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CLIMATE CHANGE AND ENVIRONMENTAL MANAGEMENT: THE GREEN ARCHITECTURE APPROACH FOR NIGERIAN HOUSEHOLDS

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Abstract

In the past two decades, there has been a global action plan to deal with the issues arising from climate change as a result of the devastating effect it has on human beings and the ecosystem. Global warming, high energy use in buildings, inadequate power supply, shortage of portable water, depletion of forest reserves, drought, flooding and environmental pollution are a great challenge to developing countries especially Nigeria. This study seeks to examine the concept of climate change in the context of the role of green architecture in environmental management of the Nigerian households. The methodology adopted was descriptive survey and the instrument for data collection was a structured survey questionnaire. The sample population was the owner occupiers within the Gwagwalada Satellite town of the Federal Capital Territory Abuja. A total sample size of one hundred and fifty participants (150) was drawn from three sub-urban layouts namely phases 1, 2 and 3 within Gwagwalada using stratified random sampling method. The findings reveal that a great majority of the respondents have no idea about green architecture/buildings, hence, do not implement environmental management principles. This implies that most households will continue to experience severe energy and water challenges as well as environmental degradation in the face of the current global climate change crisis. The study recommends a list of drastic measures which includes the launching of a green building revolution by the Federal Government of Nigeria with all stake holders on board. This will reawaken the consciousness and make more appealing the green Architecture/building concept to majority of Nigerian households thereby enhancing environmental management and ultimately national development.

Keywords: Climate change, Environmental pollution, Green Architecture

INTRODUCTION

Climate change has produced extreme weather events with severe consequences in the form of heat waves, storms, floods, drought, pollution and general environmental degradation such that humans and animals have been badly affected (Jorge *et al.*, 2022). The international community woke up to the realization that there were oceanic surges and other environmental disasters around the world requiring urgent global actions to address them. One of such global actions taken at the international level is the United Nations Sustainable development goals UNSDG (2016) which are numbered from goal number 1 to goal number 17. Goal 6 deals with issues relating to clean water and sanitation, goal

7 focuses on affordable and clean energy, goal 11 centres on sustainable cities and communities while goal 13 looks at climate action. There has been conclusive proof that the present world we live in is experiencing high temperatures and this has devastating effect on both humans and the entire ecosystem (Matawal & Maton, 2013). Fawzy *et al.* (2020) asserted that the rising temperatures also known as global warming is as a result of greenhouse gas emissions emanating from human activities and natural systems.

Experts believe that the driving force propelling the rapid rise in greenhouse emissions in the atmosphere have a direct co-relation with the high demand for energy by human actions such as in building construction activities (Leitao *et al.,* 2020; Baliram & Jadhav, 2020). Nigeria is reported to have one of the highest energy deficits globally and this implies that the demand for energy will also be very high as a result of the huge population. Hasia (2021) cited International Atomic Agency estimated that existing buildings are responsible for more than 40% of the world's total primary energy consumption and 20% of global CO_2 emission. An increasing population automatically means an expansion in the number of households thereby resulting in a sharp upsurge in the demand and consumption of energy, water, and the production of waste and greenhouse emissions (Ayu *et al.,* 2018). Gerda and Hilde (2011) asserted that the household is the basic unit of analysis in any social, economic and government model hence this study focusses on Nigerian households and how they deal with energy and water challenges.

Ebele and Emodi (2016) carried out research on climate change and its effect on the Nigerian economy. The study concluded that so many sectors such as energy, health, agriculture have been affected but not much detail on household environmental management was discussed. In the present era, human beings depend largely on buildings for most activities whether it is residential, commercial, industrial, institutional and recreational and in the process put so much stress on them (Dahiru *et al.*, 2014). Typical households are composed of buildings which are very strategic and play a very vital role in environmental management and ensuring a low carbon society (Ayu *et al.,* 2018). Green Architecture/Building is a promising way of reducing pressure on resources (Ping and Yang, 2016) and dealing with carbon emissions in the face of the challenges posed by climate change (Favor and Modupe, 2022). Mahmoud *et al.,* (*2020)* affirmed that buildings provide humans with shelter, privacy, protection and comfort therefore households must take proactive measures in managing the resources in our environment for the continuous existence of our ecosystem.

CONCEPTUAL ISSUES

Gupta (1995) refers to environmental management as a process of executing programmes towards conservation of natural resources, prevention of pollution and development of green products and technologies. The whole concept of environmental management revolves around conservation and protection of air, water, renewable energy and the entire ecosystem that support life.

The term 'green Architecture' is used interchangeably with 'green buildings' or 'sustainable architecture' and this is because they all aim at the conservation of our resources and protection of the ecosystem (Amany, 2016). According to the United States Green Building Council (USGBC) (2016), Green architecture is a philosophy of architecture that advocates sustainable energy sources, the

conservation of energy and water. It further states that it encourages the reuse and safety of building materials and the positioning of a building with special attention to its environmental impact. Similarly green buildings are buildings whose design and construction are eco-friendly in nature and encourage the use of recycled materials, alternative clean energy, rainwater harvesting and less consumption of energy and water (Amany, 2016; Anirban, 2017). Amany (2016) relates five major elements of green architecture which includes sustainable site design, water conservation and quality, energy and environment, indoor environment quality, and conservation of materials and resources.

CONTEXTUALISATION OF GREEN ARCHITECTURE

Oluwumi *et al.* (2019) carried out a study titled "Benefits and Barriers to the implementation of Green Building Standards in Universities: What are Students Views?" The study investigated the general perception of students on matters relating to green buildings within the Covenant University community. The sample population was the Covenant University, Ota, Ogun State while the sample size was 101 students under the Faculty of the Built Environment. The results of their study showed that 88.42% of the students under the Faculty of the Built Environment are aware of the concept of green buildings. However 87%-91% still display ignorance of the technical know-how, principles and management of green buildings. The study recommended a massive enlightenment programme for the University community on green building standards. The study by Oluwumi *et al*., (2019) is similar to the current study since it deals with green building. However it differs from the current study in terms of the target population. Whereas Oluwumi *et al.* (2019) focused on the Covenant University community, Ota, this study draws attention to the residential households of Gwagwalada satellite town in the Federal Capital Territory Abuja.

DRIVERS AND BARRIERS TO GREEN ARCHITECTURE

The prudent use of elements such as land, water, energy and materials has tremendous health and cost benefits to mankind. Lelei (2021) refers to green buildings as a structure which seeks to strike a balance between man and nature. George (2013) and Mukhtar *et al.,* (2020) carried out extensive studies on the drivers and barriers of green buildings. The barriers include the growing need for energy, water conservation and efficiency, reduction in pollution and wastages, improvement in indoor environment quality and reduction in building cost. On the other hand, they listed the barriers to include absence of effective Government policy, incentives on green buildings, limited knowledge and skills on green buildings and lack of technological capacity to produce green building materials.

CASE STUDIES

In an attempt to embrace the concept of green architecture in Nigerian households, there is the need for an appraisal of its trajectory especially in developed countries like China and the United States with their large population.

Green Architecture in China: First Case in Point

Developed Countries like China with its huge population have adopted the concept of green buildings shortly after the millennium in its drive towards sustainability. According to Leilei (2021), the emergence of green buildings in China can be grouped into three stages which include light green stage, deep green stage, and flood green stage. The light green stage which spanned between 2004-2008 witnessed a lot of challenges due mainly to lack of awareness, the huge cost involved and the lack of an efficient green building system in the country. The deep green stage which spanned between 2008-2010 saw the application of green architecture into the design process and this brought about the conversion of old workshops into green buildings. Green buildings were now sighted in offices, super high rise buildings, hotels, hospital, schools and museums. The flood green stage made its entry between 2011 till date and this was a time when there was now a general acceptance of green architecture by the community and fully integrated into the life cycle of a building. Ecological cities were been built in many urban areas across China and the green building rating system had become refined and well established to evaluate all buildings.

Bullitt Centre, Seattle, USA: Second Case in Point

The Bullitt centre located in Seattle USA is a typical example of model green architecture /green building and has therefore showed the way forward for building designers and developers in developing Countries like Nigeria to emulate. A model green building is a structure whose whole life cycle is geared towards conservation of resources, saving the environment, reduction in pollution and efficient use of space (Leilei, 2021). In 2014, the Bullitt centre received the Leadership in Energy and Environmental Design LEED certification from the United States Green Building Council as the greenest building in the world (USGBS, 2014). The building has a number of in-built green features such as energy and water efficiency which are key elements to be integrated in Nigerian households for sustainable environmental management.

Plate I: Bullitt centre building with array of solar panels over roof
Source: Solariapedia.com

Plate II: Interior view of Bullitt Centre work space with massive use of timber and glass
Source: Solariapedia.com

Green Features of the Bullitt Centre, Seattle, USA

1. **Energy efficiency:** The Bullitt Centre is a net zero energy building. It has installed on its roof 575 solar panels spanning 14,000 square feet generating 230,000 kilowatt hours per year by photovoltaic array. This energy is more than the buildings demands and the building can sustain itself in terms of energy and water for the next 250 years.

2. **Rain water harvesting:** All the water needs of the Bullitt centre are harvested from rain. Lying below the solar panels is a parapet roof which captures rain water and channels it down through spouts to a 56,000 gallons concrete cistern in the basement. This rain water is filtered and passed through ultra-violent light and then added with some chlorine.

3. **Grey water system collection and re-use:** The Bullitt centre has an in-built system whereby grey water from sinks and showers is channeled and stored in a 550 gallons grey water tank. The water is then treated in a three stage filtration process and re-used in the vacuum flush water system.

4. **Vacuum toilets:** The centre operates a highly efficient vacuum which uses treated grey water for flushing. The vacuum pumps extract waste through a grinder in order to get rid of problematic solids before moving them into a collection tank for treatment.

5. **Materials:** The Bullitt Centre primary structures have been built with materials expected to last up to 250 years. Exposed materials such as concrete, wood and glass have been blended into the structure thereby cutting off the need for elaborate finishes. The building components do not produce unhealthy vapours and over 300 harmful chemicals used in buildings have been avoided.

METHODOLOGY

The methodology for carrying out this study is descriptive survey research. This survey research was deemed appropriate because of its ability to collect primary data from a large group of people. The Gwagwalada Area Council in Abuja is the study area for this research as a result of the fact that it was the launching pad for the 20,000 household solar home system project of the Federal Government for rural areas in 2017. The sample population is the residential households of Gwagwalada satellite town which has very notable institutions such as the University of Abuja and its Teaching Hospital. The residential urban layout of Gwagwalada satellite town is made up of phase 1, phase 2 and phase 3. Employing random sampling method, fifty households were selected from each of the three residential neighbourhoods of phase 1, 2 and 3 to arrive at a sample size of 150 households.

The instrument for primary data collection was a structured questionnaire administered to each of the 150 households by the Authors and two other research assistants. The questionnaire was titled "Survey on Evaluation of Green Architecture Principles in Nigerian Households under the era of Climate Change" and was divided into three sections A, B, C and D. Section A shows a brief profile of the respondents, section B focused on energy, section C centred on water while section D dealt with miscellaneous issues. A five point Likert scale of strongly agree (SA), agree (A), disagree (D), strongly disagree (SD) and uncertain or not applicable (NA) was used in setting up the questionnaire. All questions were simplified for easy comprehension by the Respondents and the mean score and standard deviation was analysed as shown in tables below.

The research instrument was face validated by seminar Researchers before proceeding to the field to administer the questionnaires. The Respondents' consent was sought before being issued with the research instrument and the duration for distribution and collation was fifteen working days. A scale interval benchmark was set with 3.41-4.20 for Agreed and 4.21-5.0 for strongly agreed in order to

conclude the analysis. The data generated from the questionnaire was subjected for analysis using SPSS software (version 22). Secondary data was also extracted from journals, books and internet platforms.

The Study Area

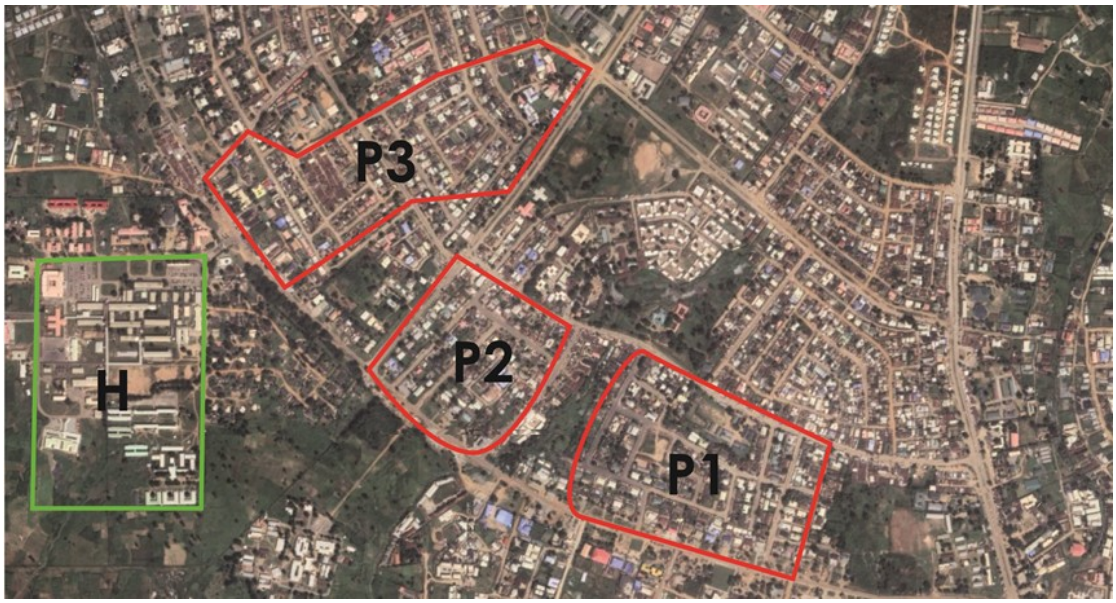

Plate I: Satellite image of Gwagwalada Residential Households

Source: google.com/maps/place/902101

LEGEND
P1 Phase 1 layout
P2 Phase 2 layout
P3 Phase 3 layout
H University of Abuja Teaching Hospital

Plate II: Street image of Gwagwalada Phase 1 Residential Households

Source: (Fieldwork, 2023)

Observation: No evidence of solar panels on roofs and no overhead storage tanks

Remarks: Noncompliance to renewable energy and water conservation principles

Plate III: Street image of Gwagwalada Phase 2 Residential Households;

Source: (Fieldwork, 2023)

Observation: No evidence of solar panels on roofs and no overhead storage tanks

Remarks: Noncompliance to renewable energy and water conservation principles

Plate IV: Street image of Gwagwalada Phase 3 Residential Households

Source: (Fieldwork, 2023)

Observation: Evidence of solar panels on right side building roof and no overhead storage tanks

Remarks: Partial compliance to green architecture principles.

Plate V: Street image of Gwagwalada Phase 2 Residential Household

Source: (Fieldwork, 2023)

Observation: Evidence of solar panels on roof and overhead storage tanks

Remarks: Full compliance to renewable energy and water conservation principles.

RESULTS AND DISCUSSION

The data collected from the questionnaires are hereby analysed and presented in the form of tables and graphs.

Table 1: Distribution of Questionnaires

Type of instrument for data collection	Questionnaire
Number of distributed questionnaires	150
Number of respondents	138
Percentage of respondents	92%

Source: (Fieldwork, 2023)

Table 1 shows that one hundred and fifty (150) questionnaires were administered to the research population and 138 were retrieved, representing a response rate of 92%. Cronbach's alpha coefficient was used to test for the reliability of the questions. The Cronbach's alpha coefficient as shown below in table 2 is equal to 0.743. This shows that the questionnaire was good.

Table 2: Reliability Statistics

Cronbach's Alpha	No. of Items
.743	16

Demographic information of Respondents

From the frequency analysis summarized in table 3 below, 62.3% of the respondents were male while 37.7% were female. This shows that both genders had a relatively good representation and input in the data collected. The table also showed that 58% of Respondents were 56 years and above while 42% were between the ages of 41-55 years. This indicates that all respondents were very mature people. Similarly 84.8% of the respondents possessed a diploma or degree certificate while 18% had a postgraduate qualification and 2% had vocational training. This implies that the respondents were well educated and understood the questionnaire. The table further shows that 64.5% of the Respondents were Civil Servants, 30% were in the academic field while 5.1% were into private businesses.

Table 3: Demographics of Respondents

Variable factor		Frequency	Percent	Valid Percent	Cumulative Percent
Gender	Male	86	62.3	62.3	62.3
	Female	52	37.7	37.7	100.0
	Total	138	100.0	100.0	
Age	41 - 55 years	58	42.0	42.0	42.0
	56 years and above	80	58.0	58.0	100.0
	Total	138	100.0	100.0	
Qualification	Vocational or ND	3	2.2	2.2	2.2
	Degree or HND	117	84.8	84.8	87.0
	Postgraduate	18	13.0	13.0	100.0
	Total	138	100.0	100.0	
Occupation	Civil Servant	89	64.5	64.5	64.5
	Lecturer/School Teacher	42	30.4	30.4	94.9
	Business Owner, Private Employer	7	5.1	5.1	100.0
	Total	138	100.0	100.0	

Source: (Fieldwork, 2023)

Figures 1 and 2 below show the frequency analysis of respondents to questions on knowledge of green architecture and protection of the environment. Results indicate that 14.5% of Respondents had no knowledge at all of green architecture while 84.8% had poor knowledge and this cuts across both genders while only 7% which were all males had good knowledge of green architecture. This implies that a total of 99.3% of respondents need to be well educated on the concept of green architecture/buildings even though they have good educational backgrounds. This major finding is in line with the studies by Muhammed *et al,* (2017), Afolabi & Adejoh (2014) that lack of awareness, education and training are stumbling blocks to achieving a green building society. However a sum total of 87.7% of the respondents also cutting across both genders acknowledge the importance of protecting the natural environment and its resources. Coincidentally, all respondents accepted the fact that energy and water are two very important necessities for the survival of human beings after shelter and food in their individual households.

Figure 1: Frequency analysis of responses on knowledge of green architecture

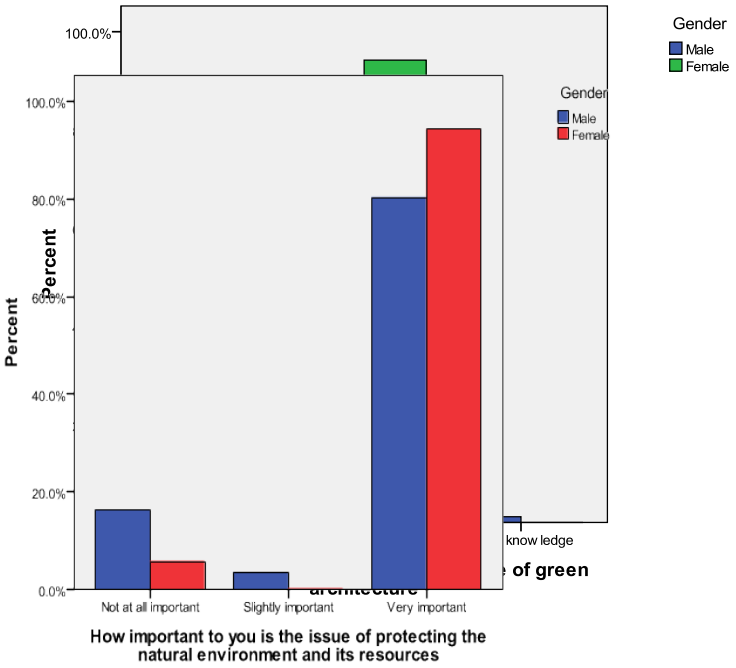

Figure 2: **Frequency analysis of responses on protection of natural environment and its resources**

Table 4 shows the duration of living in Respondents households and their basic needs. From the frequency analysis table, a total sum of 83.4% of the Respondents have lived in their residences for over 10 years which implies that they are familiar with their immediate environment and its climatic conditions. 84.8% of the Respondents depend on electricity from both the national grid and generators while only 3.6% benefit from solar power. This implies that greenhouse gases emission is very high in their neighbourhoods due to the fact that electricity from the national grid is erratic and most households fall back on generators that emit gaseous substances. The table also shows that 97.1% of

the Respondents depended on the Municipal water board for their water supply while a total sum of 2.9% had a borehole at home to complement the municipal water supply. This indicates that the water reticulation network installed by the municipal water board within the study area is functional and regular. Consequently the water quality is considered good for consumption.

Table 4: Respondents Basic Household Needs

Variable factor		Frequency	Percent	Valid Percent	Cumulative Percent
two important necessities after food	Energy and Water	138	100.0	100.0	100.0
Number of years spent in residence	1-5yrs	7	5.1	5.1	5.1
	6-10yrs	16	11.6	11.6	16.7
	11-20yrs	39	28.3	28.3	44.9
	20yrs and above	76	55.1	55.1	100.0
	Total	138	100.0	100.0	
Source of power at home	PHCN electricity only	16	11.6	11.6	11.6
	Solar panels only	1	.7	.7	12.3
	PHCN and Generator	117	84.8	84.8	97.1
	PHCN, Generator and Solar panels	4	2.9	2.9	`100.0
	Total	138	100.0	100.0	
Source of water at home	FCT Water Board only	134	97.1	97.1	97.1
	Water Board/Borehole	3	2.2	2.2	99.3
	Water Board/Borehole/Well	1	.7	.7	100.0
	Total	138	100.0	100.0	

Source: (Fieldwork, 2023)

Analysis of Energy and Water Issues in Households

Sections B, C and D of the structured questionnaire sought to know the Respondents general views and perception with regards to the energy and water they consume in their households. Six questions were asked in section B, five questions in section C and another five questions in section D.

Table 5: Energy Efficiency and Conservation in the Household

	N	Min.	Max.	Mean	Std. Deviation
1. Renewable energy like solar panels are more sustainable than generators	138	2	5	4.40	.548
2. Power supply from the national 3. grid to individual houses is irregular and not constant	138	4	5	4.67	.470
3. Most homes within the neighbourhood do not use solar energy because they cannot afford it	138	1	5	4.07	.653
4. Using solar energy has no health hazard on human beings while petrol and diesel generators do	138	4	5	4.22	.414
5. Petrol and diesel generators are too expensive to maintain due to their frequent malfunction	138	2	5	4.59	.535
6. Solar panels do not impact negatively on the environment while generators do	138	4	5	4.75	.437

Valid N (list wise)	138				

Overall averages mean score = 4.45 concluding remarks = Strongly Agreed

Source: (Fieldwork, 2023)

Table 5 discussed energy efficiency and conservation and the results showed majority of the Respondents strongly agreed on the issues raised in the questionnaire with an overall mean score of 4.5. However an insignificant number of the Respondents did not agree that most homes within the neighbourhood did not have solar energy because they could not afford it. Table 6 discussed water efficiency and conservation and an overall mean score of 4.22 was recorded. This implies that majority of the Respondents strongly agreed to the issues raised. Nevertheless, there were also an insignificant number of the Respondents with a divergent view on the question relating to most homes not having water storage tanks because the municipal water supply was regular.

Table 6: Water Efficiency and Conservation in the Household

	N	Min.	Max.	Mean	Std. Deviation
1. Rain water harvesting and storage can contribute immensely in reducing the demand for water from the municipal water board	138	4	5	4.24	.428
2. Water storage tanks/reservoirs are not common in most homes because of the regular supply of water from the municipal water board	138	2	5	4.04	.565
3. Harvesting rain water does not affect the environment negatively	138	1	5	4.35	.600
4. Buildings water needs can be met by depending only on harvested rain water without connecting to the municipal water board	138	1	5	4.06	.659
5. Recycling of used water is a good way to help conserve water and avoid wastage	138	2	5	4.41	.600
Valid N (list wise)	138				

Overall Average Mean Score = 4.22; Concluding remarks = Strongly Agreed;

Source: (Fieldwork, 2023)

Table 7 results had an overall mean score of 4.60 under the general assessment questions in section D. This implies that the vast majority of the Respondents were in strong agreement with all the issues discussed relating to climate change.

Table 7: General Assessment of Respondents on Climate Change Related Issues

	N	Min	Max	Mean	Std. Deviation
1. Climate change is a reality and all hands must be on deck to address it	138	4	5	4.73	.445
2. Using recycled materials helps to reduce the cost of building construction	138	4	5	4.57	.498
3. Buildings consume a very large amount of water during construction and post occupancy periods	138	1	5	4.42	.791
4. The Federal Government is not doing enough to address the issue of depletion of our natural resources	138	1	5	4.53	.847
5. Renewable energy sources like solar helps to reduce carbon dioxide emission in the atmosphere thereby improving indoor air quality	138	4	5	4.78	.414
Valid N (list wise)	138				

Overall average mean score = 4.60; Concluding remarks = strongly agreed

Source: (Fieldwork, 2023)

CONCLUSION AND RECOMMENDATIONS

This research examined green architecture features such as energy and water utilization and conservation in the residential households of Gwagwalada satellite town in the current era of global climate change. Key findings from this study reveal that a vast majority of the Respondents were lacking in the knowledge of green architecture despite been educated hence do not engage in environmental management practices. Another finding indicates that there is a high rate of emission of greenhouse gases within the neighbourhood as a result of the huge number of households utilizing petrol generators rather than renewable energy. Furthermore households have not cultivated the practice of harvesting rain water for storage and future use just in case the Municipal water board fails to supply water regularly. The implications of these findings are that households will continue to witness poor indoor air quality, air pollution, high temperatures, scarcity of clean water and general environmental degradation. Knowledge drives away ignorance therefore the way forward for the future of green architecture in Nigerian households can be recommended as follows;

1. The Federal Government of Nigeria should take the lead by launching a green building revolution in the country as a sign of seriousness and commitment similar to the green revolution of the agricultural sector it launched in 1980.

2. The Green Building Council of Nigeria GBCN should be invigorated and tasked to form a think-tank with all the building industry professional bodies such as the NIA, NIOB, NSE, NIQS, NITP, NIESV, and NBRRI, and develop a robust blue print that will show the way forward for green buildings in Nigeria.

3. The blue print developed by the think-tank should among other things seek to achieve the following:

a. Carry out massive enlightenment and advocacy programmes targeted at every nook and cranny of the Country on the principles of green architecture coupled with the advantages and benefits of integrating it in our various households.

b. Develop a curriculum that teaches the basics of green architecture at all levels of our educational sector while ensuring that students of the built environment in our Universities and Polytechnics undergo advanced training on the theory and practice of green architecture.

c. Persuade the Federal Government to provide subsidies and incentives for the mass production of solar panels and water storage tanks locally to enable a large number of the population easily acquire them for their homes. This will reduce dependence on generators and also encourage harvesting and storage of rain water.

d. Encourage the Federal Government to engage in partnership with real estate developers in building ecological cities across the length and breadth of our country similar to what the Chinese Government is doing.

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