity of rainstorms (Ezeokoli et al., 2015). Flooding typically occurs when the carrying capacity of rivers, streams, or drainage channels is exceeded, often due to excessive rainfall, blockage of waterways, or a combination of both (Nwilo, 2013). This challenge is particularly acute in low-lying and wetland areas such as Anambra East Local Government Area of Anambra State, Nigeria, where the saturated nature of the terrain, coupled with rising sea levels, exacerbates flood risk. In such riverine environments, periodic inundation often results in the submergence of properties, damage to infrastructure, and displacement of residents (Adeleye & Rustum, 2021).

Anambra East L.G.A., located within the lower Niger River Basin, has been a recurrent victim of severe flood disasters. The 2012 national flood disaster, for example, submerged entire communities across eight Local Government Areas in Anambra State, including Anambra East, with an estimated 10,000 homes either fully or partially submerged for extended periods (Ezeokoli *et al.*, 2015). Similarly, the 2022 flood disaster inundated approximately 98% of the landmass of Anambra East, leaving virtually all homes and public infrastructure damaged and displacing thousands of residents (NEMA, 2022). Such recurrent flooding has serious implications for the structural integrity of buildings, economic stability, and the overall resilience of communities in the region.

The construction industry plays a critical role in enhancing the resilience of buildings against flood hazards. Flood-resilient design and construction techniques aim to minimize the damage caused by floodwater when complete exclusion is impractical. These measures include elevating ground floor levels, using low-permeability materials for walls and floors, installing electrical systems above potential flood levels, and designing structures to facilitate post-flood drainage, cleaning, and drying (Ezeokoli, Okoli, & Aniegbuna, 2019). Other strategies such as embankments, rerouting floodwater channels, and retrofitting existing buildings have also been recommended to mitigate the impact of flooding in the area.

Despite the availability of such strategies, flood-related damages to building components and fabrics persist in Anambra East L.G.A., indicating gaps in the effective application of resilient construction measures. This raises critical questions about the factors influencing the adoption of flood-resilient techniques in the design and construction of buildings in the area. Consequently, this study seeks to investigate these factors, with the ultimate goal of recommending context-appropriate design and construction practices that can strengthen the resilience of buildings to flood disasters in Anambra East Local Government Area of Anambra State, Nigeria

II. LITERATURE REVIEW

A. Overview of Resilience

Resilience is the process and outcome of successfully adapting to challenging life experiences, especially through mental, emotional, and behavioral flexibility and adjustment to external and internal demands. According to USGBC (2011), resilience is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. It further includes: Design planning, Healthy sites, maintaining project sites and catastrophic events as important aspects of resilience. Resilience therefore is the capacity to withstand or to recover from difficulties, toughness, etc.

Folke (2006); and Davoudi (2012) state that Resilience is a fuzzy concept that involves a high sense of uncertainty, surprise, and unpredictability. According to Bickerstaff and Walker (2005); Folke, (2006); and Davoudi (2012), Resilience can be defined as a system's capacity to absorb disturbance and has the ability to self-organize to maintain its structure, function, and identity while experiencing change. The term "Resilience" was first introduced by Holling in 1973 as a concept to assist in conceiving the capacity of ecosystems to persist in the initial state while experiencing disturbance. Davondi (2012) states that the concept has been used in multidisciplinary knowledge, such as engineering, economics, disaster management, and planning, and replaces the term of sustainability in the daily discourse. Resilience is applied in at least three different ways. Its measurement is not based on the speed of recovery because a system can have multiple stable states' to maintain its essential function (Walker, Holling, Carpenter, and Kinzig, 2004). It should be noted that the

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concept of resilience has been adopted by and adapted to a range of disciplines such as Engineering, Ecological, and Evolutionary resilience.

Resilience according to Quinlan, Berbes-Blazque, Harder and Peterson (2016) has varying definitions and has gained importance in the climate change and flooding risks over the years. The concept as applied by Holling, (1973) to ecological systems refers to the ability of natural systems to absorb change and disturbance while preserving relationships between “State variables” (Alexander, 2013). The theory was later extended into the socio-ecological realm to describe the capacity of human communities to withstand and recover from disaster and other disruptive events (European Environment Agency (EEA), (2015). For flooding disasters, resilience often refers to urban contexts or the ability of cites to recover or absorb flood damage (Melchior and Chi-ming, 2023).

Furthermore, in terms of capacity, resilience can be characterized as:

1. The ability to resist
2. The ability to absorb and recover and
3. The ability to transform and adapt (Handayani, Fisher, Rudiarto, Setyono, and Foley, 2019)

Flood resilience according to CIRIA (2007) is constructing a building in such a way that although flood water many enter the building, its impact is reduced (i.e. no permanent damage is caused, structural integrity is maintained, and drying and cleaning are facilitated). Flood resilience is a term that has become more commonly used, and generally means that damages are minimized during times of flooding resulting in less risk to people and infrastructure and ensuring that there is ample room for flooding and river adjustment to occur where the opportunity may exist.

B. Flood-Resilient Techniques

Oluseye, Yetunde, Babatunde, and Victor, (2018) in their study on Developing flood-resilient buildings in Nigeria using majorly qualitative data. The study observed that the existing buildings are to correct some of the suspected drawbacks in the resilient of our building in Nigeria against flood. The suspected drawbacks canbe corrected but there is a limit to what can be corrected in most of the already existing buildings. Oluseye *et al.,* (2018), in Table 1 propose an expected resilience features to assist the prospective builders in developing the necessary blueprint towards achieving the goal of improving resilience in the various buildings.

Table 1: Proposed/Expected Resilience Features in Nigeria Buildings

S/ No	Proposed Resilient Features	Description	Expected Effect
1	Invulnerable Site	Buildings should be located in areas that are not prone to flood. Structures developers should avoid water ways, swampy areas, valley lands, close to canals etc.	This will make the house and the properties there in to be free from any attack or damage from a flood. A house that is free from such an area will require little or no additional features for resilience.
2	Storey Buildings, High foundation level, high building entrance level, and Column raised buildings.	Storey buildings with opened ground floors or column-raised buildings. The ground floor will not be for accommodation but just a column to raise the building.	This will raise the height of the house against the level of flood at its peak thereby water will not be able to enter the main building.
3	Tiled floors and tiled Walls	The floors of the house and the walls should be covered by ceramic tiles. The floor and walls of the building must be well-plastered with cement.	This will hasten the recovery of the building during a flood. It will reduce the extent of damage during flood events and bouncing back will never be a problem.
4	Harvesting of the rain water into a storage tank or dam, adequate channelization, and	Rather than allowing the rain water to increase the run-off when falling directly from the roof the water	This will reduce the run-off water in the community and the environment at large will not be disturbed by the

	drainage system.	should be collected through a harvester and gathered into storage or a dam in a community. The water can be recycled for domestic use or hydro energy generation.	excess water. Since most flood events are associated with the period of heavy downpour.
5	Excellent Waste Disposal Method (Waste Recycling Plant, Engineered Landfill).	Waste should not be thrown anyhow in the environment. Recycling the solid waste is the best. In situations where it is not recyclable an engineered landfill should be used rather than throwing waste in drainages, roadside, inside the rain etc.	Reduction or total elimination of blockages in the water ways and drainages will be achieved through this. This will allow the water to have free flow through the right channel.
6	Boat, Life Jackets, Tube, Snow Boards, Flood Warning Systems, scooping bowls, water pumping machine, shovel, etc.	These are materials that can assist during floods. Escaping from sudden flood events requires some of these facilities while staying alive among other things remains important; these materials can assist to a certain level.	A boat can be used to transport the occupants of the house and valuable properties during flood while the floating tube, or life jacket will help save the live of the occupants especially kids who are at more risk.

Source: Oluseye *et. al.*, 2018

III. METHODOLOGY

This study employed a survey research design to investigate the factors affecting the application of flood-resilient techniques in the design and construction of buildings in Anambra East Local Government Area of Anambra State, Nigeria. The study population comprised homeowners of residential buildings across the towns in the L.G.A. and building professionals, including Architects, Builders, and Engineers (Civil, Electrical, and Mechanical) within Anambra State. A sample of 398 homeowners and 310 building professionals was selected. Systematic sampling was used to select homeowners, while building professionals were chosen through random sampling. Data were collected using structured questionnaires administered directly to respondents or their representatives.

The collected data were analysed using the Statistical Package for Social Sciences (SPSS) version 22. Descriptive statistics such as frequencies, percentages, and mean scores were used to summarise responses, while the Relative Importance Index (RII) was employed to rank the identified factors based on their significance. This analytical approach enabled the study to systematically prioritise the factors influencing the adoption of flood-resilient building techniques, providing a robust basis for recommendations aimed at improving resilience in flood-prone areas.

IV. RESULTS AND DISCUSSION

Table 2: Distribution of Questionnaire and Percentage Response

S/N	Participant Groups	Distributed Questionnaire	Returned Questionnaire	Completed Questionnaire	Response Rate (%)
1	Homeowner	398	383	380	95
2	Building Professional	310	309	305	98
	Total	**708**	**692**	**685**	**97**

Table 2 shows the distribution and return rates of the questionnaires administered during the study. Out of the 398 questionnaires distributed to homeowners, 383 were returned, and 380 were duly completed, giving a response rate of 95%. Similarly, 310 questionnaires were given to building professionals, of which 309 were returned and 305 completed, representing a response rate of 98%. Overall, 708 questionnaires were distributed, 692 were returned, and 685 were completed, yielding a high total response rate of 97%, which indicates strong participation and reliability of the data collected for the study.

Table 3: Presence of factor(s) influencing the improvement of resilience of building to Flood

Option	Frequency	Percentage
Yes	685	100
No	0	0
Indifferent	0	0
Total	**685**	**100**

Table 3 clearly shows that all 685 respondents (100%) acknowledged the presence of factors influencing the improvement of resilience in buildings to floods. This unanimous agreement suggests that the respondents believe that various factors are crucial for enhancing the ability of buildings to withstand flood events.

The absence of responses indicating "No" or "Indifferent" further strengthens the idea that there is a widespread recognition among professionals regarding the role of these factors in improving flood resilience. The fact that no respondent disagreed or expressed indifference reflects a strong consensus on the importance of factors that can improve flood resilience, indicating that the respondents view this issue as a critical one for both current and future construction practices.

Table 4: Factors influencing improvement of resilience of buildings to flood in the neighbourhood.

S/N	Factors	5	4	3	2	1	∑f	∑fx	RII	Rank
a	Age	80	120	150	100	235	685	2980	0.68	6th
b	Income/Financial constraints	120	150	130	90	195	685	3040	0.71	4th
c	Lack of Government Support	180	180	130	90	105	685	3185	0.74	2nd
d	Lack of proper spatial planning and land use	150	180	120	80	155	685	3055	0.71	4th
e	Education and Flood Education	200	180	120	85	100	685	3180	0.74	2nd
f	No proper management of flooding by Government or communities	180	160	150	95	100	685	3165	0.73	3rd
g	Access to credit from Bank	140	120	135	105	185	685	2955	0.69	8th
h	Access to early warning information systems	220	150	120	95	100	685	3265	0.76	1st
i	Lack of influencing household flood resilience strategies	160	180	135	90	120	685	3080	0.71	4th
j	Lack of infrastructure	180	170	130	95	110	685	3170	0.73	3rd
k	Weak implementation and enforcement of laws and policies	150	140	160	90	145	685	2955	0.69	5th
l	Poor Urban Planning by Government	190	160	130	85	120	685	3135	0.73	3rd
m	Incapacity of the Government to ensure good urban governance	200	150	120	95	120	685	3145	0.73	3rd

The data in Table 4 identifies and ranked the factors influencing the improvement of building resilience to floods in the neighborhood based on their Relative Importance Index (RII). Access to early warning information systems, with the highest RII of 0.76, is ranked first, emphasizing the critical role of timely and reliable flood warnings in mitigating risks and preparing communities. Lack of government support and education/flood education are jointly ranked second (RII = 0.74), signifying the importance of institutional backing and awareness campaigns to enhance resilience.

No proper management of flooding by government or communities, lack of infrastructure, poor urban planning by government, and incapacity of the government to ensure good urban governance are tied for third place (RII = 0.73). These factors collectively underscore the need for comprehensive urban planning, adequate infrastructure, and effective governance to address flood vulnerabilities. Income/financial constraints, lack of proper spatial planning and land use, and lack of influencing household flood resilience strategies, all ranked fourth (RII = 0.71), highlight the economic and spatial challenges faced by residents. Weak implementation and enforcement of laws and policies and access to credit from banks share the fifth and eighth ranks, respectively, indicating institutional and financial hurdles in improving resilience.

Lastly, age, ranked sixth (RII = 0.68), suggests that the age of buildings or structures plays a moderate role in resilience, likely due to deterioration over time. The findings highlight the multifaceted nature of flood resilience challenges, requiring a blend of proactive governance, community engagement, financial support, and technological solutions to improve outcomes.

V. CONCLUSION AND RECOMMENDATION

This study established that flooding remains a major environmental challenge in Anambra East Local Government Area, causing widespread damage to residential buildings, infrastructure, and livelihoods. Despite the existence of various flood-resilient construction strategies, their implementation in the study area remains inadequate, leaving buildings vulnerable to recurrent flood impacts. The unanimous agreement among all respondents on the presence of factors influencing building resilience underscores the critical importance of addressing these issues in both current and future construction practices. The most influential factors identified include access to early warning information systems, government support, education and awareness, proper flood management, adequate infrastructure, effective urban planning, and sound governance. Financial capacity, proper spatial planning, and enforcement of relevant policies were also found to play significant roles in enhancing resilience. These findings highlight that improving building resilience in flood-prone areas requires a holistic approach that integrates institutional, community, economic, and technical measures.

Given the ranking of the identified factors, the most important measure for improving building resilience to floods is the strengthening of early warning information systems. The availability of timely and accurate flood alerts will allow residents and local authorities to take proactive measures, reduce losses, and safeguard both lives and property. Implementing a reliable, technology-driven early warning system, supported by effective dissemination channels, will serve as a foundation upon which other resilience strategies can be built, thereby significantly reducing the impact of flooding in Anambra East Local Government Area.

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