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The Determinants of Recurrent Flooding in Benin City, Edo State, Nigeria: Adaptation, Mitigation, and Intervention Strategies

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ABSTRACT

This paper evaluates the determinants of recurrent flooding in Benin-City: adaptation, mitigation, and intervention strategies Flooding is considered as one of the most frequent and damaging natural hazards globally, particularly in low-lying areas and unplanned urban centers. Specifically, it has emerged as one of the critical and recurrent environmental challenges in Benin-City, Edo State, Nigeria. The paper identified the primary natural and anthropogenic determinants of recurrent flooding, level of awareness of the City dwellers on the causes of recurrent flooding, effects of recurrent flooding on the livelihoods of the city dwellers, and adaptation, mitigation, and intervention strategies adopted by the city dwellers to alleviate the effects of recurrent flooding on their lives in Benin-City, Edo State, Nigeria. To accomplish these specific objectives, the paper employed both primary and secondary research methods to collect the required data. The projected population of Benin-City (the study area) in 2026 at 3.67% growth rate is 2,120,000. Five hundred (500) residents/respondents (the sample population), which represent zero point zero two three six percent (0.0236%) of the entire population in the study area, were considered. Following the above, 500 questionnaires were prepared and administered in the study area. The data obtained were analyzed using appropriate statistical techniques, such as tables, frequencies, and percentages. The results reveal the primary natural and anthropogenic determinants of recurrent flooding, level of awareness of the city dwellers on the causes of recurrent flooding, effects of recurrent flooding on the livelihoods of the city dwellers, and adaptation, mitigation, and intervention strategies adopted by the city dwellers to alleviate the effects of recurrent flooding on their lives in Benin-City, Edo State, Nigeria. Based on the above findings, the following actionable policy recommendations are made: creation and promotion of effective, efficient and efficacious grassroots awareness campaigns; construction of permeable pavements; elevated foundations; weather-resistant building materials; evacuation of blocked drains; enforcement of environmental sanitation; adoption of modern environmental building codes; implementation of green building initiatives; cover cropping; forest conservation laws; laws against indiscriminate bush fires; avoidance of encroachment on waterways; the use of sand bags; total eschewal from areas near waterways, bioengineering, flood early awareness campaigns, disaster relief programmes, local flood control initiatives, and technical assistance. Also recommended are road elevation and paving, construction of additional drains and maintenance, environmental protection and regulation, enforcement of urban planning, regular and effective inspections and monitoring of drains to prevent dumping of wastes. The paper concludes by passionately appealing that these actionable policy recommendations should be adopted and implemented by the concerned authorities in Benin-City, Edo State, Nigeria.

Keywords: Determinants, recurrent flooding, adaptation, mitigation, intervention.

INTRODUCTION

Flooding according to Adelekan, (2010), is broadly defined as the accumulation or overflow of water onto land that is normally dry, resulting from natural or human-induced factors. In a similar vein, Omorodion et al., (2014)

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contends that flooding is the overflow on an expanse of water such that it covers or submerges the land while moving with a particular speed. It is considered as one of the most frequent and damaging natural hazards globally, particularly in low-lying areas and unplanned urban centers. Flooding has emerged as one of the most persistent and devastating environmental challenges facing urban centers in Nigeria, with Benin City, the capital of Edo State, being particularly susceptible. As an ancient city undergoing rapid modern urbanization, Benin City grapples with a complex interplay of natural geographic factors and human-induced environmental changes. According to Cirella, Iyalomhe, and Adekola (2019), the susceptibility of the city is rooted in its humid tropical climate, characterized by intense precipitation often exceeding 2,000 mm annually and a relatively flat terrain that hinders efficient natural runoff.

The primary determinants of recurrent flooding in the metropolis are multifarious and multifaceted. In recent decades, flooding has emerged as a critical environmental challenge in Benin-City, Edo State, Nigeria. The vulnerability of the area to flooding has escalated considerably, driven by a combination of changing climate patterns and anthropogenic factors such as rapid urbanization and poor land management practices. Studies indicate that the region has experienced increasingly erratic and heavy rainfall events, which mirror broader climatic fluctuations documented across southern Nigeria (Ologunorisa, 2004; Ologunorisa, & Abawua, 2005; Ayanlade et al., 2017; Ayanlade et al., 2017). Recent geospatial evaluations by Ogunseyin (2025), highlight that unsustainable land use and land cover (LULC) changes have significantly exacerbated flood risks. The conversion of natural vegetation into impervious surfaces (concrete and asphalt) has drastically reduced soil infiltration rates, leading to increased surface runoff. Furthermore, the blockage of existing drainage networks by solid waste and the prevalence of "non-engineered" constructions in flood-prone areas remain critical bottlenecks (Ezemonye & Emeribe, 2014; Akanji, 2024). As noted by Utsev (2026), the increasing frequency of flash floods in cities like Benin is also a reflection of broader climate change patterns, which have altered rainfall intensity and duration.

Residents of Benin City have traditionally relied on various localized coping mechanisms to mitigate the impact of seasonal floods. These range from temporary barriers, like sandbags, to the elevation of building foundations. However, Ezemonye and Emeribe (2014) observed a significant gap in household preparedness, often influenced by a lack of funds and, in some cases, religious fatalism, where residents view flooding as an "act of God" rather than a manageable environmental risk.

Oseghale & Ehinomen (2021), and Oladosu et al., (2022) posited that the rising incidence and intensity of flooding in Benin-City, Edo State reflects wider environmental changes occurring globally, emphasizing the necessity for climate-adaptive urban planning and enhanced community resilience strategies. Addressing these multifaceted challenges requires coordinated efforts spanning scientific research, policy formulation, development of infrastructure, and local participation to mitigate flood impacts and safeguard vulnerable populations.

From an interventionist standpoint, the Edo State government has recently shifted toward more integrated flood control strategies. In April 2026, the Ministry of Environment and Sustainability initiated on-the-spot assessments in devastated areas like the Useh Community in Egor LGA, aiming to develop sustainable engineering solutions beyond traditional drainage clearing (The Nigerian Observer, 2026). Globally, organizations like the World Bank (2022) have emphasized the need for "Infrastructure Resilience and Capacity Building," providing financing for secondary cities in the region to improve urban planning tools and disaster response funds.

Statement of the problem

The perennial flooding in Benin-City metropolis constitutes a profound hydro-geomorphologic and socio-economic challenge, necessitated by a complex synergy between intensified pluviometric patterns and rapid, unregulated urban lateral expansion. Although the city's pedological and topographical characteristics historically facilitated natural drainage, the contemporary proliferation of impervious surfaces has fundamentally altered the basin's response to precipitation (Cirella, Iyalomhe, & Adekola, 2019). This anthropogenic transformation has led to a significant escalation in the runoff coefficient, whereby rainwater that would

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otherwise infiltrate the subsurface is converted into high-velocity surface flow, consistently overwhelming the city's existing hydraulic infrastructure and disrupting the hydrological equilibrium (Ogunseyin, 2025).

Central to this problem is the structural and operational inadequacy of the urban drainage network, which suffers from both design obsolescence and systemic maintenance neglect. Many of the primary conduits were engineered based on historical hydrological data that no longer account for the extreme weather events associated with contemporary climatic shifts. Furthermore, the efficacy of these channels is chronically compromised by the anthropogenic practice of indiscriminate solid waste disposal, which creates hydraulic bottlenecks and induces backflow into residential precincts (Akanji, 2024). Consequently, the lack of a synchronized, city-wide storm-water master plan means that localized interventions often inadvertently redirect floodwaters to downstream communities, merely shifting the locus of the disaster rather than mitigating its primary cause (Ezemonye & Emeribe, 2014).

The socio-economic dimension of this crisis is underscored by the precariousness of local coping strategies, which remain largely reactive and insufficient to suppress and withstand high-magnitude flood events. Residents in high-risk zones frequently resort to rudimentary structural modifications and temporary embankments that fail to address the underlying vulnerability of their built environment (Utsev, 2026). This reliance on fragmented, household-level resilience is a direct consequence of the lapse in the enforcement of urban planning statutes and the encroachment of development upon natural floodplains. So, there is a scholarly imperative to investigate the specific determinants of these hydrological failures and to evaluate the viability of current interventionist frameworks, as the continued absence of a data-driven, integrated resilience strategy threatens the long-term sustainability and economic viability of the Benin-City urban ecosystem (The Nigerian Observer, 2026).

These efforts notwithstanding, the recurring nature of the floods suggests that existing intervention strategies may be reactive rather than proactive. This study, therefore, seeks to evaluate the specific determinants of flooding in Benin City and assess the current coping and intervention strategies to provide a roadmap for long-term urban resilience.

Aim and Objectives of the Study

The primary aim of this study is to evaluate the natural and anthropogenic drivers of recurrent flooding in Benin-City, and the efficacy of current response frameworks. The specific objectives of the study are to:

i. examine the primary natural and anthropogenic determinants of recurrent flooding in Benin-City;
ii. examine the level of awareness of the City dwellers on the causes of recurrent flooding in Benin-City;
iii. examine the effects of recurrent flooding on the livelihoods of the city dwellers; and
iv. examine the current adaptation, mitigation, and intervention strategies adopted by the city dwellers to alleviate the effects of recurrent flooding on their lives.

The Study Area

The study area is Benin-City. Benin-City is the administrative Headquarters of Edo State. It doubles as the administrative headquarters of Oredo Local Government Area. Benin-City lies approximately within latitudes $6^0$20'N and $6^0$58' N of the Equator and longitude $5^0$35'E and $5^0$41'E of the Prime Meridian (Okhakhu, 2010; Eseigbe, 2011). Benin-City comprises three local government areas and they are Oredo, Egor and Ikpoba-Okha. Benin-City occupies approximately an area of 607.48sqkm with an average elevation of 77.8m above mean sea level (Ministry of Lands and Surveys, Benin-City, 2008; Okhakhu, 2010; Ilenre, 2019; Balogun & Onokerhoraye, 2022)). Owing to the latitudinal and longitudinal location of Benin City, it falls within the Sub Equatorial Humid Region.
The study area experiences the Humid Tropical Climate (because of its latitudinal location). Humid Tropical Climate is usually characterized by two seasons: dry and wet. The dry and wet seasons in the study area are usually determined by rainfall (the amount, intensity, duration and distribution throughout the study area are brought about by the wind systems, clouds cover, temperature, atmospheric pressure and the deflection of the maritime air masses). Rainfall rather than temperature (although temperature plays significant role) is the most

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influential element of climate in the study area (Udo, 1978; Okhakhu, 2010; Eseigbe, 2011; Balogun & Onokerhoraye, 2022).

The wet season is experienced from early February to mid-December every year. However, in most parts of the study area, scanty rainfall is experienced in December and January annually (Udo, 1978; Agboola and Hodder, 1979; Okhakhu, 2010; Eseigbe, 2011; Ilenre, 2019; Balogun & Onokerhoraye, 2022). Rainfall is mostly the convective type and it falls heavily with erratic down pour. The dry season normally occurs between December and January with scanty rainfall. As a result of its latitudinal location, the study area has a daily temperature of between 27 and 36ºC and a rainfall amount of about 2000-2200mm yearly (Eseigbe, 2011; Balogun & Onokerhoraye, 2022). The heavy rainfall and high temperatures experienced virtually all year round encourage the growth of rain forest vegetation. The rainfall and temperature conditions described above also encourage the growth and development of food crops (such as yam cocoyam, cassava, corn, groundnut and banana) and cash crops (such as natural rubber, cocoa, oil palm, oranges and pawpaw) (Udo, 1978; Okhakhu, 2010; Eseigbe, 2011; Ilenre, 2019; Balogun & Onokerhoraye, 2022).

The study area experiences the bimodal rainfall cycle with the highest rainfall amounts recorded in the months of July and September yearly. The hilly landscape, insolation of the sun, presence of rivers and streams, thick ever green rainforest vegetation and the availability of warm ocean currents have encouraged this heavy rainfall (Okhakhu, 2010; Ilenre, 2019; Balogun & Onokerhoraye, 2022). The second air mass which is technically termed tropical continental air mass is most dominant and felt as from mid December and persists till late January. The tropical continental air mass originates from the Sahara Desert and blows in North-East direction. This air mass is associated with the harmattan wind which is cold, dry, dusty, harsh and hazy in nature. It brings about dry season in the study area (Udo, 1978; Eseigbe, 2011; Ilenre, 2019; Balogun & Onokerhoraye, 2022).

In the study area, the wet season begins in February and attains its first peak in July while the second occurs in September. Both peaks are separated by a brief spell of dry weather technically referred to as" August Break." The wet and dry seasons as well as the double rainfall cycles are controlled by the position of the Inter-Tropical Discontinuity (ITD) whose movement is reflected in the corresponding shift within the rain belt (Eseigbe, 2011; Ilenre, 2019; Balogun & Onokerhoraye, 2022).

High relative humidity of between 75-85% occurs regularly in the study area. This relative humidity is steady in the mornings, unstable in the afternoons and appreciates during the evening and night hours because of the difference in environmental factors of evaporation, transpiration, pressure decrease and the dominance of tropical maritime air mass for a greater part of the year (Okhakhu, 2010; Eseigbe, 2011; Ilenre, 2019; Balogun & Onokerhoraye, 2022).

In the study area, the prevalent winds are the North East Trade Wind (Tropical Continental Air Mass) and the South West Trade Wind (Tropical Maritime Air Mass). The North East Trade Wind (Tropical Continental Air Mass) is dominant from late November to early February yearly while the South West Trade Wind (Tropical Maritime Air Mass) prevails from late February to late November/early December yearly. The wind system in the study area has an average speed of 70-80km/h yearly (Udo, 1978; Okhakhu, 2010; Eseigbe, 2011; Ilenre, 2019; Balogun & Onokerhoraye, 2022).

CONCEPTUAL, THEORETICAL FRAMEWORKS AND EMPIRICAL LITERATURE REVIEW

Conceptual Framework

The concept of flooding is fundamentally defined in contemporary literature as the presence of water on land that is typically dry, occurring when the volume of water within a body of water, such as a river or drainage conduit, exceeds its total capacity or when heavy precipitation surpasses the soil's infiltration rate. According to Ogunseyin (2025), flooding in tropical urban centers is increasingly characterized as a hydro-meteorological hazard that is no longer merely a natural phenomenon but a "socio-natural" crisis where human activity dictates the severity of the impact. A key issue highlighted in recent scholarly discourse is the transition from "riverine flooding" to "pluvial flooding," which occurs specifically when extreme rainfall creates a flood independent of an overflowing water body, a frequent occurrence in densely built environments like Benin-City (Akanji, 2024). This shift underscores the critical role of surface permeability and the failure of artificial drainage systems in managing localized runoff volumes.

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The determinants of flooding are categorized into primary natural triggers and secondary anthropogenic drivers, each playing a distinct role in the hydrological cycle. The natural determinants are predominantly meteorological and topographical; as noted by Cirella, Iyalomhe, and Adekola (2019), high-intensity rainfall acts as the primary forcing agent, while the low-lying, flat terrain of certain urban basins inhibits the gravitational flow of water, leading to prolonged stagnation. However, recent contributions from Utsev (2026) emphasize that climate change has intensified these natural determinants, resulting in "flash floods" that occur with such rapidity that traditional early warning systems are rendered ineffective. This meteorological volatility is now a baseline determinant that complicates urban environmental planning across West Africa.

Anthropogenic determinants, or human-induced factors, are often cited as the most significant variables in modern urban flood risk. Urbanization is a central concept here, defined by World Bank (2022), is the process where natural, absorbent land cover is replaced by impervious materials like concrete and asphalt, which drastically increases the runoff coefficient. Another critical human determinant is "drainage pathology," a term used to describe the failure of hydraulic infrastructure due to poor design or the systemic blockage of channels with solid waste. Akanji (2024) argues that in rapidly growing Nigerian cities, the lack of integrated waste management systems directly causes drainage failure, transforming essential infrastructure into a flood catalyst. Furthermore, the encroachment of physical structures into natural wetlands and floodplains (often a result of weak spatial planning enforcement) removes the city's natural "buffers," forcing water into residential and commercial spaces.

The synergy between these determinants creates a feedback loop where the impact of a single rainfall event is magnified by existing structural vulnerabilities. A major scholarly concern is the resilience gap, which refers to the inability of current infrastructure to adapt to the rising frequency of these flood determinants. Recent data from the Ministry of Environment and Sustainability (2026) suggest that unless intervention strategies move beyond reactive channels clearing to address the root causes of land-use change and drainage encroachment, the determinants will continue to outpace engineering solutions. Consequently, the literature increasingly advocates for "Nature-Based Solutions" (NBS) alongside traditional engineering, suggesting that restoring urban green belts and improving soil porosity are as essential as constructing concrete culverts for long-term flood mitigation.

Theoretical Framework

A theoretical framework serves as the conceptual anchor for this study, providing a lens through which the relationship between the determinants of flooding and the efficacy of intervention strategies can be scrutinized. For this research, the framework is constructed by synthesizing the Social Amplification of Risk Framework (SARF), the Theory of Planned Behavior (TPB), and The Theory of Urban Resilience to capture both the institutional and individual dimensions of flood management.

The Social Amplification of Risk Framework (SARF), as applied by Akanji (2024), provides the structural basis for analyzing how flood determinants are perceived and addressed at the societal and institutional levels. According to this framework, flooding is not merely a hydrological event but a risk signal that is "amplified" or "attenuated" by social stations, such as government agencies, the media, and community leaders. In Benin City, the recurring nature of floods acts as a signal that should theoretically trigger robust intervention strategies; however, institutional attenuation often caused by political inertia or fragmented urban planning frequently results in reactive rather than proactive policy responses. Ogunseyin (2025), argues that when the risk signal is filtered through an inefficient administrative lens, the resulting intervention strategies often fail to address the root anthropogenic determinants, such as the paving over of floodplains and the lack of integrated waste management systems. Thus, SARF is utilized here to investigate the disconnection between the severity of flood determinants and the adequacy of governmental interventions.

The Theory of Planned Behavior (TPB): On the individual and household levels, the framework incorporates the Theory of Planned Behavior (TPB) to explain the coping aspect of the study. This theory posits that the adoption of any coping strategy is driven by an individual's behavioral intention, which is shaped by their attitude toward flood risk, the social pressure to act (subjective norms), and their perceived behavioral control. Utsev (2026), notes that in many Nigerian urban centers, while residents possess a high "risk awareness" (attitude), their "perceived behavioral control" is severely limited by socio-economic constraints like poverty and a lack of technical expertise. This explains why coping strategies in areas like the Egor axis are often rudimentary, such as the use of sandbags, rather than more effective structural modifications. By applying TPB, this study evaluates how the interplay of these psychological and economic factors determines the level of resilience at the community level.

Urban Resilience Theory

Another theory yet very apt in the analysis of urban flooding is the Urban Resilience Theory. Urban Resilience Theory succinctly refers to the study of how cities, as complex social-ecological–infrastructural systems, absorb, adapt, and transform in response to shocks and long-term stresses such as floods, climate change, economic crises, pandemics, and rapid growth and development. It draws its scope heavily from ecology, systems theory, and disaster risk reduction. A commonly used definition comes from the resilience literature in ecology: resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change, so as to still retain essentially the same function, structure, identity, and feedbacks (Holling, 1973). In urban studies, this theory has been expanded to include governance, infrastructure, social equity, and economic systems.

In Urban Resilience Theory analysis, key dimensions of Urban Resilience are recognized. In other words, Urban resilience is always comprehended through four broad inter-related dimensions, namely: Physical/infrastructural resilience-roads, housing, drainage, energy systems, and their ability to withstand shocks; Social resilience-community networks, social capital, inequality, and collective action; Economic resilience-ability of urban economies to recover from disruptions; and Institutional/governance resilience-policies, planning systems, and leadership capacity.

Urban Resilience Theory is applied in the following areas in urban risk management studies:

1. Disaster Risk Reduction and Climate Adaptation

Urban resilience is widely applied in managing flooding, heat-waves, storms, and sea-level rise. Cities design flood barriers, drainage systems, and early warning systems based on resilience principles.

Example: Flood-resilient urban drainage systems in cities like Rotterdam and Lagos coastal planning initiatives.

2. Urban Planning and Smart Growth Planners use resilience thinking to: design flexible land-use systems avoid high-risk zones, promote mixed-use development, and integrate green infrastructure

3. Infrastructure Design

Resilience informs the creation of: redundant transport networks, decentralized energy systems (e.g., microgrids) resilient water supply systems.

4. Public Health and Pandemic Preparedness

The COVID-19 pandemic highlighted urban resilience in: hospital surge capacity, emergency logistics, housing density, and disease spread management

5. Socio-economic Recovery

Resilience frameworks guide post-disaster recovery strategies, ensuring that rebuilding does not reproduce vulnerability but reduces it.

The Relevance of Urban Resilience Theory in Urban flood Risk Management

1. Increasing Urbanization

More than half the world population lives in cities, making urban systems critical points of vulnerability and innovation

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2. Climate Change Pressure

Urban areas are major contributors to and victims of climate change, making resilience essential for survival and sustainability.

3. Complexity of Modern Cities

Cities function as intertwined systems; failure in one sector (e.g., energy) affects transport, health, and economy.

4. Sustainable Development Goals (SDGs)

Urban resilience supports:

SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action)

Criticisms Levelled Against Urban Resilience Theory

Despite the popularity and wide applicability of Urban Resilience Theory in urban risks analyses and management, it has suffered untold and vehiment critiques from several users for the following reason enumerated below:

1. Ambiguity and Conceptual Vagueness

Critics argue that resilience itself is too broad and loosely defined, making it difficult to operationalize and implement (Manyena, 2006).

2. Status Quo Preservation Bias

Some scholars and researchers over the years argue that resilience can imply “bouncing back” to an unjust or unequal system, rather than transforming it (Vale, 2014).

3. Depoliticization of Urban Problems

Resilience discourse may shift attention away from political and structural causes of vulnerability (e.g., inequality, governance failures) toward technical fixes.

4. Inequality and Social Justice Concerns

Resilience strategies may disproportionately benefit wealthier groups, while marginalized communities remain vulnerable.

5.Measuremen Challenges

There is no universal metric for urban resilience, making comparison and evaluation difficult across cities.

6. Overemphasis on Adaptation

Some critics argue that it downplays the need for systemic transformation, especially in the context of climate change.
The integration of these three theories forms a comprehensive framework where SARF analyzes the macro-level triggers and institutional intervention failures, TPB elucidates the micro-level constraints on household coping mechanisms While Urban Resilience Theory looks at the steps taken to surpress, withstand and overcome the risk of recurrent flooding in Benin-City. This trio approach allows the study to capture the entire "flood experience" in Benin City, from the physical determinants identified by geospatial data to the human responses that either mitigate or exacerbate the crisis. Consequently, the framework provides a logical pathway for

identifying why existing strategies are falling short and what sustainable, integrated frameworks are necessary to bridge the gap between risk perception and effective flood resilience (World Bank, 2022).

Empirical Literature Review

The following empirical review provides a structured analysis of existing research regarding the drivers and management of urban inundation. By synthesizing diverse scholarly contributions, this section evaluates the findings of previous studies to establish a baseline for the current investigation. The review is organized to first present global perspectives on urban flood resilience before focusing on localized empirical evidence from Benin City and the broader Nigerian context.

On a global scale, the work of GIZ (2025), "Urban Floods: Implications for Resilience" provides a multidimensional empirical analysis of catastrophic flooding events in developing urban centers across various continents. The study employed a vulnerability assessment methodology categorized into social, economic, and infrastructural dimensions across multiple regional hotspots. The abstract highlights a critical transition from traditional riverine flooding to complex urban pluvial flooding. The findings revealed that economic vulnerability is exacerbated by the fact that 82% of affected household heads had no assets outside of flood-prone zones, leading to a "poverty-flood trap." The study concluded that urban resilience is weakening under the weight of unplanned growth and recommended that interventions shift from reactive reconstruction to proactive, evidence-based policy coordination.

In a broader international context, Mensah and Ahadzie (2020), examined flood management in West African secondary cities in their study. The work was aptly titled, "The Impacts of Flood and Local Communities' Coping Strategies." The study utilized a convergent parallel mixed-method design to assess the resilience of households along major river basins. The results indicated that while local households employ diverse coping strategies such as sandbagging, raised elevations, and dikes, these measures are "insufficiently effective" against high-magnitude events. The authors concluded that there is a significant gap between scientific flood modeling and indigenous knowledge, proposing that global intervention strategies must move toward "anticipatory actions" that incorporate local wisdom rather than imposing top-down, non-contextual engineering solutions.

In furtherance of the global discourse, Hudson et al., (2019), presented a longitudinal study titled "Subjective Well-being and the Psychology of Flood Risk." The research assessed the long-term mental and economic impacts of flooding across various international case studies. Using a comparative statistical analysis of subjective well-being data, the researchers found that the trauma of experiencing a flood has a large negative impact that is "incompletely attenuated" over time, even with government financial aid. The study concluded that "anticipatory flood resilience"-where households feel they have the agency to prepare-leads to higher subjective well-being than reactive intervention. This underscores a global shift in intervention philosophy toward psychological and community empowerment as a core component of flood management.

Concluding the global perspective, Maranzoni et al., (2023), contributed a technical review titled, "Advances in Urban Flood Modeling," which explored the efficacy of innovative monitoring networks in reducing flood damage worldwide. The study utilized Earth observation technologies and machine learning algorithms to model floodwater intrusion into buildings. The findings revealed that using non-conventional data sources, such as crowd-sourced information from social media, can improve the predictive accuracy of urban flood models by 30%. The study concluded that the future of flood intervention lies in "Smart City" technologies that provide real-time alerts, enabling residents to implement coping strategies hours before peak inundation, thereby drastically reducing property loss and casualty rates.

Transitioning to local empirical evidence, Cirella, Iyalomhe, and Adekola (2019), conducted a study titled, "Determinants of Flooding and Strategies for Mitigation: Two-Year Case Study of Benin City." This research, set within the Oredo, Egor, and Ikpoba-Okha Local Government Areas (Benin-City), aimed to prioritize mitigation by identifying flood-prone zones and their drivers. Utilizing a mixed-method approach that triangulated empirical field results with secondary geospatial data, the study found that excessive unsustainable land use/land cover (LULC) changes, characterized by a 118% increase in built-up areas, have drastically reduced soil infiltration. The researchers concluded that the combination of heavy rainfall and chronic drainage

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blockage remain the leading cause of property destruction, recommending a transition toward disaster risk reduction (DRR) strategies that integrate localized flood hazard mapping.

Focusing specifically on the human element in Benin-City, Ezemonye and Emeribe (2014), researched on "Flooding and Household Preparedness in Benin-City, Nigeria." This study investigated why urban residents remain vulnerable despite the recurring nature of the hazard. Using a cross-sectional survey methodology and ANOVA statistical testing, the researchers discovered a startling lack of household preparedness; 95% of respondents identified their religious belief system as a governing factor for not utilizing formal preparedness measures, often viewing floods as unavoidable spiritual events. The study concluded that lack of funds and fatalistic socio-cultural beliefs are the primary barriers to effective coping, suggesting that community sensitization must be the first line of mitigation before large-scale engineering interventions can succeed.

Ogunseyin (2025), in the study "Geospatial Analysis of Land Use Change and Flood Risk Index in Edo State," provided a localized geospatial evidence, specifically focusing on the urban-rural interface of Benin-City. The methodology involved the supervised classification of Landsat imagery and the application of the Soil Conservation Service Curve Number (SCS-CN) method to deduce runoff impacts. The study found that vegetation loss of over 50% in the last decade has significantly increased the city's flood susceptibility index. The researcher concluded that the "paving of the city" is the primary anthropogenic determinant of flooding, suggesting that the most effective intervention strategy would be the enforcement of "green-belts" and the restoration of natural moats as primary flood receptacles.

Finally, Utsev (2026), in the "Special Report: Flood Alert and Resilience Structures in Nigeria" provides and lends support to an empirical review of current structural interventions across southern urban centers, including Benin-City. The methodology involved an "on-the-spot" technical assessment of drainage infrastructure and stakeholder interviews. The findings indicated that "drainage pathology"-where infrastructure exists but is rendered dysfunctional by solid waste and poor connectivity-is a major determinant of flash floods. The study concluded that current interventions are largely "seasonal and remedial," calling for a national urban drainage master plan that moves away from fragmented, state-level projects toward a synchronized hydrological framework localized to the specific needs of the Niger Delta and Edo regions.

Research Methods

The data required for this study were collected from both primary and secondary sources. The primary source formed the major source of data used in this paper. The primary data were collected by the administration of questionnaires, personal observations and interviews in the field. The projected population of Benin-City (the study area) in 2026 at 3.67% growth rate is 2,120,000. Out of this population, a sample population of 500 respondents which represent 0.0236% of the population of the entire study area were reached and selected for data collection through the use of questionnaires, personal observation, and oral interviews. The preliminary and actual field surveys showed that there are 10 wards in Ikpoba-Okha Local Government Area, 12 wards in Oredo Local Government Area, and 10 wards in Egor Local Government Area. Thus, there are 32 wards in Benin-City. As obtainable in other parts of the world, human population is unevenly distributed across Benin-City. Therefore, the questionnaires were administered to reflect the human population in Benin-City. Following that, Oredo Local Government Area got 200 questionnaires, Ikpoba-Okha and Egor Local Government Areas got 150 questionnaires each. The higher number of questionnaires administered in Oredo Local Government Area was incontrovertibly a sound reflection of the population in the local government area. All the five hundred questionnaires administered were retrieved with high level commitment, passion, and perseverance. The outcome of the administered, and retrieved questionnaires were used for the study aptly. Random and convenience sampling techniques were adopted and used to select the respondents for interview. Questions were asked on the determinants of recurrent flooding in Benin-City, the level of awareness of the city dwellers on the causes of recurrent flooding in Benin-City, the effects of recurrent flooding in Benin-City, and the coping, mitigation and intervention strategies adopted in Benin-City.

The secondary data used in this paper were the population data from the Office of the National Population Commission (NPC), Benin-City, textbooks, journals, internet, newspapers, magazines, gazettes, telephone conversations (in areas with rugged, floodable, and highly forested terrains), periodicals, inaugural lecture pamphlets, and amongst others. The data collected were scientifically and painstakingly collated and analyzed using tables, frequencies and percentages.

RESULTS AND DISCUSSIONS

The recognizance and actual field surveys carried out on the determinants of recurrent flooding in Benin-City: Adaptation, mitigation, and intervention strategies, unveils the natural and anthropogenic determinants of recurrent flooding in Benin City, the level of awareness of the City dwellers on the causes of recurrent flooding in Benin-City; the effects of recurrent flooding on the city dwellers, and the adaption, mitigation and intervention strategies adopted in the study area.

The Primary Natural and Anthropogenic Determinants of Recurrent Flooding in Benin-City

Table 1 shows the primary natural and anthropogenic determinants of recurrent flooding in Benin-City. The Table shows clearly that excessive rainfall is by far the most exerting of all the primary natural and anthropogenic determinants of recurrent flooding in Benin-City. It recorded 58 respondents which represent 11.6% of the sample population in the study area and it is followed by blockage of drainage channels which recorded 50 respondents representing 10.0% of the sample population in the study area. Inadequate and outdated drainage channels recorded 46 respondents which represent 9.2% of the sample population, persistent encroachment on moats and waterways, and unregulated and poor approach to waste disposal recorded 44 respondents each which represent 8.2%, deforestation recorded 38 respondents representing 7.6%, asphalted/concreted urban floor recorded 32 respondents representing 6.4%, soil type and topography recorded 29 respondents each representing 5.8%, poor housing recorded 28 respondents representing 5.6%, unguided agricultural activities 24 respondents representing 4.8%, unregulated land use patterns recorded 22 respondents representing 4.4%, location/nearness to waterways recoded 19 respondents representing 3.8% , high temperature recorded 14 respondents representing 2.8%, poor and ineffective sensitization recorded 12 respondents representing 2.4%, season recorded 10 respondents representing 2.0%, and finally, the last in the order of responses of the respondents was religion/superstition which recorded 04 respondents representing 0.8% of the sample population in the study area. The findings above is in congruence with the earlier findings of Ezemonye and Emeribe (2014), Omorodion et al., (2014), Oseghale and Ehinomen (2021; 2022) , Oladosu et al., (2022), & Odiana et al., (2023) that the causes of flooding are attributed to some environmental factors such as heavy and excessive rainfall, lack of adequate town planning techniques, poor drainage system, high level illiteracy, unregulated and poor approach to waste disposal, encroachment on moats/waterways, blocked gutters and culverts, inadequate and outdated drainage channels, deforestation, unguided agricultural activities, religious fatalism, and amongst others.

Table 1: The Primary Natural and Anthropogenic Determinants of Recurrent Flooding in Benin-City

The Primary Natural and Anthropogenic Determinants of Recurrent Flooding in Benin-City	Frequency	Percentage (%)
Erratic and excessive humid tropical rainfall	58	11.6
Location/nearness to waterways	19	3.8
High temperature	14	2.8
Soil type	29	5.8
Topography	29	5.8
Persistent encroachment on moats and waterways	44	8.2
Blockage of drainage channels	50	10.0
Unregulated land use patterns	22	4.4

Poor and ineffective sensitization	12	2.4
Unregulated and poor approach to waste disposal	44	8.8
Deforestation	38	7.6
Inadequate and outdated drainage channels	46	9.2
Poor housing	28	5.6
Unguided agricultural activities	24	4.8
Religion/superstition	04	0.8
Season	10	2.0
Asphalted/concreted urban floor	32	6.4
Total	500	100

Source: Field survey, 2026

The Level of Awareness of the City Dwellers on the Determinants of Recurrent Flooding In Benin-City

Table 2 depicts the level of awareness of the city dwellers on the determinants of recurrent flooding in Benin-City. The table goes further to specifically show that the level of awareness of the city dwellers on the determinants of recurrent flooding in Benin-City is very high because 367 respondents representing 72.8 % of the sample population have a very high awareness level, 74 respondents representing 11.48% have high level of awareness, 44 respondents representing 8.8% have average awareness level, 11 respondents representing 2.2% have low awareness level, and lastly 4 respondents only representing 0.8% of the sample population in the study area have a very low level of awareness. This result shows that the level of awareness of the city dwellers on the causes of recurrent flooding in Benin-City is very high.

Table 2: The Level of Awareness of the City Dwellers on the Determinants of Recurrent Flooding In Benin-City

The Level of Awareness of the City Dwellers on the Determinants of Recurrent Flooding In Benin-City	Frequency	Percentage (%)
Very High	367	72.8
High	74	14.8
Average	44	8.8.
Low	11	2.2
Very low	4	0.8
Total	500	100

Source: Fieldwork, 2026

The Effects of Recurrent Flooding on the City Dwellers

Table 3 clearly depicts the effects of recurrent flooding on the city dwellers in Benin-City, Edo State, Nigeria. From the Table, seasonal flooding/erosion which recorded 80 (16.0%) respondents had the highest responses and it is followed by loss of lives and properties 64 (13.8%) respondents of the sample population in the study

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area. Damage to infrastructure recorded 53 (10.6%) respondents, transportation problems and submergence of buildings recorded 40 (8.0%) respondents each, soil impoverishment recorded 34 (6.8%) respondents, low agricultural production recorded 33 (6.1%) respondents, and health challenges recorded 31 (6.2%) respondents of the sample population in the study area. The other effects include: reduction in outdoor activities which recorded 26 (5.2%) respondents, reduction in income, and disruption of schedules recorded 22 (4.4%) each, increased rate of accident, and maintenance cost recoded 16 (3.2%) respondents each, loss of man hour recorded 11 (2.2%) respondents, psychological problem/trauma recoded 8 (1.6%) respondents, and finally, migration of city dwellers which is the least of the responses recoded 4 (0.8%) respondents of the sampled population in the study area. From the table, it is crystal clear that seasonal flooding/erosion, loss of lives and properties, damage to infrastructure and submergence of buildings (they have the same number of responses each), loss of lives and properties, transportation problems, soil impoverishment, low agricultural production and health challenges are the effects of recurrent flooding in Benin-City, Edo State, Nigeria. The result above is in sharp concord with the earlier findings of Akpan & Udoh, (2020), Oseghale and Ehinomen (2021; 2022), Oladosu et al., (2022), & Odiana et al., (2023) that residents of urban centres often face flood induced challenges such as water-logging, damage to homes, offices, business centres, other infrastructure and farmlands, as well as outbreaks of waterborne diseases.

Table 3: The Effects of Recurrent Flooding on the City Dwellers in Benin-City

The Effects of Recurrent Flooding on the City Dwellers in Benin-City	Frequency	Percentage (%)
Low agricultural production	33	6.6
Damage to infrastructure	53	10.6
Health challenges	31	6.2
Submergence of buildings	40	8.0
Soil impoverishment	34	6.8
Transportation problems	40	8.0
Seasonal flooding/erosion	80	16.0
Migration of city dwellers	04	0.8
Loss of lives and properties	64	12.8
Loss of man hour	11	2.2
Maintenance cost	16	3.2
Psychological problems/trauma	08	1.6
Reduction in outdoor activities	26	5.2
Increased rate of accident	16	3.2
Reduction in income	22	4.4
Disruption of schedules	22	4.4

Source: Field survey, 2026

The Adaptation, Mitigation and Intervention Strategies Adopted to Alleviate the Effects of Recurrent Flooding in Benin-City, Edo State, Nigeria

The adaptation, mitigation and intervention strategies adopted over the years in Benin-City to alleviate the effects of recurrent flooding include but not limited to: creation and promotion of effective, efficient and efficacious grassroots awareness campaigns; construction of permeable pavements; elevated foundations; the use of weather-resistant building materials; drains; evacuation of blocked drains; enforcement of environmental sanitation; adoption of modern environmental building codes; implementation of green building initiatives; cover cropping; forest conservation laws; laws against indiscriminate bush fires; avoidance of encroachment on waterways; the use of sand bags; and total eschewal from areas near waterways.

Besides the adaptation, and mitigation strategies, various bodies such as governments (local, state and federal), corporate bodies, organizations, integrated strategies and approaches, and the communities have adopted intervention strategies in addressing the effects of recurrent flooding in Benin-City, Edo State, Nigeria. The intervention strategies of governments (local, state and federal) are road elevation and paving, additional drainage construction and maintenance, environmental protection and regulation, enforcement of urban planning, flood early awareness creation, and disaster relief programmes. The corporate bodies have intervened through provision of funds, community development programmes, and partnership with government. The organizations have intervened through advocacy, and awareness creation, and technical assistance. Integrated strategies, and approaches have intervened through environmental management, bioengineering, multi-stakeholder collaborations, and data and research. Finally, at the community levels intervention strategies include: creation of awareness at the grassroots levels, maintenance of drainage channels at the local levels, and local flood control initiatives.

CONCLUSION

Recurrent flooding is a global phenomenon driven by long-term climate variability-shifts in rainfall, temperatures and other weather patterns as well as anthropogenic factors, and it poses significant threats across various sectors of the urban environment. Precisely, Benin-City with its unique geographical, climatic characteristics and rapid urban growth faces significant threats to its existing and future environments. These attributes make Benin-City highly vulnerable and susceptible to the effects of recurring flooding. To ensure that the effects of recurrent flooding in Benin-City, Edo State, Nigeria on the present and future environments are avoided or at least alleviated, various adaptation, mitigation, and intervention strategies such as creation and promotion of effective, efficient and efficacious grassroots awareness campaigns; construction of permeable pavements; elevated foundations; weather-resistant building materials; evacuation of blocked drains; enforcement of environmental sanitation; adoption of modern environmental building codes; implementation of green building initiatives; cover cropping; forest conservation laws; laws against indiscriminate bush fires; avoidance of encroachment on waterways; sandbagging; and total eschewal from areas near waterways are being practiced. Besides the adaptation, and mitigation strategies, various bodies such as governments (local, state and federal); corporate bodies; organizations; integrated strategies and approaches; and the communities have adopted intervention strategies in addressing the effects of recurrent flooding in Benin-City. The interventions of governments (local, state and federal) are road elevation and paving, drainage construction and maintenance, environmental protection and regulation, enforcement of urban planning, flood early awareness creation, and disaster relief programmes. The interventions of corporate bodies are provision of funds, community development programmes, and partnership with governments. The interventions of organizations are through advocacy, and awareness creation, and technical assistance. The interventions of Integrated strategies and approaches are environmental management, data and research bioengineering, and multi-stakeholder collaborations. Finally, at the community levels, intervention strategies are creation of awareness at the grassroots levels, maintenance of drainage channels at the local levels, and local flood control initiatives. This paper concludes by advocating for the implementation of the recommendations, policy interventions and carrying out further researches that are necessary and would ensure the resilience of the inhabitants in the face of the effects of recurrent flooding on the present and future environments and the general well being in Benin-City, Edo State, Nigeria.

RECOMMENDATIONS

This paper examined the effects of recurrent flooding in Benin-City; adaptation, mitigation, and intervention strategies. Based on the findings of this paper, the following actionable policy recommendations are made: creation and promotion of effective, efficient and efficacious grassroots awareness campaigns; construction of permeable pavements; elevated foundations; weather-resistant building materials; construction of additional drains; evacuation of blocked drains; enforcement of environmental sanitation; adoption of modern environmental building codes; implementation of green building initiatives; cover cropping; forest conservation laws; laws against indiscriminate bush fires; avoidance of encroachment on waterways; the use of sand bags; total eschewal from areas near waterways, bioengineering, flood early awareness campaign, and disaster relief programmes, local flood control initiatives, and technical assistance. Also recommended are road elevation and paving, construction of additional drains and maintenance, environmental protection and regulation, enforcement of urban planning, regular and effective inspections and monitoring of drains to prevent dumping of wastes are passionately recommended. These actionable policy recommendations should be adopted and implemented by the concerned authorities in Benin-City, Edo State, Nigeria.

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