IJMCER

International Journal of Multidisciplinary and Current Educational Research (IJMCER)
ISSN: 2581-7027 ||Volume|| 7 ||Issue|| 3 ||Pages 01-10||2025||

Spatial Assessment of Building Collapse In Connection With Fluctuations in Climate Characteristics over the Niger Delta Region

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ABSTRACT: Climate changes will not be homogeneous or uniform globally but that substantial differences in temperature and precipitation trends at the regional level will occur with declining health reduced building lifetime and significant risk of collapse. This study aimed at assessing the connection between building collapse and fluctuations in climate characteristics over the Niger Delta region. The ex-post facto research design was adopted in this study since the data were acquired mainly from the secondary sources. The data on building collapse was obtained from the archive of National Emergency Management Agency (NEMA) whereas weather data including (temperature and rainfall) were assessed from the archive of Nigeria Meteorological Agency (NIMET) for a period of forty (41) years. The multiple regression analysis was used to analyze the relationship between building collapse and climate characteristics in the area and the results of the analysis between temperature, rainfall and cases of building collapse showed variation in the correlation values across different cities as follows, Akure (sig. F= 001); Benin (sig. F= 0.952), Warri (sig. F= 0.399), Yenagoa (sig. F= 0.00), Port Harcourt (sig.F= 0.004); (sig. F= 0.399), Yenagoa (sig. F= 0.00), Uyo (sig.F= 0.044), Calabar (sig.F= 0.902), Owerri (sig.F= 0.003), and Umuahia (sig. F= 0.015). The results of the analysis clearly revealed that the there is a variation in building collapse across different cities due to differences in climate characteristics. Nevertheless, the influence of rainfall and temperature on building collapse in the region is significant. The study concludes that buildings are vulnerable to climate change implying that there is a significant connection between changing climate characteristics and increased risk of building collapse On the strength of the findings therefore, use of climate resilient materials in building construction, flood prediction and early warning, sensitization, timely relocation of residents and public warning of its consequences of flooding were prioritized recommendation provided by this study for urgent implementation.

KEYWORDS: Climate, Prediction, Variability, Building collapse, Flooding

I. INTRODUCTION

Buildings are structures which are specially designed and planned to provide the spaces and facilities needed for its purpose. They serve as shelter for man, his properties and activities. Buildings are expected to be properly planned, designed, constructed, managed and maintained to offer desired satisfaction to the occupant, enhance the environment and aid national development (Babalola 2015). Good buildings, as characterized by Oni (2010) are those that offer security, safety, convenience, social satisfactions, psychological and economic satisfactions to the occupiers. Similarly, Omole (2001), opined that building condition is the totality of the 'state' of the physical, environmental and the satisfactory level of a particular dwelling unit, measured against some variable of liveability at a particular time. It is therefore expected of buildings to meet the needs of the present as well as contribute to future needs thereby echoing building sustainability. When internal load-bearing structural elements fail, a building will collapse into itself, and exterior walls pulled into the falling structure. As reported by Rodziewicz et al. (2020) building collapse is the sudden structural failing, partially or entirely, of a building, threatening human life and health. Ramírez-Eudave (2022) opined that building collapse is the failure of load-bearing structural elements, causing a building to fall or fail catastrophically. It is clearly documented in the literature that buildings can be vulnerable to climate change and more worrisome is the fact that in the future there may be an increase in the risk of collapse, declining health and significant loss of value as a result of more storms, snow or subsidence damage, water encroachment, deteriorating indoor climate and reduced building lifetime (Barrelas et al., 2021). Qin et al. (2023) stated that climate change is a complex variable that affects the design of a building and its occupants. Temperature, precipitation, wind, and sunlight are all key factors in defining climate and influencing the architecture of a building. Climate change is the significant variation of

Average weather conditions becoming, for example, warmer, wetter, or drier over several decades or longer. It is the longer-term trend that differentiates climate change from natural weather variability. Impacts related to climate change are evident across regions and in many sectors important to society, such as human health, agriculture and food security, water supply, transportation, energy, and biodiversity and ecosystems; impacts are expected to become increasingly disruptive in the coming decades (Malhi et al., 2020). Birkmann et al. (2022) opined that global climate change refers to variations in the Earth's climatic conditions stemming from internal and external forces. The Earth's natural internal variability causes climate to vary over millennia and this variation is projected to increase the frequency and intensity of extreme weather events, such as heat waves, droughts, and floods. These changes are likely to increase losses to property and crops, and cause costly disruptions to society (AghaKouchak et al., 2020). According to Adom, & Amoani, (2021) the effects of climate change on building design is a worrisome issue as flooding, wind storm among others drastically affect buildings and sometimes leads to building failures and in extreme cases, complete collapse. Igwe & Umbugadu (2020) highlighted; bad design, faulty construction, poor quality of materials and construction methods, foundation failure, fire outbreak, natural phenomenon and inadequate maintenance as fundamental causes of building collapse. On the other hand, structural failure,

Poor workmanship, carelessness, excessive loading, illegal conversion, hasty construction, obstruction of water course were listed as other causes together with inadequate preliminary works, adoption of wrong foundation, poor concrete mix ratio, improper walling, lack of approved structural design, poor building material specification, ineffective supervision, lack of quality maintenance, fire disaster, illegal conversion and climate or natural phenomenon. Hall cited in Olanitori, (2011) also attributed faulty design, faulty execution of work and use of faulty materials to be major causes of building failure. Yusuf as quoted by Ebehikhalu & Dawam, (2014) classifies the causes as physical factors, ecological status of the site, composition of technical components, social factors, economic factors, engineering factors, human factors, government policies and political factors. Additionally, environmental changes, natural and manmade hazards, improper presentation and interpretation in the design have also been described as the major causes of building collapse. In recent times, building collapse in Nigeria has become a major source of concern not only to professionals like Architects, Structural Engineers, and the Builders but also to the government as well was the public and other stakeholders associated with the building industry.

This is so because the various cases of building collapse have caused irreparable losses of lives and properties thereby limiting the future uses of those lost lives and properties which in turn have negatively impacted the socio-economic status of its citizenry and working contrary to the sustainable development goal. All the continents, Australia, America, Asia, Europe and Africa are experiencing climate change resulting in heavy rains, river overflows, hurricanes, typhoons, tsunamis, extreme weather externalities that is consequential to building collapse. The impacts of climate change from rising temperatures to glacial melting and rising sea levels threaten global building construction safety, stability and sustainability of this century (Tubridy, 2020). Barnouin (2020) noted that humanity stands at a defining moment in history of building collapse arising from climate change menace with a perpetuation of spatial building disparities in nations of the world giving rise to alteration of existing local temperature, humidity, precipitation, wind, and solar exposure by climate change that vastly influence the type of construction materials used and the overall design of the building. Accordingly, Felicioni et al. (2020) noted that worldwide, multiple events of building collapse from climate change are recorded each year, with an average of eight building collapses per year, resulting in greater than 300 deaths each year and the Niger Delta is not exempted from this speculation. Consequently, this study is necessitated to spatially assessed the connections between building collapse and climate change in the region to enable adequate planning and decision making in relation thereto on the account that planning system should take the possible impacts of climate change such as heavy rainfall and increased risk of flooding, into account when taking decisions on the locations of new development and other changes in land use (Masik et al., 2021). Also, to help reduce the impact of climate change on building collapse by adopting reasonable and implementable climate change policies like mitigation and adaptation with capacities as it is clear that a nation with a focused climate change policy and mitigation and adaptation techniques is in a better state and stage of preparedness to respond to climate change impacts than a country without such preparatory plans (Abbasi & Nawaz, 2020; Eneji et al., 2021).

II. MATERIALS AND METHODS

Physical Background of the Study Area : The Niger Delta with an estimated area of about 70,000 km^2 is one of the World's largest deltas. The Niger Delta Region is located on latitudes 4^0 10' to 6^0 20' N and longitudes 2^0 45' to 8^0 35' E (Figure 1). It is bounded to the south by the Atlantic Ocean, to the east by the Cameroun Mountain, to the west the region is bounded by western states of Nigeria such as Osun and Ogun, while to the north the region is bounded by Kogi, Anambra and Ebonyi states. The Niger Delta is located along the Atlantic coast which forms the southern boundary of Nigeria, and it is the entrance of Rivers Niger and Benue into the ocean through a web of rivers, creeks, and estuaries. It is the largest wetland in Africa and the third largest in the world, with about 2370 square kilometres of rivers, creeks and estuaries. Its vegetation is predominantly of the forest type with 8600 square kilometres of swamp forest and about 1900 square kilometres of mangrove forests (Alagoa, 2005). The region situated in the southern part of Nigeria, is bordered in the east by the Republic of Cameroun and in the south, by the Atlantic Ocean. Within Nigeria, the region is defined geographically and politically; the latter being for revenue sharing purposes. The geographic Niger Delta includes the littoral States of Rivers, Bayelsa, Delta Cross River and Akwa- Ibom and has an area of about 67,284 square kilometres with a combined population of 16,331,000 persons. The political Niger Delta includes these and in addition, Abia, Edo, Imo, and Ondo states, with a total area of 112,110 square kilometres of land as at 2006. The region represents about 12% of Nigeria's total surface area (NDDC, 2006).

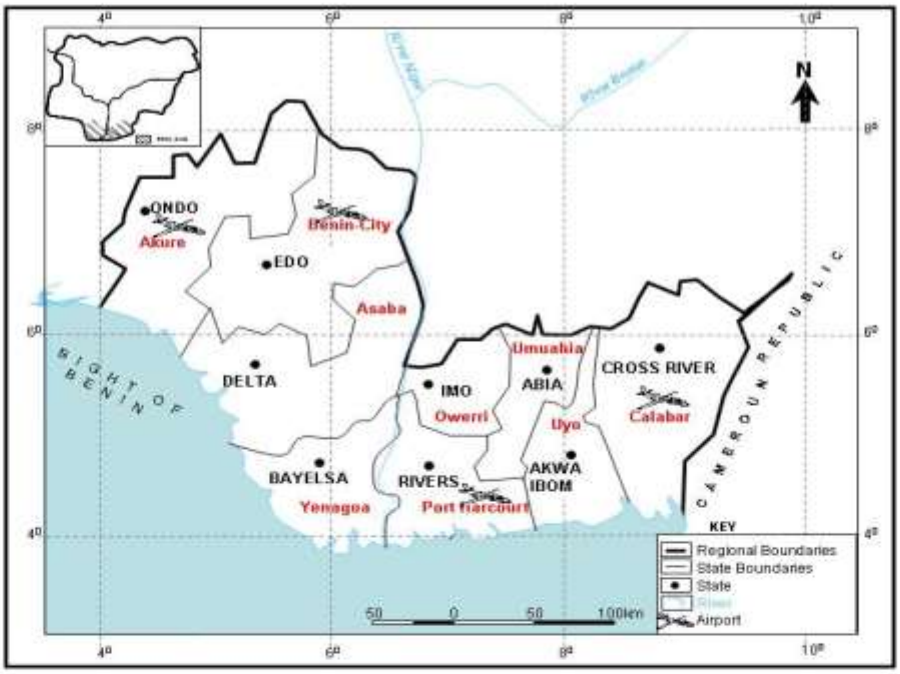

Figure 1: Niger Delta States

Method of Data Collection and Analysis : The ex-post facto research design was adopted in this study since the researcher relies on existing data (secondary) and has no opportunity to control the outcomes on the data. The data for this study was acquired principally from the secondary sources and the data used includes cases of building collapse in the region obtained from the archive of National Emergency Management Agency (NEMA) whereas weather data used in this study were assessed from the archive of Nigeria Meteorological Agency (NIMET) for a period of forty (41) years. The multiple regression analysis was used to analyze the relationship between building collapse and climate characteristics in the area.

III. DISCUSSION OF RESULTS

Table 1: Monthly distribution of temperature (°C) across the Niger Delta Region

Months	Akure	Benin	Warri	Yenagoa	Port Harcourt	Uyo	Calabar	Owerri	Umuahia
JAN	24.6	24.5	25.1	25.3	25.1	25.4	25.4	24.7	24.4
FEB	26.1	25.9	26.5	26.5	26.3	26.5	26.5	26.1	25.8
MAR	26.5	26.4	26.8	26.8	26.7	26.8	26.8	26.7	26.5
APR	26.2	26.4	26.7	26.6	26.5	26.6	26.6	26.7	26.4
MAY	25.7	25.9	26.2	26.3	26.2	26.3	26.3	26.3	26.0

JUN	24.9	25.1	25.4	25.4	25.3	25.4	25.4	25.4	25.2
JUL	24.1	24.3	24.6	24.6	24.6	24.7	24.7	24.7	24.5
AUG	23.9	24.2	24.5	24.5	24.5	24.5	24.5	24.6	24.5
SEP	24.4	24.6	24.8	24.8	24.9	24.9	24.9	24.9	24.7
OCT	25.0	25.2	25.4	25.3	25.3	25.2	25.2	25.3	25.0
NOV	25.4	25.6	25.9	25.9	25.8	25.8	25.8	25.8	25.4
DEC	24.6	24.6	25.4	25.6	25.3	25.4	25.4	24.9	24.5

Source: NiMet , (2021).

The analysis of the monthly distribution of temperature in the Niger Delta region is presented in Table 1. The distribution of temperature in all the cities in the region show an observable unique pattern created by the cT and the mT. The case of Benin shows similarity with Akure with a reflection of the two major seasons. Like what obtained in Akure, March also recorded the highest temperature in Benin. This pattern is slightly replicated in all the cities under investigation where the highest temperature is recorded in the month of March. It was an expected coincidence for all the cities to record the lowest temperature in August because of the little dry spell (august hiatus) in the region. It is inferred that the distribution of temperature in the Niger Delta region is heavily influenced by the cT and the mT, with some distortions from the equatorial easterlies.

Table 2: Monthly distribution of rainfall across the Niger Delta Region

Months	Akure	Benin	Warri	Yenagoa	Portharcourt	Uyo	Calabar	Owerri	Umuahia
JAN	15.6	10.1	18.0	29.5	27.3	26.2	26.2	13.6	12.5
FEB	29.8	28.5	31.7	45.3	41.8	56.0	56.0	27.4	24.0
MAR	72.1	88.1	99.8	131.5	125.8	140.2	140.2	86.6	83.2
APR	130.8	151.3	168.7	200.7	186.8	204.0	204.0	152.8	143.9
MAY	179.7	198.9	230.5	272.3	257.3	266.8	266.8	211.3	200.6
JUN	269.3	271.6	307.1	392.8	369.2	376.2	376.2	294.3	263.5
JUL	254.7	260.8	259.7	375.2	366.8	429.5	429.5	267.4	245.6
AUG	200.5	234.1	220.4	353.7	366.1	442.9	442.9	268.3	251.5
SEP	284.8	288.1	304.4	402.4	399.7	447.4	447.4	331.0	301.4
OCT	216.5	228.6	256.3	315.0	313.4	358.8	358.8	278.0	273.2
NOV	50.5	58.2	81.4	117.6	120.1	144.7	144.7	80.6	77.9
DEC	19.1	16.6	26.0	39.5	35.1	31.3	31.3	20.2	13.3

Source: NiMet , (2021).

The analysis of the monthly distribution of rainfall in the Niger Delta region is presented in Table 2. The distribution of rainfall in all the cities in the region show the pattern created by the influences of the tropical maritime and the tropical continental air masses. Evidently, the city of Akure recorded the highest amount of rainfall in the region during the rainy season. Dual peak of rainfall volume was recorded in Akure in June and September with 269.3mm and 284.8 mm respectively. The sharp decline in the volume of rainfall in the month of august is adducible to the annual august hiatus in the region. The pattern in Akure is also slightly replicated in other cities in the region but with some exceptions. It is evident that all the cities recorded dual peak of rainfall, the months of January, February, March, October, November and December recorded the lowest amount of rainfall in all the cities. Gradual increase in the amount of rainfall begins from March which peaks in July before the august hiatus. The case of Uyo and Calabar does not suggest that the August hiatus affected the volume of rainfall given that the month of august recorded more rainfall than the month of July which is not consistent with other cities in the region. It is also very conspicuous that Owerri and Umuahia recorded the hiatus in July which has been confirmed in many studies from traditional knowledge in the region. Many residents in agrarian communities usually expect the hiatus in July and august in the Niger Delta region.

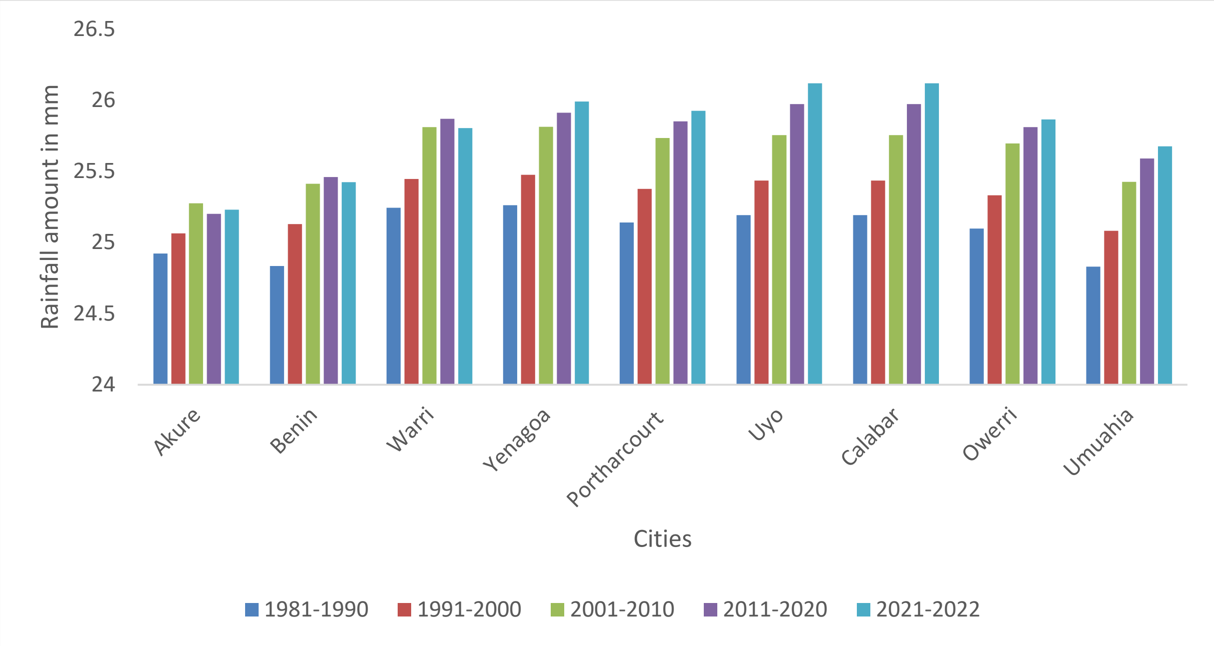

Figure 1: Decadal rainfall distribution in the Niger Delta Region
Source: NiMet , (2021).

The decadal distribution of rainfall from the year 1981 to the year 2022 is presented in figure 1. The distribution of rainfall across the five decades under investigation is a mirror reflection of the yearly distribution of rainfall. Uyo and Calabar recorded the highest amount of rainfall, Akure recorded the lowest volume of rainfall within the period under investigation.

Table 3: Decadal change in the rainfall distribution across the Niger Delta Region

Cities	1981-1990	1991-2000	Detected change	2001-2010	Detected change	2011-2020	Detected change	2021-2022	Detected change
Akure	1690.7	1519.8	170.9	1605.2	-85.4	1926.9	-321.7	2479.5	-552.6
Benin	2023.4	1960.1	63.3	1521.9	438.2	1790.3	-268.4	2049.7	-259.4
Warri	2138.4	2206.4	-68.0	1593.6	612.8	1978.6	-385.0	2494.6	-516.0
Yenagoa	3204.7	2880.4	324.3	2097.2	783.1	2480.1	-382.9	2874.2	-394.1
Port Harcourt	3157.2	2742.2	415.0	2050.3	691.9	2457.9	-407.6	2758.1	-300.1
Uyo	3093.4	2851.9	241.5	2970.5	-118.7	2783.3	187.2	2905.3	-122.0
Calabar	3093.4	2851.9	241.5	2970.5	-118.7	2783.3	187.2	2905.3	-122.0
Owerri	2317.7	2247.0	70.7	1612.6	634.4	1924.3	-311.7	2156.4	-232.1
Umuahia	2092.5	2047.1	45.4	1704.4	342.8	1751.8	-47.5	1725.0	26.9

Source: NiMet , (2021).

The analysis of changes in rainfall distribution across different decades in the Niger Delta is presented in Table 3. Akure recorded a sharp reduction in the volume of rainfall from the years between 1981/1990 and 1991/2000 with 170.9mm reduction in volume. Port Harcourt recorded more reduction with 415mm, while Umuahia recorded 45.4mm reduction in the volume of rainfall between the two decades. All the cities in the region showed a significant reduction in the volume of rainfall from 19881/1990 to 1991/2000. It is evident that previous reports on the significant reduction in the volume of rainfall in 2021 as compared to what obtained in 1981 is valid. For instance, Yenagoa, Port-Harcourt, Uyo and Calabar that recorded over 3000mm of rainfall in 1981 had a decline of below 3000mm in 2021 in the region.

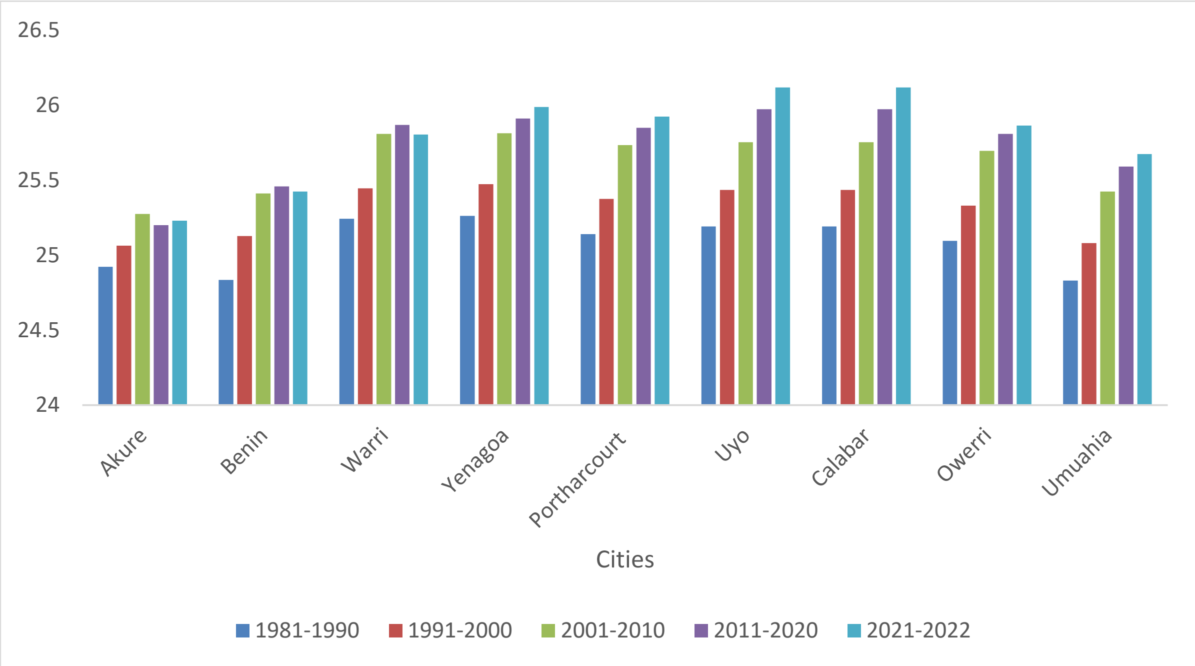

Figure 2: Decadal temperature distribution in the Niger Delta Region
Source: NiMet , (2021).

The analysis of variation of temperature characteristics in different decades is presented in figure 2. The city of Akure recorded the lowest temperature in the region. Dual peak of temperature was recorded in two cities such as Uyo and Calabar. It is common across all the cities in the region that temperature varies across different years, and in different decades under investigation.

Table 4: Decadal change in the temperature distribution across the Niger Delta Region

	1981-1990	1991-2000	Detected change	2001-2010	Detected change	2011-2020	Detected change	2021-2022	Detected change
Akure	24.9	25.1	-0.1	25.3	-0.2	25.2	0.1	25.2	0.0
Benin	24.8	25.1	-0.3	25.4	-0.3	25.5	0.0	25.4	0.0
Warri	25.2	25.4	-0.2	25.8	-0.4	25.9	-0.1	25.8	0.1
Yenagoa	25.3	25.5	-0.2	25.8	-0.3	25.9	-0.1	26.0	-0.1
Port Harcourt	25.1	25.4	-0.2	25.7	-0.4	25.9	-0.1	25.9	-0.1
Uyo	25.2	25.4	-0.2	25.8	-0.3	26.0	-0.2	26.1	-0.1
Calabar	25.2	25.4	-0.2	25.8	-0.3	26.0	-0.2	26.1	-0.1
Owerri	25.1	25.3	-0.2	25.7	-0.4	25.8	-0.1	25.9	-0.1
Umuahia	24.8	25.1	-0.3	25.4	-0.3	25.6	-0.2	25.7	-0.1

Source: NiMet , (2021).

The analysis of the decadal changes in the temperature distribution across the Niger Delta region is presented in table 4. All the cities in the region showed a significant rise in temperature from what obtained in 1981 to the case in 2022 which is consistent with previous reports on rising temperature in the regions.

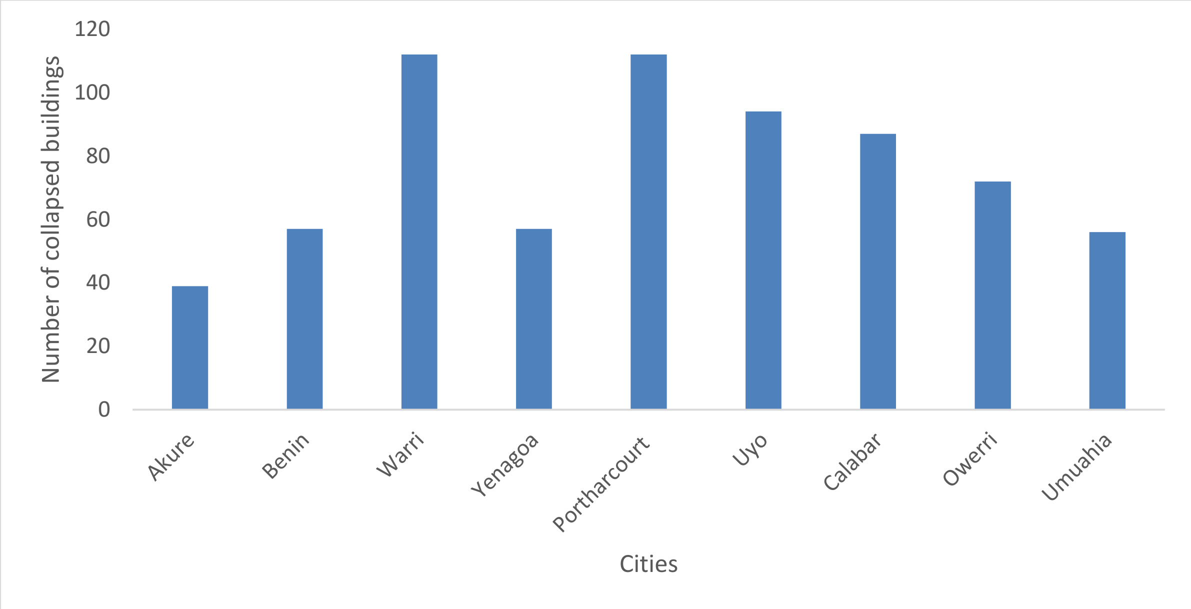

Figure 4: Spatial distribution of collapsed building across the Niger Delta Region

The variation in the distribution of building collapse in the Niger Delta region is presented in figure 4.. It is evident that Warri and Port Harcourt recorded that highest number of collapsed buildings in the regions the average of 100 housing. This is consistent with the location of Warri in the coastal part of the region and the influences of windstorms influenced by the cT and the mT air masses. The frequency and intensity of rainfall in the region (especially at the peak rain months of June, July, and August) can be adduced to why the two cities have recorded the highest amount of building collapsed. Akure and Benin recorded the lowest amount of collapsed building in the region and this is adducible to the reduction in wind storms from the tropical maritime as you proceed into the hinterland climatic belt in the region, also the effects of the cT is reduced in the hinterland climate belt. The reduction in the amount of rainfall in Akure and Benin in recent decades can also be linked to why the two cities recorded reduced amount of building collapsed in the region. Other cities such as Umuahia, Owerri, Uyo and Calabar have also recorded considerable number of building collapsed, but curiously, the case of Yenagoa showed significant variation with that of Port Harcourt that have close proximity and similar microclimatic characteristics. This could be linked to the aerial extent of both states, differences in housing development and population size of the two places.

The climate situation in the study area : The climate situation in the Niger Delta region has shown a significant shift within the period under investigation from 1981-2022. The study revealed marked similarity in the micro climatic parameters such as rainfall and temperature across all the sampled cities in the nine states of the region. There is decadal, yearly and monthly variation in the temperature and rainfall across region, and it showed a marked reduction of the amount of rainfall after the year 2001. The period between 1981 and 2000 recorded the highest amount of rainfall in the region. But the case is different for temperature where all the states recorded significant increase in temperature from the year 2000 to 2021. In terms of the monthly distribution of temperature and rainfall in the region, there is a reflection of the influences of the cT and mT. It is reported in all the states that rainfall is low in January, February, march, October, November and December which are the dry season months. All the states also showed remarkable increase in rainfall from the month of April to September. The city sampled also showed that the rainy season in the region records dual peak of rainfall which is reported before and after the hiatus. Many of the states showed that the hiatus, which is the little dry spell during the rainy season is more prevalent in august but there are some states with exceptions where the hiatus occurred in July. It was evident that rainfall and volume reduced significantly during the hiatus in the region. Outcome of this study is consistent with previous studies in the literature, for instance Agho & Uyigue (2007) that the location of the Niger Delta region of the world makes it highly vulnerable to flooding. Flooding in the region is not only caused by the many river crisscrossing the region and rise in sea level, the intensity and frequency of rainfall over the decades contributes enormously to cases of flooding in the region. Different studies have linked the nature of climate and the location of the Niger Delta to diverse environment al and socioeconomic problems, but there is currently no existing documentation of climate on building collapse in the region. Uyigue & Agho (2007) linked the occurrence of flooding and coastal erosion to climate events in the Niger delta region. Okon & Egbon (1990) show rise in sea level occasioned by rainfall in the Niger delta region, flooding in low lying areas in the region was also observed. The implication is that flooding and coastal erosion poses severe danger for vulnerable communities. Climate change would cause increase in aridity and desert encroachment in the northern part of Nigeria, but the case of the Niger Delta would manifest in flooding and erosion. They also reported that the case of Egor and Ogida communities in Edo state where several housing have collapsed and abandoned by the owners due to flooding where flood is never anticipated. The persistence of below mean rainfall in the last two decades in the Niger Delta is an indication of an abrupt change in climate, other studies have reported that climate change would create uncertainties in rainfall pattern, and the time and amount of rainfall. In terms of temperature, previous studies have recognized the rising temperature in the region which could be linked to gas flaring activities and the global warning across the world. Other human activities have also reported increase in concrete and dark surfaces as a cause of rising temperature in the urban areas in the region. Some 45.8 billion kilowatts of heat are revealed into the atmosphere in the region given the over 123 flaring sites that flares gas daily. The searing heat from the flare stacks have been reported as a major contributor to rise in temperature. gas flaring has also been linked to acid rain by Odjugo (2008), other studies have reported that acidification of rain water that falls on building roofs causes defects and corrosion, but the economic implications on the people is not reported.

Eronmhonsele & Erhabor (2021) deployed across sectional description survey design to investigate the nexus between climate change and socioeconomic activities in the Niger Delta region. They reported rising temperature in the region, and adduced it to the global warming, however, from a microclimatic perspective. They recognized the industrial activities and the decades of gas flaring as major contributors to warming in the region. According to them, 75% of the total gas production in the region is flared off into the atmosphere, and this amount to 70 million cubic meters of gas flaring and 75 million of carbon dioxide in the region. Nigeria accounts for 17.2% of global flaring and virtually all the cases are in the Niger delta region. Expectedly the effects of flaring gases on temperature cannot be underwritten, but the micro effects have not been sufficiently documented in the literature. Due to the low efficiency of the gas flaring incidences in the region, much of the gas is released as methane which has very high warming potential than CO_2. Other studies have recognized sea level rise in the region, shift in rainfall pattern and destruction of properties. Eronmhonsele & Erhabor (2021) reported that there is reduced amount of rainfall in some communities in the Niger Delta region in recent years which is consistent with what is reported in this study, but the potency of rainfall to cause severe and irrecoverable damages to properties have not changed in the regions.

Table 5: Multiple regressions models for the relationships between temperature, rainfall and cases of building collapse in the Niger Delta Region.

Model Summary

Cities	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
Akure	.559[a]	.312	.277	.82698	.312	8.857	2	39	.001
Benin	.051[a]	.003	-.050	1.11960	.003	.049	2	38	.952
Warri	.215[a]	.046	-.003	2.09444	.046	.941	2	39	.399
Yenagoa	.628[a]	.395	.364	1.02470	.395	12.710	2	39	.000
Port Harcourt	.499[a]	.249	.211	1.43130	.249	6.470	2	39	.004
Uyo	.384[a]	.148	.104	2.17466	.148	3.380	2	39	.044
Calabar	.073[a]	.005	-.046	1.43543	.005	.104	2	39	.902
Owerri	.513[a]	.263	.225	1.54515	.263	6.947	2	39	.003
Umuahia	.441[a]	.195	.153	1.13006	.195	4.710	2	39	.015

a. Predictors: (Constant), Temperature, Rainfall

The analysis of the relationship between temperature, rainfall and cases of building collapse is presented in Table 5. it is evident from the multiple regression model that that is a positive relationship between rainfall, temperature and building collapse, this connotes that the two climate parameters influences the trend, magnitude and severity of building collapse in the Niger Delta region.

However, the model showed variation in the correlation values across different cities.The multiple regression model analysis for Akure (sig. F= 001) suggest that there is a positive relationship between temperature, rainfall and cases of building collapse, the relationship is positive in Benin (sig. F= 0.952), Warri (sig. F= 0.399), Yenagoa (sig. F= 0.00), Port Harcourt (sig.F= 0.004). The case of Warri show a positive relationship between building collapse, rainfall and temperature (sig. F= 0.399), Yenagoa show positive correlation (sig. F= 0.00), Port-Harcourt show positive relationship (sig.F= 0.004), Uyo show positive relationship (sig.F= 0.044), Calabar (sig.F= 0.902), Owerri (sig.F= 0.003), and Umuahia (sig. F= 0.015). The implication of the outcome of the multiple regression analysis is that the influence of rainfall and temperature on building collapse in the region is significant. However, there is a variation across different sampled cities due to differences in the amount of rainfall and characteristics of temperature.

IV. CONCLUSION AND RECOMMENDATIONS

It is obvious that climate crises have intensified and extreme weather events become sporadic; thus buildings in the Niger Delta region are increasingly exposed to defects and damages. It was evident that the decades before the year 2000 recorded the highest amount of rainfall in the region. All the sampled cities showed dual peak of rainfall before and after the little dry spell in the region. Curiously, in spite of the slight reduction in rainfall and significant increase in temperature, the manifestations of climate change such as flooding and coastal erosion have remained unchanged. The implications are dire as there is empirical documentation on rising temperature. Beyond rise in temperature, there is a global distortion in the volume, intensity and frequency of rainfall. The case of the Niger Delta has shown significant reduction in rainfall in the past decade. This study focused specifically on temperature and rainfall as influencers of building defects and collapse in the region, and the outcome of statistical analysis revealed that building collapse is heavily linked to climate events. Therefore, this study concludes that the exposure of the built environment to climate events is inevitable given that climate change is a global environmental malady. But the localized impacts on buildings and the people can be minimized through the implementation of adaptive and mitigation strategies. Consequently, use of climate resilient materials in building construction, flood prediction and early warning, timely relocation of residents in coastal communities before imminent flood to reduce the losses of life and properties to flood and sensitization and public warning of consequences changing climate characteristics were recommended for immediate action.

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