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FLOOD VULNERABILITY AND ADAPTATION PRACTICES OF RESIDENTIAL AREAS IN ABUJA, NIGERIA

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Abstract

The increasing effects of flooding in flood-prone areas over the years cannot be overstated in terms of reducing flood damage. There are several measures of various characteristics, each of which has its own justification in flood protection. The concepts of vulnerability, hazard, and risk have been extensively used in various disciplines with different meanings, impeding cross-disciplinary cooperation for dealing with hazardous events. In Nigeria, there has been an occurrence of flooding and many households have been rendered homeless and many lives have been lost due to this devastating issue. This article aimed to examine flood vulnerability and possible adaptation practices for residential buildings as well as the potential for resiliency in the event of its occurrence. The objective was to propose appropriate resilient strategies to mitigate flood risk in Abuja, Nigeria. The paper adopts a purposive sampling technique in the selection of some areas for the study. A structured questionnaire survey was used to get information on the residents, and also a site risk assessment was taken on the selected areas. A total of 174 questionnaires were administered, with a valid rate of 96.6% and a reliability value of 0.606. The result shows that an average percentage of residential areas are affected by floods with low resilience strategies. The study concludes that the government should have policies to set the rules of implementation and possible resilience strategies to mitigate the occurrence of floods for the residents.

Keywords: Flood risk, vulnerability, hazard, residential properties, resilience

Introduction

The world is affected by natural disasters on a yearly basis, with flooding having one of the greatest damage potentials of them all (John-Nwagwu, et al., 2014). Flooding, as defined by Getahun and Gebre (2015) is the surplus flow of water which surpasses a river channel's carrying capacity, drainage system, dams, and any other water bodies. Meanwhile, Oyebode (2021) expanded further to describe flood as the most expensive and one of the deadliest natural disasters in the world. Flood occurrence reportedly dates back to the 16th century and according to USDC (2011) has caused massive loss of lives, destruction of property, and degradation of farmlands.

In recent years, the effects of flooding have become increasingly common at an increasing scale and severe as a result of increasing population growth and human interventions such as socio-economic activities in the floodplain (Abdullah et al., 2019). This has led to massive loss of life and property as a result of the ingress of water into developed physical infrastructure. In Africa, the number of people affected by floods in East Africa alone, as reported by BBC (2020), was estimated at about 3 million between 2016 and 2019. In Nigeria, according to Ayoade (1985) and Okeke (2006) cited in Obeta, (2014), floods have also been a reoccurring and increasing issue, causing a lot of disaster to socio-economic activities.

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In the year 2012, Nigeria recorded a total of 363 deaths, 597,476 destroyed houses and close to 2.3 million people displaced due to flooding (NEMA, 2013). In Abuja, the Federal Capital Territory (FCT) of Nigeria, areas such as Gwagwalada, Lokogoma, and Lugbe environs have reported massive rises in water levels, causing varying levels of property damage as well as loss of life. The effect has resulted in environmental degradation, as illustrated in Plates 1 and 2.

Plate 1. The flood affected area in Trademore Estate Lugbe, Abuja, Source: Adenekan (2021)

Plate 2. The flood affected area in Lugbe, Abuja. Source: Adenekan (2021)

Given the intensity and scale of the danger arising from floods, it is observed that many housing design and construction techniques in the study area do not take cognisance of environmental health challenges arising from the effects of flood into consideration and how they could be addressed. Hence, measures that need to be put in place to ensure the resilience of buildings and other infrastructure at risk to prevent possible damage are grossly lacking. The non-conforming housing design and construction techniques required to tackle flooding in the events of its occurrence forms the basis for this study. This study highlights the level of risk residential environments in Abuja, Nigeria is exposed to due to flooding and the assessment of how the risk could be mitigated. The study is generally driven by two key objectives: (1) to investigate the risks residential buildings are prone to as a result of flooding and (ii) to determine the flood resilient strategies that could be employed to mitigate flood risk to residential building occupants.

Review of Literature

In the literature, the incident of flooding has been viewed from many perspectives. Obeta (2014) indicated that flooding has caused a serious negative impact on people due to its devastating nature. The growing number of flood victims, as well as the impediment to sustainable development, demonstrates little knowledge of flood resilience strategies (Nkwunonwo et al., 2016). Adetunji and Oyeleye (2018) opined that potential victims of flood disasters are often affected by limitations which force them to live within flood plains. This is characterised by an absence of zoning regulations, flood control, emergency response infrastructure, and early warning systems (Oyebode, 2021). Based on Nwigwe and Emberga (2014) perspectives, flood is viewed as the occurrence of an unfortunate incident that can be caused by either natural causes. For natural causes, this could be heavy or torrential rains while human causes could be as the result of construction flaws resulting to dam failure, broken water pipes, and leakages.

Noren et al. (2016) postulated that humans play a part in the occurrence of natural disasters through such activities as illegal use of drainage channels, land reclamation, and poor physical planning, amongst others. Deforestation, development in technology, industrialization, urbanization, burning of fossil fuels, and agricultural activities are other notable causes. Among other notable causes of floods is climate change through which the rise in global temperatures can result in severe floods in several regions of the world. This particularly exacerbate the incidence of flooding by increased weather unpredictability (Agbonkhese et al., 2014) prolonged periods of rainfall leading to destructive effect of floods on built properties.

A concept rooted in how people or societies are likely to be affected by flood phenomena is termed vulnerability to flood occurrence. It is the sensitivity of the community or people to flooding considering the socio-economic, environmental and physical components which can be understood through an assessment of flood vulnerability components and factors. According to Intergovernmental Panel on Climate Change (IPCC, 2007) vulnerability is the degree to which a system is susceptible and unable to cope with adverse effects of climate change. It quantifies the associated risks within the context of environmental and socio-economic capacity to adapt to flood events. Scoones (1998) posited that flood vulnerability is influenced by personal or group characteristics in terms of their capacity to anticipate and cope with the impacts of flood. However, for vulnerability to exist, the capacity of the population to absorb, respond and recover from the impacts must be taken into consideration as postulated by Ngie (2012).

An IPCC (2014) report viewed vulnerability as an already-existing condition that is assessed without the use of exposure indicators (to hazard). As a result, markers for a system's intrinsic qualities of "sensitivity" and "adaptive capability" are used to evaluate it. On the hand, adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007). Different social groups or classes within a society are differentially at risk, both in terms of probability of occurrence of an extreme flood event and helping different classes to recover (Cardona 2003; Nethengwe, 2007).

Vulnerability has two phases: an external side of risks, shocks, and stress to which an individual or household is exposed; and an internal side of defenselessness, which refers to a lack of resources to cope without suffering irreparable loss (Agbonkhese et al., 2014). It exposes the building structure to risk, which affects the functionality and efficiency of the built environment. Thus, when considering vulnerability and adaption, resilience is an important factor that must not be overlooked. Adebimpe et al. (2018) expressed that resilience is the capability to encompass or recuperate from disruption in a reasonable time. Structurally, buildings including the materials with which they are constructed must be able to withstand the stress associated with high-impact floods. Bowker et al. (2007) cited in Ezeokoli (2019) stated that achieving flood resilience in buildings is through durable construction done in such a way that water can enter the building but the impact will be reduced.

Two main approaches to resilience are presented by Holling (1973) cited by Tri et al. (2017) as engineering and ecological approach. While engineering resilience deals with the capacity of a system to return to a stable equilibrium following a disturbance (Holling, 1973, cited by Tri et al., 2017) ecological resilience on the other hand represents the dynamics of the system focusing on preserving the engineering systems' functional stability. Through various equilibria, ecological resilience investigates how the system might adapt and reorganise itself. The ability of an ecosystem to withstand disruptions, be ready for future floods, and integrate multiple resources are all aspects of ecological resilience (Liao, 2012). The ability to learn from each flood and adapt the system to internal and external changes is an indication of ecological and attribute of ecological resilience.

Nkwunonwo et al. (2016) referring to the need for a form of resilience argued that there is need for coping and adaptation strategies to climate change as the impacts of flooding increase significantly with threatening proportions resulting in loss of life and property to urban dwellers and flood victims. This argument was initially advanced by Anunobi (2013) who expressed that some form of adaptation to flood risk disaster is essential. Meanwhile, Batica (2015) in their survey carried out using a survey approach on flood resilience assessment in urban environments and mitigation strategy development argued that the basic function of resilient buildings is to prevent water from entering the building and provide the possibility of normal activities in the environment.

COH (2015) demonstrated how resilient buildings can be achieved through the use of materials such as concrete, steel, treated plywood, glass, and many others for various aspects of building components. Within the guidelines, materials to avoid for flood resilient buildings such as engineered wood laminate flooring, carpeting, wood flooring, cork, fiberless insulation, wallpaper, plaster, cork and many others were also highlighted. The guidelines further provided some guides as strategies such as using Design Flood Elevation (DFE). This is the elevation to which construction is regulated. It is determined as DFE = BFE+Freeboard. BFE stands for Base Flood Elevation and while Freeboard stands for specific height above the anticipated flood elevation (COH, 2015). This strategy makes provision for flood protection, prevention, and preparedness which according to Zevenbergen et al., (2020) are all priorities for resilient strategies for buildings of the present and the future.

Building strategies for flood-prone areas as opined by Lukasz and Magda (2020) are based on two opposite concepts namely avoiding and resisting. When water overflows into the built environment, it could cause dampness to buildings through capillary action, which invariably damages the building material and its structural stability. Hence, the need for strategies to avoid water intrusion into the building calls for avoidance technology as part of resilient strategies to reduce the risk of vulnerability of buildings and other physical infrastructures to improve safety and protection of socio-economic activities. Therefore, the use of existent techniques from time past employed in mitigating flood risk and creating a road map for maximum adaptability of buildings to the effect of flood becomes necessary.

Adaptation and risk (vulnerability, exposure) in response to flooding (hazard)

In the rapidly urbanising world, floods are wreaking increasingly more havoc, with disproportionately large consequences for the most vulnerable and disadvantaged (Jongman, 2018). Effective adaptation plans that include infrastructure for flood protection, natural solutions, and risk finance schemes are required to manage floods and mitigate their financial effects. The annual cost of damage would be reduced by hundreds of billions of dollars, and the number of people living in extreme poverty would decrease by 26 million people if all natural disasters could be abruptly and completely abolished (Hallegatte, 2017). Disasters, however, cannot always be avoided. A variety of interventions are necessary for effective adaptation to growing flood risk, including structural flood protection measures, early warning systems, risk-informed land planning, nature-based solutions, social protection, and risk financing mechanisms (Aerts et al., 2014). However, in places with high population and asset concentrations, physical flood protection systems like dikes and levees are typically cost-effective (Ward et al., 2017).

The Netherlands is the best example of a nation that largely relies on such structural measures because it is both densely populated and highly susceptible to flooding. A dike system that offers protection against disasters that only happen once every 10,000 years covers the majority of the shore (Jongman, 2018). However, such protection measures necessitate substantial capital expenditures for both construction and upkeep, which political momentum and government budgets frequently fail to cover. According to Temmerman et al. (2013), governments have recently been using nature to control flooding. These naturally occurring alternatives include enlarging natural floodplains; safeguarding and developing wetlands; reviving coral and oyster reefs; and investing in urban green spaces to lessen run-off. These adaptation methods have been used in the United States, where natural wetlands are thought to have saved $625 million in Hurricane Sandy damage (Narayan et al., 2017).

Nature-based adaptation strategies in the Gulf of Mexico might even cut overall risk by an astounding $50 billion, with an average benefit to cost ratio of 3.5 (Reguero et al., 2018). The nationwide "Sponge Cities" programme of China has begun implementation in 16 pilot cities, where enormous amounts of green space will be incorporated into urban planning to minimise surface flooding (Jongman, 2018). Nature-based solutions can have a wide range of advantageous benefits for ecosystem protection, carbon sequestration, tourism, and local employment, in addition to significantly lowering flood risk. Various stakeholder groups must frequently be involved in the implementation of natural techniques, assisting with awareness-raising and consensus-building.

Amphibious Building Techniques and Less Flooding

Elizabeth et al. (2017) pointed out that an amphibious flood mitigation system consists of two basic parts. For homes in places where rising flood levels don't come with high flow rates, amphibious foundations provide a practical, liveable option to permanent static elevation. This term refers to retrofit construction in which buildings are elevated on vertical structural supports to a height above the projected 100-year flood level, i.e., putting a building "up on stilts" (English et al., 2016). Basic amphibious operations require vertical guiding to avoid lateral movement and buoyancy to allow momentary flotation. A house is more resilient to flooding in recognition of the variable elevation, which does so without permanently subjecting the building to stronger winds. Any increase in wind speed and force is minor compared to the exponential rise in force that would occur from permanently elevating the house, as it stays close to the ground until catastrophic flooding occurs.

An existing structure can be retrofitted with a buoyant foundation, a flood-mitigation technology that enables it to rise with the water during a flood and securely sink back to the ground when floods subside. This method protects a home from the devastating effects of floodwater and is completely passive, working with changing water levels rather than against them. It guarantees that possessions are safe and that residents won't experience protracted eviction. Three easily constructed components are used in the design of a buoyant foundation: buoyancy blocks to give flotation; vertical guidance posts to direct the movement of the building, and a structural frame to connect these to the existing structure of the house. (Best Climate Solutions, 2006). The Turner et al. (2003) conceptual framework, which shows how vulnerability is a function of exposure, sensitivity, and adaptive capacity, was adopted and adapted for this investigation. The main components of vulnerability are exposure, sensitivity, and resilience. Exposure is the term used when the operational system is altered and operates differently than it would normally.

A system is exposed to external influences that can change its state as opined by Judy et al. (2011). The existing sociological and ecological conditions have made the system vulnerable. The chance or potential for a danger to have an effect on the system is known as susceptibility. Susceptibility, according to Samuels et al. (2009), is the likelihood that floods will have a detrimental impact on the environment and society. A risk could affect both the socioeconomic environment and the natural environment. According to Galderisi et al. (2005) resilience is the ability of a community to modify itself to reach an acceptable structural and functional level in the face of changes in a dangerous region. This calls for the system to be robust, or to be able to continue operating and performing its functions after interruptions.

The Intergovernmental Panel on Climate Change (IPCC 2007) defined sensitivity as the extent to which a system is impacted by an exposure, either negatively or positively. Environmental and socioeconomic systems are sensitive to diverse things. Impacts of floods are a major source of sensitive concern. A system may be vulnerable to both direct (physical) and indirect (socio-economic) effects, such as the age structure of the population and the amount to which mortality increases during a heatwave. As an example, a given change in rainfall may have an effect on a city's water supply (Judy et al. 2011). Figure 1 shows the conceptual framework developed for this study to guide the collection of appropriate data.

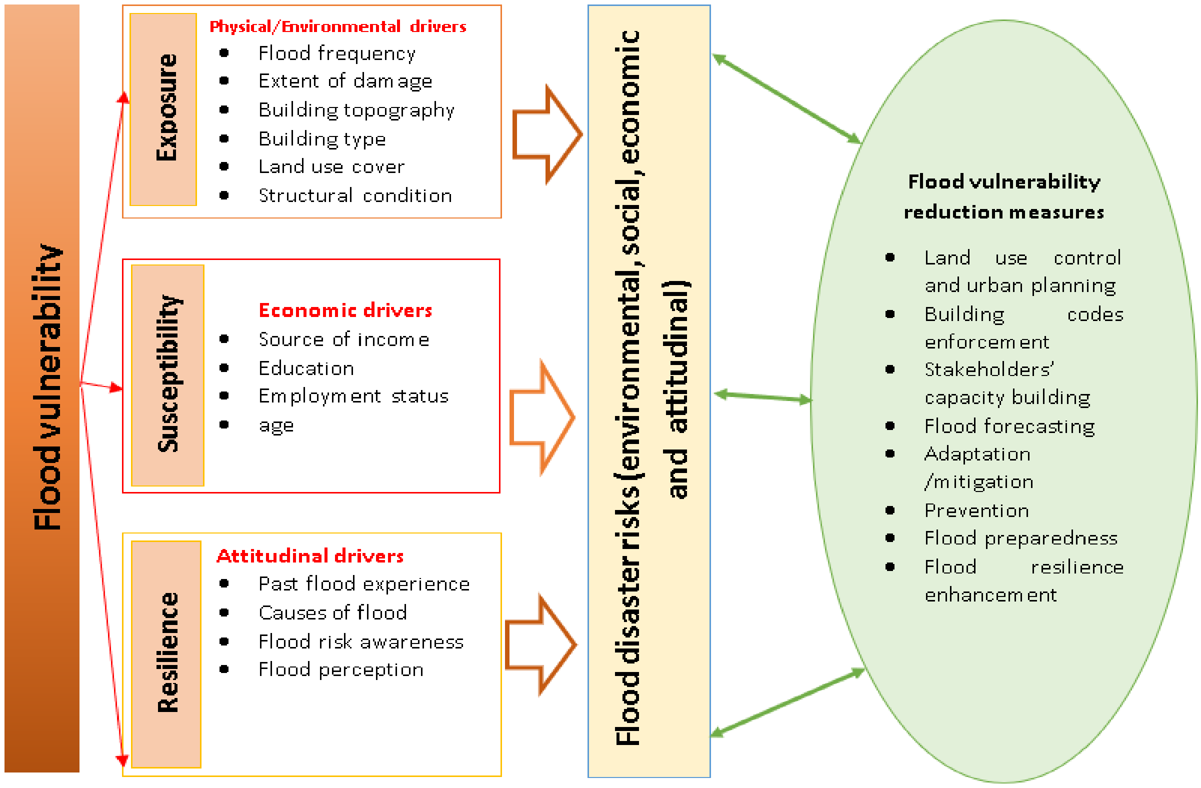

Figure 1. Conceptual framework developed for the study

Materials and Method

Study Site

This study was conducted in the Lokogoma, Galadimawa, Lugbe, Kubwa, and Gwagwalada areas of Abuja, Nigeria. Abuja is the Federal Capital of Nigeria and is located within the North Central geo-political zone of Nigeria. It is bounded on the north, east, south, and west by Kaduna, Nassarawa, Kogi, and Niger states, and has a land area of 7,607 square kilometers. Abuja is geographically situated between latitudes 8.25 and 9.25 north of the Equator and longitudes 6.45 and 7.39 east of the Greenwich Meridian. It is a region with steep, irregular terrain, undulating plains, and is distinguished by varied degrees of harshness Balogun (2001). The sandstone belt in the south-west is only somewhat rugged, while the eastern, central, and south-east regions are the most so.

The north-eastern "pan-handle" side of the FCT contains its highest point. This is located in the Bwari Area Council, where there are numerous peaks that rise to a height of 60 metres. Abuja is made up of six (6) geographical locations (Bwari, AMAC, Gwagwalada, Kwali, Abaji, and Kuje). The study locations are Gwagwalada, which is an area council, and AMAC, where other locations (Lokogoma, Lugbe, Kubwa, and Galadimawa) are situated. The maps showed in Figure 2a and Figure 2b indicates that Gwagwalada and AMAC are the most affected by flood vulnerability.

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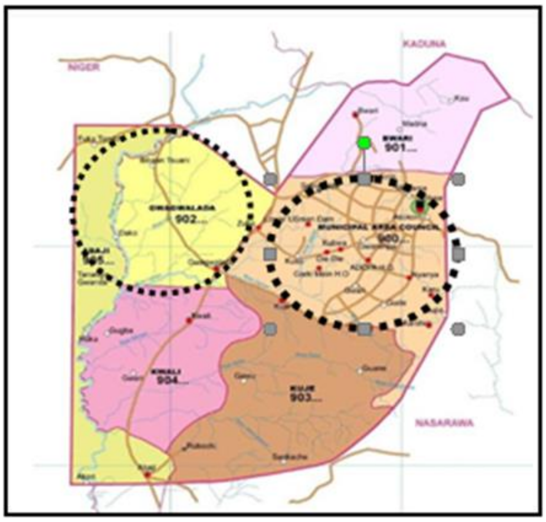

Figure 2a. Study Site map (Abuja)
(Source: Mallo et al., 2021)

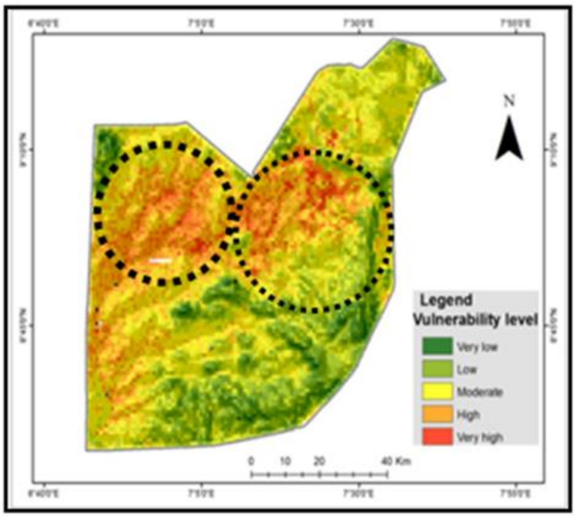

Figure 2b. Flood vulnerability sites in Abuja

Data Collection Procedure

In this study, quantitative research methods were used. In quantitative research, the methodology is more deterministic with defined fundamentals, dictating the strategy or design that should be used. Due to the study's quantitative nature, a descriptive approach was used as the primary method of data gathering. Data for this study was collected from primary and secondary sources to present a description of the phenomenon and the experience of the respondents. Instruments used included a questionnaire survey and a field observation checklist developed by the researchers. The questionnaire contained both closed-ended and open-ended questions in order to elicit information. Primary data was collected via field survey from residents of Lokogoma, Galadimawa, Lugbe, Kubwa, and Gwagwalada areas of Abuja due to largely reported cases of flooding in these areas. A purposive sampling and random sampling technique were utilised in the collection of the primary data. The sites were purposively selected while the respondents were randomly selected.

Purposive sampling was used in accordance with Creswell et al. (2011) views that the researchers intentionally select individuals and sites that hold the required information to elicit data. This method was employed because the research focused on flood-prone residences within the study area alone. The consent of the respondents was sought by explaining the intent of the study. The right of the respondents to withdraw their participation in the filling of the questionnaire was also explained prior to the commencement of administering the questionnaire. Secondary data was obtained from relevant literature, which included journals, press reports, publications, unpublished works, books, and the internet. Research was conducted by consultation and an extensive review of literature pertaining to flood risk and resilience.

Based on data obtained from the National Population Commission of Nigeria (NPC, 2006), the population of the study communities is as follows: Lokogoma has 77,622; Lugbe 3.2 million; Kubwa 776,298; Gwagwalada 442,591; and Galadimawa 8000, which amounts to a total population of 4,504,511. The total number of flood-affected residences in the lowland is 1210 (Table 1). Two hundred and fifty (250) residences were randomly selected as the projected sample size from the five (5) selected communities for the study.

Table 1. Respondents Response Rate

Location	Sampled number of respondents	Distribution (No)	Returned (No)	Response rate (%)
Lokogoma	280	50	41	82%
Lugbe	270	50	43	86%
Kubwa	240	50	34	68%
Gwagwalada	220	50	30	60%
Galadimawa	200	50	26	52%
Total	1210	250	174	69.6%

Reliability and Validity of the Research

A total of fifty (50) questionnaires were administered to each selected sub-area to cater for possible errors amongst the five (5) selected areas, summing to a total of 250 administered questionnaires, out of which 174 were returned with 69.6% as the response rate. With a total of 174 questionnaires returned a valid rate of 96.6% and a reliability value of 0.606 was obtained. Thus, the sample size of 174 is considered adequate for the survey based on the published table by Bartlett et al. (2001) for determining the minimum returned sample size for a given population size of 1000 for continuous data where alpha = 0.05 and t = 2.58. The questions asked covered how often floods occur, the duration of floods, the damage caused, and some resilience measures to mitigate their occurrence. A variety of sources reviewed the survey before it was put into use. A pretest of the survey was conducted on a number of occasions with a small sample size, and the data collection instruments were designed around the results of the pilot research. Flaws that were found during the pre-testing were corrected before the instruments was finally administered to the respondents in order to improve their validity.

Results and Discussion

The following sections present the results of the findings from the survey carried by the study.

Demographic details and background of the respondents

Table 3 shows the demographic profile of the respondents based on gender, age, academic qualification, and level of income of the respondents. The female respondents constitute the largest gender with (58.6%), followed by males with (38.5%), and others with (2.9%). Also, the age range of 40 years and above constitutes the majority with (43.7%), followed by 29-39 years with (33%) and 18-28 years with (23%). As can be observed, the respondents with masters constitute the majority with 84.5%, followed by bachelor's degrees with 12.6% and secondary school with (2.9%). This indicates that the majority of the respondents are educated and the required information about flood risk and its impacts on the communities will be expected. Additionally, nearly half (47.7%) of the respondents earn below N100,000 as their monthly income. This demonstrates the poor low-income level of the respondents.

Table 3. Demographic data of Respondents

Characteristics	Frequency	Percentage	Characteristics	Frequency	Percentage
Gender			Educational qualification		
Male	67	38.5	Primary	5	2.9
Female	102	58.6	Secondary school	22	12.6
Others	5	2.9	Bachelor’s Degree	147	84.5
Total	174		Masters		
Age			Level of income		
18-28 years	40	23	Below N20,000	11	6.3
29-39 years	58	33	N21,000-N50,000	20	11.5
40-above	76	43.7	N51,000-N80,000	17	9.8
Total	174		N81,000-N100,000	35	20.1
			N100,000 and above	91	52.3

Risk encountered by the residents as a result of flooding

The respondents were asked to determine the risk occupants are faced with as a result of excessive flooding. The survey questions range from how often floods occur in the area to the maximum duration of floods. The respondents were presented with four options from very often to never. The result of the first survey question shows that 27% of the respondents rarely experience flooding; 21.3% often experience flooding; and 9.8% experience flooding very often (Table 4). The second survey question was on the duration of floods in the area. The result shows 39.7% of the respondents experienced flooding within 0–6 hours while 23.6% experienced flooding within 7–12 hours (Table 4). This indicates that residents in the area experience flooding with consequential damage.

Table 4. Risk encounter as a result of flood by the residents

Survey questions	Options	Frequency	Percentage
How often flood occur since living in this location	Very often	17	9.8
	Often	37	21.3
	Rarely often	47	27
	Never	73	42
Maximum duration of flood	0-6 hours	69	39.7
	7-12 hours	41	23.6
	12-24 hours	28	16.1
	2 days and above	10	5.7
	No flood	26	14.9

Level of damage to the residents from continuous flooding

Table 5. Damages encounter as a result of flood to the residents

Survey questions	Options	Frequency	Percentage
Building fitting and fixture damaged during flood	Not damaged	41	23.6
	Negligible	43	24.7
	Barely damage	73	41.9
	Serious damage	12	6.9
	Very serious damage	5	2.9
Damaged to exterior wall	Not damaged	19	10.9
	Negligible	43	24.7
	Barely damage	75	43.1
	Serious damage	31	17.8
	Very serious damage	6	3.4
Damage to interior wall	Not damaged	33	19
	Negligible	42	24.1
	Barely damage	63	36.2
	Serious damage	32	15.4
	Very serious damage	3	1.7
Damage to footing and foundation	Not damaged	38	21.8
	Negligible	42	24.1
	Barely damage	61	35.1
	Serious damage	30	17.3
	Very serious damage	2	1.1
Damage to opening such as doors and windows	Not damaged	37	21.3
	Negligible	42	24.1
	Barely damage	59	33.9
	Serious damage	32	18.4
	Very serious damage	2	1.1

Survey questions were also carried out to determine the level of damage the residents encounter as a result of continuous flooding. The respondents were also presented with four options (not damaged, negligible, barely damaged, serious damage, and very serious damage). The result in Table 5 shows that the building fittings and fixtures are barely damaged by flood with a percentage of the respondent being 41.9%. The exterior walls of the building are barely and seriously damaged by flood with a percentage of the respondent being 43.1% and 17.8% respectively. The interior walls of the building are barely and seriously damaged by flood with a percentage of the respondents being 36.2% and 15.4%. The footing and foundation are being affected by flood barely and seriously with a percentage of the respondents being 35.1% and 17.3%. Also, the openings are being affected by flooding barely and seriously, with a percentage of the respondents being 33.9% and 18.4%. The result shows that there are still areas that experience serious damage as a result of flooding

Flood occurrence within each community in the study site

Figure 3 shows the data from the respondents on the occurrence of floods in each community in the study area. The respondents were presented with 4 options (very often, often, barely often, and never). The result shows that the occurrence of floods is often experienced but not on a regular basis. According to the obtained data, Galadimawa records 1%, Gwagwalada 4%, Kubwa 5%, Lokogoma 4%, and Lugbe 3% of regular flooding (Figure 3). This shows that there are still occurrences of flooding in the area and suggests that measures should be taken to mitigate its occurrence or provide adequate resilience. Due to excessive flooding, there is a need to maintain and protect the floodplains and build infrastructure. According to Ward et al. (2017), in places with high population and asset concentrations, physical flood protection systems like dikes and levees are typically cost-effective. Overflowing and possibly flooding will occur if flood waterways are not maintained.

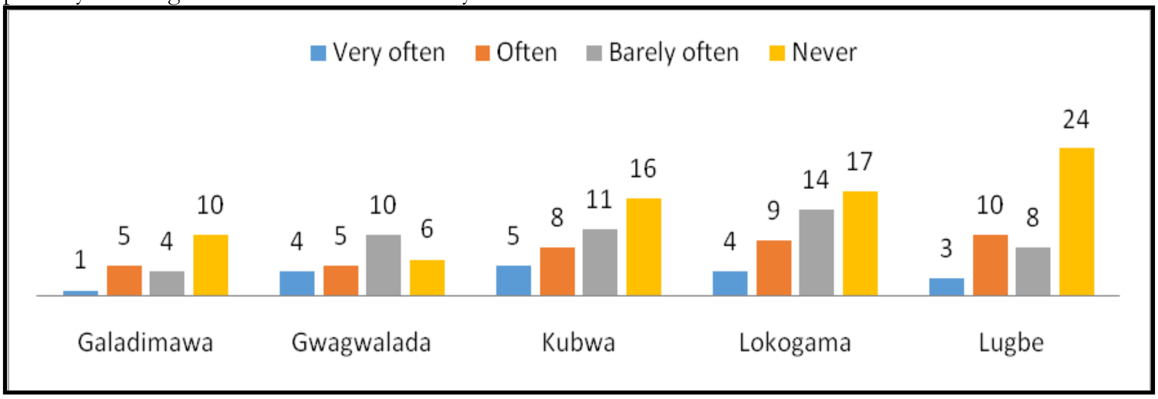

Figure 3. Frequency of flood in the study area

Damages experienced as a result of the flood

Figure 4 shows the data of the respondents on the damages experienced as a result of the flood. 17% of the respondents experienced damage due to building fittings; 35% experienced damage to exterior walls and 25% experienced damage to interior walls; 9% experienced damage to footing and foundation; and only 7% of the respondents experienced damage to openings such as doors and windows.

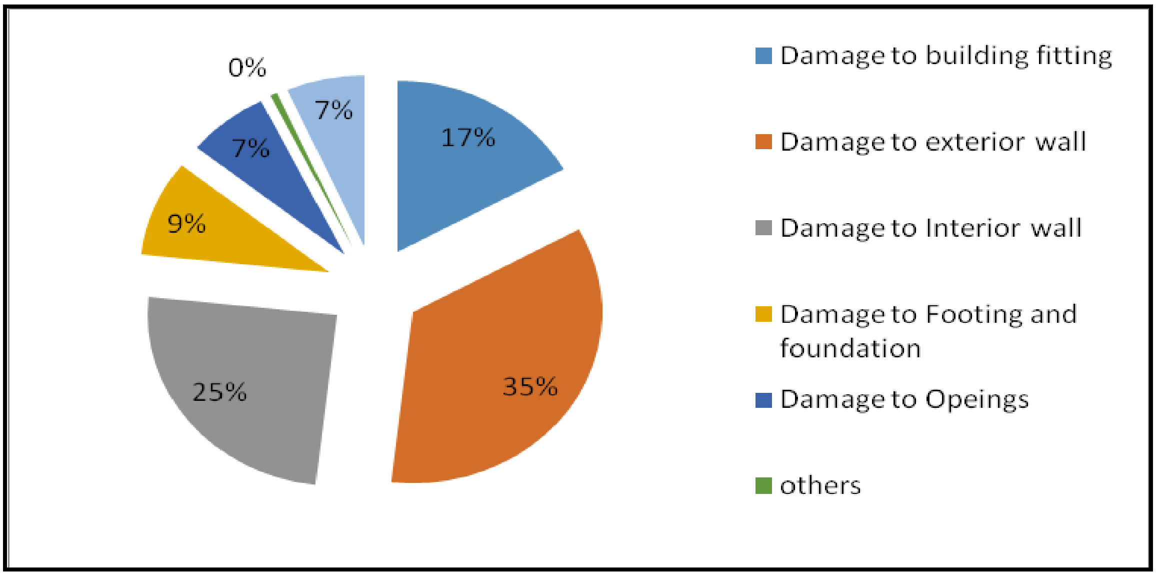

Figure 4. Data of level of damage by flood

Flood related problems associated with the building

Figure 5 shows the data of the respondents on the problems encountered as a result of the flood. 12% of the respondents experience negative health outcomes, 11% of the buildings collapse due to flooding, while 29% of the respondent's experience moisture, and 15% of the respondents' materials deteriorate due to flooding, and only 1% of the respondents die due to flooding. The result shows that the residents still suffer different degrees of problems due to the occurrence of floods in the area. Azad et al. (2013) stated the devastating effects of floods on human beings in Bangladesh. The authors stated the effects as loss of life, food scarcity, increase in disease, loss and destruction of property, damage to farm crops, and increased in-woman vulnerability. This shows that the occurrence of floods has many negative impacts and affects the residents generally, especially women.

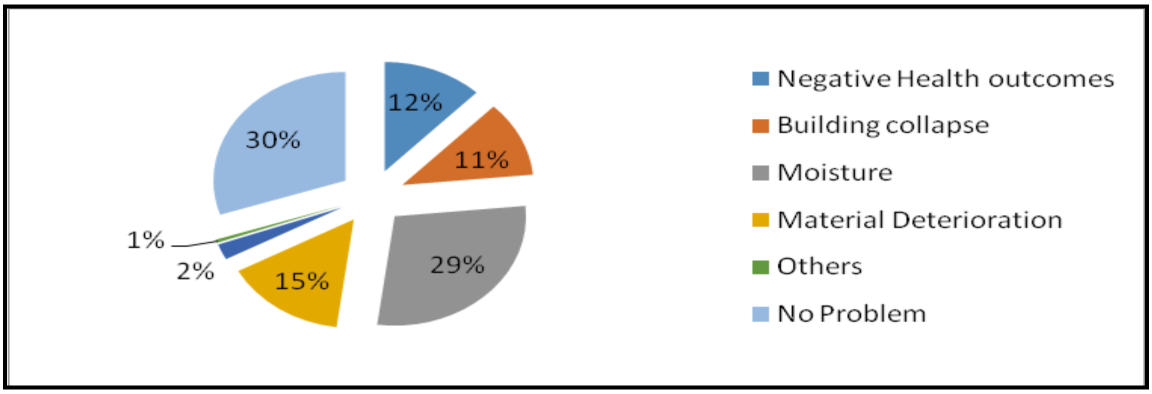

Figure 5. Flood related problems associated with the building

Presence of flood resilience in sampled sites

To determine the flood resilience strategies that could be employed to mitigate flood risk to the residential building occupants, Table 6 shows the data from the respondents to determine how resilient the structures are to flooding. The respondents were given four variables (completely inadequate, inadequate, adequate, and very adequate) to determine the flood resistance of the structures. The result shows that 48.9% of the sampled respondents state that there are inadequate resilience features to mitigate floods in the residential buildings in the study area.

Table 6. Presence of flood resilience in sampled sites

Variables	Frequency	Percentage Frequency	Valid Percntage	Cumulative percent
Very Adequate	7	4.0	4.0	4.0
Adequate	61	35.1	35.1	39.1
Inadequate	85	48.9	48.9	88
Completely Inadequate	21	12.0	12.0	100.0
Total	174	100.0	100.0	

Measure taken to prevent the building from flood

Figure 6 shows that 31 of the respondents applied temporary barriers to control flooding; 54 of the respondents-controlled flooding by channelling the water away from the building; 33 of the respondents used elevated or raised floors; and lastly, 66 of the respondents used water proofing as a measure to prevent the building from flooding. The result shows that the residents adopt resilient ways to mitigate floods in the areas.

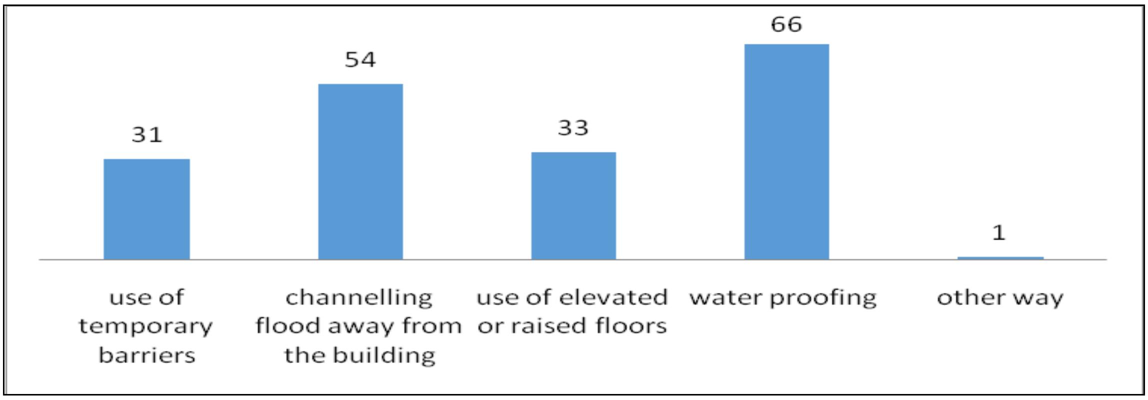

Figure 6. Measure taken to prevent the building from flood

From Table 7, the measures taken by the respondents to prevent the building from being flooded only yielded a low result, as only 25.3% of the respondents were satisfied that the measure, they had taken actually caused a reduction in flood risk. This percentage is very low; this implies that other measures need to be adopted in order to reduce flood risk, as the initial measure did not result in a reduction in flood risk.

Table 7. Impact of flood resilience

Variables	Frequency	Percentage Frequency	Valid Percntage	Cumulative percent
Very Satisfied	15	8.6	8.6	8.6
Satisfied	44	25.3	25.3	33.9
Not Satisfied	63	36.2	36.2	70.1
Very Satisfied	52	29.9	29.9	100.0
Total	174	100.0	100.0	

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Discussion of findings

The field observation surveys were carried out in Lugbe, Kubwa, and Gwagwalada areas of Abuja, Nigeria to show the extent of flood risk damage to residents of these areas. The surveys show that most of the buildings have been affected by the menace that triggers the buildings' vulnerability to flooding and endangers the residents' life. The majority of the buildings were completely destroyed, and some are inhabitable due to damage. This finding is in line with the outcome of Douglas (2017) cited in Atufu and Holt (2018) who found in their study on the effects of flooding in Lagos, Nigeria having grave consequences that affect day-to-day life of the residents.

In addition to this finding, the study also stated that damage to property is the most affected of the listed impacts by the flood. It was discovered that nearly half of the respondents (47.7%) earn less than N100,000 each month. This reflects the respondents' low-income status. This finding supports Coutio's (2004) claim that poverty is a major factor that increases vulnerability and impacts of floods, which are likely to last longer among the poor because people who live in flood-prone areas have fewer options for evacuation and are more vulnerable to flood-related diseases, which can be fatal.

The study also found that the majority of respondents were women over the age of 40, supporting the assertion of Few et al., (2003) that marginalised groups, such as the elderly, disabled, and women, are particularly vulnerable and have fewer social powers, economic resources, and physical capacity to anticipate, survive, and recover from the effects of massive floods. This is especially true given Pilon's (1999) contention that gender-biased attitudes and stereotypes might complicate response and lengthen recovery time from flood repercussions. Thus, Considering the risks with consequential damage encountered by the residents as a result of flooding it is necessary to consider some adaptation and mitigation strategies such as an amphibious flood mitigation system and flood-mitigation technology that enables an existing structure to rise with the water during a flood and securely sink back to the ground when floods subside. This could serve as protection measures for the houses from the devastating effects of floodwater. This view supports the assertion of De Graaf (2008) measures to reduce flood vulnerability such as damage prevention, damage reduction, damage reaction and damage anticipation. This strategy is completely passive and work with changing water levels rather than against them.

The measures will go a long way to assist when such a menace occurs and could also avert the occurrence of damages to the buildings and the residents as well as to reduce vulnerability. Owing to the level of damage posed to the residents from continuous flooding, this calls for certain measures to be taken at the professional level such as during the planning stage by the professionals to identify the flood-prone areas to ensure that the buildings are located outside the known hazard areas. Human interference with natural processes to a large extent, where possible, should be limited and/or avoided. The appropriate use of land use control and enforcement certain building codes and policies to guide developers on building on waterways could mitigate the rate of flood disasters in the environment.

Recommended Strategies for Residential Building Resiliency

Floods are becoming more common in Nigeria. As a result of the findings of this study, proposed flood risk mitigation solutions for residential buildings should include resilience adaptable strategies. Such as keeping flood water out (dry flood-proofing) or preventing flood water by raising the building or allowing flood water to take action while reducing damage (wet flood-proofing). Figure 7 depicts examples of resilience adaptive site techniques that could be used, as adapted from Burden (2013) and cited in Sholanke et al., (2021). As mentioned in the literature, other resilience measures stated like robust or durable construction and the materials used and the integration of using design flood elevation (DFE) to achieve a specific height above the anticipated flood elevation are further recommendations. The building should be designed to operate in a flood zone at a height of three feet above the projected flooding occurrence. Other additional strategies needed for residential building resiliency include:

- **Location of projects outside of known hazard sites**
  Designers should advocate for project sites outside of flood-prone areas so that design efforts and construction can be focused on maximising operational efficiency. Development should concentrate on areas safe from hazardous flooding to ensure a reduction of future losses.

- **Maintenance and protection of floodplains and upland forest**
  Adequate maintenance and protection of floodplains, dams, and river corridors is the most effective way to prevent future floods. Protection of these critical areas gives room for the water to spill over their banks when serious storms occur. Also, forested areas provide watershed benefits.

- **Adequate maintenance of building infrastructure**
  Standard design and maintenance of ditches and water control structures in building infrastructure is very vital to ensure an adequate channel of the water in the right direction without overflowing into houses and communities. Adoption of suspended pavement systems can create a strong substrate in these areas while allowing high-water absorption through their medium of uncompacted soil.

Implication to Architectural practice design

Professionals must be proactive in designing adaptive measures in order to cope if a flood occurs. The professional point of view in combating flooding is to create design measures in a situation where there is high demand for houses in the areas close to water. To address such a problem, the implementation of some design measures will be extremely beneficial. The need to introduce floating and amphibious housing designs in flood-prone areas is needed to reduce its effects on buildings and their users. An amphibious house is a building that rests on the ground, but whenever a flood occurs, the entire building rises up in its dock, buoyed by the floodwater.

It brings together standard components from the construction and marine industries to create an intelligent solution to flooding. Floating and amphibious houses are built to be located in a water body and are designed to adapt to rising and falling water levels. Floating houses are permanently in the water, while amphibious houses are situated above the water and are designed to float when the water level rises. Amphibious houses are usually attached to flexible mooring poles and sit on concrete foundations. If the water level rises, they can move upwards and float. The fastenings to the mooring post limit the motion caused by water. These types of houses are popular in highly populated areas where there is a high demand for houses near or on water. Floating and amphibious houses are very effective in dealing with floods because they adapt to rising water levels.

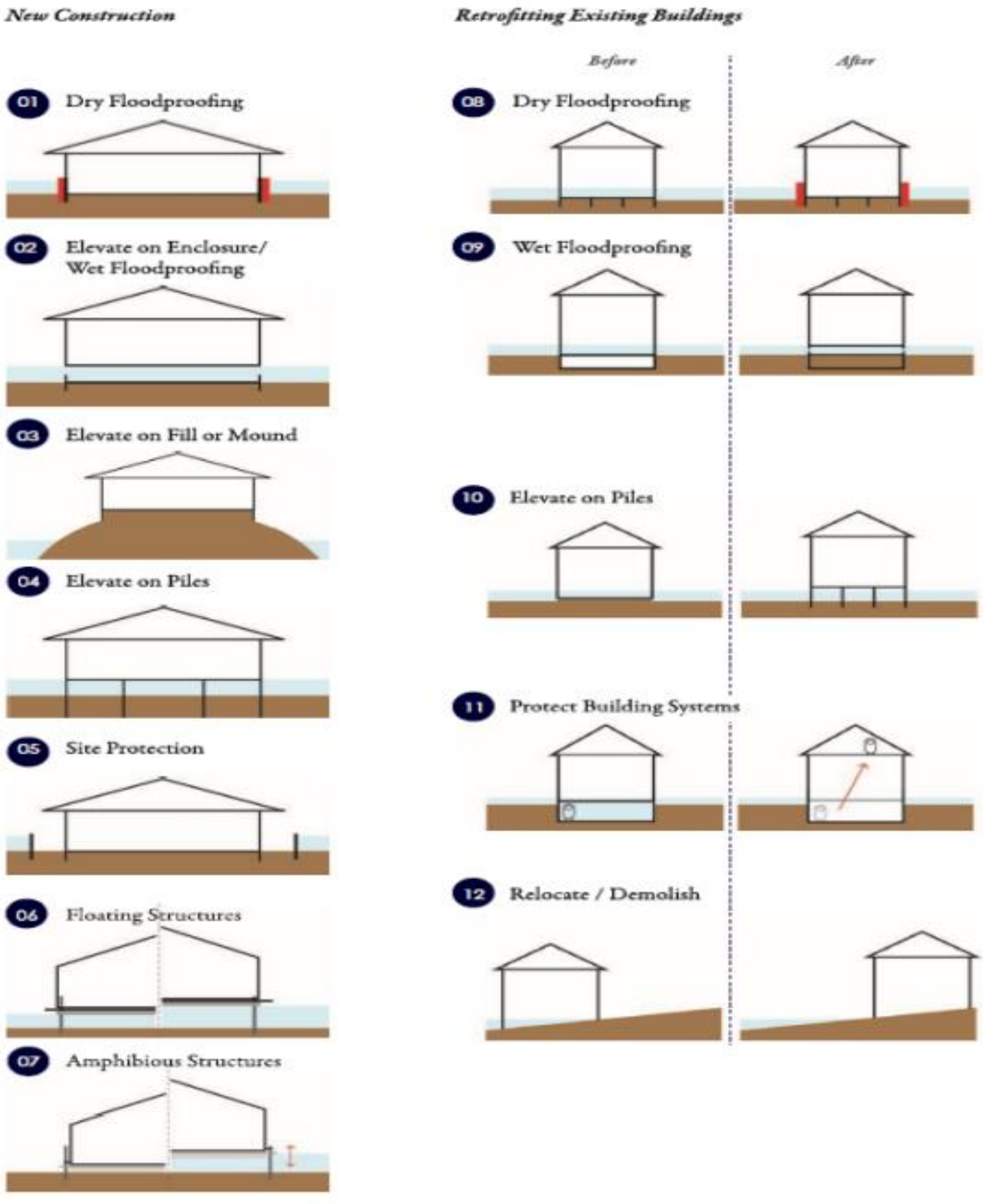

Figure 7. Resilient Adaptive Site Strategies, Source: (Burden 2013)

Conclusion

This paper investigated and identified the risk and resilience level of flood-prone areas within selected locations in Abuja, Nigeria as well as determined the flood resilient strategies that could be employed to mitigate flood risk to residential buildings. Results obtained show that there is an average percentage of residential areas that are affected by flooding in varying capacities. Further enquiry, however, goes to show that 48.9 percent of the sample population do not possess the knowledge of flood resilience within their buildings, while 12.0 percent are not sure. Among the 35.1 percent who know about flood resilience and its applications, only 25.3 percent agree that these measures have resulted in a reduction of damage due to flooding. The findings reveal that despite the average level of risk posed to residential areas, very much still needs to be done in order to educate the general populace on flood-resilient measures to be taken especially when building in flood prone areas. This paper further provides insight into steps which can be employed to raise awareness and implementation levels of flood resilience strategies. It contributes to the body of knowledge in such a way that it promotes the benefits of flood resilience in residential areas in Nigeria. Focus should be taken away from flood risk alone and redirected to flood resilience awareness. This would serve the proverbial purpose of "killing two birds with one stone" as it would enlighten the general populace on the varieties and benefits of resilience strategies while encouraging them to utilise them more, ultimately resulting in a safer residential environment.

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Conflict of Interests
The authors declare no conflict of interest.

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