Journal of Biodiversity and Environmental Sciences | JBES
ISSN: 2220-6663 (Print); 2222-3045 (Online)
Website: https://www.innspub.net
E-mail contact: info@innspub.net
Vol. 27, Issue: 3, p. 39-49, 2025

RESEARCH PAPER

OPEN ACCESS

The effects of climate change on built structures in Benin-city, Edo state, Nigeria

A. E. Ilenre*[1], Y. H. Tashok[2], E. N. Uhumuavbi[2]

[1]*Department of Geography and Environmental Management, Faculty of Environmental Studies, Ambrose Alli University, Ekpoma, Nigeria*

[2]*Department of Architecture, Faculty of Environmental Studies, Ambrose Alli University, Ekpoma, Nigeria*

Key words: Climate change, Built structure, Nigeria

DOI: https://dx.doi.org/10.12692/jbes/27.3.39-49 [Published: September 06, 2025]

ABSTRACT

This paper examines the effects of climate change on built structures in Benin-City, Edo State, Nigeria. Questionnaires administration and oral interview to 500 respondents via random was employed. The findings highlighted the major causes of climate change, the major evidences of climate change, the level of awareness of the inhabitants on the effects of climate change on built structures, the climate change induced effects on built structures, and the mitigation strategies and policies adopted by the City dwellers in Benin-City. Based on the findings, the following actionable policy recommendations are made: effective and regular creation and promotion of community awareness on the effects of climate change on built structures in Benin-City. Edo State, Nigeria; climatic conditions should be monitored to help predict potential climate change related 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. implementation of green building initiatives, and environmental sanitation; modern building techniques and technologies such as the use of cool roofs, construction of permeable pavements, elevated foundations, regular and effective inspections and monitoring of drainage channels to prevent dumping of wastes should be religiously enforced. Where the drainage channels are found to be blocked, the concerned authorities should ensure that they are evacuated aptly. The 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 climate change on built structures in Benin-City. Edo State, Nigeria.

***Corresponding Author:** A. E. Ilenre ✉ abilenre@gmail.com

INTRODUCTION

Climate change can be referred to 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. Built structures refers to any structure that is made of wood, stone, brick concrete or steel built with a roof and walls such as house, factory, road, 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 planet Earth as a result of the unguided human activities. From the foregoing, climate change can be referred to 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 Oxford Advance Learner's Dictionaries (2025), built structures refer to man-made constructions such as: buildings, bridges, roads, dams, monuments, infrastructure (ports, stadiums, and so forth). So, built structures can be defined as any structure that is made of wood, stone, brick concrete or steel built with a roof and walls such as house, factory, road, and so on.

Climate change, characterized by long-term shifts in temperatures and weather patterns, poses an unprecedented global challenge with far-reaching effects on human societies and the built environment. As a phenomenon driven largely by anthropogenic activities, its manifestations, including rising temperatures, altered precipitation patterns, increased frequency and intensity of extreme weather events, and sea-level rise, are becoming increasingly evident across the globe (IPCC, 2023). Nigeria, situated in a vulnerable region (tropical), is not exempt from these impacts. Specifically, Benin City in Edo State, with its unique geographical and climatic characteristics, faces significant threats to its existing and future built structures. The implications of these climatic shifts for infrastructure range from accelerated material degradation and structural instability to increased maintenance costs and potential collapse, ultimately affecting urban resilience and socio-economic stability. Understanding these implications is crucial for developing effective adaptation and mitigation strategies to safeguard the infrastructure of the city and ensure the well-being of its inhabitants now and in the years ahead (Balogun and Onokerhoraye, 2022). While its impacts are felt worldwide, developing nations like Nigeria are acutely susceptible due to their high reliance on natural resources and often inadequate infrastructure to cope with extreme weather events. This vulnerability is worsened by rapid urbanization and existing environmental challenges, leading to considerable damage to properties and loss of livelihoods.

According to Balogun and Onokerhoraye (2022), Benin City, the capital of Edo State in Southern Nigeria, exemplifies a city grappling with the escalating consequences of climate change on its built structures. Located within the humid tropics, Benin City experiences a distinct rainy season with high-intensity rainfall, often characterized by double maxima. Recent studies have confirmed a significant increase in average temperature, rainfall, and humidity in Benin City over the past few decades (Balogun and Onokerhoraye, 2022). This evolving climate, coupled with anthropogenic activities, has profound implications for the durability, stability, and functionality of buildings and infrastructure within Benin-City.

Statement of the research problem

Climate change, is a global phenomenon characterized by long-term shifts in temperatures and weather patterns. It poses significant threats across various sectors, with the built environment being particularly vulnerable. While its impacts are felt worldwide, developing nations like Nigeria are acutely susceptible due to their high reliance on natural resources and often inadequate infrastructure to cope with extreme weather events (Okhakhu, 2019). On a global scale, the relationship between climate change and the built environment has received considerable attention. This therefore, suggests that several researches have been carried out in this area. For instance, Ojo and Adebayo (2012) examined climate change and the built environment in Nigeria and noted that Nigeria's vulnerability is compounded by a lack of climate-sensitive architectural practices and poor enforcement of environmental regulations.

Akinbamijo (2015) researched on climate change and housing delivery: adaptation strategies and policy implications for Nigerian cities and he highlighted the socio-economic cost of climate-related damage to infrastructure in urban Nigeria, estimating billions of naira lost annually due to flood-induced structural failure. Uji (2016) examined sustainable architecture and climate change in Nigeria and he noted that most buildings in Nigeria are designed without considering future climatic conditions, leading to higher risks of thermal discomfort, structural failure, and accelerated aging of materials. Furthermore, Osagie and Ogieva (2019) examined climate change and the vulnerability of building foundations in Benin City. In their research, they noted that most residential buildings in the City were not designed to accommodate changes in groundwater levels and hydrological shifts brought about by climate change, making them susceptible to foundation instability and moisture penetration. In a similar vein, Balogun and Onokerhoraye (2022) carried out an assessment of the urban climate of Benin City, Nigeria. From their findings, they recommended the need for incorporating climatic elements into urban planning and development processes in Benin City to achieve sustainable and resilient habitats. Available literature on the effects of climate change on built structures in Benin-City, Edo State, Nigeria revealed that they focused attention on closely related areas thereby bringing about the neglect of the effects of climate change on built structures in Benin-City, Edo State, Nigeria. From the numerous detailed studies carried out, it is clear that studies in the specific area in Benin-City, Edo State, Nigeria are non-existent. This non-existent scenario of the above subject matter is what this current paper intends to fill.

The overall aim of this paper is to assess the effects of climate change on built structures in Benin-City, Edo State, Nigeria. The specific objectives are to:

1. identify the major causes of climate change in Benin-City;
2. identify the major evidences of climate change in Benin-City;
3. ascertain the level of awareness of the inhabitants on the effects climate change on built structures in Benin-City;
4. identify the climate change induced effects on built structures in Benin-City; and
5. identify the mitigation strategies and policies adopted by the City dwellers.

Literature review

The discourse on climate change extensively highlights its far-reaching consequences, extending beyond environmental degradation to direct impact on human settlements and infrastructure. In the context of Benin City, a burgeoning urban center in the southern region of Nigeria, these implications are particularly pronounced due to its geographical characteristics, rapid urbanization, and susceptibility to extreme weather events. On a global scale, the relationship between climate change and the built environment has received considerable attention. The primary climate change-related hazards impacting the built environment of Benin City are increasingly frequent and intense rainfall, leading to widespread flooding and severe gully erosion. The city's rapid territorial expansion, often without commensurate infrastructural development, particularly in drainage networks, has significantly reduced infiltration capacity as natural ground cover is replaced by impervious urban surfaces. This contributes to severe surface inundation, mudflows, and the submergence of built houses (Balogun and Onokerhoraye, 2022).

The destructive impact of flooding manifests in various ways, including buildings being washed away, floatation of lightweight structures, material damage due to inundation, undercutting of foundations, and damage from debris impact (Dimuna *et al.*, 2024). Erosion, while often more gradual, also leads to significant structural degradation, particularly through gully formation worsened by poor road designs and exposed land surfaces in built-up areas.

Beyond direct physical damage from rainfall, rising temperatures contribute to the urban heat island (UHI) effects, increasing internal building temperatures and demanding more energy for cooling, thereby affecting energy efficiency (UNEP, 2013; World Health Organization, 2021).

Furthermore, changes in wind patterns and increased storm intensity can lead to structural failures, roof leakages, and accelerated deterioration of building fabrics (Johns and Fedeski, 2017). These cumulative impacts translate to increased construction and maintenance costs, reduced property values, and significant disruptions to socio-economic activities (Aiyegbajeje and Adejugbagbe, 2017).

Despite the evident and significant impacts of climate change on the built environment across Nigeria, including Benin City, there remains a gap in understanding the specific implications for built structures and the effectiveness of existing adaptation and mitigation strategies (Akinwaminde *et al.*, 2022). Previous researches have highlighted the need for incorporating climatic elements into urban planning and development processes in Benin-City to achieve sustainable and resilient habitats (Balogun and Onokerhoraye, 2022). This study seeks to bridge this knowledge gap by thoroughly examining the multifaceted implications of climate change on built structures in Benin City, providing valuable insights for policymakers, urban planners, climatologists, and the construction industry to foster more resilient and sustainable urban development in the face of a changing climate.

Researchers such as Oreskes *et al.* (2010) have identified heat stress, moisture damage, sea-level rise, and increased frequency of natural disasters as major threats to infrastructure resilience worldwide. In cities across Europe, Asia, and North America, policy makers have begun implementing adaptation strategies, such as climate-resilient building designs, green infrastructure, and revised urban planning codes to mitigate the effects of climate change on infrastructure. By comparison, many cities in sub-Saharan Africa, including Benin City, are still grappling in terms of planning and investment in climate-adaptive infrastructure.

Local scholars have also contributed to the understanding of this issue. Ojo and Adebayo (2012) noted that Nigeria's vulnerability is compounded by a lack of climate-sensitive architectural practices and poor enforcement of environmental regulations. Uji (2016) emphasized that most buildings in Nigeria are designed without considering future climatic conditions, leading to higher risks of thermal discomfort, structural failure, and accelerated aging of materials.

Furthermore, Akinbamijo (2015) highlighted the socio-economic cost of climate-related damage to infrastructure in urban Nigeria, estimating billions of naira lost annually due to flood-induced structural failure.

In Benin City specifically, the increasing incidents of building collapse and road degradation during heavy rainfall seasons underscore the urgent need for climate-responsive construction practices. The absence of adequate maintenance, combined with the use of substandard materials and poor urban planning, amplifies the impacts of climate variability on infrastructure. For example, Osagie and Ogieva (2019) observed that most residential buildings in the city were not designed to accommodate changes in groundwater levels and hydrological shifts brought about by climate change, making them susceptible to foundation instability and moisture penetration.

Globally, climate-smart design principles and materials are being adopted to address these vulnerabilities. Innovations such as cool roofs, permeable pavements, elevated foundations, and weather-resistant construction materials have shown promising results in increasing infrastructure resilience in countries like the Netherlands, Japan, and the United States (IPCC, 2022). Nigerian cities, including Benin City, can benefit from adopting similar strategies, while also integrating indigenous knowledge systems and locally available materials in climate adaptation planning.

The implications of climate change on built structures in Benin City are multifaceted, affecting structural integrity, safety, and sustainability. As climate variability continues to intensify, there is an urgent need for a comprehensive response involving architects, engineers, climatologists, urban planners, and policymakers. Effective adaptation strategies must prioritize building resilience, enforce construction standards, and promote community awareness to ensure that the built environment remains safe and sustainable in the face of a changing climate.

This literature review delves into the specific ways climate change affects built structures in Benin City, Edo State, Nigeria examining its impact on roofs, and walls.

Effects on roofs

Roofs are the primary protective layer of any building. They are highly exposed to the direct impacts of climate change, especially in a region characterized by intense rainfall and increasing temperatures. Studies focusing on the Niger Delta, including Benin City, emphasize that perennial flooding, a direct consequence of climate change, severely compromises roof integrity (Dimuna *et al.*, 2024). Prolonged exposure to moisture due to heavy downpours leads to water penetration, causing deterioration of roofing materials such as corrugated iron sheets, asbestos, and even modern aluminum sheets (World Bank, 2023). This can manifest as rusting, rotting of supporting timber structures, and growth of mold and mildew, significantly reducing the service life of roofs and necessitating frequent and costly repairs (Aiyegbajeje and Adejugbagbe, 2017). Furthermore, the increasing intensity of wind associated with more severe storms can directly lift or damage roofing materials, leading to immediate structural failures and exposing the interior of buildings to further damage (Johns and Fedeski, 2017).

Effects on walls

Building walls in Benin City are similarly vulnerable to the adverse effects of climate change, particularly from increased precipitation and fluctuating temperatures. Heavy rainfall and prolonged periods of saturation contribute to dampness and moisture ingress, leading to efflorescence, discoloration, and the growth of fungi and algae on exterior wall surfaces (Aiyegbajeje and Adejugbagbe, 2017). For buildings constructed with less resilient materials like sandcrete blocks, continuous exposure to moisture can reduce their compressive strength and lead to cracks and spalling (Akinwumi, 2014). Gully erosion, a severe problem in Benin City worsened by intense rainfall and poor drainage, directly threatens the foundations and stability of walls, leading to structural collapse in severe cases. Changes in temperature, especially the increase in daily and seasonal temperature variations, can also cause thermal expansion and contraction in wall materials, contributing to cracking and weakening of the structure over time.

In conclusion, the literature review clearly reveals that climate change poses a multi-faceted threat to built structures in Benin City. From the direct physical degradation of roofs and walls to the accelerated deterioration of building materials and the shortened longevity of houses, the impacts are profound. The rising temperatures and urban heat island effects further stultify these challenges, while the economic consequences manifest as direct damages, increased operational costs, and broader socio-economic disruptions. Addressing these challenges requires a concerted effort towards resilient urban planning, adoption of climate-adaptive building codes, and significant investment in sustainable infrastructure development.

MATERIALS AND METHODS

Study area

The study area is Benin-City and it is the administrative headquarters of Edo State. 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; Ilenre, 2019). 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).

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 and 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, presence of thick ever green rainforest vegetation and the availability of warm ocean currents have encouraged this heavy rainfall (Okhakhu, 2010; Ilenre, 2019; Balogun and 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 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).

In the study area, the first peak of rainfall is experienced in July, whereas the second peak is experienced in September. 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).

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 times 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).

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 structured 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, a sample population of 500 respondents which represent 0.0245% of the population of the entire study area were reached for data collection via the use of structured 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 and built structures are unevenly distributed in Benin-City. So, the questionnaires were administered to reflect the human population and built structures in the three local government areas. Owing to 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 unarguably a sound reflection of the population and number of built structures in the local government area.

All the five hundred questionnaires administered were painstakingly retrieved and used for the study. 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 level of awareness of the inhabitants on the effects of climate change on built structures, the effects of climate change on built structures and the mitigation strategies adopted by the inhabitants in the study area.

The secondary data used in this paper include but not limited to the population data as generated by 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.

RESULTS AND DISCUSSION

The causes and effects of climate change on built structures in any part of the globe in general and Benin-City in particular are a function of both natural and anthropogenic factors. These factors act in combination or individually to affect built structures in Benin-City, and other places having the same or similar environmental factors.

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%) responses ranks highest among all the major causes and it is followed by industrial activities which has 79 (15.8%) responses of the sample population in the study area. Also, deforestation had 60 (12.0%) responses, use of fluorinated gases which ranks next to it had 41 (8.2%) responses of the sample population. The others which include bush burning has 31 (6.2%) responses, agricultural activities has 25 (6.2%) responses, heat from concrete floors has 16 (3.2%) responses, emissions from dump sites has 18 (3.6%) responses, and finally heat from roof tops has 14 (2.8%) responses of the sample population.

Table 1. The major causes of climate change in Benin-city

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

Major evidences of climate change in Benin-city

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%) responses of the sample population ranks first. The table further shows that excessive temperature ranks second with 106 (21.20%) responses of the sample population and it is followed by delayed rainy season 102 (20.04%) of the sample population, erratic rainfall with 100 (20.00%) responses of the sample population. Also, are destructive thunderstorms with 41 (8.20%) responses of the sample population, disappearance of August Break recorded 23 (4.00 %) responses while strong and desiccating winds, which is the least recorded 20 (4.00%) of the sample population in the study area.

Table 2. Major proofs of climate change in Benin-city

Major evidences of climate change in Benin-city	Frequency	Percentage (%)
Early cessation of rainy season	111	22.20
Delayed rainy season	102	20.04
Erratic 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

Level of awareness of the inhabitants on the effects of climate change on built structures in Benin-city

Table 3 reveals the level of awareness of the inhabitants on the effects climate change on built structures in Benin-City. Table 3 clearly shows that 347 (69.4%) respondents of the sample population possess very high level of awareness on the effects of climate change on built structures in Benin-City. In like manner, 112 (22.4%) respondents of the sample population possess a high level of awareness on the effects of climate change on built structures in Benin-City. In addition, 36 (7.2%) respondents of the of the sample population possess a low level of awareness on the effects of climate change on built structures in Benin-City. Lastly, Table 3 shows that, 5 (1%) respondents of the sample population possess a very low level of awareness on the effects of climate change on built structures in Benin-City. From the findings above, it is crystal clear that a very high percentage of the sample population is of a very high level of awareness on the effects of climate change on built structures in Benin-City, Edo State, Nigeria.

Table 3. Level of awareness of the inhabitants on the effects climate change on built structures in Benin-city

Level of awareness	Number of response	% response
Very high	347	69.4
High	112	22.4
Low	36	7.2
Very low	5	1.0
Total	500	100.00

Source: Fieldwork, 2025.

Effects of climate change on built structures in Benin-city, Edo state, Nigeria

Table 4 is explicit on the effects of climate change on built structures in Benin-City. Table 4 reveals that flooding of houses is the greatest of all the effects of climate change on built structures in Benin-City because it recorded the highest, which is, 86 (17.2%) respondents of the sample population in the study area. Also, Discoloration of walls, roofs, gates, doors and electrical installations ranked next and recorded 67 (13.4%) respondents of the sample population in the study area. Losing, leakages and blowing off of roofs had 61 (12.2%) respondents of the sample population in the study area. Others are exhumation and exposure of foundations with 54 (10.8%) respondents, building collapse and Pulling down of Electricity poles both recorded 48 (9.6%) respondents each, creation of cracks in walls recorded 44 (8.8%) respondents, damage to communication masts recorded 37 (7.4%) respondents, tearing or cutting of roads recorded 31 (6.2%) respondents, lightning fire incidences in built structures recorded 16 (3.2%) respondents, and finally, effects on other built structures such as moulds, drawings, signpost/bill boards and graves recorded 8 (1.6%) respondents of the sample population in the study area.

Table 4. Effects of climate change on built structures in Benin-city

Effects of climate change on built structures in Benin-city	Frequency	Percentage (%)
Discoloration of walls, roofs, gates, doors and electrical installations	67	13.4
Flooding of buildings	86	17.2
Creation of cracks in walls	44	8.8
Losing, leakages and blowing off of roofs	61	12.2
Tearing or cutting of roads	31	6.2
Pulling down of Electricity poles	48	9.6
Damage to communication masts	37	7.4

Lightning fire incidences in built structures	16	3.2
Effects on other built structures such as moulds, drawings, signposts/billboards, etc.	08	1.6
Exhumation and exposure of foundations	54	10.8
Building collapse	48	9.6
Total	500	100

Source: Fieldwork, 2025.

Mitigation strategies adopted by the inhabitants in the study area

The mitigation strategies adopted by the inhabitants of Benin-city over the years include but not limited to the following: creation and promotion of community awareness, the use of cool roofs, permeable pavements, elevated foundations, weather-resistant building materials, evacuation of blocked drainage channels, enforcement of environmental regulation, adoption of environmental building codes, implementation of green building initiatives, and environmental sanitation.

CONCLUSION

Climate change, as a global phenomenon characterized by long-term shifts in temperatures and weather patterns, poses significant threats across various sectors, with the built environment being particularly vulnerable. Precisely, Benin city with its unique geographical, climatic characteristics and rapid urbanization faces significant threats to its existing and future built structures. These attributes make Benin city highly vulnerable and susceptible to the effects of climate change on built structures in Benin-city. In order that the effects of climate change on built structures in Benin-city are averted or at least alleviated, various mitigation strategies which include creation and promotion of community awareness, the use of cool roofs, permeable pavements, elevated foundations, weather-resistant building materials, evacuation of blocked drainage channels, enforcement of environmental regulation, adoption of environmental building codes, implementation of green building initiatives, and environmental sanitation in Benin-city, Edo State, Nigeria are apt. 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 climate change on built structures in Benin-City.

RECOMMENDATIONS

This paper examined the effects of climate change on built structures 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 effects of climate change on built structures in Benin-City. Edo State, Nigeria;climatic conditions should be monitored to help predict potential climate change related 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. implementation of green building initiatives, and environmental sanitation; modern building techniques and technologies such as the use of cool roofs, construction of permeable pavements, elevated foundations, regular and effective inspections and monitoring of drainage channels to prevent dumping of wastes should be religiously enforced. Where the drainage channels are found to be blocked, the concerned authorities should ensure that they are evacuated aptly.

REFERENCES

Agbonkhese O, Akomolafe D, Adekunle A, Ogundipe O. 2014. Building collapse in Nigeria: The trend of casualties in the last decade (2000–2010). International Journal of Civil Engineering and Technology **5**(6), 1–6.

Agboola OP, Badr SA, Yakubu AD, Maher A. 2023. Built environment transformation in Nigeria: The effects of a regenerative framework. https://www.tandfonline.com/doi/full/10.1080/13467581.2023.2238045

Agboola SA, Hodder BW. 1979. West Africa in its continent. Oxford University Press, London, 14–19.

Aiyegbajeje AA, Adejugbagbe JA. 2017. Effects of weather on service lives of external building finishings: A case study of Ilaro, Ogun State. Fifth National Conference on Economic Transformation and Environmental Sustainability in Nigerian Built Environment. https://eprints.federalpolyilaro.edu.ng/655/1/ADEJUGBAGBE%20EFFECT%20OF%20WEATHER%20ON%20SERVICE%20LIVES%20OF%20EXTERNAL%20BUILDING%20FINISHNGS.pdf

Akinbamijo OB. 2015. Climate change and housing delivery: Adaptation strategies and policy implications for Nigerian cities. Journal of Environmental Studies and Management **8**(2), 89–97.

Akinwaminde DO, Hahn P, Atewologun OM. 2022. Climate risks and its implications on real estate investment in Edo State, Nigeria. https://ideas.repec.org/p/afr/wpaper/2022-003.html

Akinwumi II. 2014. Earth building construction processes in Benin City, Nigeria and engineering classification of earth materials used. Indian Journal of Traditional Knowledge. https://www.researchgate.net/publication/266854830_Earth_building_construction_processes_in_Benin_City_Nigeria_and_engineering_classification_of_earth_materials_used

America's Climate Choices (AMC). 2010. Panel on advancing the science of climate change. National Research Council, Washington DC.

Balogun TF, Onokerhoraye AG. 2022. Assessment of the urban climate of Benin City, Nigeria. Journal of Environment and Earth Science **12**(4).

Dimuna KO, Ekhaese EN, Ndimako OO. 2024. Climate change impact on the architecture and built environment dwellers' well-being in Niger Delta Region: A systematic review. Frontiers in Climate. https://www.frontiersin.org/articles/10.3389/fclim.2024.1498938/full

Efe SI, Eyefia OA. 2014. Urban warming in Benin City, Nigeria. Atmospheric and Climate Sciences **4**(2), 241–252. http://www.scip.org/journal/acs

Eseigbe JO. 2011. The impact of soil erosion on the physical landscape in the Benin Metropolis, Edo State, Nigeria. Unpublished PhD thesis, Department of Geography and Regional Planning, Ambrose Alli University, Ekpoma, Nigeria.

Ilenre AE. 2019. The impact of some climatic elements on the yield of natural rubber (*Hevea brasiliensis*) in Ikpoba Okha Local Government Area of Edo State, Nigeria. Unpublished PhD thesis, Department of Geography and Environmental Management, Ambrose Alli University, Ekpoma, Nigeria.

Intergovernmental Panel on Climate Change (IPCC). 2022. Climate change: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Johns S, Fedeski S. 2017. Understanding the impact of climate change on buildings: A guide to climate change adaptation for building professionals. Routledge Taylor & Francis.

Ministry of Lands and Surveys. 2008. Maps (Edo State and Ikpoba–Okha L.G.A.). Benin City, Nigeria.

National Population Commission (NPC). 2006. Population estimate report. NPC Headquarters, Benin City, Nigeria, 1–2.

Nwafor JC. 2007. Global climate change: The driver of multiple causes of flood intensity in Sub-Saharan Africa. Paper presented at the International Conference on Climate Change and Economic Sustainability, Nnamdi Azikiwe University, Enugu, Nigeria.

Ojo JS, Adebayo KO. 2012. Climate change and the built environment in Nigeria. International Journal of Sustainable Development **5**(1), 36–43.

Okhakhu PA. 2010. The significance of climate elements in planning environment in the humid tropics. Unpublished PhD thesis, Department of Geography and Regional Planning, Ambrose Alli University, Ekpoma, Nigeria.

Okhakhu PA. 2019. Research methods in climatology. Ambrose Alli University Publishing House, Ekpoma, Edo State, Nigeria, 1–2.

Oreskes N, Conway EM, Shindell M. 2010. The collapse of Western civilization: A view from the future. Daedalus **139**(4), 40–58.

Osagie AA, Ogieva I. 2019. Climate change and the vulnerability of building foundations in Benin City. Edo Journal of Architecture and Planning **2**(1), 45–57.

Oxford Advanced Learner's Dictionaries. 2025. https://www.oxfordlearnersdictionaries.com

Udo RK. 1982. The human geography of tropical Africa. Ibadan, Nigeria: Heinemann Educational Books (Nig.) Ltd.

Uji ZA. 2016. Sustainable architecture and climate change in Nigeria. Journal of the Nigerian Institute of Architects **3**(2), 21–33.

United Nations Environment Programme (UNEP). 2009. Buildings and climate change: Summary for policy-makers. www.unep.fr/scp/sun

Usuemerai CO, Oyewole AO. 2024. An assessment of the sustainability of locally sourced timber specimens for use as building material. Journal of Energy and Environment **6**(4), 29–40. www.nipesjournals.org.ng

World Bank. 2023. Benin country climate and development report. https://www.worldbank.org/en/country/benin/publication/benin-country-climate-and-development-report

World Health Organization (WHO). 2021. Health climate change survey report: Tracking global progress. https://www.who.int/news-room/fact-sheets/detail/climate-c