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EFFECTS OF CLIMATE CHANGE ON BUILDINGS IN ONDO STATE

Ajayi babatunde Francis [1]
[1]Adeyemi College of Education, Ondo
Okolie Kelvin Chucks[2]
[2]Nnamdi Azikiwe University, Awka Anambra State

Abstract
Climate change is a global phenomenon and its effects on buildings and the environment is devastating. In order to understand why the climate, change, it is important to understand the structure of the atmosphere. Ondo State as the study area, has two distinct seasons, the raining and the dry season. The raining season which runs between April and October and the dry season between November and March of every year.
The aim of the research work therefore is to examine the climate, causes of climate change and effects of climate change on buildings in the study area with a view to suggesting mitigating strategies against the effects of climate change on buildings. The study adopted extensive review of literature, used the mixed method/approach in obtaining both quantitative and qualitative data to meet the objectives of the study. Data collection instruments used included, structured close ended questionnaires and open-ended questions for interviews conducted on selected professionals and focus groups. The data analysis was done using statistical tools such as percentiles, mean score, Cochran return sample size formulae and the Analysis of Variance (ANOVA) used for the tests of hypotheses. The analysis revealed that there is evidence of climate change .and the effects of climate change on buildings in the study area is significant while the major factor contributing to the causes of climate change is anthropogenic due to bush and fossil fuel burning. The study also identified mitigating and adaptation strategies such as green building technology, use of high resilient and sustainable materials for construction of buildings in the study area while acknowledging the green building concept as the most effective strategy to reduce the effects of climate change on buildings in Ondo state. Because of the immense benefit derivable from the green building concept, the study recommended continuous enlightenment, of the public on the need to embrace green practices, while government should create a Green Building Assessment Unit in the Urban and Planning Department of Ministries of Works and Housing to promote, and monitor the implementation and enforcement of green practices in Ondo State (the study area) while encouraging house owners to embrace green practices by providing incentives such as rebate on tenement rates .

Keywords: Climate, Climate Change, Mitigate, Effects Green building.

Introduction

The United Nations on Environmental programme (UNEP (2000) described climate change as an extreme reaction of weather phenomenon which crates negative impact on agricultural resources, human health, depletion of ozone layer, vegetation, soil and doubling the carbon dioxide (C02) in the atmosphere. In order to understand why the climate change, what constitute the climate should be examined and understood. Meteorologists has affirmed that the atmosphere is divided into layers based on temperature and zones of temperature changes (Oloyede, Akinloye & Adeniyi, 2018). The layers consist of troposphere, stratosphere, mesosphere and thermosphere. The earth atmosphere is a complex fluid system of gases and suspended particles which did not have its origin in the beginning of the planet. The atmosphere as at today has been derived from the earth itself by chemical and biochemical reactions. These can be defined as the earth atmosphere interface and space interface. Climate varies because of the mechanism that give rise to climate. Climate depends on the nature of the general circulation of the atmosphere of the atmosphere which is determined by a complexity of factors processes that constitute the global climate system. According to Oloyede, Olaoye & Adeniyi (2018), the prominent and permanent feature of the world's climates today is change. The negative effects of climate change on buildings ranging from dampness, damaged roofs corroded roof, exposed foundation to collapsed building are all common features on buildings in Ondo State. Broadly speaking, climate change causes are attributed to bio-geographical (natural) and

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anthropogenic (man-made) factors. Bio geographical factors are due to orbit variation, volcanism ocean variability, solar radiation and plate tectonics while anthropogenic factors, due to human activities such as construction, transportation, farming, burning of fossil fuel industrialization and urbanization. These activities increase the concentration of Green House Gases (GHGs) referred to as forcing climate change gases in the atmosphere. The effects of the concentration of Green House Gases or forcing climate change gases is a global threat. While the effects due to bio-geographical factors may not be pronounced in the study area, anthropogenic factors being human activities for their daily survival is inevitably pronounced.
The impact of human activities increase the incidences of climate change with its resultant effects such as flooding or corrosive roofs, exposed foundation, damaged or blown roofs, structural failure, dampness, on walls ,and collapsed buildings. . Most of the towns and cities in Ondo State, the study area are ancient and densely populated with their hubs not well planned. The vulnerability of these areas to the negative effects of climate change is a serious source of concern, Unlike in the past when people of the area had the notion that climate change is an issue of developed and industrialized world, recent events and occurrences have changed that perception Despite the precarious situation due to the effects of climate change on buildings in the study area , little or no data on how to mitigate the effects are not available hence the need to examine the climate, climate change, its causes, effects on buildings and ways to mitigate the effects.
This research work is therefore imperative as it examines the climate, climate change and identifies the factors responsible for causing climate change with a view to suggesting ways to mitigate the negative effects of climate change on buildings in Ondo State. The focus will be the effects of climate change on residential buildings which are more in number and mostly affected.

Literature Review
Climate Change
Climate change is a major problem caused by the increase in human activities carried out for his survival. Beyioku (2016), likened these activities and actions to human mismanagement of the earth which has several direct and indirect impacts on health and infrastructures.
For a better understanding of the factors responsible for climate change it is expedient to understand the structure of the atmosphere. According to meteorologists, atmosphere has been sub-divided into layers based on temperature and zones of temperature changes.
The layers consist of the troposphere, stratosphere, mesosphere and thermosphere. The earth's atmosphere which is a complex fluid of gases and suspended particles did not have its origin from the beginning of the planet. Ayodele et al (2018).The atmosphere as of today has been derived from the earth itself by chemical and biochemical reactions. These can be defined as the earth atmosphere interface and space interface.
Gases like nitrogen, oxygen, argon, carbon dioxide and water vapour etc. make up the total volume of atmosphere. Together with suspended particles such as dust and soot constitute the gaseous turbidity in troposphere. Out of all the layers that form the atmosphere viz: troposphere, stratosphere, mesosphere, thermosphere and ozone layer which is the region of concentration of the ozone molecule (0_3) in the earth's atmosphere sits at an attitude of about10-50 kilometres. The Ozone layer shield the earth's life from the harmful effects of the sun's ultraviolet radiation. Ozone therefore can be classified as natural and man-made house gas. A reduction in concentration of ozone layer can lead to cooling of the earth's statoscope and some surface climatic effects, lead to the incidences of skin cancer and adverse impacts on crops and animals.

The climate state of a place at any given period is determined by three factors (Ologunorisa, 2018), such as;
i. The amount of solar energy received by the climate system
ii. The way the energy is distributed and absolved over the earth's surface depending on earth's atmosphere composition, its topography, .extent of the snow cover and the distribution of continents and oceans.
iii. The nature of the interaction processes between the components making up the global climate system.
Besides, disasters associated with natural hazards such as flood, cyclone, earthquake, tsunami, volcanoes, land slide and drought the most recent increase in atmospheric concentration of Green House Gases (GHGS) and the harmful impact on human health is due to anthropogenic factors (man-made).
Green House Gases (GHGs) such as water vapour, introns oxide (N_20), methane (CH_4), carbon dioxide ($C0_2$) referred to as "forcing climate change gases" are gases that block heat from escaping, long lives gases that remain semi-permanent in the atmosphere and do not respond physically and chemically to change in temperature (NASA 2019). Most of the towns and cities in Ondo State, the study area are ancient and densely populated with their

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hubs not well planned. The vulnerability of these areas to the negative effects of climate change is a serious source of concern, Despite the precarious situation due to the effects of climate change on buildings in the study area, little or no data on how to mitigate the effects are not available hence this study which examines climate change, its causes, effects on buildings and ways to mitigate the effects.

Climatic Conditions and Causes of Climate Change in Ondo State

The climate in Ondo state is tropical with two distinct seasons, the raining and the dry season. The raining season runs between April and October and the dry season between November and March of the year. The average annual temperature is34.0°C (93.2° F) and March has the hottest day on average. Ondo is on an elevation of253.23metres above the sea level and has a tropical wet, dry or savannah climate. The city's yearly temperature is 28.42° C. Ondo receives about 182.94mmof precipitation and has 267raining days which is 73% of the time annually. There are clear evidences of changes in the above statistics over some years now and the climate exhibiting various features climate change with shorter raining season and longer dry season, heavy storm, change in wind directions, and rise in sea level leading to negative impacts on buildings such as damaged roof, corrosive roofs, exposed foundation, damped walls and uncomfortable interiors due to either excessive heat or cold.

Human activities in urban and industrialized nations have been identified to account for 60% of the global industrial carbon dioxide emission. Seychelles (2001) affirmed that industrialized countries account for 80% of the carbon build up in the atmosphere to date. Similarly, Odjugo (2010), agreed that developed nations emit 75% of the GHGs into the atmosphere with dire consequences on the environment.

The negative environmental impact of human activities such as transportation, construction carried out to meet daily needs are major factors exerting pressure on the environment, (Adegbile, 2013), agreed that construction account for significant volume of GHGs emission to the atmosphere. While anthropogenic factors are attributed to human activities such as construction, urbanization, burning of fossil fuel, transportation, and bush burning (Ede, Kolapo and Opeyemi, 2013). As an agrarian society, anthropogenic factors such as construction, transportation, farming, bush burning, and burning of fossil fuel are the major causes of climate change in Ondo state. These human activities have increased the emission of Green House Gases (GHGs) into the atmosphere. Virtually all the towns in the study area had experienced various degrees of devastation from flooding, erosion, windstorm, acid rain, bush fire, fading or corrosive roofs, exposed foundation, damaged roof, structural failure, stained walls, dampness and collapsed buildings. Left over rubbles of burnt or collapsed buildings are common physical features in the study area

Effects of Climate Change on Buildings in Ondo State, Nigeria

The effects of Climate change has become visible globally and in Nigeria. There are several impacts of Climate Change on buildings and human health in Nigeria and Ondo State. Odjugo (2011), opined that Nigeria temperature had been on the increase .which became so rapid since the early 1970s.

The study also established that rainfall pattern in Nigeria has shown a declining trend. The increasing temperature and the decreasing rainfall are basic feature of global warming. Coastal erosion and short term weather related issues such as high winds and flooding are common features in Communities such as Ilaje,Ese Odo, Okitipupa,of Ondo State. These weather related issues influences the choice of site, construction; building technique and material for construction. The potential risk of severe weather and climate condition also influence planning and project completion timeline in the study area

Rudiapan (2012), examined the danger faced by the people living along the coastline due to erratic and unpredictable weather conditions, sea erosion, reduction in the natural protective system in form of decline mangrove, and the fast advancing Sahara desert at an average of 600 meters per year with its effect on nearly 60 million people on account of loss of 0.4million hectares of farm land due to desertification..

Climate change and buildings has an intertwined relationship, as buildings may contribute to climate change and buildings are also vulnerable to climate change. Buildings are vulnerable to climate change because all the indicators of climate change such as flood, extreme wind, acid rain, bush fire, extreme temperatures, tropical cyclones, extreme rainfall, sea level rise, ultraviolet (uv) radiation changes, solar radiation, wind direction changes have adverse effects on the effective functionality of buildings.

Human being cannot but build, because buildings provide shelter which is a very essential need of man for survival, how to ensure that the design concepts and construction activities do not compromise the ability of future generations in achieving human needs should therefore be of great concern. It is imperative to understand the

impacts and effects of climate change or buildings in order to determine the process of deciding on new strategies and technology that would mitigate the effects of climate change on buildings.

Buildings are vulnerable to climate change. Climate change brings about increase risk of building collapse, declining health and significant loss of value as a result of more storms, water encroachment, deteriorating indoor climate and reduced building life-time. (Ministry of Environment and Foods of Denmark/ Environmental Protection Agency, 2012). In the same vein, increase in ground water level could lead to increased risk of erosion. Storm will constitute a safety risk, more and longer-lasting heat waves could have health related consequences especially on the elderly and the weak.
According to Brain (2012), the building envelope is particularly vulnerable to changes in climatic conditions, for instance, 25% increase in peak wind gusts could lead to a significant increase in damage caused by wind borne debris and wind loading in excess of the design loads. Cities and towns such as Akure, Okitipupa, Owo Ikare in the study area, with high density of property, people and services are more vulnerable when extreme weather or natural disasters strike. He further identified some environmentally induced factors which may have direct impacts on buildings to Include:

(i) A higher solar intensity resulting from exterior and interstitial surface temperature and for the exposed components, higher levels of UV and resultant damage
(ii) A shift in the type, form, pattern and intensity of precipitations. This can increase the number of times components may experience wetting and drying and increased frost penetration.as can be noticed on buildings in Ondo state
(iii) Shifts in the peak and frequency in high humidity levels
(iv) Changes in seasonal range temperature combined with increased frequency and longevity of heat waves or cold snaps
(v) Increased frequency and intensity of wind and flooding events which has displaced some communities along the coastal areas of Ondo state.

These changes in temperature, moisture levels and precipitation can lead to dimensional changes of material which can in turn lead to cracking, fissuring in polymer-based materials such as vinyl cladding, window frames, sealants and gaskets.(Ajayi el al 2023)
Other climate change factors including increase in dust, particulate matter, smoke and acid rain can also have significant implication on buildings. Beside the effects of Ultra-Violet (UV) radiation, Mechanical agents such as wind driven dust or rain can contribute to premature/ accelerated deterioration. Biological agents carried by the atmosphere can deposit fungi or moulds on surfaces while chemical agents transported by atmospheric moisture (e.g rain or water vapour) or direct deposition can lead to corrosion in metals, or deterioration of concrete, stone, fenestration components as well as roofing and cladding components.
In Nigeria and the study area of Ondo State, inhabitants are already heavily hit by flooding, ill health, displacement, , windstorm, water logging, swamp, deforestation, pollution, and increase in heat causing excessive dryness. All these have both direct and indirect impacts on buildings in the study area.

Mitigating the Effects of Climate Change in Ondo State
Mitigation involves directly reducing buildings energy use, especially the amount of carbon based energy that buildings utilize that directly contribute to greenhouse gas emission. Mitigation also involves selecting land for buildings to minimize the demand for carbon based transportation and the energy used to construct urban infrastructure. Mitigation is also achieved by increasing the capacity of carbon soaks e.g. through reforestation. According to the IPCC's 2014 assessment report, "mitigation is a public good, climate change is a case of the tragedy of the commons". Buildings and land development are vulnerable to the effects of climate change and mitigation can be adopted to minimize the vulnerability.
Nigeria is one of the countries adjudged to be vulnerable to negative effects of climate change. This, Iroye (2013), adduced to her low level of economic development induced by high poverty rate. The option left in view of this weak adaptive capacity in addressing the challenges of climate change rest in mitigation response strategies to climate change. Ologunlorisa (2015), observed that despite the vulnerability of Nigeria and the study area to issues of flood, ocean surges desertification and other climate change induced disaster, very little has been achieved in the area of adaptation hence he suggested the following adaptation options

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(i) Protecting the resources in the coastal areas by constructing Dams, creating wetlands, Designing new building codes. Protecting threatened ecosystem, planning retreat for rising sea and enacting regulations against new coastal development.

(ii) Building responses capacity by improving weather and water resources management practices.
Confronting climate change through actions which focus on exclusively on addressing specific impacts e.g relocating communities.

In both developed and developing countries like Nigeria, sustainable and resilient buildings has been described as a convenient solution to challenges of climate change mitigation and adaptation to the impacts of climate change (Martins,Capillo, Meirovich & Navarette, 2013). According to the 2014 report of the United Nations Intergovernmental Panel on climate change, the heat trapping greenhouse gases that has driven recent global warming lingers in the atmosphere for hundreds of years will continue even if we stop emitting greenhouse gases today ,therefore the option left is to adapt responsive strategies. Responding to climate change involves two pronged approach: Reducing emission of and stabilizing the level of heat trapping, greenhouse gases in the atmosphere (Mitigation), Adapting to the climate change already in the pipeline (Adaptation.). Mitigation and adaptation concepts are hereunder discussed:

Mitigation Concept

Mitigation involves directly reducing buildings energy use, especially the amount of carbon based energy that buildings utilize that directly contribute to greenhouse gas emission. Mitigation also involves selecting land for buildings to minimize the demand for carbon based transportation and the energy used to construct urban infrastructure. Mitigation is also achieved by increasing the capacity of carbon soaks e.g. through reforestation. According to the IPCC's 2014 assessment report, "mitigation is a public good, climate change is a case of the tragedy of the commons". Buildings and land development are vulnerable to the effects of climate change and mitigation can be adopted to minimize the vulnerability.

Climate Change Mitigating Strategies

Samar, Ahmed & John (2020), identified three Broad Climate Change Mitigation Strategies to include Conventional Mitigation Approach, Negative Emission Technology or Carbon Dioxide Removal Method and Radiative forcing geology mining technologies.

Conventional Mitigation Approach

The Convectional Mitigation approach or (Negative Emission Technology) employs decarbonisation Techniques and Technologies that reduces carbon dioxide ($C0_2$), example is renewable energy, and fuel switching efficiency gains, nuclear power and carbon capture strange utilization. These technologies are well established and carry acceptable level of managed risk.

Negative Emission techniques (C)arbon Dioxide Removal Methods).

This set of techniques and methods have been recently proposed. They are potentially deployed to capture and sequester carbon dioxide ($C0_2$) from the atmosphere.

The main negative emission techniques widely used include bio energy, carbon capture, bio clear, enhanced weathering, direct air carbon capture, and strange ocean fertilization, ocean alkalinity, enhance direct soil carbon sequestration, afforestation and reforestation, wetland construction and restoration (Lawrence et al, 2013).

Radiactive Forcing Geoengineering

This approach revolves around the principle of altering the earth's radiation balance through the management of solar and terrestrial radiation.

The technique is referred to as radiative forcing geo- engineering technology and the main objective is temperature stabilization or reduction. Some of the technologies that are known include: stratospheric aerosol injective, marine sky brightening, cirrus cloud shining, space – based mirrors, surface bared brightening and various radiation management technologies.

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These techniques are at early trial stages and carry a lot of uncertainty and risk in terms of practical large scale deployment.
The study area is a low- tech zone hence most of the sophisticated technologies are not in use or common, only the conventional approach such as renewable energy, fuel switch and efficiency gain, carbon capture utilization are now becoming popular in the study area.

Adaptation
This consist the selection of construction materials and designs that reduce damage from flooding, and storms. The selection of building sites that is not prone to natural disasters is another adaptation strategy. This planning and design actions constitutes "resilient" development techniques that address the challenges of adaptation to climate change (Martins et al 2013).
Figure 2,1 shows how sustainable and resilient building contributes to mitigation and adaptation strategies

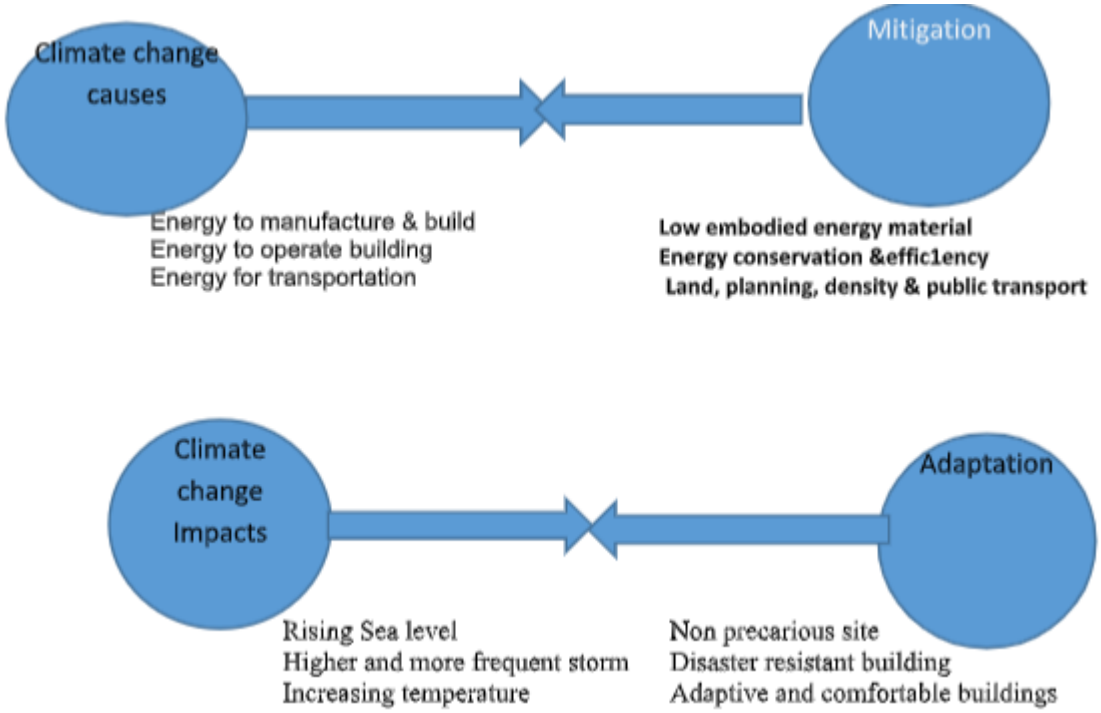

Fig 2.1 Climate Change effects and strategies in public Buildings
Source: Adopted from Martins et al (2013

Methodology
After an extensive review of relevant literature on issues surrounding climate change and its effects on buildings in the study area, the study adopted the mixed method approach where quantitative and qualitative data were collected via questionnaires to building owners, tenants and professionals in the built environment. The qualitative data were obtained through interviews using structured and open ended questionnaires. The size of the study population is huge and heterogeneous hence, the Cochan's sample size formulae was adopted to calculate the ideal sample size given a desired level of precision, desired confidence level and estimated proportion of the attributes present in the population. From the foregoing, the sample size of the respondents for this study is 384.
The targeted population for this study include professionals in the built environment, researchers in tertiary institutions, building owners and users within the three senatorial districts of Ondo State.400 questionnaires were distributed and 300 were returned out of which 150 respondents were professionals in the built environment such

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as Architect, Quantity Surveyors, Civil, Electrical Engineers, Builders and Estate Managers thereby giving well informed opinions on the subject matter.

The study population is drawn from six local governments, i.e two local governments per Senatorial area are adopted as shown in table 3.1.

Table 3.1 Selected local governments for study population

S/N	Local Government	Senatorial District	Population
1	Akoko North East	Ondo North	175,409
2	Owo	Ondo North	218,886
3	Ondo West	Ondo Central	283,672
4	Akure South	Ondo Central	353,211
5	Okitipupa	Ondo South	233,565
6	Ilaje	Ondo South	209,625
	Total		1,474,368

Source: NBS Census 2006

The six local governments are carefully selected across the three senatorial districts to disaggregate the population to urban, coastal, and rural areas. Okitipupa and Ilaje in the South are located in the riverine areas where ocean surge, incursion and other impacts of climate change are visible, Akure and Ondo West are the most Urban with industrialization in the increase while Owo and Akoko have erosion menace and symptoms of encroachment synonymous with the North.

Stratified Sampling technique was chosen for the research in a bid to have a good representation of each local government that form the population in the data collected. As earlier discussed the population of this study is large and heterogeneous, hence the choice of this technique .Akoko North East, Owo, Ondo West, Akure South, Okitipupa and Ilaje form the strata in which random sampling are applied within each local government and the target groups which include building Owners, Professionals, Tertiary Institutions, Ministries, Agencies and departments in the study area.

In addition to quantitative data collected through the administration of survey questionnaires , years of practice, academic qualification, professional qualification, type of dwelling, years of experience, involvement in informational development activities in the community and all roles being played to lay credence to collected data.

Under questionnaire survey, typical variables were identified and listed for respondent to evaluate. Close ended questions were easily asked and quick to answer (Fellow and Liu, 2008).

It requires no writing and their analysis straight forward. Likert-types scale on interval of 1 to 5 was used where 1 represent the least scoring and 5 the highest scoring while Likert type of scale of hypothesis was on interval of 0 to 5 respectively. In-depth interviews were conducted to obtain qualitative data from purposely selected interviewees, Experts and focus groups that had considerate potential skills and attributes of moderating of data rescoring which influenced data collected and also have capacity to proffer solution to open ended questions raised in the course of the interviews on issues relating to mitigating the effects of climate change on buildings in the study area.

The analysis of the collected data was carried out using descriptive and inferential statistical methods as appropriate. Percentiles and ANOVA, that is, Analysis of Variance using software package for social sciences (BMSPSS version 23)was used to analyse both Null and Alternative hypotheses at 5% level of significance to determine the means and univariate was employed for the analysis. The correlation table coefficients and the residual statistics is obtained from the output which is used for testing the hypotheses .ANOVA analysis would be employed to test the postulated Hypothesis which is to ascertain how significant the effects of climate change on building is. The level of significance at which the Hypothesis could be rejected or accepted was fixed at 0.05 (5% significance level)

Data Analysis

In order to have a balanced opinion and make researchable findings on the research topic, Effects of Climate Change on Buildings in Ondo state ,on buildings in Ondo State, oral interviews were conducted while structure questionnaires were administered to selected group including professionals in the built environment, home owners, and tenants relevant to the study.

This is to reconcile the literature review and desk researches with what is actually obtainable in practice.

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Four hundred (400) copies of questionnaires were distributed to the three senatorial districts of Ondo State but three hundred (300) copies were responded to and returned. These were found suitable and used for the analysis.

Table 4.1: Questionnaire Administration to Respondents and their Responses

Respondents	Distribution	Responses	% of Responses
Owners Occupier (non-professional)	100	80	80%
Tenants (non-professional)	100	70	70%
Professionals in Built Environment	200	150	75%
Total	400	300	75%

From Table 4.1, 75% of the Questionnaires sent out were returned. The total percentage of responses were used for the analysis. This indicates that the information reflected in the table covered the relevant shades of opinions and should therefore be regarded as representing a true picture of what is holding generally as far as this research work is concerned.

Table 4.2: Respondents' Academic Qualifications

Respondents Qualification	Distribution	Responses	% of Responses
ND/NCE		85	28%
BSC/HND		90	30%
MSc/MBA etc		85	28%
PhD		40	14%
Total		300	100%

Source: Field Survey (2020

Figure 4.2 Academic qualification of respondents

Table 4.2 shows the academic qualifications of respondents. And it shows that the highest number of respondents have HND/BSc, 28% have ND/NCE. 28% also have MSc/MBA while 14% of respondents have PhD. This shows that the respondents are educated and adequate to give informed opinions on the subject matter.

Table 4.3: Respondents' Professions (professionals in the built environment)

Respondents Profession	**Responses**	**% of Responses**
Architecture	20	13
Building	30	20
Quantity Surveying	30	20
Engineering	25	17
Surveying	15	10
Estate Management	30	20
Others	-	-
Total	150	100

Source: Field survey 2020

Figure 4.3 Professions of respondents

Figure 4.3 shows the spread of professionals in the built environment that responded, 20% are Builders, Estate Valuers and Quantity Surveyors,17%,are Engineers,13% Architects and !0% are Surveyors. This spread is adequate to give diverse and sound opinions on the subject matter.

Table 4.4: Experience of Professional Respondents in Construction

Range of Years	Mid-Point (X)	Frequency (f)	FX
0-5	2.5	20	50
6-10	8	25	200
11-15	13	35	455
16-20	18	50	900
Above 30	30	20	600
Total		150	2205

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Source: Field Survey 2020.

Mean age of professional respondents = $\frac{\sum fx}{\sum f} = \frac{2205}{150 - 14}$

Table 4.4 shows that the average years of experience of professional respondents is 14 years which means, they are experienced enough to give informed information and opinion on the subject matter.

Table 4.5: Age of Buildings

Range of Years	Mid-Point (X)	Frequency (f)	FX
0-5	2.5	40	100
6-10	8.0	40	320
11-15	13	40	528
16-20	18	45	810
21-25	23	40	920
26-30	28	50	1400
Above 30	30	45	1350
Total		300	5428

Source: Field Survey 2020

Average age of Building = $\frac{\sum fx = 5428}{\sum f \quad 300} = 18\text{years}$

Table 4.5 shows the age distribution of the buildings which gives the average age to be 18 years. This shows that the buildings have existed for reasonable number of years and would have experienced different impacts of the climate to form the basis for this research work.

Table 4.6: Types of Buildings

Type of Building	Responses	% of Responses
Residential	220	73.3%
School	-	-
Commercial	50	17%
Any Others	30	10%
Total	300	100%

Figure 4.6 Types of buildings

Table 4.6 shows that 73.3% of the respondents stay in residential building while 17% are in commercial and the remaining are others such as hotel and guest houses. The large percentage of residential is appropriate as the research work focuses on residential houses.

Table 4.7: Location of Respondents in the State

Respondents' Location	No. of Responses	% of Responses
Coastal Area	70	24
Central Area	130	43
Northern Area	100	33
Total	300	100%

Source: Researchers fieldwork 2020

Figure 4.7 Location of respondents

Table 4.7 shows that 24% of the respondents are in the coastal area, 43% in the Central while 33% are in the Northern area. The distribution gives a wide coverage of the types of climate experienced in the three geological zones of the state, hence effects of climate change in diverse dimensions are recorded and are suitable for the research work.

Contributing Factors to Climate Change in the Study Area

Table 4.8: Contributing Factors to Climate change.

	Contributing factors to climate change	Scores						
		4	3	2	1	Mean Score	% MS	Ranking
1	Orbit Variation	80	70	50	100	2.43	4th	

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2	Ocean Variability	150	25	50	25	2.67	4th
3	Solar Radiation	100	100	120	30	3.23	2nd
4	Urbanization	120	130	50	-	3.23	2nd
5	Bush Burning	100	100	150	50	3.0	1st
6	Pollution from Oil/Bitumen Explorations	150	50	50	50	3.0	3rd
	Transportation	150	50	30	20	2.8	4th

From table 4.8, respondents rated the suggested factors contributing to climate change occurrences in the study area using the following rating/scores: S.A = Strongly Agree (5), A = Agree (4), N.S = Not Sure (3), D = Disagree (1). This is to determine the major factors contributing to the causes of climate change and the respondents level of agreement with the identified variables.
From the analysis in able 4.8 and going by the rules of ranking ie Ms.>2.5 are significant it can then be deduced that bush burning, pollution from oil/bitumen exploration, transportation, solar radiation, ocean variability and orbit variation are all significant factors causing climate change.in the study area.
While bush burning ranked first of the factors contributing to climate change causes, followed by Urbanization, Solar radiation and pollution from oil exploration.

Table 4.10: Effects of Climate Change on Buildings

Effects of Climate Change on Buildings	Highly significant 4	Very significant 3	Significant 2	Not significant 1	Mean Score	Remarks
Bleaching of roof	200	50	40	10	3.5	1st
Roof damage/Blown off	150	50	50	50	3.0	3rd
Dampness on walls	100	80	50	70	3.4	2nd
Energy/Water Shortage	50	75	50	125	2.2	5th
Exposed foundation/erosion	150	55	45	10	2.9	4th
Poor/deteriorating indoor	180	50	50	20	3.3	

The identified effects of climate change on buildings in the study area were ranked to know the level of significance of the effects. Table 4.10 shows clearly that roof bleaching is the most significant effect followed by damaged roof and dampness on walls resulting in stained walls, walls covered with spirogyra and some vegetation and deteriorating indoor. This is also confirmed from interviews conducted via telephone conversations and short messages (SMS) where respondents emphasized the various causes of climate change. The literature reviewed the works of Udeyi (2010), Ojudgo (2011), Adeyemi K & Opeyemi J (2013), established the causes of climate change.
Ojudgo (2011,) further affirmed climate change is caused by natural (Bio geographical) and anthropogenic (Man-made) factors. These factors were broken down to Bio-geographical i.e Orbit variation, Volcanism, Ocean Variability Solar Radiation, Haze and Anthropogenic: Transportation, Bush Burning, Burning of fossil fuel, Industrialization, and Urbanization.
These factors were ranked by respondents in table 4.10 and from the opinions of respondents, bush burning has the mean score of 3.5 followed by pollution from oil exploration, followed by poor/deteriorating indoors. Complaints of very hot indoors during the dry season and extreme cold indoors during the harmattan season are rampant. Shortage of energy and water though noticed as occupants experienced dry up of wells and shortage of water during the dry season while wind storm and excessive rain disrupt energy supply during the raining season.

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Another significant effects on buildings is the flooding and erosion due to excessive rainfall. The flood erodes the soil around foundation thereby exposing and weakening it which threatens the stability of the building and sometimes lead to collapse of the building.

Testing of Hypothesis

H0: There is no significant effects of climate change on buildings in the study area.

$H_{1:}$ There is significant effects of climate change on buildings in the study area.

Decision rule: Reject the Null hypothesis if Fc>Ft

From the statistical table 4.10, the effects of climate change on buildings were identified and roof bleaching ranked first among the effects experienced on buildings in the study area, however this was further subjected to test whether these effects are significant. The analysis using SPSS version 23 brought out the ANOVA table in table4.11

Table 4.11. ANOVA table.

Table 4.11. ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	13969.843	3	4656.614	8.364	.109[b]
	Residual	1113.490	2	556.745		
	Total	15083.333	5			

a. Dependent Variable: Highly Significant

b. Predictors: (Constant), Not Significant, Significant, Very Significant

From the ANOVA table 6.12, Fc=8.364) while Ft at .10 degree of significance and at 3, 2 degree of freedom =9.34.

Decision: Since Ft (9.34) is greater than Fc (8.3640), the Null hypothesis which states that there is no significant effects of climate change on buildings in the study area is rejected while the alternative hypothesis which states that there is significant effects of climate change on buildings in the study area is accepted.

It can then be concluded that there is significant effects of climate change on buildings in the study area.

This supports the opinions expressed by respondents in table 4.10 roof bleaching, damage/blown off roofs were ranked as first and second effects of climate change on buildings in the study area.

Table 4.12: Strategy to Reduce the Effects of Climate Change on Buildings in Ondo State.

Strategies to reduce Effects of climate change on Buildings	Strongly Agree 5	Fairly Agree 4	Agree 3	Not sure 2	Not Agreed 1	Mean score
Mitigation	200	50	40	5	5	4.45
Adaptation	150	50	50	20	30	3,9

From table 4.12 respondents ranked to determine the most effective strategy to reduce the effects of climate change on buildings in the study area the suggested strategies used to reduce the ffects of climate change on buildings were ranked using the following rating/scores: S.A =Strongly, Agree (5) FA = Fairly Agree (4), A= Agree (3), N.S = Not Sure (2), NA = Not Agree (1). This is to determine the more effective strategy to adopt. From the analysis in able 4.12 and going by the rules of ranking ie Ms.>2.5 mitigation strategy has the higher mean score with adaptation ranked 2nd with a score of 3.9 .It can be concluded that respondents who are mainly professional in the built environment strongly agreed that mitigation is a more effective strategy to adopt in reducing the effects of climate change on buildings in the study area.

Conclusion

Climate change is a global phenomenon and its effects on the eco system and buildings cannot be over emphasized. This research work has identified, and examined the factors contributing to the causes of climate change, in the

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study area Seven factors which includes Orbit variation, Ocean variability, solar radiation urbanization Bush burning, Pollution from oil exploration and transportation were identified .Bush burning ranked first, while urbanization, pollution from oil/bitumen exploration ranked 2nd and 3rd respectively. Transportation, orbit variation and ocean variability followed in 4th 5th and 6th positions .The study also reveal there is significant effects of climate change on buildings in the study area. The effects ranges from bleaching roof, damaged roof, and dampness on walls ,exposed foundation, Energy /water shortage to poor and deteriorating indoors The analysis of the effects of climate change on buildings show that roof bleaching is the most prevalent ranking first, followed by roof damage and dampness which are also very common due to strong winds and excessive rainfall.in the study area. Having extensively reviewed the concept of green building, it is agreed that the concept is an eco- friendly, sustainable concept which can be a veritable tool to mitigate the effects of climate change on buildings in the study area. The study also revealed that green concept is a more effective strategy to reduce the effects of climate change on buildings than adaptation

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