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THE IMPACT OF CLIMATE CHANGE INDUCED FLOODING IN BENIN-CITY, EDO STATE, NIGERIA

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Abstract: *This paper examines the impact of climate change induced flooding in Benin-City, Edo State, Nigeria. Climate change is the technical terminology used to describe the significant and long lasting change in statistical distribution of weather patterns over periods ranging from decades to millions of years. Flooding is the overflow on an expanse of water such that it covers or submerges the land while moving with a particular speed. The aim of the paper includes to identify: the major causes of climate change in the study area, examine the major proofs of climate change flooding in the study area, examine the major causes of flooding in the study area, the major impact of climate change induced flooding and the strategies adopted by the city inhabitantss to mitigate the impact of climate change induced flooding in Benin-City. To achieve the aim of this paper, questionnaires were administered and oral interviews conducted to 500 respondents which represents 0.0245% of 2,045,000 (the projected population of the study area in 2025). Random sampling method was employed to collect the required data from the appropriate sources. The data collected were analysed using tables, frequencies and percentages. From the analyses, the following major findings emerged and they are: burning of fossil fuels, industrial activities and, deforestation were the major causes of climate change; early cessation of rainy season, excessive temperature, erratic rainfall and delayed rainy season are the major evidences of climate change; seasonal flooding/erosion, damage to infrastructure, submergence of buildings, loss of lives and properties, transportation problem, low agricultural production and health problems are the impact of climate change induced flooding in Benin-City, Edo State, Nigeria. Consequent upon the findings of this paper, the following mitigating and coping strategies are made and they are: creation and promotion of effective community awareness, construction of permeable pavements, elevated foundations, weather-resistant building materials; construction of additional gutters where appropriate, evacuation of blocked drainage channels, enforcement of environmental sanitation, adoption of modern environmental building codes, implementation of green building initiatives, avoidance of encroachment on waterways and total eschewal from areas near waterways.. The paper*

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concludes by passionately soliciting for the implementation of the recommendations and policy interventions of this paper in Benin-City, Edo State, Nigeria and other climes having the same or similar environmental factors and challenges.

Introduction

Urban areas across the globe have been plagued by one form of crisis or another resulting from disasters from time immemorial. Prominent among these crises plaguing the urban centres is flooding, often referred to as urban flooding. Smith & Ward, (1998) Adelekan, (2010).Flooding is broadly defined as the accumulation or overflow of water onto land that is normally dry, resulting from natural or human-induced factors. Furthermore, Omorodion et al., (2024) 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. America's Climate Choices (AMC) (2010), opined that climate change is the statistical distribution of weather patterns, when that change lasts for an extended period of time, that is, decades to millions of years. In a similar vein, Okhakhu (2019) observed that climate change is the realistic increase in the average temperatures of the global environment (atmosphere, lithosphere, hydrosphere, biosphere, cryosphere) and other constituent elements which constitute the plane. Climate change therefore, can be perceived of as the technical terminology used to describe the significant and long lasting change in statistical distribution of weather patterns over periods ranging from decades to millions of years.

According to Douglas et al., (2008), flooding can be classified into several types including riverine (fluvial), flash floods, coastal floods, and urban or pluvial floods. In the Nigerian context, fluvial and urban flooding are the most common, especially in areas like southern Nigeria where high rainfall and rapid urban growth converge. Flooding is a natural hydrological process involving the inundation of normally dry land due to excessive water accumulation, often triggered by intense rainfall, river overflow, or human-induced alterations of the environment. 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; Ayanlade et al., 2017). Furthermore, Oseghale & Ehinomen, (2021) argued that upstream hydrological interventions, including dam water releases, have exacerbated flood severity, frequently overwhelming local drainage systems and resulting in substantial socio-economic impacts,

including displacement and loss of property in affected communities within Benin-City, Edo State, Nigeria.

The interplay between natural climatic variability and human activities has transformed what was once a seasonal hazard into a recurrent disaster. This transformation underscores the complexity of flood dynamics in the area, where inadequate infrastructure, deforestation, and changes in land use have diminished the natural capacity of the environment to absorb and channel water efficiently (Akpan & Udoh, 2020; Oladosu et al., 2022). Residents of the urban centre, Benin-City, Edo State, often face challenges such as water-logging, damage to homes, offices, business centres, other infrastructure and farmlands, as outbreaks of waterborne diseases associated flood events. These outcomes not only disrupt livelihoods but also strain local governance and emergency response systems, highlighting an urgent need for integrated flood risk management that considers both climatic and anthropogenic drivers.

Oseghale and Ehinomen (2021), Oladosu et al., (2022) and Omorodion et al., (2024) 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.

The City's geographical location, characterized by low-lying floodplains and the availability of rivers of which Ikpoba River stands out, make it vulnerable to riverine and urban flooding. Studies on Benin City show that flooding results not only from intense precipitation but also from rapid urbanization and land-use changes that reduce natural infiltration and exacerbate runoff (Egbokhare et al., 2019; Akpan & Udoh, 2020). These transformations have led to increased surface imperviousness and blockage of drainage systems, compounding flood risks in the area (Oguntunde et al., 2021; Oladosu, 2022).

Scholars have expressed concerns regarding the compounding effects of climate change, deforestation, and poor urban planning on flooding patterns in Edo State, Nigeria (Adelekan, 2016; Adedoyin et al., 2020). Climate variability influences the frequency and intensity of rainfall events, while human activities alter natural water flow regimes and drainage capacities (Olajuyigbe & Ajao, 2020). These combined factors contribute to recurrent flooding events that threaten livelihoods, infrastructure, and health in and surrounding communities.

Locally, flooding is often perceived as a seasonal hazard with which residents have learned to cope through various adaptive behaviors, such as elevating building foundations and community-driven drainage clearing (Eze &Uzoho, 2018). However, many also express frustration with the limited interventions and infrastructural support from local authorities, highlighting gaps in flood

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management strategies and public awareness (Igbinosa & Okafor, 2019). Furthermore, remote causes such as upstream dam releases and land degradation beyond the immediate floodplain influence the hydrological dynamics that lead to flooding, implicating broader governance and environmental management challenges (Olagunju et al., 2021).

Oseghale and Ehinomen (2021) & Oladosu et al., (2022), noted that environmental factors including increased runoff due to land-cover change, soil saturation from prolonged rainfall, and inadequate drainage infrastructure interact to exacerbate flood hazards in Benin-City. The cumulative impacts of flooding extend beyond local concerns to global issues of climate resilience and sustainable urban development, underscoring the need for integrated approaches to flood risk reduction in line with global climate adaptation frameworks (UNDRR, 2022; IPCC, 2023).

2. Statement of the problem

Flooding has become a recurrent and increasingly severe environmental problem in Benin-City, Edo State, Nigeria, posing serious threats to human health, livelihoods, infrastructure, and local ecosystems. Over the past two decades, the area has witnessed a noticeable increase in the frequency and intensity of flood events, a trend that aligns with broader patterns of climate change across the globe including southern Nigeria. Irregular rainfall patterns, prolonged wet seasons, and sudden heavy downpours largely attributed to climate change have overwhelmed existing drainage systems and increased the risk of both flash and riverine flooding in the region (Oseghale and Ehinomen 2021; Oladosu et al., (2022; Omorodion et al., 2024).

This growing challenge is further compounded by rapid urbanization, deforestation, poor waste disposal practices, and unregulated land-use changes that have significantly reduced the area's natural capacity to manage storm-water. In many parts of Benin-city, natural waterways have been obstructed by informal settlements and infrastructure, while drainage systems are either poorly maintained or entirely lacking. These conditions have led to frequent inundation of homes, road networks, markets, and farmlands, resulting in the displacement of residents, wanton destruction of property, disruption of livelihoods, and the spread of waterborne diseases such as cholera and typhoid fever (World Health Organization (WHO) 2021; World Bank, 2023).

Despite the increasing severity and frequency of these flood events, there remains a lack of localized, data-driven research that specifically investigates the links between climate variability, environmental degradation, and flood patterns in Benin-City. While several studies have examined flooding in urban areas including Benin City, few have provided focused, empirical assessments of how climatic factors interact with land-use practices and local responses in this City. For instance, Oseghale and Ehinomen (2021) examined the socio-economic consequences of recurrent flooding in Benin-City, Edo State and identified poor waste disposal, blocked culverts, and a lack of effective flood warning systems as critical drivers of urban

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flooding in Benin-City. They concluded that although rainfall intensity is increasing due to climate change, the more immediate causes of flood disasters in the area are infrastructural and behavioral. Furthermore, Odiana et al., (2023) evaluated variations in rainfall in Benin-City and its implications in flood occurrences using climate data from 1991to 2022. They noted that Benin-City is currently experiencing rising temperature trend with neither increase nor decrease in rainfall. The study also observed that the study area is likely to experience flooding owing to its location in the southern part of Edo State, Nigeria with respect to slope and rainfall factors. They recommended public awareness on climate change and its likely effects on flooding. In a similar vein, Omorodion et al., (2024) examined flood management in an urban area (a case study of Benin metropolis). They found that the causes of flooding in Benin-City are attributed to some environmental factors such as heavy rainfall, lack of adequate town planning techniques, poor drainage system, high level illiteracy, ignorance of dumping refuse on flood paths, and so forth. The research further recommended the construction of good roads, controlled dump sites, putting in place laws that would ensure that indiscriminate dumping of waste is eradicated or at least reduced to the barest minimum and quick response of the authorities in charge of the menace of flooding to attend to affected persons with dispatch. From the several yet detailed studies carried out in the area of flooding in Benin-City, Edo State, Nigeria, (of which some were reviewed in this paper) it is unarguably clear that studies focusing specifically on the impact of climate change induced flooding in Benin-City, Edo State, Nigeria are non-existent. This paper therefore aims to fill this critical research gap by examining the impact of climate change induced flooding in Benin-City, Edo State, Nigeria.

3. Aim and Objectives of the Study

The overall aim of this paper is to examine the impact of climate change induced flooding in Benin-City, Edo State, Nigeria. The specific objectives of this paper are to:

i. examine the major causes of climate change in Benin-City;
ii examine the major proofs of climate change having impact on flooding in the study area;
iii examine the major causes of flooding in the study area;
iv. examine the major the impact of climate change induced flooding in Benin-City; and
iv. examine the strategies adopted by the city dwellers to mitigate the impact of climate change induced flooding in Benin-City.

4. The Study Area

The study area is Benin-City. Benin-City is the administrative Headquarters of Edo State. It is also the administrative headquarters of Oredo Local Government Area. Benin-City lies roughly within latitudes 6°20'N and 6°58' N of the Equator and longitude 5°35'E and 5°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, 2016;

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Ilenre, 2019; Balogun & Onokerhoraye, 2022)). Going by the latitudinal and longitudinal location of the study area, it falls within the Sub Equatorial Humid Region.

As noted earlier, the study area is located within the Sub Equatorial Humid Region and as a result, it experiences the Humid Tropical Climate. 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 (albeit temperature plays significant role) is the most 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; Ilenre, 2019). Rainfall is mostly the convectional type and it falls heavily with torrential 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 36^{o}C 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).

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 or early December. 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).

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).

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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 enhances 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).

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)).

5. Literature review

5.1 Concept of Flooding

Flooding is broadly defined as the accumulation or overflow of water onto land that is normally dry, as a result of natural or human-induced factors (Smith & Ward, 1998). It is considered as one of the most frequent and damaging natural hazards globally, particularly in low-lying areas and unplanned urban centers. According to Douglas et al., (2008), flooding can be classified into several types including riverine (fluvial), flash floods, coastal floods, and urban or pluvial floods. In the Nigerian context, fluvial and urban flooding are the most common, especially in areas like southern Nigeria where high rainfall and rapid urban growth converge (Adelekan, 2010).Urban flooding occurs when heavy rainfall exceeds the capacity of drainage systems, often worsened by impervious surfaces, blocked drains, and poor land-use practices. Riverine flooding, on the other hand, results from the overflow of rivers due to persistent or intense rainfall, sometimes aggravated by upstream water releases, as is often the case in southern Nigeria during wet seasons (Ologunorisa & Abawua, 2005). The socio-economic impacts of flooding are severe, ranging from infrastructure damage and disruption of transportation to outbreaks of diseases and loss of life (Etuonovbe, 2011). In developing countries, these impacts are intensified by weak institutional frameworks, poor urban planning, and inadequate disaster preparedness (Aderogba, 2012).

5.2 Theoretical Framework

This study is anchored on the Pressure and Release (PAR) Model developed by Blaikie, Cannon, Davis, and Wisner (1994), a widely accepted framework in disaster studies. The model conceptualizes disasters not merely as outcomes of natural hazards, but as the result of a progression of vulnerability. According to the PAR model, disasters occur when a natural hazard (such as flooding) intersects with a series of vulnerabilities rooted in social, economic, political, and environmental conditions. These vulnerabilities are categorized into three levels: root causes (e.g., poverty, marginalization, weak governance), dynamic pressures (e.g., urbanization, population growth, lack of infrastructure), and unsafe conditions (e.g.,

settlements on floodplains, poor housing quality).

As relating to Benin-City, the PAR model provides a structured way to examine how flooding is not simply the result of intense rainfall, a natural hazard, but a disaster produced through layers of vulnerability. Root causes such as institutional failure and poor enforcement of urban planning regulations enable dynamic pressures like unregulated urban sprawl, deforestation, and indiscriminate waste disposal. These in turn create unsafe conditions such as blocked drainages, the proliferation of informal housing in flood-prone areas, and inadequate flood early warning systems. When these vulnerabilities intersect with the triggering event of climate-induced heavy rainfall, the result is frequent and damaging floods. The PAR model thus offers a lens through which the multifaceted risk factors behind flooding in Benin-City can be dissected and understood, pointing toward both structural and immediate interventions.

In addition to the PAR model, this paper also draws on Systems Theory, originally articulated by Von Bertalanffy (1968), which emphasizes the interdependence and interaction of various components within a system. In environmental studies, systems theory has been applied to understand the complex and interconnected nature of human and ecological systems, wherein a change in one variable can produce cascading effects across other components of the system. This theoretical lens discourages reductionist thinking and encourages a holistic view of environmental problems.

Systems Theory is particularly relevant in analyzing the interplay between climate change, land use, and urban management in Benin-City. For example, increased rainfall due to global climate shifts (one component) influences runoff and water retention capacity, which are further affected by deforestation and soil sealing caused by urban development (another component). These environmental changes interact with human systems, such as infrastructure design and waste management practices, thereby amplifying flood risks. Understanding the flooding problem in Benin-City through a systems approach ensures that no single variable is isolated from others. It supports the argument that effective flood mitigation must account for the dynamic relationships between climatic, environmental, infrastructural, and socio-political systems.

Together, the PAR Model and Systems Theory provide a robust theoretical foundation for this study. While the PAR model offers a framework for tracing the social and structural production of disaster vulnerability, Systems Theory ensures a holistic understanding of how multiple interconnected variables contribute to flood risks in Benin-City. These theories not only guide the analysis but also inform the design of sustainable, integrated solutions that target both immediate risk factors and long-term systemic vulnerabilities.

5.3 Empirical Review

Empirical studies across the globe including Nigeria reveal that flooding is increasingly driven by a combination of climate variability and human-induced environmental changes.

Olaniran and Babatolu (1996) observed a significant increase in rainfall intensity and unpredictability in southern Nigeria over recent decades, correlating directly with the frequency of flood events. Ayanlade et al., (2017) further established that climate change has disrupted traditional rainfall patterns in Nigeria, with marked consequences for flood-prone areas such as Edo State. In a study of Benin City, Ezenwaji et al., (2014) found that unplanned urban expansion and the proliferation of informal settlements in floodplains significantly heighten flood risk. Their findings indicate that over 60% of flood-affected areas lacked formal drainage infrastructure, with residents resorting to improvised, short-term coping mechanisms. Similarly, Igbokwe et al., (2008) used GIS and remote sensing to map flood-vulnerable areas in southern Nigeria and found that land-use change, particularly the conversion of wetlands to residential areas, directly increased surface runoff and reduced water retention capacity.

Furthermore and specifically in Edo State, Oseghale and Ehinomen, (2021) examined the socio-economic consequences of recurrent flooding in Ikpoba-Okha and Ugbowo areas. Their study identified poor waste disposal, blocked culverts, and a lack of effective flood warning systems as critical drivers of urban flooding. They concluded that although rainfall intensity is increasing due to climate change, the more immediate causes of flood disasters in the area are infrastructural and behavioral. In a similar vein, Egboka et al., (2015) & UNDRR, (2022) stressed the importance of community awareness and participation in flood mitigation, arguing further that local knowledge and adaptive behavior can significantly reduce vulnerability. However, their research also revealed that many communities perceive flooding as an unavoidable natural event, which limits proactive engagement in long-term solutions. In line with this, Olanrewaju et al., (2019) & World Health Organization (WHO). (2021) advocated for participatory planning approaches, integrating both scientific data and community-based insights to enhance resilience in flood-prone urban neighborhoods.

Expanding on these insights, Adelekan (2010) conducted a detailed study on flood risk and vulnerability in urban coastal communities in Lagos. The objective of the study was to assess household-level vulnerability and coping mechanisms in a low-income flood-prone area. Using survey research and participatory mapping, the findings showed that residents were highly exposed to flooding due to poor housing, inadequate drainage, and proximity to waterways. The study concluded that local vulnerability is shaped not only by environmental hazards but also by social inequality, reinforcing the need for inclusive flood governance and community-based resilience planning.

Similarly, Abah (2013) investigated the impact of seasonal flooding in Makurdi, Benue State, using qualitative interviews and spatial data to assess flood patterns and local responses. The study found that persistent encroachment on floodplains and insufficient enforcement of building codes contributed significantly to the worsening flood situation. It emphasized the

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disconnect between existing urban planning policies and implementation at the grassroots level. The research concluded that long-term flood mitigation requires not only infrastructure but also governance reforms and sustained public education.

Additionally, Odekunle et al., (2008) analyzed climate change signals and their correlation with flood frequency in southwestern Nigeria. Using meteorological data spanning three decades, the study identified statistically significant increases in the frequency of high-intensity rainfall events. The authors noted that flood risk was highest in areas with uncoordinated urban development and poorly integrated land use plans. They recommended improved early warning systems and land-use zoning policies aligned with climate projections as critical strategies for adaptation.

Collectively, these studies highlight several converging themes: the intensifying role of climate variability, the influence of urban planning deficiencies, and the need for participatory, location-specific solutions. While these works contribute significantly to understanding flood dynamics in Nigerian cities, most of them remain focused on major urban centers such as Lagos, Benin City, and Makurdi. There remains a notable research gap in studies that focus specifically on the localized dynamics of climate-related flooding in Benin-City, Edo State, Nigeria which combines peri-urban development, fragile drainage infrastructure, and socio-economic vulnerabilities. Most existing studies treat Edo State as part of broader regional assessments, overlooking the unique hydrological, urban, and socio-ecological characteristics of Benin-City, Edo State, Nigeria. This paper seeks to fill this gap by providing an integrated analysis of climate trends, land-use patterns, and community responses in Benin-City with the goal of informing more targeted and sustainable flood mitigation strategies.

6. 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 and personal observation in the field.

The projected population of Benin-City (the study area) in 2025 is 2,045,000. Out of this population figure a sample population of 500 respondents (0.0245%) of the total population of the study area were contacted for data collection via the use of questionnaires and oral interview. 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. So, there are wards 32 in Benin-City. As obtainable in other climes, human population is unevenly distributed in Benin-City. Owing to that, the questionnaires were administered according to the human population in the three local government areas. So, 200 questionnaires were administered in Oredo Local Government Area, 150 questionnaires each was administered in Ikpoba-Okha and Egor Local Government Areas. The higher number of questionnaires administered in Oredo Local Government Area was due to the higher number of wards and population. All the five hundred

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questionnaires administered were painstakingly monitored so, at the end, all of them were completely retrieved and used for this paper. Random sampling techniques were adopted and used to select the respondents for interview. Questions were asked on the causes of climate change, the evidences of climate change, the major causes of flooding, the major effects of climate change on flooding in the study area and the strategies adopted by the city dwellers to mitigate climate change induced flooding in the study area.

The secondary data used in this paper were the population data from the National Population Commission (NPC), Benin-City, textbooks, journals, internet, and amongst others. The data collected were collated and analysed using tables, frequencies and percentages.

7. RESULTS AND DISCUSSION

The causes and effects of climate change on flooding in any part of the world in general and Benin-City in particular are a function of both natural and anthropogenic (human) factors. These factors work singly or in combination to cause flooding and by extension it effects in Benin-City, Edo State, Nigeria.

7.1 The Major Causes of Climate change in Benin-City

Table 1 reveals the major causes of climate change in Benin-City, Edo State, Nigeria. It reveals that burning of fossil fuels with 126 (43.2%) respondents ranked highest among all the major causes and it is followed by industrial activities which had 79 (15.8%) respondents of the sample population in the study area. Deforestation had 60 (12.0%) respondents, use of fluorinated gases which ranks next to it had 41 (8.2%) respondents of the sample population. The others which are bush burning had 31 (6.2%) respondents, agricultural activities had 25 (6.2%) responses, heat from concrete floors had 16 (3.2%) respondents, emissions from dump sites had 18 (3.6%) responses, and finally heat from roof tops had 14 (2.8%) responses of the sample population.

Table 7.1: The Major Causes of Climate Change in Benin-City, Edo State, Nigeria

The Causes of climate Change in Benin-City	Frequency	Percentage (%)
Burning of fossil fuels	216	43.2
Deforestation	60	12.0
Industrial activities	79	15.8
Use of fluorinated gases	41	8.2
Agricultural activities	25	5.0
Bush burning	31	6.2
Emissions from dump sites	18	3.6
Heat from concrete floors	16	3.2
Heat from roof tops	14	2.8.
Total	500	100

Source: Field survey, 2025

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7.2 The Major Evidences of Climate Change in Benin-City, Edo State, Nigeria

Table 2 depicts the major evidences of climate change in Benin-City. The Table clearly reveals that early cessation of rainy season with 111 (22.20%) respondents of the sample population ranked highest. The Table also shows that excessive temperature ranked next with 106 (21.20%) respondents and it is followed by delayed rainy season 102 (20.04%) respondents, and irregular rainfall with 100 (20.00%) responses of the sample population in the study area. Also, are destructive thunderstorms with 41 (8.20%) respondents, disappearance of August Break recorded 23 (4.00 %) respondents while strong and desiccating winds, which is the least recorded 20 (4.00%) of the sample population in the study area.

Table 2: The Major Evidences of Climate Change in Benin-City, Edo State, Nigeria

The major The major evidences of climate change in Benin-City	Frequency	Percentage (%)
Early cessation of rainy season	111	22.20
Delayed rainy season	102	20.04
Irregular rainfall	100	20.00.
Excessive temperature	106	21.20
Strong and desiccating winds	20	4.00.
Destructive thunderstorms	41	8.20
Disappearance of August Break	20	4.00
Total	**500**	**100**

Source: Field survey, 2025

7.3 The Major Causes of Flooding in Benin-City, Edo State, Nigeria

Table 3 depicts the major causes of flooding in Benin-City. The Table shows clearly that excessive rainfall is by far the highest of all the major causes of flooding in Benin-City as it had 103 (20.6%) responses of the sample population in the study area. Persistent encroachment into waterways and blocked gutters/culverts had 53 (10.6%) responses each, poor drainage and high temperatures had 48 (9.6%) responses each, poor land use plans and Poor housing had 39 (7.8%) responses each of the sample population. Ineffective awareness and poor waste Disposal had 31 (6.2%) responses each, nearness to waterways had 24 (4.6%) responses and absence of vegetation cover had 22 (4.4%) responses of the sample population in the study area. From the results above, it is crystal clear that excessive rainfall is by far the highest of all the major causes of flooding in the study area, followed by persistent encroachment into waterways, blocked gutters/culverts, poor drainage, high temperature, poor land use plans and poor housing in the study area. The findings above is in tandem with the earlier findings of Oseghale and Ehinomen (2021), Oladosu et al., (2022), Odiana et al., (2023), & Omorodion et al., (2024) that the causes of flooding are attributed to some environmental factors such as heavy rainfall, lack of adequate town planning techniques, poor drainage system, high level illiteracy, ignorance of dumping refuse on flood paths, encroachment

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on waterways, blocked gutters, culverts and so forth.

Table 3: The Major Causes of Flooding in Benin-City

The major causes of flooding in Benin-City	Frequency	Percentage (%)
Excessive rainfall	103	20.6
Nearness to waterways	24	4.8
Poor drainage	48	9.6
Nature of soil	09	1.8
Poor housing	39	7.8
Persistent encroachment on waterways	53	10.6
Blocked gutters and culverts	53	10.6
Poor land use plans	39	7.8
Ineffective awareness	31	6.2
Poor waste Disposal	31	6.2
Absence of vegetation cover	22	4.4
High temperature	48	9.6
Total	500	100

Source: Field survey, 2025

7.4 The Impact of Climate Change Induced Flooding In Benin-City, Edo State, Nigeria

Table 4 shows clearly the impact of climate change induced flooding in Benin-City, Edo State, Nigeria. From the Table, seasonal flooding/erosion which had 84 (16.8%) recorded the highest responses. Damage to infrastructure and submergence of buildings had 74 (14.8%) responses each, loss of lives and properties had 69 (13.8%) responses, transportation problem had 54 (10.8%) responses and low agricultural production and health problems had 47 (9.4%) responses each in the study area. Others are: soil degradation/impoverishment which had 27 (5.4%) responses, loss of man hour had 18 (3.6%) and finally, migration which had 6 (1.3%) responses of the sampled population in the study area. From the table, it is clear that seasonal flooding/erosion which had the highest responses followed by damage to infrastructure and submergence of buildings (they have the same number of responses each), loss of lives and properties, transportation problem and low agricultural production and health problems (they have the same number of responses each) are the impact of climate change induced flooding in Benin-City, Edo State, Nigeria. The result above is in congruence with the earlier findings of Akpan & Udoh, 2020; Oladosun et al., 2022) 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.

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Table 4: The Impact of Climate Change Induced Flooding in Benin-City, Edo State, Nigeria

The Impact of Climate Change Induced Flooding in Benin-City, Edo State, Nigeria	Frequency	Percentage (%)
Low agricultural production	47	9.4
Damage to infrastructure	74	14.8
Health problems	47	9.4
Submergence of buildings	74	14.8
Soil degradation	27	5.4
Transportation problem	54	10.8
Seasonal flooding/erosion	84	16.8
Migration	06	1.2
Loss of lives and properties	69	13.8
Loss of man hour	18	3.6
Total	500	100

Source: Field survey, 2025

8 The Strategies Adopted to Mitigate the Impact of Climate Change Induced Flooding in Benin-City, Edo State, Nigeria

The mitigation strategies adopted in Benin-City over the years to mitigate the impact of climate change induced flooding in Benin-City, Edo State, Nigeria are: creation and promotion of effective community awareness, construction of permeable pavements, elevated foundations, weather-resistant building materials; construction of additional gutters where appropriate, evacuation of blocked drainage channels, enforcement of environmental sanitation, adoption of modern environmental building codes, implementation of green building initiatives, avoidance of encroachment on waterways and total eschewal from areas near to waterways.

9. Conclusion

Climate change, as a global phenomenon characterized by long-term shifts in temperatures and other weather patterns, poses significant threats across various sectors, with flooding as a very serious challenge. Precisely, Benin City with its unique geographical, climatic characteristics and rapid urbanization faces significant threats to its existing and future environments. These attributes make Benin-City highly vulnerable and susceptible to the impact of climate change induced flooding in Benin-City, Edo State, Nigeria. To ensure that the impact of climate change induced flooding in Benin-City, Edo State, Nigeria on the present and future environments in Benin-City are averted or at least ameliorated, various mitigation strategies such as creation and promotion of effective community awareness, permeable pavements, elevated foundations, weather-resistant building materials, evacuation of blocked drainage channels, enforcement of environmental sanitation, adoption of environmental building codes, implementation

of green building initiatives, avoidance of encroachment on waterways and total eschewal from areas near to waterways in Benin-City, Edo State, Nigeria are apt. This paper concludes by advocating 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 flooding associated with climate change on the present and future environments in Benin-City, Edo State, Nigeria.

10. Recommendations

This paper examined the impact of climate change induced flooding in Benin-City, Edo State, Nigeria.. Based on the findings of this paper, the following actionable policy recommendations are made: effective and regular creation and promotion of community awareness on the impact of climate change induced flooding in Benin-City, Edo State, Nigeria, climatic conditions should be monitored to help predict potential rainfall and flooding hazards and how to circumvent them; practicing the use of weather-resistant building materials and implementation of green building initiatives should be encouraged across the study area; regular and effective enforcement of environmental regulation, environmental sanitation and adoption of environmental building codes should be adopted and implemented. Also recommended is the construction of permeable pavements, elevated building foundations, regular and effective inspections and monitoring of drainage channels to prevent dumping of wastes should be religiously enforced. Where the drainage channels are blocked, the concerned and appropriate authorities should ensure that they are evacuated aptly. Finally, avoidance of encroachment on waterways and total eschewal from areas near to waterways in Benin-City, Edo State, Nigeria are passionately recommended.

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