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| Research Article |

Assessment of the Perennial Floods Affecting Residential Areas Along River Tille, Katsina Metropolitan, Katsina State, Nigeria

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Abstract: Flooding constitutes a significant environmental challenge across Nigeria, recurring annually and notably affecting residential zones situated adjacent to streams, rivers, and Fadama areas. This study evaluates the perennial floods impacting residential locales along River Tille in Katsina Metropolitan, Katsina State, Nigeria. The research methodology encompassed field visits to the river-adjacent residential areas over a three-year span (2020-2022) and the dissemination of semi-structured questionnaires to ten respondents from six residential areas along the river. Findings indicate that the floods, attributed to factors such as heavy rainfall, proximal housing construction, the infilling of Maliyau pond, and inappropriate waste disposal, recur yearly. These floods have led to the loss of lives, property damage, and structural collapses. While local community initiatives have sought to mitigate these impacts, success has been limited. In response, the State Government, in collaboration with the World Bank in August 2020, initiated a flood control project, which commenced in September 2020 and concluded in 2021. Observations in 2022 revealed substantial flood management improvements, although certain project aspects remain unaddressed by the contractors. Further actions are recommended to ensure the project's full efficacy in managing the perennial floods and minimizing adverse effects on the community. This research is significant, offering detailed insights into the persistent flood issues in metropolitan river areas and assessing a government-executed flood control initiative.

Keywords: Assessment, Perennial floods, River Tille, Katsina Metropolitan

INTRODUCTION

Flooding occurs as a result of heavy or prolonged rainfall exceeding the absorptive capacity of the soil and the flow capacity of rivers, streams, and coastal areas. A flood is an overflow of water that submerges land that is usually dry (NGS, 2014). Dogondaji et al. (2017) observed that flooding is the occurrence of an excessive volume of water in an area usually dry, which has refused to percolate or flow away easily. It usually occurs mostly when there is heavy downpour in an area of land, and all the rain does not sink into the soil but flows on the earth's surface as floods (Agbonkhese et al., 2017). Flooding is a type of extreme weather event that happens when there is heavy rainfall in a short time.

Based on the types of flooding, three major types are identified: river flooding, coastal flooding, and urban flooding. Thus, river flood plains and coastal areas are most susceptible to flooding arising from natural factors such as heavy downpour. However, flooding can also occur in areas with usually long periods of heavy rainfall that are not located along rivers or coastal areas.

River flooding is defined as when the water normally flowing in the river channel overflows its banks and spreads out onto the surrounding land area or its flood plain (Nelson, 2015). River flooding poses a major problem to people living in residential areas along the rivers. For example, the Mississippi River has overflowed its banks for thousands of years, causing extensive damage to properties in cities such as New Orleans during 2005's Hurricane Katrina. River flooding is projected to increase in many regions of the world, particularly Africa and Asia, owing to climate change and socio-economic changes and development (Merz et al., 2021). The impacts of flooding are expected to rise at a global level due to population increases, economic growth, and climate change; hence, understanding the physical and spatiotemporal characteristics of risk drivers (hazard, exposure, and vulnerability) is required to develop effective flood mitigation measures (Tang et al., 2021).

Bangladesh is the most flood-prone area in the world, as the country contains many rivers within its land area. The 2022 floods in Bangladesh were caused by torrential rains and incessant downpours

from upstream regions, which made rivers overflow, affecting an estimated 7.2 million people (IFRC, 2022). At any time throughout the world, a river somewhere is flooding, and its waters are threatening communities, their properties, and even their lives. Few of these events are reported in the headlines due to their local impact. However, the floods in central Europe and China have drawn international attention (Rentschler et al., 2022).

In Nigeria, floods have become an annual occurrence, particularly in states of the federation located along major rivers Niger and Benue, such as Adamawa, Anambra, Bayelsa, Benue, Delta, Edo, Kebbi, Kwara, Nasarawa, and Taraba. River flood plains, stream banks, and coastal areas are the most susceptible to flooding. Flooding is the most common disaster in Nigeria, with the majority of Nigeria's states increasingly suffering from annual flooding during the seasons, caused by increased precipitation linked to climate change. In 2012, the country witnessed its worst flood in 50 years, where 363 people died by the end of October of that year. Some 2 million people were displaced, and 618,000 houses were destroyed. In 2022, as of October 2022, the Nigerian Federal Government stated that 2.5 million people were affected, with 82,000 houses damaged by the floods of 2022 (Aminu et al., 2022). In fact, the yearly occurrence of floods in Nigeria is often a result of inadequate infrastructure and non-implementation of environmental guidelines on flood prevention and mitigation (Idrees et al., 2022). The Nigerian Hydrological Services Agency (NIHASA) usually issues an annual flood outlook that predicts flood risks in states and local government areas (LGAs), but not much is done by those in authority to prevent and control the floods.

Katsina State, located in the North West zone, is also affected by floods on an annual basis, particularly during the rainy season, which starts from May to September. Statistics released by the Katsina State Emergency Management Agency (KATSEMA) (2022) have shown that in 2020, fifteen LGAs were affected, eight persons lost their lives, seventeen were injured, and 6,500 houses were affected. In 2021, four LGAs were affected, ten persons lost their lives, ten were injured, and 1,500 houses were affected. In 2022, twenty-seven LGAs were affected, twenty-six persons lost their lives, twenty were injured, and 16,625 houses were affected (KATSEMA, 2022). The annual flood outlook released by NIHASA (2023) has listed three LGAs under the probable flood risk areas during the rainy seasons. The LGAs are Faskari, Kankara, and Katsina, with Katsina LGA already experiencing floods as predicted by the agency.

Katsina LGA, where the metropolitan area is located, is among the settlements affected by floods on an annual basis, particularly residential areas located along rivers such as the Ginzo and Tille rivers that pass through the urban area. For example, on July 26, 2021, 3 hours of rainfall resulted in parts of the metropolitan being submerged with floods, such as Kofar Kaura roundabout near River Ginzo and Katsira road (Sardauna, 2023). In 2022, records of flood incidences released by KATSEMA (2022) have shown that some of the areas affected by floods on August 28 and 29 are Gadar Nayalli, Kofar Sauri, Tudun Matawalle, and Tudun Katsira, located along the Rivers Ginzo and Tille. On July 3, 2023, intense rainfall led to the flow of a large volume of rainwater, causing flooding along River Ginzo at Sabuwar Unguwa, leading to the death of two persons and the destruction of over 200 houses (Ibrahim, 2023).

Some studies have been conducted on perennial floods in the urban areas of Nigeria. Zanuwa et al. (2018) study on the flood menace in urban Zaria revealed that floods occur every rainy season, posing negative effects on people and their properties. The major causative factors of floods are intensive rainfall, low topography, lack of dam embankment and regulatory outlets, as well as the flow of streams and dam bursts. The study recommended the conversion of mud houses to bricks, seeking experts' advice, use of appropriate building materials, building only in approved ways and places, moving valuable property to a safe place, coordinating with the government and other NGOs to support victims, and timely evacuation from affected houses.

Umahio (2020) reported that in Kwara State capital Ilorin, the perennial flooding of the Asa River is caused by dumping waste materials around the river and building houses along the river flood plains. Stakeholders called for the government to dredge the river and build an embankment to prevent the flow of floodwater into residential areas. Mashi et al. (2020) studied community perception towards flood risks in a traditional African city. The study found out that floods are on the increase due to climatic change and increasing urbanization, inadequate flood-conveying structures with few in most cases used as sites for waste disposal, inadequate coordination between institutional stakeholders responsible for physical planning, waste, and emergency management in the area.

Ladan & Saulawa (2021) studied the 2018 flood disaster in Jibia town in Katsina State, Nigeria. The study indicated that floods are the most universally experienced natural disaster, particularly in settlements around water bodies, which is caused by unprecedented heavy rains, stream diversion, and silting of the stream pool, blockage of floodwaters by the Gada river, silting of the Jibia dam, inadequate

drainages, and construction of houses close to the storm drainage. Ladan & Mayaki (2023) studied flood incidences as a public health challenge in Katsina State, northern Nigeria. The study found out that flood incidences have become a public health challenge as a result of the loss of lives, injuries to flood victims, destruction of houses, and creation of displaced persons. This is despite the efforts of the State Government in tackling the challenges posed by the floods to public health.

The perennial flooding of rivers and streams across Nigeria has become a nightmare to many residents, particularly during the rainy season. The perennial floods have caused untold hardships to many residents whose houses are located along rivers and streams. NIHASA (2020) even urged the Federal Government to create laws to mitigate the occurrence of perennial flooding in the country. Based on this, perennial flooding of rivers and streams needs to be studied with a view to identifying the causes and offering solutions towards halting the perennial floods for the sustainable development of city residents.

The study is significant as it is one of the few studies focusing on the River Tille. There are several studies on the two rivers that surround Katsina city, but the majority of them focus on River Ginzo, not the river Tille. Therefore, this study will add to the available body of knowledge on the river Tille, which is presently needed in view of the several environmental challenges facing Katsina metropolitan.

The problem the paper is addressing is the perennial floods affecting residential areas along River Tille in Katsina metropolitan, Katsina State, Nigeria. The research question this research seeks to answer is how can the perennial floods affecting residential areas along River Tille in Katsina metropolitan, Katsina State, be assessed? The objectives of the study are to examine the perennial occurrence and causes of the floods affecting residential areas along River Tille in Katsina metropolitan, explain briefly the impacts of the occurrence of perennial floods along the river, highlight the measures adopted by residents in responding to the occurrence of the perennial floods affecting their areas, highlight the efforts of the State government in tackling the perennial floods, assess the recent efforts of the State government in tackling the floods, and recommend appropriate measures to tackle the perennial floods affecting residential areas along the river.

METHOD

Description of the Study Area

The study area, Katsina metropolitan, is the capital of Katsina State, created from the defunct Kaduna State on September 27, 1987. The metropolitan area is situated at latitude 12°30' N and longitude 7°36' E, lying 173.42 km along the highway from Kano to Maradi in Niger Republic (Encyclopedia Britannica, 2023). It serves as the headquarters of Katsina Local Government Area (LGA), one of the thirty-four LGAs in Katsina State. As of 2023, the metropolitan area boasts an estimated population of 524,000, with a growth rate of 3.76% from the previous year (Macrotrends, 2023).

In terms of its physical setting, Katsina city is positioned on a spur of land between the courses of the Rivers Ginzo and Tille, flowing in a north-easterly direction. It is located at the narrow neck of the watershed between the Gada and Tagwai river basins (Lock, 1977 as cited in Danjuma, 2017b). The climate is characterized as tropical wet and dry, with a short-wet season from June to September and annual rainfall ranging from 550mm to 700mm (Abaje et al., 2017). The long dry season spans from October to April, dominated by the continental air mass, especially from November to February. The vegetation is Sudan Savanna grassland, featuring short scattered trees and grasses, which have been significantly modified by human activities over decades. For instance, the Nassarawa Forest Reserve, located within the catchment area of River Tille, has experienced deforestation due to encroachment for settlement and farming activities.

River Tille, along with River Ginzo, drains the entire Katsina metropolitan and its surrounding areas, forming two distinct watersheds named after them (Ibrahim, 2015). Over time, River Tille has undergone significant changes due to hydrologic, geomorphic, and urbanization processes within and outside its catchment areas, resulting in the shrinking of its channel to resemble more of a stream. However, the large volume of rainwater flowing in the river during annual or sporadic floods depicts its river status (Ibrahim, 2015).

The River Tille originates from the Bugaje ridge located to the northwest, flows into the Maliyau pond, and is met by seasonal rainwater flow from areas around the Federal Teaching Hospital Katsina. It then moves near the Eid ground to Tundun Yanlihidda, Tundun Baras, Lambun Dan Lawan, and continues to flow into the River Ginzo at a confluence outside the city.

Figure 1 below shows the map of the study area, with River Tille indicated in the northeastern part. The points marked as 1 to 6 represent the sample points or residential areas where questionnaires were distributed and completed: 1 for Kofar Guga, 2 for Tudun Yanlihidda, 3 for Tudun Baras, 4 for

Rafukka, 5 for Kofar Sauri, and 6 for Kaita road. These areas, developed outside the old Katsina city wall or Ganuwa in Hausa, accommodate low-income and poverty-stricken members of the society (Danjuma, 2017a). They are susceptible to various natural and man-made hazards, including flooding and soil erosion.

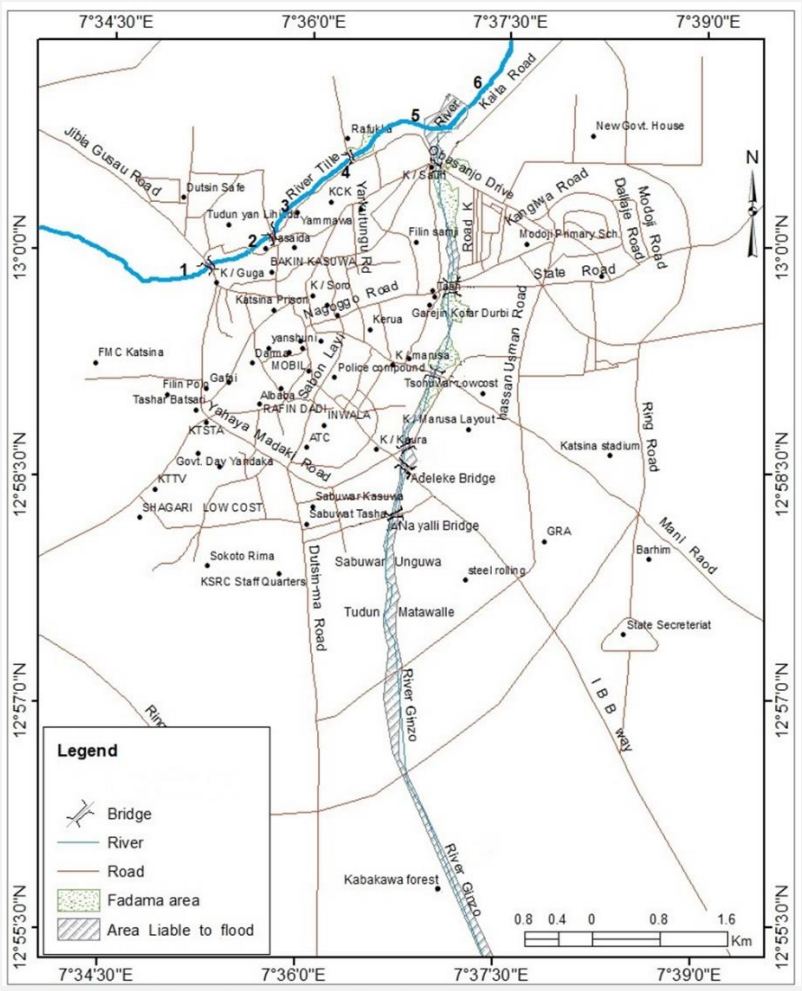

Figure 1. Map of Katsina Metropolis showing River Tille as the Study Area.

Methods

Data for the study were collected using a semi-structured questionnaire, with sixty (60) questionnaires administered to ten (10) respondents in each of the six residential areas along the river during the last field visit. The areas, as indicated in Figure 1, are Kofar Guga, Tudun Yanlihidda, Tudun Baras, Rafukka, Kofar Sauri, and Kaita road. Purposive sampling was employed to select respondents who are adults knowledgeable about the flood situation in their areas. The questionnaire is divided into Section A, gathering demographic characteristics, and Section B, addressing the main objectives of the study concerning the floods' occurrence, causes, impacts, and efforts to control them from 2020 to 2022.

Field visits for direct observation were conducted on February 6, 2021, September 28, 2022, and August 5, 2023, observing issues related to the perennial floods along the river from the Katsina State Transport Authority (KTSTA) garage at Kofar Guga up to the West African Examination Council (WAEC) main office along Kaita Road—a nearly 7 km stretch.

Additionally, the study area map, sourced from National Aeronautics and Space Administration (NASA) and SPOT Image (NOA) 2013, was updated to reflect the 2021/2022 situation. This map highlights the study and residential areas along the river's course. An Infinix Note 8 mobile phone was used to capture images of areas affected by the floods, which are incorporated into the article as visual evidence.

Secondary data were collected through desk research from a variety of sources, including textbooks, conference papers, daily newspapers, and online materials. Descriptive statistics in the form of percentage averages and tabulations were used for data analysis, appropriate for the study's descriptive research design. The analysis provided a descriptive qualitative overview of the findings, expressed in tables and pictorial evidence, including stormwater drainage systems constructed to ease the flow of floodwaters.

Demographic characteristics of the respondents were analyzed through tabulation and explanation, with each response recorded and aggregated to determine characteristic frequencies, such as gender, age range, marital status, etc., calculated as a percentage of the total number of respondents (60). The responses to the research questions were similarly processed to derive frequencies based on the total respondent count, particularly for questions regarding the causes of the perennial floods along River Tille. Other research questions were addressed through discussions based on summary responses and observations made during the field visits.

RESULTS & DISCUSSION

Demographic Characteristics of the Respondents

The demographic characteristics of the respondents indicate a significant gender disparity, with 48 out of 60 respondents being male (80%), and 12 respondents female (20%). This gender distribution reflects the cultural norms of the study area, where males are more commonly found outdoors and are more likely to respond to environmental surveys.

In terms of age distribution, the majority of respondents (23.3%) are within the age range of 45-49 years, followed by equal percentages (20.0%) in the 35-39, 50-54, and 55-59 year ranges. The 40-44 year age group was the least represented, with 16.6% of respondents.

Marital status showed that 90% (54 respondents) are married, while 10% (6 respondents) are divorced, all of whom are female. This may be attributed to the predominance of male homeowners who are heads of households. Within the married group, 55.5% have one wife, 37.03% have two wives, and 7.40% have three wives. The number of children per respondent varied, with 60.0% having 1-4 children, 10.0% having 5-9 children, and 30.0% having 10-14 children.

Educationally, 33.3% of respondents have received Qur'anic education, 13.3% have completed primary school, 23.3% have secondary school education, and 30.0% have attained tertiary level education.

Occupationally, 33.3% are traders, 26.6% work in the private sector, 20.0% are farmers, and 10.0% are either civil servants or artisans/craftsmen.

These demographic characteristics are summarized in Table 1 below.

Table 1. Demographic Characteristics of the respondents

S/No.	Characteristics	Frequency	Percentage (%)
1.	*Gender*		
	Male	48	80.0
	Female	12	20.0
2.	*Age Group*		
	35 – 39 years	12	20.0
	40 – 44 years	10	16.0
	45 – 49 years	14	23.3
	50 – 54 years	12	20.0
	55 – 59 years	12	20.0
3.	*Marital Status*		
	Married	54	90.0
	Divorced	06	10.0
4.	*No of Wives*		
	One	30	55.5
	Two	20	37.037
	Three	04	7.407
5.	*Number of Children*		
	1 – 4	36	60.0
	5 – 9	06	10.0
	10 – 14	18	30.0

S/No.	Characteristics	Frequency	Percentage (%)
6.	*Educational Qualification*		
	Qur'anic Education	20	33.3
	Primary School	08	13.3
	Secondary School	14	23.3
	Tertiary Level	18	30.0
7.	*Occupational Status*		
	Civil Servant	06	10.0
	Farming	12	20.0
	Trading	20	33.3
	Private Sector	12	26.6
	Artisans/Craftsmen	06	10.0

Source: Field survey (2023)

River Tille and the Occurrence of Floods along the River

Regarding the frequency of flood occurrences along River Tille, all respondents confirmed that floods happen annually, thus indicating a perennial event. However, perceptions vary regarding the severity of these floods. Specifically, 28 respondents, constituting 46.66%, characterized the floods in the year 2020 as the worst. Meanwhile, 20 respondents, or 33.33%, reported that the floods occurring in 2021 were also severe. A smaller group, 12 respondents or 20.00%, described the floods in 2022 as having minimal impacts. This reduction in severity could be attributed to the flood control measures implemented by the State Government, aimed at mitigating the negative impacts on residents. These observations align with findings from Oruonye (2015), who reported annual overflow from River Lamurde in the Jalingo metropolis, Taraba State, Nigeria, during the rainy season. This study also noted that most buildings located along the floodplains were within the flood risk zone.

Causes of the Perennial Floods along River Tille in Katsina Metropolitan

In addressing the research question regarding the causes of perennial floods along River Tille, respondents identified several factors. These causes are detailed in Table 2 below.

Table 2. The causes of perennial floods along River Tille in Katsina Metropolitan

S/no	Causes of the perennial floods	Frequency	Percentage
1.	Occurrence of heavy rainfall	18	30.00%
2.	Building and other structures close to the river channel	13	21.66%
3.	Filling up of Maliyau pound	11	18.33%
4.	Dumping waste materials into storm water drainages	10	16.66%
5.	Building on waterways serving as tributaries to River Tille	08	13.33%

Source: Data analysis (2023)

The most cited cause, by 30.00% of respondents, is heavy rainfall, which has been increasing annually, resulting in the river channel and other drainage systems being overwhelmed and leading to flooding. Climatic changes have made heavy rainfall more frequent at the onset of the rainy season, contributing significantly to flooding incidents, such as the one on July 20th, 2020, that affected the KTSTA garage at Kofar Guga (Figure 2). Data from Katsina State Emergency Management Agency (KATSEMA, 2022) shows that heavy rains leading to flooding in 2022 occurred mainly in July and August in Katsina Metropolitan. This aligns with findings by Saleh & Inkani (2024), who documented a corresponding increase in average annual rainfall in Katsina LGA, predicting continued extreme weather events like flooding.

The second major cause, according to 21.66% of respondents, is the construction of houses and other structures close to the river channel. This has led to the gradual build-up of structures on what used to be open river flood plains, directly causing overflow into residential and commercial properties during heavy rains. The lack of planning and government development control in areas like Kofar Guga, Tudun Yanlihidda, Tudun Baras, Rafukka, and Kofar Sauri exacerbates the situation. The State Government's efforts to concretize the river channel for improved stormwater flow required the demolition of many such structures. The building of Masari quarters besides Federal Teaching Hospital Katsina has further led

to the flow of more storm water towards the River Tille adding more water which to leads to more flooding. This finding is similar with the study by Ladan (2022) on Jibia flood disaster in Katsina State where most of the houses and other structures affected severely are those to the Dan Abdallawa stream channel.

Figure 2. Heavy rainfall causing flooding at KTSTA garage at Kofar Guga on July 20th 2020.

Filling up Maliyau Pond is identified as the third major cause of the perennial floods, according to 18.33% of the respondents. This pond plays a crucial role in the river's course, serving as a natural storage basin for rainwater as it flows from Kofar Guga through the Tudun Yanlihidda quarters. Observations from field visits revealed that approximately 70-75% of the pond has been filled with laterite and gravel for the construction of a fuel station named Alhaji Usman Sarki Global Investment Limited. As a result, rainwater that would normally be stored in the pond now overflows into the adjacent motor park or into the stormwater drainage system, leading to flooding, particularly in the Tudun Yanlihidda area. The majority of flooding incidents in Tudun Yanlihidda can be attributed to the infilling of Maliyau Pond. A study by Ladan (2015) demonstrated that ponds in the Katsina metropolitan area are integral for capturing rainwater from the surrounding area, thus preventing it from flooding homes and other structures. However, when these ponds are filled, the lack of water storage capacity directly contributes to flooding, as the excess rainwater has nowhere to go.

Dumping waste materials into stormwater drainages is identified as a significant factor contributing to flooding, with 16.66% of respondents acknowledging this issue. The practice of disposing waste directly into the drainage systems by traders, food vendors, tea sellers, and mechanics, particularly in front of the Kofar Guga motor park, severely obstructs the flow of rainwater. This blockage results in flooding during the initial rainfall events of the season. Reports indicate that individuals also use wheelbarrows to deposit waste into the stormwater drainages, exacerbating the problem. Despite complaints from motor park officials to the Katsina State Environmental Protection Agency (KATSEPA) for waste clearance, the response has been inadequate. This scenario aligns with findings by Mokuolo et al. (2022), highlighting the significant role of solid waste in causing persistent urban flooding in Isale Koko, Ilorin East LGA of Kwara State, Nigeria.

The issue of waste in the stormwater drainage, a visual testament to this problem, underscores the need for more effective waste management practices and public awareness campaigns to mitigate the risks of flooding. The waste dumped inside the storm water drainage can be seen in Figure 3.

Building on waterways has been identified by 13.33% of respondents as a significant cause of flooding along River Tille. A notable example is Turare United Petroleum Nigeria Limited, situated outside the Kofar Guga city gate, which obstructs the natural flow of rainwater, subsequently causing overflow into areas such as the KTSTA garage. The construction along the river from the Kofar Guga Bridge to Kaita road, especially where tributaries meet the river, further exacerbates flooding due to urban expansion into these critical waterways. The impeded flow of rainwater during significant rainfall events highlights a systemic issue in urban planning and management within the region. This

phenomenon aligns with findings by Umar & Gray (2023), which underscore the broader trend of urban flooding exacerbated by the encroachment on waterways and canals, marking it as a key factor in the persistence of floods in urban centers across Nigeria.

Figure 3. Waste Materials dumped inside a storm drainage in front of Kofar Guga Motor Park.

Impacts of the Floods on the Residential Areas

The impacts of perennial floods on residential areas within the study period (2020-2022) have been notably negative, according to the respondents. These impacts include:

(i) *Loss of Lives:* Floodwaters often carry individuals, particularly children, who are unable to swim in the torrential flows, leading to drownings. A resident from Kaita Road Quarters reported that each year, at least two people, mostly children, are found dead in the river after floodwaters recede. In 2022, two children accidentally fell into the stormwater drainage while observing the flood on August 19th.

(ii) *Destruction of Houses:* Many homes, especially those constructed from mud, collapse when infiltrated by floodwaters. The most affected are those situated close to the river. Some residents have attempted to rebuild their homes with the hope of withstanding future floods.

(iii) *Destruction of Personal Property:* This includes motor vehicles parked at KTSTA garage and Kufar Guga Motor Park, along with documents, mattresses, clothing, and files in residential areas like Tudun Yanlihidda and Tudun Baras, which have repeatedly lost belongings to the floods.

(iv) *Collapse of Perimeter Walls:* Floodwaters have caused the collapse of perimeter walls surrounding the KTSTA garage, leading to significant water flow into the area and damaging vehicles. Other walls around private residences in Tudun Baras and Rafukka have also collapsed.

(v) *Disturbance to Local Businesses:* Shops near Kofar Guga Motor Park often cannot open during heavy rains due to floodwaters blocking entrances and sometimes entering the shops, damaging property. Business owners may close until the following day when the water has receded.

(vi) *Obstruction of Movement:* Floodwaters covering bridges and streets hinder the movement of people and motorcycles. Visibility of submerged bridges is lost, forcing individuals to wait for water to subside before passing.

(vii) *Agricultural Impact:* Floods damage crops by saturating the soil and introducing pollutants like polythene and cellophane, which adhere to and suffocate plants. This is particularly prevalent in areas adjacent to the river where farmland, gardens, and irrigated fields rely on river water for irrigation.

(viii) *Agricultural Benefits:* Conversely, floods also enrich farmlands, gardens, and irrigated fields with alluvium, beneficial for growing market garden crops. Despite urbanization pressures, these areas continue to be used for agricultural purposes, highlighting the dual nature of flood impacts.

These findings echo those of Nnodim & Ezekiel (2020), who also identified predominantly negative effects of perennial floods on people's livelihoods, despite the nuanced benefits to agriculture in certain contexts. The overall impact of floods on residential areas underscores the need for comprehensive flood management and mitigation strategies to protect communities and livelihoods.

Efforts of Local Communities in Responding to the Impacts of the Perennial Floods

In addressing the research question concerning the local communities' efforts to respond to perennial floods, several initiatives have been identified:

(i) *Emergency Evacuation and Vehicle Safety:* During the 2020 floods, KTSTA garage workers evacuated the premises to ensure personal safety. Efforts were also made to move flooded vehicles out of the garage to mitigate further damage.

(ii) *Structural Modifications to Shops:* Shop owners near the stormwater drainages have elevated the entrances to their shops to prevent floodwaters from entering, thereby safeguarding their properties.

(iii) *Community Engagement on Waste Disposal:* Concerned shop owners have been actively communicating with the public about the consequences of improper waste disposal into the stormwater drainages and its direct contribution to flooding, urging for responsible waste management practices.

(iv) *Use of Sandbags for Flood Defence:* Residents, particularly in Tudun Yanlihidda and Tudun Baras, have resorted to filling empty sacks with sand to barricade against floodwaters, stabilizing the soil and protecting their homes.

(v) *Agricultural Water Management:* Farmers affected by flooding have employed water pumping machines to drain floodwater from their fields, especially in areas lacking natural waterways or drainage systems. This practice was observed on September 24th, 2022, during a field visit following overnight rainfall.

(vi) *Advocacy for Infrastructure Development:* Prominent community members and activists have been petitioning local politicians, the Katsina Local Government Council, and the State Government for the urgent construction of stormwater drainage systems along River Tille to manage the floods. Additionally, some residents have voiced their concerns and the need for effective drainage systems through live radio broadcasts on Vision FM and other stations.

These community-driven efforts mirror findings from Fatemi et al. (2020), which highlighted that local communities in peri-urban areas of Dhaka, Bangladesh, have similarly adopted immediate and short-term preventive measures against the adverse effects of perennial flood events. These proactive measures by the communities along River Tille underscore the critical role of local actions and advocacy in addressing the challenges posed by perennial flooding, emphasizing the need for collective responsibility and governmental support in flood management and mitigation strategies.

Efforts of Katsina State Government Towards Controlling the Perennial Floods

In response to significant flooding in July – August 2020 within Katsina Metropolitan, the State Government initiated several flood control projects, including the River Tille flood control project extending from Kofar Guga to Shinkafi Bridge along the Ring Road. This initiative is part of the Katsina Town Storm Water Drainage Management Project under the Nigeria Erosion and Watershed Management Project (NEWMAP), executed by Mother Cat Construction Company and Triacta Construction Company (Figure 4).

Figure 4. Katsina town and storm water drainage project billboard outside Kofar Sauri city gate.

The project encompasses constructing an 11-km, 5-meter-wide concrete-lined drainage along River Tille. During a visit on September 23, 2020, the State Governor directed the project manager to implement several measures, including:

- Vegetation Planting: To plant trees and other vegetation beside the drainage to secure the land compensated to the public.
- Linking Drainages: To connect residential drainages close to the stormwater system, ensuring runoff flows into the storm drainage and away from homes.
- Waste Disposal Facilities: To establish 90 refuse collection centers to encourage proper waste disposal and prevent dumping in the new stormwater drainage.
- Project Completion: To expedite the project's completion before the 2021 rainy season, aiming to prevent further flooding experiences for the affected communities.

Figure 5 below shows a section of the constructed drainage at Tudun Yanlihidda residential area.

Figure 5. A section of the river converted to storm water drainage for flood control constructed by Katsina State Government from 2020 – 2021.

These state government initiatives to control perennial flooding in Katsina mirror efforts in other regions, such as Lagos State, where Oshodi (2013) identified various flood mitigation and adaptation strategies to address the challenges posed by perennial flooding in the megacity.

Assessing the Katsina Town Storm Water Drainage Management Project

Following the completion and subsequent handover of the Katsina Town Storm Water Drainage Management Project to the State Government, the 2022 rainy season served as a critical assessment period for its efficacy in flood control. Observations made during a significant rainfall on August 19, 2022, include:

(i) *Flood Containment:* The constructed stormwater drainage successfully contained most of the floodwater, though some overflow occurred due to the intensity of the rain. It was estimated that the project controlled flooding by approximately 80%, earning public gratitude for the State Government's efforts (Kabir, 2022).

(ii) *Safety Concerns:* During the flooding, some residents observed the floodwater flow from bridges; tragically, two individuals accidentally fell into the storm drainage and were carried away. Their bodies were later recovered near Shinkafi village, highlighting safety risks associated with the project.

(iii) *Lack of Vegetation:* Contrary to directives from the State Governor, no trees or other vegetation were planted alongside the storm drainage. The absence of this vegetation left areas that could have served as flood plains for overflow unmitigated.

(iv) *Incomplete Infrastructure:* Some side-link up drainages, intended to direct water from nearby residences into the main storm drainage, were not constructed. This oversight led to soil erosion and the formation of puddles in areas where water could not drain efficiently into the storm system.

(v) *Waste Disposal and Management:* Despite plans, no refuse collection centers were constructed along the drainage, leading to visible refuse dumps and waste accumulation within the drainage system. This debris could obstruct floodwater flow during rainy periods.

(vi) Future Water Management Proposals: In response to the project's completion, the State House of Assembly proposed the construction of an earth dam at the end of the storm drainage. This initiative aims to store floodwater for human use and irrigation, addressing water scarcity during the dry season.

The effectiveness of the Katsina stormwater management drainage project in controlling floods, similar to the success of the Jibia flood control project reported by Ladan & Saulawa (2021), underscores the importance of comprehensive planning and execution in flood mitigation efforts. However, the observations from 2022 highlight areas for improvement, particularly in safety measures, infrastructure completion, and waste management, to enhance the project's overall efficacy and sustainability.

CONCLUSION & RECOMMENDATIONS

Conclusion

The River Tille, encircling Katsina city, has been a source of annual flooding, impacting residents with loss of life and property damage. Despite various flood control initiatives by the State Government since 2000, particularly along River Ginzo, River Tille remained unaddressed until 2020 under Governor Masari's administration. The Katsina Town Storm Water Drainage Management Project, completed in 2022, marks a significant effort towards mitigating the effects of these perennial floods. While the project has considerably reduced flooding, certain aspects remain incomplete, posing a risk of future floods.

This study highlights the urgent need for policymakers and implementers to ensure comprehensive completion of the project's outlined tasks and recommendations. There is a call for cooperation between KATSEPA, the residents' committee, and other stakeholders to address the remaining challenges effectively. The implementation of these measures is crucial for the long-term management and prevention of flood impacts along River Tille.

This research enriches existing knowledge on managing perennial floods in residential areas near rivers within metropolitan settings of developing countries. It offers valuable insights for environmentalists, urban planners, and policymakers, providing a basis for informed decision-making in urban environmental management. Future research should explore an integrated approach to addressing perennial flooding, focusing on sustainable, community-engaged strategies for flood prevention and control.

Recommendations

To effectively mitigate the perennial flooding along River Tille and safeguard the residential areas, the following recommendations are proposed:

1. Public Enlightenment Campaigns: The Katsina State Government should initiate public awareness campaigns targeting residents along the river. These campaigns should emphasize the dangers of standing on bridges to watch floodwaters, aiming to prevent the loss of lives, as witnessed during the 2022 floods.
2. Protection of Open Spaces: The State Government should task KATSEPA with ensuring that the open spaces adjacent to the stormwater drainage are not claimed for construction purposes. Preserving these areas is crucial to minimizing the risk of future floods.
3. Waste Management: KATSEPA should provide sufficient waste collection containers at strategic locations, including in front of the Kofar Guga motor park and along River Tille. This measure is aimed at preventing waste disposal near the newly constructed stormwater drainage system, which can lead to blockages and exacerbate flooding.
4. Security for Project Facilities: The community of residents should collaborate to provide security measures for the flood control project facilities to prevent vandalism. Thieves targeting materials such as concrete, iron rods, and wood from the project site, as well as sand mining activities along River Tille, should be strictly prohibited to maintain the structural integrity of the flood control measures.
5. Community-led Environmental Sanitation: The committee of residents should organize and participate in monthly environmental sanitation activities. These activities should include clearing drainages, collecting waste, and ensuring proper disposal to prevent the accumulation of waste in and around the stormwater drainage, further mitigating the risk of flooding.

Implementing these recommendations requires a cooperative effort between the government, local communities, and environmental agencies. Such a collaborative approach will not only address the

immediate concerns related to flooding but also contribute to the long-term sustainability and resilience of the residential areas along River Tille.

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