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SPECIAL ISSUE: CELEBRATING 20 YEARS OF GEOGRAPHY IN KADUNA STATE UNIVERSITY - ADVANCES AND FRONTIERS IN GEOGRAPHY

Perceived Impacts of Stormwater on Urban Residential Neighbourhoods in Zaria Metropolis, Kaduna State, Nigeria

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ABSTRACT
Urban centers in developing nations like Nigeria are increasingly vulnerable to stormwater challenges due to rapid urbanization, poor drainage systems and climate variability, among others. This study assesses the perceived impacts of stormwater on urban residential neighbourhoods in Zaria Metropolis, Kaduna State, Nigeria. A cross-sectional survey design was employed, with data collected from 384 respondents selected through purposive sampling across various communities to ensure participation of individuals with direct experience of stormwater effects. Data were analyzed using descriptive statistics, Weighted Mean (WM), and Standard Deviation (SD) to determine both the level of agreement and the degree of variability in residents' responses. The findings identify key contributors to stormwater runoff, with improper waste disposal into water channels (WM = 4.00; SD = 1.34), unregulated urban development (WM = 3.97; SD = 1.49), and absence or poor maintenance of drainage channels (WM = 3.87; SD = 1.42) emerging as the most critical factors. Natural drivers such as heavy rainfall and deforestation further intensify these human-induced challenges. In terms of impacts, residents reported severe effects including increased mosquito breeding and disease outbreaks (WM = 3.98; SD = 1.34), difficulty in movement during rainfall (WM = 3.92; SD = 1.44), and damage to household items and personal belongings (WM = 3.92; SD = 1.43), alongside dampness in building foundations and widespread erosion. The study therefore concludes that, stormwater presents major environmental, health, and economic risks in Zaria's residential neighbourhoods, largely due to inadequate urban planning, poor waste management, and insufficient drainage systems. Based on the findings, the study recommends the need for improved enforcement of development control, strategic investment in drainage infrastructure, enhanced waste management programmes, and strengthened community participation in stormwater adaptation practices.

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1 Introduction

Urban centres worldwide are grappling with increasing volumes of stormwater as urbanization accelerates and climate variability intensifies. In many cities, the rapid growth of impervious surfaces such as roads, rooftops, and parking lots has drastically reduced the ground's ability to absorb rainfall, thereby increasing surface runoff and altering the natural hydrological balance of urban catchments (Romano, 2024). This situation is worsened by the conversion of green and permeable spaces into built-up areas, leading to changes in infiltration rates, evapotranspiration, and groundwater recharge (Klungniam, 2016). According to Nnachi et al. (2018), uncontrolled urban expansion in many developing countries has resulted in decreased drainage efficiency and heightened flood hazards. Similarly, Nafisatu et al. (2025) observed that unplanned land use, coupled with inadequate stormwater infrastructure, contributes significantly to waterlogging, erosion, and the degradation of urban ecosystems. These processes collectively highlight how stormwater has evolved from a natural hydrological phenomenon into a major environmental management challenge in rapidly growing cities across sub-Saharan Africa.

In the context of Nigerian cities, this challenge is particularly acute due to rapid population growth, inadequate sewer systems, and changing rainfall patterns. Drainage systems that once accommodated moderate storm events are now under pressure from more intense rainfall, increased impervious surfaces, and poor maintenance. Quantitative analyses of open drainage and stormwater runoff in Nigeria indicate widespread shortcomings in traditional drainage systems, with consequences including flooding, stagnant water, surface water pollution, and reduced groundwater recharge (Adelekan, 2016). A closer look reveals that inadequate drainage capacity, ineffective conveyance networks, and blocked channels are significant contributors to urban flood risk.

Residential neighbourhoods in rapidly urbanizing towns are especially vulnerable to the impacts of stormwater. A residential neighbourhood may be defined as an area predominantly occupied by dwelling units, along with associated infrastructure such as access roads, drainage, utilities, and open spaces (Yakubu et al., 2019). In such neighbourhoods, stormwater can lead to a range of perceived impacts, including house flooding, erosion of building foundations, damage to roads and infrastructure, disruption of essential services, and reduced outdoor

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recreational space. In the urban catchment of Port Harcourt, for example, simulated results showed infiltration of 0.79 inches while runoff reached 0.74 inches within a sub-catchment, illustrating the significant magnitude of surface flow that bypasses landscape infiltration (Akukwe, 2018).

The term *perceived impact* underscores the idea that, beyond measurable hydrological changes, residents' subjective understanding and appraisal of stormwater effects are crucial. While hydrological models may estimate runoff volumes or flood frequencies, the lived experiences of residents—such as property damage, nuisance flooding, health risks, or loss of amenities—constitute the perceived impact. For instance, Ogbonna et al. (2020), in a study conducted in Aba, identified structural deficiencies in drainage networks, including narrow channels, low invert grades, incomplete conveyance, and a lack of outlets. These deficiencies contributed to increased surface runoff and flooding, yet little attention was paid to how residents themselves perceived these impacts.

In the case of Zaria in Kaduna State, Nigeria, urban residential neighbourhoods are exposed to specific stormwater hazards. Zaria is a historic city experiencing both expansion and increasing impervious cover, resulting in stressed drainage infrastructure. Despite anecdotal reports of frequent flooding in residential areas, there is a paucity of systematic assessment of how residents perceive stormwater impacts, particularly within Zaria Metropolis, or how these perceptions vary across neighbourhoods, infrastructural settings, and socio-economic contexts. Moreover, previous stormwater research in Nigeria has largely focused on modelling and infrastructure evaluation (e.g., Orimoogunje & Aniramu, 2025) rather than resident perceptions and social impacts. One of the few studies in this area is that of Musa et al. (2024), who examined flood risk perception among farmers in Kofar Kona, Zaria City. However, the study did not address how stormwater affects residential neighbourhoods within the metropolis.

Consequently, this study aims to assess the perceived impacts of stormwater on urban residential neighbourhoods in Zaria Metropolis, Kaduna State. Specifically, it addresses the following research questions:

1. What are the major factors contributing to stormwater generation and runoff in urban residential neighbourhoods of Zaria Metropolis?

2. How do residents perceive the impacts of stormwater on their neighbourhoods in Zaria Metropolis?

2 Theoretical Framework: Hydrological Cycle Theory

The hydrological cycle theory explains how water continuously moves between the earth's surface, the atmosphere, and underground systems through processes such as rainfall, evaporation, infiltration, and runoff (Karterakis et al., 2014). The origins of this concept can be traced to ancient philosophers such as Hippocrates and Aristotle, who attempted to describe natural water movements, although their explanations were not scientifically grounded (Aristotle, 1984). A more accurate scientific understanding emerged in the 17th century when researchers like Pierre Perrault, Edme Mariotte, and Edmund Halley demonstrated that rainfall is the primary source of river water and that evaporation and condensation are the major drivers of the water cycle. In the 20th century, Robert Horton expanded the theory by explaining how soil absorption, land cover, and surface characteristics determine the amount of runoff and the likelihood of flooding (Koutsoyiannis & Angelakis, 2003).

One major strength of the hydrological cycle theory is that it provides a solid scientific foundation for understanding how water naturally circulates through different components of the environment. However, a key limitation is that the original theory focused predominantly on natural systems and did not sufficiently account for human activities—such as urbanization, deforestation, and land-use change—which are now known to significantly alter natural water patterns.

In relation to the present study in Zaria Metropolis, the hydrological cycle theory helps explain why stormwater problems arise in urban residential neighbourhoods. As the city expands, more land becomes covered with concrete, buildings, and roads, reducing the soil's capacity to absorb rainfall. This results in increased surface runoff, blocked drains, and localized flooding. Damp walls, flooded compounds, poor drainage, and increased mosquito breeding may reflect disruptions in the natural water cycle caused by human development and inadequate stormwater management systems.

The theory, therefore, supports this study by linking residents' perceptions of stormwater impacts to actual physical processes influenced by urban growth, poor planning, and improper waste disposal practices. It demonstrates that the stormwater-related challenges experienced by residents are not accidental but arise from changes that interfere with the natural movement and storage of water.

3 Materials and Methods

3.1 Study Area

Zaria Metropolis is located between Latitudes 11° 00' 00" North and 11° 15' 00" North of the Equator and Longitudes 7° 40' 00" East and 7° 50' 00" East of Greenwich Meridian (Figure 1). It is one of the major urban centres in Kaduna State, Northwestern Nigeria, situated about 80 km northeast of Kaduna city. The metropolis comprises two Local Government Areas (LGAs) which are Zaria and Sabon Gari. It shares boundaries with Giwa LGA to the west, Soba to the east, and Igabi to the south (Ati & Sawa, 2018). The climate of Zaria is classified as *Aw* under the Köppen climatic classification, characterized by a tropical continental climate with distinct wet and dry seasons. The wet season is influenced by the moist southwesterly maritime air mass, while the dry season is dominated by the dry northeasterly continental air mass (Umar, 2025). The area records an annual rainfall range of about 1,000 mm to 1,200 mm, typically beginning in April and ending around October (Umar, 2025). Average monthly temperatures vary between 17°C during the Harmattan period and 36°C at the height of the dry season.

Zaria's topography is gently undulating, with elevations ranging from 550 m to 700 m above sea level. The underlying geology consists mainly of Precambrian basement complex rocks, which, combined with shallow soils and impervious surfaces, influence stormwater flow and infiltration patterns (Murtala & Abaje, 2018). The drainage pattern is dendritic, with numerous natural and artificial channels that collect runoff from the built-up areas into seasonal streams such as River Kubanni. However, many of these drainage channels are narrow, unlined, and frequently blocked by waste, which limits their discharge capacity during peak rainfall events. Socio-economically, Zaria Metropolis is an educational, commercial, and administrative centre, hosting institutions such as Ahmadu Bello University (ABU) and several government and private establishments. The area also supports diverse economic activities including trading, small-scale manufacturing, transportation, and peri-urban agriculture (Murtala & Abaje, 2018). According to the National Population Commission (NPC, 1991), the population of Zaria Metropolis was 438, 978 which is currently projected to be 1, 014, 096 people, reflecting rapid urban growth and expansion into flood-prone areas. Residential neighbourhoods such as Samaru, GRA, Tudun Wada, and Sabon Gari are experiencing increasing housing density and conversion of open spaces into built-up plots, which has reduced surface permeability.

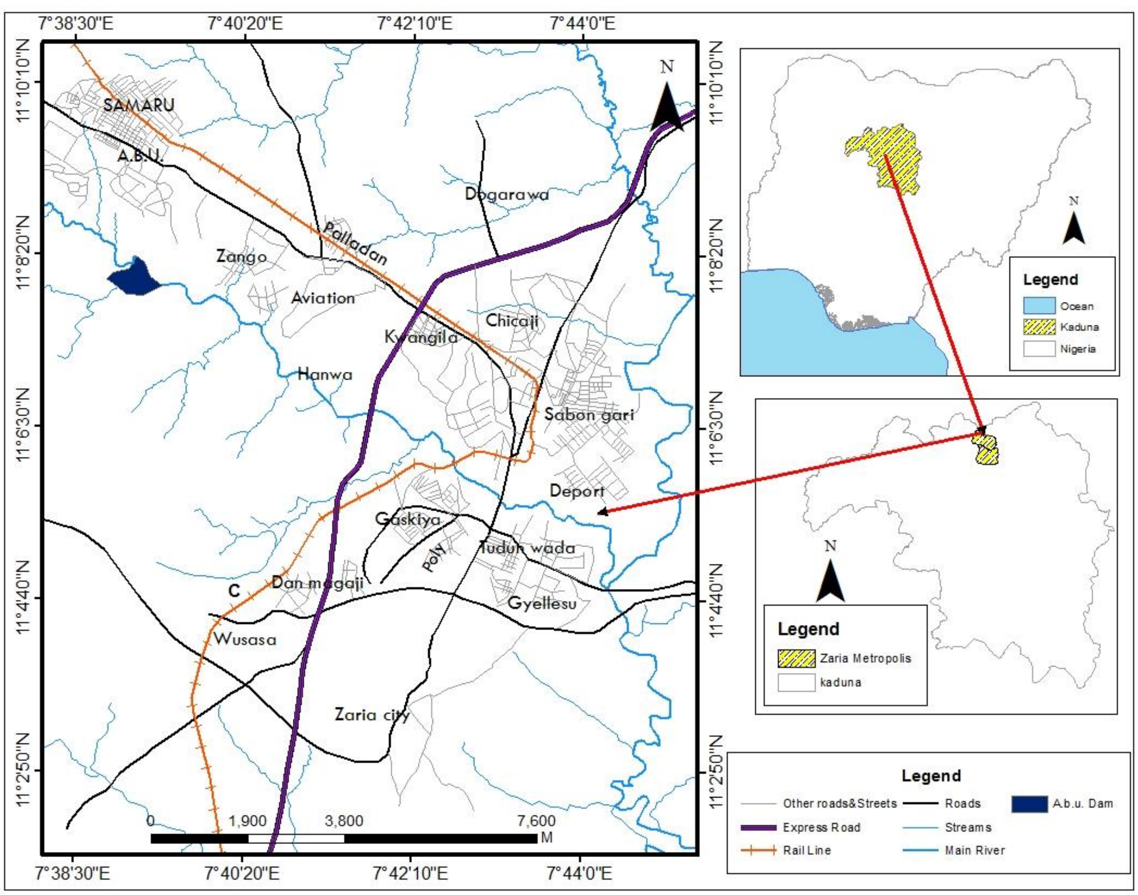

Figure 1: Zaria Metropolis
Source: Adapted and Modified from Administrative Map of Kaduna State (2025)

Rapid population growth and urbanization in Zaria have created pressure on existing infrastructure, especially drainage systems. Inadequate planning, encroachment on floodplains, and poor maintenance of stormwater channels have exacerbated flooding and waterlogging in many parts of the metropolis (Tende, et al, 2025). Studies by Ataguba and Brink (2021) and Oladokun and Proverbs (2016) have shown that similar cities in Nigeria experience recurrent stormwater management challenges due to unregulated urban development and insufficient drainage networks. Given these conditions, Zaria presents a critical setting for assessing the perceived impacts of stormwater on residential neighbourhoods. Its combination of dense population, varied topography, and inadequate drainage infrastructure makes it vulnerable to runoff-related hazards such as flooding, erosion, and infrastructure damage.

3.2 Sample Size and Sampling Technique

The total population of Zaria metropolis was used to determine the sample size for the study. However, due to the deficiency of the 2006 population data in providing figures for localities and wards, the 1991 census data is used for this study. The 1991 population was 438, 978 which is projected to 2025 as 1, 014, 096 using 2.11% growth rate (World Population Review, 2025). According to Krejcie and Morgan's (1970) technique, where a population is between 1, 000, 000 and 2, 500, 000, the sample size to use is 384 at 95% confidence level with a 5% margin of error. Since the population is within this range, the study used 384 as the sample size.

The purposive sampling technique was adopted for the study in two (2) stages. This method was considered appropriate because it enables the researcher to intentionally select individuals who have direct knowledge and experience of the causes and effects of stormwater in the area. In the first stage, the various neighbourhoods that have high frequencies of stormwater effects were identified with the help of Environmental Units of Zaria and Sabon Gari LGAs' staff. In the second stage, respondents were carefully chosen from individuals who have stayed within the various neighbourhoods for at least 10 years and have adequate information on stormwater impacts in the areas. The number of respondents was therefore proportionate to the total population of each ward within the metropolis (Table 1). However, in determining the proportionate sample size, the 1991 census data for the various sampled communities were used. This is due to the deficiency of the 2006 population data in providing data for various localities. The proportionate sampling was determined using a formula in Eqn. (1):

$$\mathrm{Pr} = \frac{n \times \mathrm{SS}}{N} \quad (1)$$

Where: Pr = proportion of respondents; n = population of each of the selected areas; SS = Sample Size; and N = total population of all the selected areas

Table 1: Population and Sample Size

Communities	1991 Data	2025 Projected	Sample Size
Tudun Jukun	10, 320	21, 197	59
Magume	3, 436	7, 057	20
Kofar Kuyambana	1, 551	3, 186	09
Hanwa	2, 435	5, 001	14
Muchia	29, 836	61, 283	170
Jushin Waje	19, 915	40, 905	112
Total	67, 493	138, 629	384

3.3 Data Analysis

In order to ensure the validity and reliability of the research instrument, the questionnaire was subjected to a pre-test by administering a few copies to the target population. Based on the result of the pre-test, necessary corrections were made with the help of the expert's counselling. In order to determine the consistency, validity, and reliability, the questionnaire items were therefore subjected to statistical analysis using SPSS version 24, and Cronbach's Alpha. The result of the reliability coefficient obtained was 0.87. This indicates that the items were valid, consistent, and reliable to be used for the study.

Subsequently, data generated for the study were analyzed using descriptive statistics such as percentages and means. In addition, a Weighted Mean (WM) was computed to provide a clearer measure of the average level of knowledge of the factors and extent of stormwater impacts, especially where Likert-scale questions were used. The Likert scale was rated as 1 = Strongly Disagree, 2 = Disagree, 3 = Indifferent, 4 = Agreed and 5 = Strongly Agree. The formula for WM is given as Eqn. (2):

$$WM = \frac{\sum f \times w}{\sum f} \quad (2)$$

Where f = frequency of responses, w = assigned weight (example, 1 = strongly disagree to 5 = strongly agree).

The weighted means are interpreted using the following range:

4.50 – 5.00	Very high
3.50 – 4.49	High
2.50 – 3.49	Moderate
1.50 – 2.49	Low
1.00 – 1.49	Very low

Also, to determine the degree of agreement or otherwise among the respondents, standard deviation (SD) is calculated using Eqn. (3):

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} \quad (3)$$

Where s = sample standard deviation, xi = each individual score, x¯ = sample mean, n = sample size

4 Results

4.1 Socio-demographic/economic Characteristics

Table 2 presents the socio-demographic and economic characteristics of respondents in Zaria Metropolis. Factors such as age, gender, education, and occupation influence awareness, vulnerability, and adaptive capacity to stormwater-related challenges in the study area.

Table 2: Socio-demographic/economic Characteristics of the Respondents

Parameters	Options	Frequency	Percent (%)
Age	30 – 40	128	33
	41 – 50	114	30
	51 – 60	86	23
	61 years and above	52	14
Total		380	100
Gender	Male	210	55
	Female	170	45
Total		380	100
Level of Education	Informal	76	20
	Primary	132	35
	Secondary	71	19
	Tertiary	101	26
Total		380	100
Occupation	Trading	126	33
	Civil servant	80	21
	Artisanship	154	41
	Others	20	5
Total		380	100
Marital status	Married	281	74
	Single	45	12
	Divorced/widowed	54	14
Total		380	100
Family size	Less than 5 members	61	16
	6 – 10 members	213	56
	11 – 15 members	88	23
	More than 15 members	18	5
Total		380	100

The age distribution based on Table 1 indicates that a majority (33%) of respondents were between 30 and 40 years, followed by 30% within the 41–50 age group, suggesting that most respondents are in their active working age. This implies that the sampled population possesses experiential knowledge of environmental and infrastructural changes within their neighbourhoods. The gender composition shows that males constituted 55% while females made up 45%, indicating a fairly balanced representation and reflecting household-level participation in stormwater-related experiences. In terms of education, 35% of the respondents attained primary education, 26% had tertiary qualifications, while 20% had no formal education, showing a mixed literacy level that may influence understanding and response to stormwater management practices in the metropolis.

The occupational profile shows that artisans formed the largest group (41%), followed by traders (33%) and civil servants (21%), indicating that most residents are engaged in informal economic activities, which often depend on daily mobility and are therefore highly susceptible to stormwater disruptions. The marital status distribution shows that the majority (74%) were married, reflecting a household-based population where decisions on housing and environmental management are jointly made. Family size data reveal that 56% of respondents had between 6 and 10 members, indicating large households typical of urban northern Nigeria. Larger family sizes may increase vulnerability to stormwater impacts due to household congestion, waste generation, and pressure on drainage facilities. Overall, the socio-economic structure of residents in Zaria Metropolis suggests moderate literacy, predominance of informal livelihoods, and dense household composition. These factors can collectively shape how stormwater risks are perceived and managed in the area.

4.2 Major Factors Contributing to Stormwater Generation and Runoff

Table 3 presents the respondents' views on the major factors contributing to stormwater generation and runoff in urban residential neighbourhoods of Zaria Metropolis. The findings show that both human and environmental factors play significant roles. The highest weighted mean (WM = 4.00) with a relatively low standard deviation (SD = 1.393) was recorded for improper waste disposal into water channels, indicating strong agreement among respondents that indiscriminate dumping of refuse in drainage systems is a major contributor to stormwater-related problems. Field observations confirmed that neighbourhoods such as Sabon Gari and Tudun Wada are particularly affected, where residents dispose of solid waste in open drains, leading to frequent blockages during heavy rainfall. This aligns with Ataguba and Brink (2021), who reported that poor waste management practices significantly increase flood risks in many Nigerian cities. Similarly, the absence or poor maintenance of drainage channels (WM = 3.87; SD = 1.515) was identified as another critical factor, with the SD indicating a moderate level of variation in respondents' views. This finding is consistent with Ologunorisa and Abaje (2016), who noted that neglected drainage infrastructure is a major cause of recurrent urban flooding in northern Nigeria.

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Table 3: Factors Contributing to Stormwater in the Study Area

SN	Effects of Flooding	SD (%)	D (%)	I (%)	A (%)	SA (%)	WM	SD
A	Increase in built-up and impervious surfaces	12	9	3	27	49	3.65	1.431
B	Poor or blocked drainage channels	14	11	6	21	48	3.78	1.488
C	Unregulated urban development	11	10	3	23	53	3.97	1.403
D	Inadequate urban planning and land use control	10	7	3	31	41	3.62	1.313
E	Absence/poor maintenance of drainages	12	15	4	12	57	3.87	1.515
F	Improper waste disposal into water channels	10	11	3	21	55	4.00	1.393
G	Heavy and prolonged rainfall during wet season	11	14	6	31	38	3.71	1.387
H	Lack of awareness on stormwater management	13	16	3	22	46	3.72	1.498
I	Poor road construction/inadequate slope design	16	15	5	31	33	3.50	1.481
J	Deforestation and loss of vegetative cover	12	11	6	30	41	3.77	1.399

***Average Weighted Mean @ 3**

Unregulated urban development (WM = 3.97; SD = 1.403) and the expansion of built-up and impervious surfaces (WM = 3.65; SD = 1.431) were also strongly perceived as major contributing factors, indicating that respondents generally agreed on the hydrological consequences of rapid urbanization. Communities such as Samaru and GRA have witnessed a rapid conversion of open lands into residential and commercial plots, thereby reducing infiltration capacity and increasing surface runoff. This finding supports the observations of Ataguba and Brink (2021), who reported that uncontrolled urban expansion significantly alters hydrological processes and increases stormwater generation. Additionally, inadequate urban planning and weak land-use control (WM = 3.62; SD = 1.313) further exacerbate stormwater challenges, with the relatively lower standard deviation suggesting a more uniform perception among respondents. Studies by Oladokun and Proverbs (2016) across Nigeria and Abaje et al. (2015) in Kaduna similarly highlight that weak enforcement of planning regulations contributes to drainage congestion, blockage of natural channels, and stormwater accumulation.

Environmental factors also play an important role. Heavy and prolonged rainfall during the wet season (WM = 3.71; SD = 1.387) was widely recognized as an aggravating factor, especially in low-lying communities such as Gyallesu, Magume, Zango, and Kwangila. Likewise, deforestation and the loss of vegetative cover (WM = 3.77; SD = 1.399) contribute significantly to stormwater generation, as vegetation that naturally enhances infiltration and slows down runoff is cleared for construction activities. This observation aligns with the findings of Idowu et al. (2013), who reported that vegetation loss reduces infiltration rates and heightens flood risks in northern Nigerian cities.

Further, lack of awareness and poor community practices in stormwater management (WM = 3.72; SD = 1.498) emerged as a key factor, reflecting gaps in environmental education, household disposal behaviour, and community participation in drainage maintenance. Poor road construction and inadequate slope design (WM = 3.50; SD = 1.481) were also highlighted, with the relatively higher standard deviations for these variables suggesting varied experiences and perceptions across different neighbourhoods—likely due to differences in local infrastructure quality.

Taken together, these results underscore the combined influence of infrastructural deficiencies, behavioural practices, and ecological changes in exacerbating stormwater challenges in Zaria Metropolis. They demonstrate that stormwater problems arise not from a single cause but from a complex interaction of human activities, environmental change, and weak institutional controls.

4.3 Residents' Perception of the Impacts of Stormwater on Residential Neighbourhoods

Table 4 presents the perceptions of residents regarding the impacts of stormwater within residential neighbourhoods of Zaria Metropolis. The weighted means and corresponding standard deviations offer insight into the level of agreement among respondents on key stormwater-related challenges, as well as the variability of these perceptions across different communities. Higher weighted means indicate stronger perceived impacts, while the size of the standard deviation reflects how uniformly or inconsistently these impacts are experienced across neighbourhoods such as Samaru, Gyallesu, Zango, and GRA.

The results in the table, therefore, provide a comprehensive understanding of how stormwater affects households, infrastructure, and general living conditions, highlighting both widely shared experiences and location-specific variations in stormwater vulnerability. This forms a crucial foundation for identifying priority areas for intervention and for developing tailored stormwater management strategies within Zaria Metropolis.

Table 4: Perceived Impacts of Stormwater in the Study Area

SN	Impacts	SD (%)	D (%)	I (%)	A (%)	SA (%)	WM	SD
A	Flooding of houses and compounds	18	12	7	22	41	3.56	1.553
B	Erosion around buildings and streets	12	15	6	20	47	3.75	1.473
C	Damage to roads and drainages	15	11	7	21	46	3.72	1.505
D	Seepage and dampness in walls and foundations	12	11	6	18	53	3.88	1.456
E	Disruption of electricity and water supply	12	21	11	17	39	3.52	1.481
F	Increase in mosquito breeding/disease outbreak	10	8	6	26	50	3.98	1.341
G	Difficulty in movements during rainfall	12	10	5	20	53	3.92	1.440
H	Increase in cost of house maintenance	12	22	6	17	43	3.57	1.513
I	Reduction in property value	13	15	5	25	42	3.68	1.469
J	Damage to household items	11	11	6	19	53	3.92	1.426

***Average Weighted Mean @ 3**

The results in Table 4 show that flooding of houses and compounds is a common challenge, with a weighted mean score of 3.56 and a standard deviation of 1.553, indicating a moderate level of agreement but also noticeable variation in experience across different areas. Communities such as Tudun Jukun, Hanwa, Muchia, and Kofar Kuyambana frequently reported flooding, primarily due to inadequate drainage channels, obstruction of stormwater pathways, and poor urban layouts. This finding corroborates the report of Abaje et al. (2015), who emphasized that insufficient drainage facilities and uncoordinated physical development significantly contribute to recurrent flooding in Kaduna State, including parts of Zaria Metropolis.

Erosion around buildings and streets also emerged as a major concern, with a mean score of 3.75 and a standard deviation of 1.473, reflecting strong agreement among respondents and slightly less variability compared to flooding. This challenge is particularly pronounced in neighbourhoods such as Jushin Waje, Babban Dodo, Hanwa, and Gyallesu, where unpaved roads, exposed surfaces, and limited vegetation cover exacerbate runoff velocity and soil displacement. Similarly, road and drainage damage recorded a mean score of 3.72 with a standard deviation of 1.505, further underscoring the significant infrastructural strain associated with uncontrolled stormwater flow. These observations align with the findings of Nkwunonwo et al. (2020), who noted that rapid urbanisation, weak development control, and inadequate stormwater management systems intensify erosion processes and accelerate infrastructure deterioration in many Nigerian cities.

Health and household-related impacts were also widely acknowledged. The highest weighted mean score was recorded for mosquito breeding and disease outbreaks (mean = 3.98, SD = 1.341), indicating very strong and fairly consistent agreement across the sampled population. Dampness in walls and foundations (mean = 3.88, SD = 1.456) and damage to household items (mean = 3.92, SD = 1.426) were also common, suggesting that prolonged moisture exposure and poor building resilience are pervasive issues. These challenges were especially prevalent in low-lying communities such as Tudun Jukun, Fanfon Gwaiba, Jushin Waje, and Muchia, where stormwater accumulation and stagnation persist long after rainfall events. These findings are consistent with Adelekan (2016), who reported that recurring flooding and poor drainage infrastructure in urban centres contribute to building degradation, heightened health risks, increased exposure to vector-borne diseases, and declining property values.

Overall, the results from Table 4 highlight the multifaceted impacts of stormwater on residents' well-being, infrastructure integrity, and environmental quality across Zaria Metropolis. The spatial variation in reported effects underscores the need for community-specific interventions and comprehensive stormwater management strategies.

5 Conclusion

This study concludes that stormwater remains a critical environmental and infrastructural challenge in Zaria Metropolis. The problem is largely driven by rapid urbanization, poor drainage maintenance, improper waste disposal, and inadequate development control, all of which contribute to widespread flooding, erosion, health hazards, and economic losses across residential neighbourhoods. Addressing these impacts requires coordinated and multi-level action. Local government and urban planning authorities must enforce development regulations, expand existing drainage networks, ensure routine maintenance, and integrate stormwater-sensitive design into future urban growth plans. Environmental and waste management agencies should strengthen routine waste collection, promote community-based sanitation programmes, and enforce penalties for practices that obstruct drainage channels. Additionally, state emergency and environmental agencies need to intensify public awareness campaigns, provide early-warning information, and offer technical guidance for flood preparedness and response. Importantly, local communities also have a vital role to play through proactive adaptation measures such as constructing raised thresholds, using sandbags, regularly clearing drains around homes, and adopting household-level water diversion and temporary storage techniques. By aligning institutional responsibilities with community participation and early adaptation strategies, Zaria Metropolis can move toward more sustainable stormwater resilience and reduced vulnerability in the years ahead.

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