Adopting Green Building Concept to Mitigate the Effects of Climate Change on Residential Buildings in Ondo State, Nigeria

Ajayi babatunde Francis[1], Okolie Kelvin Chucks[2], Ekekezie Charity.Uchenna[3]

[1]Directorate of Physical Planning, Works and Services,Adeyemi Federal University of Education, Ondo
[2]Department of Building, Nnamdi Azikiwe University, Awka Anambra State
[3]Department of Building, Enugu State University of Science and Technology Enugu

ABSTRACT: This study examined the causes and effects of climate change on buildings with a view to adopting the green Building Concept being a response strategy to mitigate the effects of climate change on buildings. Extensive review of literature and mixed method/approach were adopted to obtain data for the study. Questionnaire was used to elicit data for the study. 300 was the sample size for the study. 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 findings of the study revealed that there is significant effects of climate change on buildings in the study area and that Green building concept is beneficial in mitigating the effects of climate change on buildings. The benefits derivable from adopting the green building concept in mitigating the effects of climate change on buildings and the dwellers were identified. These benefits include social, cultural, Energy conservation and improved Indoor air for comfortable living. The study therefore recommends 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) and should also grant incentives to home owners in form of rebates on tenement payments to encourage embracing green practices among others.

KEYWORDS: Green building, Climate change, Mitigating, Residential building.

INTRODUCTION

The effects of climate change such as flooding, erosion, acid rain, excessive heat are visible on buildings in Ondo State. Virtually all the towns and cities have various degrees of devastation from flooding, erosion, windstorm, acid rain and bush fire. Fading or corrosive roofs, exposed foundation, damaged or brown roofs, structural failure, stained walls, and dampness. Left- over rubbles of burnt or collapsed buildings are common physical features on buildings in the study area. The study area is one of the states that has the coastal, forest and the Sahel regions making it vulnerable to negative effects of climate change in different forms. The coastal areas are prone to excessive flooding due to rise in sea level and heavy rainfall, the forest area has damages from windstorm and falling trees, dampness due to longer raining season while the Sahel has damages from strong windstorm, surface erosion and poor and uncomfortable interiors due to excessive heat. The vulnerability of these areas to the negative effects of climate change is high, hence a serious source of worry. Despite these precarious conditions of buildings in the study area and its attendant effects on the health of dwellers and the environment, very little research activities and data are available on the adoption of a sustainable concept such as the green building concept to mitigate the effects of climate change on buildings in the study area. This situation supports the views of Onyekuru and Marchant (2011), that the African built environment is bereft and rarely incorporate ingredients of green buildings that would enhance sustainability and resilient buildings to tackle climate change effects. It is therefore apt to suggest that research relating to the adoption of green building concept to mitigate the effects of climate change on buildings in Nigeria and the study area in particular is lacking.

Though Nduka` and Ogunsanmi (2014), also acknowledged some studies by Ameh, Isijiola & Achi 2007); Udechukwu and Johnson (2008), Nwoko and Onukwube (2011); Otegbulu and Waniko (2014), which focused on sustainability of public buildings, analysis of the effects of green design on environmental stability, including its implication and occupiers preference with respects to building components and their appreciation of green elements, the works only revealed that Nigerians are not green conscious in building design and Environmental Management.

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This was confirmed in Otegbulu (2011) and Waniko (2014), which affirmed that some buildings in Nigeria embody one of the various verifiable characteristics of green design but buildings with holistic approach are yet to be seen because professionals within the built environment are just aware of green building concept and its benefits, but little or poor implementation in building development process is visible. The National Building Code (2006), published to improve planning of the cities, curb incessant building collapse, fire infernos reduce quackery, use of substandard materials for construction and ensure maintenance of structures had little on green building concept incorporation from design to operation stage. This omission of this important aspect of sustainable building concept, is a huge gap at this auspicious period of climate change threat to the built environment. This research work aims at establishing the factors contributing to the causes of climate change, identify the effects of climate change on buildings with a view to adopting the green building concept as a tool to mitigate these effects. To achieve this, aim the following objectives would act as guide:

To establish the factors causing climate change in the study area

To identify the effects of climate change on buildings in the study area

To identify the factors militating against the adoption of green building concept.to mitigate the effects of climate change on buildings.

To determine the benefits of adopting green building conception mitigate effects of climate change on buildings

LITERATURE REVIEW

The negative effects of climate change on the built environment has become a source of worry to the global community. The World Bank report (2005), affirmed that 2.4 billion people, live in high risk disaster areas. According to the United Nation on Environmental Programme (UNEP) (2000), climate change is an extreme reaction of weather phenomenon which creates negative impact on agricultural resources, human health, vegetation, soil, depletion of ozone layer, and doubling the carbon dioxide (CO_2) in the atmosphere.

Odjugo (2011) describe climate change as the end product of a changing when the level of climatic deviation from normal is very significant over a long period of time and such deviation has clear and permanent impact on the ecosystem.

Factors Responsible for the Causes of Climate Change in the Study Area.

Climate change is caused by bio-geographical (natural) and anthropogenic (man-made) factors. The bio-geographical factors are due to orbit variation, volcanism, ocean variability, solar radiation and plate tectonics while anthropogenic factors are attributed to human activities such as construction, transportation, farming, burning of fossil Fuel, urbanization and industrialization (Ede, Kolapo & Opeyemi 2013).

Beside disasters associated with major natural hazards such as flood, cyclones, earthquake, Tsunami, volcanoes, landslides, and drought, the most recent increase in atmospheric concentration of Green House Gases (GHGs) and its harmful impact on human health is a global threat.

Green House Gases (GHGs) such as Water vapour, Nitrous oxide (N_2O), Methane (CH_4),Carbon dioxide (CO_2) referred to as "Forcing Climate Change gases" are gases that block heat from escaping, long lived gases that remain semi-permanent in the atmosphere and do not respond physically and chemically to changes in temperature.(NASA 2019)

Human activities in Urban and Industrialized nations have been identified to account for 60% of the global industrial carbon dioxide emission. Odjugo (2010), affirmed that developed nations emit 75% of the GHGs into the atmosphere with dire consequences on the environment.

The negative environmental impact of human activities carried out to meet daily needs such as construction activities, transportation, burning of fossil fuel etc. are major factors exerting pressure on the environment. Similarly construction activities account for significant volume of GHGs emitted to the atmosphere globally. These views supported the observation of Schmidt (2000), that building activities are responsible for approximately one-third of ecological disasters.

Climate change and buildings therefore has an intertwined relationship as buildings may contribute to climate change while they are also vulnerable to climate change. According to UN Habitat report (2009), buildings are vulnerable to climate change because all the indicators of climate change such as flood, extreme wind, acid rain, bush fire, extreme temperature, tropical cyclone, extreme rainfall, sea level rise, Ultra-Violet (UV) radiation changes, Solar radiation, wind direction changes and other adverse effects have huge consequences on the effective functionality of buildings.

Human beings cannot but build, how to ensure that the design concepts and construction activities do not compromise the ability of future generation in achieving human needs should be of great concern. According to Kolawole and Angboji (2005), the friendliest way to handle the environment is not to build, but without construction, life can be miserable and threatening, for

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shelter is needed among other things for protection against inclement weather and for healthy living. They therefore opined that what is needed is dynamic equilibrium, that is, a production process that is friendly to the ecosystem, yet competitive and possess no form of threat environmentally.

Effects of Climate Change on Buildings in Ondo State Nigeria

The effects of Climate change has become visible globally and in Nigeria. There are number of impacts of Climate Change on human health in Nigeria. In the opinion of Odjugo (2011), Nigeria temperature had been on the increase. The increase became so rapid since the early 1970s. He further observed that the mean temperature between 1971 and 2008 was 27.83 with a mean increase of $1.78^{\circ}C$ which is higher than the global increase of $0.74^{\circ}C$ since instrumental measurement started in 1960.

It has also been 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 drought, and short-term weather-related issues such as high winds and flooding which 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 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 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.

The study 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.

(iii) Shifts in the peak and frequency in high humility 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

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.

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.

The Concept of Green Building

Green or going Green has been defined differently depending on the aspect. According to Zugefun, (2008), Green can be used to reference how products are made or what make up a product. Green has also been interchangeable with sustainability in that by reducing the demand on natural resources, Society will be assured a place in the global future. The United States Environmental Protection Agency (USEPA) defined green building as the practice of creating structures and using processes that are environmentally responsible and resource- efficient throughout a building's life cycle from siting to design, construction, operation, maintenance, renovation and deconstruction (Howe, 2011).

The United States Green Building Council (USGBC) also described Green Building as a high performance building that is energy and water efficient, has good air quality, uses environmentally sustainable materials and also uses the building site in a sustainable manner.

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The World Building Council (2019), described green building as that which has its design, construction and operations reduce or eliminate negative impacts and can create positive impacts on our climate and natural environment. Green buildings preserve precious natural resources and improve quality of life. . For a building to be classified green, it must have the following features: Efficient use of energy, water and other resources, Use of renewable energy such as solar energy, pollution and waste reduction measures and enabling of re-use and recycling, good indoor environmental air quality, use of materials that are non-toxic, ethical and sustainable, consideration of the quality of life of occupants in design and operations and a design that enables adaptation to an enhancing environment.

The total idea of green building concept is therefore to fulfill human and societal wellbeing. It is one of the models created for global sustainability in the events of uncontrolled and continuous environmental degradation and unavoidable climate change impact in every facet of our society (Daramola, Adebayo and Afolabi, 2014). Abualrejal (2017), emphasized that Green building serves as the basis of sustainable construction development as it is a building that meets the prerequisite building performance standards, while diminishing the disruption to and enhancing the ecosystems in the native, provincial and universal circumstances. Additionally, green building also help to enhance resident's health through the design of a healthy interior environment.

Green concept focuses on the life cycle of buildings hence it is expected to have effects on building development process which entails the stages involved from the client's decision to build, through design, construction, completion and maintenance of the structure. The ability to make a building sustainable and resilient means that the buildings must be able to mitigate and adapt to climate change. The green building concepts captures these essence as it is also cost effective and achievable. For a building to become "Green," consideration must be given at each stage of the development process. The client must have the understanding of green building concept to be able to give his briefs, the designers must inculcate the green building concept during design while the constructor must ensure the construction method and the materials used are green and sustainable.

Benefits of Adopting Green Building Concept to Mitigate the Effects of Climate Change on Buildings

The total idea of green building concept is to fulfill human and societal wellbeing. It is one of the models created for global sustainability in the events of uncontrolled and continuous environmental degradation and unavoidable climate change impact in every facet of our society (Daramola, et al 2014).

The USGBC's purpose of creating the Leadership in Energy and Environmental Design (LEED) is to create a healthy work environment, build energy efficient buildings, and pursue sustainability and renewable energy (Alex Shim 2016). An average LEED certified building uses 32% less electricity and save 350metric tons of carbon dioxide emission annually.

Green concept focuses on the life cycle of buildings hence it is expected to have effects on building development process which entails the stages involved from the client's decision to build, through design, construction, completion and maintenance of the structure. According to Brahmanand (2012), green building design is rooted in an understanding of natural system and the behaviour of eco-systems which facilitates and preserves the relationship between nature and buildings. It encompasses the whole process of planning, design, construction, use and maintenance spanning the whole life cycle of the building.

Turcotte, Villareal & Bermingham (2006) and Billie 2012), in their separate studies identified and grouped the potential benefits of green building concepts into environmental, financial, social and cultural benefits.

Environmental Benefits of Green Building

The ability to make a building sustainable and resilient means that the buildings must be able to mitigate and adapt to climate change. Buildings consume a lot of natural resources which has a wide range of environmental impacts. These environmental concerns are driving forces behind the sustainable and green construction movement. The US Environmental. Protection Agency has indicated that buildings use 30% of the materials consumed in the US. This also applies to what is obtainable in Nigeria and the study area in view of the materials used for building construction such as concrete, steel, glass, clay, rock and other energy intensive materials. The process of their extractions and production depletes nonrenewable resources and has environmental effects. Qureshi (2018), examined the LEEDS 'certification for effective reduction in climate change and affirmed that the LEED certified buildings (i.e Green Buildings) play a key role in reducing the negative impacts of the built environment.

The LEEDs process addresses a structure's planning, design, construction, operations end-life as well as considering energy, water, indoor environment quality, materials selection and location. By adopting the green building concept, we can maximize both the economic and environmental performance. Most of the Countries that have embraced and adopted the green building concept have obviously benefitted and agreed it is the way forward in preserving resources and sustaining the environment (Al-Kaabi et al 2009). It is therefore imperative and in order to achieve significant benefits, for the design and construction team to adopt an integrated approach from the earliest stages of a building project.

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Indoor Environmental Quality (IEQ)

Indoor Environment Quality (IEQ) is the inside condition of the building. The different aspects of IEQ cover quality of air, daylight soothing acoustic and low usage of lighting and thermal conditions. Green building focuses on each aspect of IEQ that protects human health and improves quality of life.

Energy Efficient Construction

The concept of energy efficient, eco-friendly buildings has been more serving. The approach is becoming more popular in view of recent global warming occasioned by rising energy cost, scarce oil reserves, limited water supply and health concerns among others.

According to the WGBC, the planet seems to have run short of natural resources essential for our survival. Green construction includes the use of renewable energy such as solar, and wind therefore reducing artificial energy or light. The materials are less hazardous and perfectly fits with environmental-friendly standards.

Sustainable Materials Resources

Building construction use significant quantity of natural resources and materials. The building industry consumes 3 billion tons of raw materials annually (Bakens, 2003). In order to achieve sustainable construction and green building, the choice and selection of materials must focus on the goals of minimizing consumption and depletion of material resources, minimizing the life-cycle impact of materials on the environment, and minimize the impacts of materials on indoor environmental quality. To achieve these goals, much strategies can be applied such as the use of salvaged and remanufactured materials, use of recycled content products and materials, use of materials from renewable sources, use of locally manufactured materials, use of durable materials and materials that are reusable, recyclable or biodegradable (Grottfried, 1996).

Economics Benefits of Green Building

Several studies have suggested that green construction can result in significant economic savings by improving employee's productivity, increasing benefits from improvement in health and safety, and providing savings from energy, maintenance and operational costs (Ries 2007).

Dwacket (2018), examined the economic performance of green building in terms of energy Consumption. The investigation showed that green building saved 71.1% of energy compared to industry baseline. It also revealed that for 60 years green building saved 24,751,980 Kwh. In Kats (2003), the benefits of green buildings which includes cost savings from reduced energy, water, waste disposal, lower operations and maintenance, enhanced occupant productivity and health were ex-rayed. Apart from direct cost benefits, green buildings also provide economic benefits to both building owners and the society. Sustainable and green building features can promote better health, comfort, wellbeing and productivity of building occupants, which in turn reduces absenteeism, laziness and increase productivity that can translate into large financial benefits (Brahmanand, 2012). The society therefore tends to gain from lower risks, longer building lifetime, less time and lower costs of projects.

Social Benefits of Green Building

The social benefits of green infrastructures are related to improvement in the quality of life, health and wellbeing. The benefits derived from building green explained by Turcolt et al (2006), include enhanced occupant's comfort and health, heightened aesthetic qualities, minimized strain on local infrastructure which are linked with increased worker's productivity and health benefits It has been established that about 40% of all illness can be traced to the buildings and homes where people live, work, attend school church or sporting events. The sick building syndrome symptoms such as headache, fatigue, dizziness, irritation of skin, eyes nose and difficulty in breathing are drastically reduced in sustainable and green building.

Cultural Benefits

Beside maintaining the local environment in its original form or with little distortion, green technology make use of local materials, renewable energy, water harvesting, waste disposal in manners devoid of emitting GHGs to the environment. Building green minimizes materials impact through appropriate material choices (Nielson et al, 2009). Sammer (2013), agreed that there are benefits accruable from selection of appropriate technologies and choice of materials. Green building tends to sustain the environment, preserve cultural identity, minimize strain on local infrastructure and build fences around the natural environment to combat the impact of climate change.

METHODOLOGY

An extensive review of relevant literature on issues surrounding green building concept and effects of climate change on buildings was first undertaken. The methods of data collection for this research is mixed method approach where quantitative and

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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 was 384.

The targeted population for this study includes professionals in the built environment, researchers in tertiary institutions and 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.

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 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, rural and local 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 and in view of the large and heterogeneous, population of the study area.

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 in 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 analyze 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 was obtained from the output which was used for testing the hypotheses

To evaluate user's acceptance and adaptation of green building practices and establish factors that can contribute to acceptance, benefits of adopting Green Building concept, and factors inhibiting the adoption of green building concept, understanding and perception of users, mean score for each of the significant factors would be calculated and ranked using these formulae:

Mean Score $= \dfrac{X_1W_1+X_2W_2+X_3W_3+\text{-----------------}XnWn}{N}$

Where   W = Weight of answer choice

X = Response count for answer choice

N= Total number of respondents

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From the computation, most significant constraint factor in a sub-set was one with the highest mean score value. The factor having the average or higher value is considered significant as shown in equation 1 while the insignificant factors are identified using equation 2.

Significant Constraint Factor $= M_s > 2.5$----------- 1

Non-significant Constraint Factor $= M_s < 2.5$----------- 2

Where $1 < M_s < 5$ on 5-point Likert rating.

Based on the means score values of the constraints in a given set, the variables were ranked or rated.

Test of Hypotheses

The Hypothesis of this research would be put to null (Ho) and alternative (Hi) form respectively. Anova analysis would be employed to test the postulated hypotheses. The level of significance at which any of the Hypotheses could be rejected or accepted was fixed at 0.05 (5% significance level).

Validity and Reliability of the Instrument

The instrument especially the questionnaires were subjected to content validity test by distributing the questionnaires to key professionals in the field of study to validate the questions. The questionnaires were made sufficiently specific and designed to avoid ambiguity so as to maintain consistency.

DATA ANALYSIS AND FINDINGS

Data Collection

In order to have a balanced opinion and make researchable findings on the research topic, Adoption of Green Building Concept for mitigating the effects of climate change on buildings in Ondo State, the researcher conducted oral interviews and administered structure questionnaires to selected group including home owners, and professionals in the built environment such as Architect. Quantity Surveyors Builders Town and Regional Planners, Estate Managers and Land Surveyors that are considered relevant to the study. This is to reconcile the literature review and desk researches with what is actually obtainable in practice.

Administration of Questionnaires

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 2. 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 2, 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 3. 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

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Table 3 shows that the highest respondents have HND/BSc, 28% have ND/NCE. The same 28% have MSc/MBA while 14% of respondents have PhD. This shows that the respondents are educated and adequate to give informed opinion on the subject matter.

Table 4. 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

Table 4 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 5. 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

Source: Field Survey 2020.

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

Table 5 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 6. 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 = $\frac{\sum fx}{\sum f} = \frac{5428}{300}$ = 18years

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Table 6 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 7. Types of Buildings

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

Table 7 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 and the rating system developed is on residential homes.

Table 8. 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

Table 8 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 ihe Study Area

Table 9. Contributing Factors to Climate change.

	Contributing factors to climate change	Scores						
		4	3	2	1	Mean Score	% MS	Ranking
1	Bush burning	100	100	150`	50	3.4	1st	
2	Solar Radiation	100	100	120	30	3.23	2nd	
3	Ocean Variability	120	130	50	-	3.23	2nd	
4	Pollution from Oil/Bitumen exploration	150	50	50	50	3.0	3rd	
`6	Transportation	150	50	30	20	2.8	4th	
7	Urbanization	150	25	50	25	2,67	5th	
8	Orbit Variation	80	70	50	100	2.43	6th	

From table 9, 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 9 and going by the rules of ranking i.e Ms.>2.5 are significant it can then be deduced that bush burning, solar radiation, urbanization 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 Solar radiation ,Ocean variability, pollution from oil exploration, transportation, urbanization and orbit variation in that order.

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Table 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
Dampness on walls	100	80	50	70	3.4	2nd
Poor/deteriorating indoor	180	50	50	20	3.3	3rd
Roof damage/Blown off	150	50	50	50	3.0	4th
Exposed foundation/erosion	150	55	45	10	2.9	5th
Energy/water shortage	50	75	50	125	2.2	6th

The identified effects of climate change on buildings in the study area were ranked to know the level of significance of the effects in addressing objective No. 3 of the research work. Table 6.10 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. Deteriorating indoor too is significant ranking third. This is also confirmed from interviews conducted via telephone conversations and SMS where respondents emphasized the various causes of climate change in addressing objective number three of this research work. The literature reviewed the works of Udeyi (2010), Ojudgo (2011), Adeyemi K and Opeyemi J (2013) to establish the causes of climate change.

Ojudgo (2011) 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 4.12 and from the opinion of respondent's bush burning ranked first with a mean score of 3.5 followed by pollution from oil exploration. 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.

Another significant effect on buildings is the flooding and erosion due to excessive rainfall. The erosion 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.

Hypothesis 1
Ho There is no significant effects of climate change on buildings in the study area.
Decision rule: Reject the Null hypothesis if Fc>Ft
From the statistical table10, 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 table 6.12

Table 11. ANOVAª

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	13969.843	3	4656.614	8.364	.109b
	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.11, Fc=8.364) while Ft at .10 degree of signifance 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.

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This supports the opinions expressed by respondents in table .11 roof bleaching, damage/blown off roofs were ranked as first and second effects of climate change on buildings in the study area.

Table 12. Benefits Of Adopting Green Building Concept

S/No.	Benefits of Green Building Concept	Highly beneficial 4	Very beneficial 3	Beneficial 2	Not beneficial 1	Mean Score	Ranking
1.	Economic use of Energy/Water resources	150	100	30	20	3.3	2nd
2.	Reduction in Green Gasses Emission	100	100	50	50	2.8	4th
3.	Control of Flooding and reduced danger to foundation	50	200	35	15	1.6	5th
4.	Reduction in Acid rain that carried roof	150	100	50	-	3.3	2nd
5.	Improved indoor air for comfortable living	200	75	25	-	3.6	Ist

Mean Score = $\frac{\sum FX}{N}$

The objective No. 4 of the study is to determine the benefits of adopting green building Concept to mitigate the effects of climate change on buildings. The literature review identified the benefits of adopting Green Building Concept, Turcotte, Villarul & Bermigham (2012) and Billic (2012), identified and grouped the benefits of green building concepts into environmental, financial, social and cultural benefits.

These are further broken into Economic use of Energy and Water Resources, Reduction in green gasses, erosion control, flooding, and reduction in acid rain that corrodes roofs and improved indoor air for comfortable living. How beneficial the adoption of the green building concept in mitigating the effects of climate change on buildings in the study area was evaluated as shown in hypothesis number two.

From table 12, adoption of Green Building Concept is highly beneficial in ensuring improved indoor air condition with a mean score of 3.6 in the rating. This is followed by economic use of energy/water and reduction in effects of acid rain on roof. This is followed by reduction in green gas emission and control of erosion rated as beneficial and not beneficial respectively. Further clarification on how these factors is beneficial were made during oral interviews and opinions to support these ratings included the use of Green certified materials for electrical/plumbing installation and roofing materials which would have resistance to acid rain and the reduction of green gas emitting activities in the building while natural lighting and ventilation are improved by passive architecture etc.

The Objective no4 of this work is to examine the benefits of adopting the green building Concept in mitigating the effects of climate change on buildings in the study area. Based on the statistics in table 12 which was further analyzed using SPSS 23 the anova table 13 is used for testing hypothesis No2.

Ho Green Building concept is not beneficial and adoptable for mitigating the effects of climate change   ` buildings in the study area

H$_1$ Green Building concept is beneficial and adoptable for mitigating the effects of climate change on buildings in the study area.

Decision Rule: Reject Null hypothesis if Fc>Ft

From the statistic in table .13 and using SPSS 23 the Anova table6.14 is obtained for this analysis.

Table 13. ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	6998.571	3	2332.857	1633.000	.018[b]
	Residual	1.429	1	1.429		
	Total	7000.000	4			

a. Dependent Variable: Highly Beneficial

b. Predictors: (Constant), Not Beneficial, Very Beneficial, Moderately Beneficial

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From the ANOVA table 13, Fc=1633while Ft at .0.1 degree of signifance and at 3,1 degree of freedom =215.7.

Decision

Since Fc is greater than Ft, the Null hypothesis which states that Green Building is not beneficial and adoptable for mitigating the effects of change on buildings in the study area is rejected while the alternative hypothesis which states that Green Building concept is beneficial and adoptable for mitigating the effects of climate change on buildings in the study area is accepted.

It can therefore be concluded that green building concept is beneficial for mitigating the effects of climate change in the study area.

Table 14. Factors Militating Against the Adoption of Green Building Concept

S/N	Factors Militating against adopting Green Building Concept	SA 5	A 4	NS 3	D 2	SD 1	Mean score	Ranking
1	Economic/financial factor	150	50	30	50	20	3.5	1st
2	Sustainable site Energy	70	100	50	30	50	3.4	2nd
3	Market forces	100	50	40	60	50	3.3	3rd
4	Behavioural/Organization Constraints	100	50	50	50	50	3.3	4th
5	Lack of Awareness	60	50	110	50	30	3.2	5th
6	Effect of Water	50	100	50	50	20	3.2	6th
7	Cultural Barriers	50	100	20	50	80	3.0	7th

Source: Researcher's fieldwork 2020.

Table 14 shows the analysis of the factors militating against the adoption of green building concept in the study area, Economic and Financial factor ranked 1st with a mean score of 3.4 while sustainable energy, market forces ranked 2nd with a mean score of 3.4. Market forces, Organization constraints with a mean score of 3.3 ranked 3rd while Lack of awareness, Effect of water and cultural Barriers ranked 5th,6th and 7th respectively.

From this analysis, it can be justified that the major factors affecting the adoption of the concept in the study area are Economic/Financial, Sustainable energy, market forces and Cultural barriers which are in conformity with views of research works reviewed in the literature.

DISCUSSION OF FINDINGS

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 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 solar radiation ocean variability and, pollution from oil/bitumen exploration ranked 2nd and 3rd respectively .This analysis confirms the actual situation in the study area where pronounced heat ,sea incursion and air pollution are common in the study area. Transportation, urbanization and orbit variation in 4th 5th and 6th positions These factors were rated low as factors contributing to climate change in the study area.

The study also reveals 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. Despite the benefits derivable from the adoption of green building concept as a tool to mitigate the effects of climate change on buildings the study identified the factors militating against the use of the concept in the study area. The analysis in table 14 shows the ranking of the identified factors militating against the adoption of green building concept in Ondo State. Financial factor ranked first with a mean score of3.4 while cultural barriers and effect of water ranked 2nd with a mean score of 3.4.

From this analysis it can be deduced that the major factor affecting the adoption of green building concept is financial consideration. This tallies with the views expressed by most researchers that green concept require high initial cost.

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CONCLUSION

Based on the extensive review of relevant literature, coupled with the analysis and discussion of data gathered, It can be concluded that climate change is a reality and it is affecting buildings in Ondo state. This must stop otherwise the effects would be difficult to cope with. The best option left to arrest this ugly situation is to adopt a pragmatic and sustainable tool such as the Green Building Concept considering its benefits and recorded as the friendliest mitigating model available now.

RECOMMENDATIONS

Based on the research analysis and the conclusion already drawn, the following recommendations are proposed:

1. Continuous enlightenment of the public of the danger of climate change and the benefits of embracing Green and sustainable practices.
2. Government to create enabling environment and enact legislation or policies on green practices.
3. Governments should create a Green Building Assessment Unit in the Urban and Regional Planning Ministry who should be trained as Green Building Assessors/inspectors to monitor the implementation of green practices during pre, and post construction stages.
4. Government should put in place incentives in form of rebate and provision of some basic infrastructure for effective compliance with the green practice rules
5. Professionals in the built environment should take up training courses in green building assessment and certification thereby creating job opportunities in the building industry.
6. Government should encourage the use of local and renewable materials and limit importation to non-available construction materials for construction projects

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