



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 11, November 2020

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 7.512**

9940 572 462

6381 907 438

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# Effects of Climate Change Adaptations on the Performance of Office Workers in Enugu State

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**ABSTRACT:** The causes, problems and solutions of climate change are highly associated with human activities. The driver of most human activities, especially in the modern societies, is energy and which sources generate much of the gases that pollute the atmosphere. Greater percentage of energy required for various human activities is derived from non-renewable sources like fossil fuel. The major by-product of burning fossil fuel is carbon dioxide. High concentration of this gas and other heat-trapping gases in the upper atmosphere contribute greatly to increasing the earth's temperature and the overall greenhouse effects. Global warming is posing a very big challenge to human existence and natural environment. Climate changes also have negative effects on human comfort, performance and productivity. The aim of this paper was to evaluate the effects of climate changes adaptations on the performance of office workers in Enugu metropolis. This was achieved by understanding the effects of passive design techniques in office buildings that help to cushion indoor ambience. A Survey of the workers' perception of the effectiveness of passive design elements targeted for climate change adaptation was also carried out. Using the Frequency Distribution table and simple percentage approach, the result showed that passive adaptation measures are capable of reducing the adverse effect of climate change. Hence, recommendations on how to improve climate change adaptations were made.

**KEYWORDS:** Fossil fuel, Greenhouse gas, Climate change, Adaptation Carbon emissions, Heat-trapping gases, Regression Analysis. Upper atmosphere.

## I. INTRODUCTION

The earth's climate has been changing and as evidenced in the unprecedented rise in global temperatures, including in the tropics. In past decades, changes in climate were more gradual and more likely as results of natural phenomena and seasonal changes. But, the trend and the patterns of changes that emerged in the last few decades have deviated from these norms and are linked to the effects of human activities (Susan, 2004). Curiously some of these human activities were efforts aimed at moderating indoor temperatures, especially in the tropics; like cooling/heating of indoor spaces to achieve comfort. Cooling indoor spaces in most developing countries rely greatly on non-renewable energy sources. In Nigeria and most African countries, there is much dependence on fossil fuel for energy supply due to inadequate and high cost of electricity.

Burning of fossil fuel, for energy, generates increased emission of carbon dioxide and other gases into the atmosphere. High concentration of these gases in the atmosphere has resulted in the trapping of heat on the lower atmosphere, thereby slowing the loss of heat energy to space and the consequent creation of the greenhouse effects. This process has negatively altered climates and seasons and is a threat to humans and other biological entities on earth. The impact of global warming is felt at both local and international levels. In an attempt to save our planet from the influence of climate change, the United Nations has been spearheading many initiatives in this direction. One of those initiatives is the United Nations Framework Convention on Climate Change (UNFCCC).

These international organizations have advocated mitigation and adaptation as ways of combating climate change. These approaches involve human interventions that are aimed at reducing sources of greenhouse effects that are major causes of global warming (IPCC, 2014). Adaptation is a process of adjusting to the effects of actual or expected climatic conditions. Considering the two processes of mitigation and adaptation in the context of climate change, it is important to give due consideration to the building industry where greater percentage of greenhouse gases are generated. According to the United Nations Environment Programme (UNEP) report, the building sector contributes up to more than 30% of yearly greenhouse gas emissions in both developed and developing nations and consumes up to 40%

of all energy production in many parts of the world (UNEP, 2009). Also the efforts of cooling/heating to adapt to effects of climate change revolve around the built environment.

Buildings and its immediate environments should be considered for effective and palliative measures against the impact of climate change. Many studies on climate change have been conducted in parts of world especially in the tropical regions where the effects of climate change are felt more (Evan and Steven, 2009; Snow and Prasad, 2011; Abimaja, and Akingbohungebe, 2013; Oluwafemi, Oluwayemi and Ikenna, 2015 and Alozie, Eze and Trouke, 2016). The adaptive techniques of minimizing the negative effects of climate change in the tropics is an area requiring more interest.

## II. STATEMENT OF PROBLEM AND STUDY AREA

In the tropics, heat has been a major factor of discomfort in indoor spaces. It is even felt more these days because of observable increases in temperatures due to climate change. Unconducive indoor environments affect human concentration and productivity negatively. In most cases, building designers employ artificial mechanical means achieve indoor comfort but these are not only expensive but also contribute to the climatic and environmental degradation since much of these energies are non-renewable. More employment of artificial mechanical means led to scarce or minimal consideration of sustainable passive building design techniques, probably because their contribution to indoor comfort in relation to human productivity, especially in the tropics, has not been duly evaluated.

For an appropriate tropical climate study area, the research was carried out in Enugu metropolis in Enugu State, located in the South Eastern Nigeria. The State has a landmass of 4,267,837sqkm and is located between latitudes  $06^{\circ}26'$  and  $06^{\circ}30'$  N and longitudes  $07^{\circ}27'$  and  $07^{\circ}37'$  E located on the East of Niger Delta (Ugwuoti, Onah and Ojinnaka, 2019), The topography of Enugu city is characterized by undulating landscape of hills and knolls and is on a high relief of about 228.9m above sea level (Reifsnnyder, William, Darnhofer, 1989) and Sanni et al., 2007), The metropolis falls within the tropical zone, with a mean annual temperature of between  $22.7^{\circ}$  C and  $30.8^{\circ}$  C and relative humidity between 40% and 80% (Nwachukwu and Ukpabi, 2008). Enugu has a hot humid climate with the peak of humidity being experienced between March and November (Reifsnnyder, William, Darnhofer, 1989) It experiences two major seasons, the rainy and dry seasons.

## III. AIM AND OBJECTIVES

The aim of this paper was to evaluate the influence of different adaptive and passive design techniques intended to cushion the effects of climate change on indoor work spaces in order to improve comfort and productivity of office workers in the tropics, using Enugu urban as a study ground. The paper focused on evaluating different passive design measures and various adaptive techniques against climate change of office buildings. These were done by

- i. ascertaining the effects of window size and orientation, in relation to sun direction, on indoor heat of office buildings in Enugu urban;
- ii. identifying adaptive measures and techniques for cushioning changes in climates;
- iii. evaluating the influence of these adaptive measures on thermal comfort of office workers in Enugu urban;
- iv. determining the relationship between indoor comfort and productivity in office work environment.

While undertaking to achieve this aim, through these objectives, this work hypothesized few assumptions that included:

- i. that window size and orientation, in relation to sun, have no significant influence on the ventilation and indoor heat of office buildings;

- ii. that individual adaptive measures have no significant impact on thermal comfort of office workers

- iii. that human comfort in office buildings do not significantly influence concentration and productivity of the workers.

Hence, the study covered office buildings of core civil servants within Enugu urban. Enugu urban comprised Enugu East, Enugu North and Enugu South Local Government Areas. Core civil servants are the ones in State Ministries and Parastatals, excluding teachers and other workers in school systems. The study concentrated on this category civil servants because their works are carried out in office settings.

## IV. CLIMATE CHANGE ADAPTATION MEASURES

Adaptive approach states that if variation occurs to produce discomfort, the tendency is for people to react in different ways in order to restore comfort condition (Yau, and Chew, 2014). According to (Almeida, Vasco and Delgado, 2015) the interest in adaptive model began in the 70's in response to the energy crisis experienced at that time. In recent years, renewed interest is due to climate changes. The adaptive approach suggests that people's satisfaction with an indoor climate is attained by matching the actual thermal environmental condition at the existing time and space with their



individual thermal adaptation and expectations (de Dear and Brager, 2002). The heat balance approach is based on experimental results in climatic chambers using a heat balance equation which considered steady climate regime. But the adaptive model assumes a dynamic regime in which an individual is allowed to interact physically and psychologically with the specific environment.

The adaptive model gives the individual the opportunity of playing fundamental role in the creation of his own thermal environment. This is achieved by allowing the individual to interact with the environment, modifying behaviours and habits or, gradually adapting the individual's expectations (Brager and de Dear, 1998). Some of the advantages of adaptive model are in response to energy crisis and climate change. Allowing people to control and modify indoor air temperature to be closer to the outdoor can result to improvement in both comfort conditions and reduction in energy consumption (Milne, 1995). According to Brager, Paliaga, and de Dear, (2004) there is a statistical relationship which states that the indoor temperature is influenced by outdoor temperature. This mostly implies that thermal comfort is a function of outdoor temperatures. Hence, adaptive process usually considers three forms of adaptation to the environment namely; physiological adaptation, psychological adaptation and behavioural adjustment (de Dear, Brager and Cooper, 1997).

#### V. PHYSIOLOGICAL ADAPTATION

Another issue in the consideration of temperatures and human comfort is physiological adaptation. Physiological adaptation is concerned with maintaining body temperature at a comfortable level. According to Yao, Li and Liu, (2009) this adaptation involves perspiration, vasoconstriction and vasodilatation that involve changes performed by the thermo-regulation mechanisms under certain conditions to adjust the body response to the environmental conditions. These adaptive measures depend more on the state of health and body condition of individuals involved.

#### VII. PSYCHOLOGICAL ADAPTATION

This describes a feeling of thermal perception based on past experiences (de Dear and Brager, 2002). The human body sensitivity will be reduced if exposed to a certain thermal level over a period of time. It is the effect of cognitive and cultural variables that describes the extent to which habituation and expectation alter thermal perception.

#### VIII. BEHAVIOURAL ADAPTATION

Behavioural adaptation embraces all actions consciously or unconsciously taken to ensure thermal equilibrium (Almeida, Vasco and Delgado, 2015). It can be classified into three categories namely; personal adjustment, technological adjustment and cultural adjustment (Yau and Chew, 2014) Personal adjustment involves modifying certain activities, clothing, posture, consuming hot or cold drinks/food, moving to other locations and so on. Technological adjustment includes modifying the environment or surroundings like turning on/off air-conditioners and opening/closing windows while cultural adjustment could come in the form of scheduling activities according to the dictates of requirements of thermal comfort.

#### IX. THERMAL COMFORT AND OFFICE PERFORMANCE

Indoor temperature is one of the fundamental factors of indoor environment and thermal comfort. It can be controlled with some level of accuracy depending on the building envelope and its HVAC system. Several human responses like comfort, quality and performance at work, are affected by indoor temperature (Oli, William and QH Lei, 2006). Temperature or thermal state, being a major indicator of indoor discomfort, is linked to productivity. [18] developed a relation between performance and temperature. It showed a decrease in performance by 2% per °C increase in temperature within the range of 25-32°C, and no effect on performance in temperature range of 21-25 °C. These range of temperatures depend on other metrics of human comfort, like air velocity and relative humidity. At moderate air speed, the negative effect of air temperature on human comfort could be minimized and could also as well enhance office performance level.

Similar study on the effect of temperature on task performance in an office buildings was carried out in Tokyo Japan during the summer under mandatory electricity savings. The researchers imposed a variation of indoor temperature and ventilation conditions and concluded that users expressed discomfort at higher temperatures and recommended a maximum operative temperature of 27° C (Tanabe, Iwahashi and Tsushima, 2014), A survey conducted through self-assessment, showed that users that were thermally uncomfortable had a loss of productivity of 6.6% (Tanabe, Iwahashi and Tsushima, 2014) These studies revealed that there is a close link between indoor comfort and level of productivity of office workers. However, apart from temperature and other metrics of indoor comfort, there are passive design

techniques that can influence indoor heat, comfort and performance of office workers. Some of these passive measures are natural ventilation and orientation.

#### X. NATURAL VENTILATION.

Natural ventilation is the intentionally directed flow of outdoor air through an enclosed space under the influence of wind and thermal pressures through adjustable openings (Ahmed and Abdul-Gani, 2011) It can effectively control temperature, especially in hot and humid climate regions. Windows, doors and skylights are some of the openings within a building envelope that have significant influence on the thermal performance of buildings. This is because both the needed natural air-flow and undesirable solar heat-gain pass through these openings. A research carried out by Jinghua Yu (2008) posited that heat-gain through the exterior windows accounts for 25% to 28% of the total heat gain. The aim of natural ventilation is to provide human comfort with minimal energy demand. Cross ventilation is an effective passive technique and requires openings on, at least, two sides of an enclosed space. The sizing and placement of these inlets and outlets openings will determine the direction and velocity of air flowing through the indoor spaces. For greater efficiency of cross ventilation, there should be equal or greater outlet openings.(Grondzik, Kwok, Stei, and Reynolds, 2010).

#### XI. METHODOLOGY OF THE STUDY

Descriptive survey method was used in this study and this influenced the data collection. The use of survey method to gather data helped provide accurate information because of the spread of the agents of study (Kothari and Garg, 2014), This design was also used to obtain descriptions on the impact of climatic conditions on the performance of office workers.

#### XII. STUDY DATA AND SAMPLE FRAME

The population of this research comprises of core civil servants in Enugu. Core civil servants are workers under some key ministries, parastatals and Boards within Enugu urban. The total number of these civil servants were five thousand, four hundred and thirty-five (5435), as obtained from the Ministry of Establishment of Enugu State for the 2019. fiscal year.

#### XIII. SAMPLE AND SAMPLING

Using 5,435 as target population of core civil servants in Enugu metropolis, the sample size was determined using the formula as cited in Robert-Jan Mora and Bas Kloet (2010). With 95% confidence level and 5% level of precision (allowance error), the sample size was determined to be 373, as shown below. Going forward, an allowance of 5% was made for low response rate. Therefore, a total number of 395 core civil servants were administered the questionnaires. Core civil servants in this context means the ones working at State government ministries while excluding all teachers in the State owned schools. Taro Yamane's principles was used in determining the sample size, where:

$n = \frac{N}{1+N(e)^2}$  where n= desired sample size N= the entire population e = level of significance of limit of tolerable

error assumed to be 5% or 0.05 1= unit constant figure Therefore  $n = \frac{N}{1+N(e)^2} = \frac{5435}{1+5435(0.05)^2}$

$n = \frac{5435}{14.5875} = 372.57$  n = 373

The sampled civil servants were contacted and administered with the copies of the structured questionnaires and their responses were promptly collected same day.

#### XIV. DATA COLLECTION INSTRUMENT FOR DATA COLLECTION

Structured questionnaire was the instrument used for the collection of primary data. Onodugo, Ugwuonah and Ebinne, (2010) stated that interview is a question and answer situation between a researcher and a respondent with a view to eliciting relevant information or data for a study being carried out. The copies of structured questionnaire were administered to respondents that formed the sample size and for the purposes of sourcing primary data.



**XV. VALIDATION OF INSTRUMENT**

This was done by subjecting the draft questionnaires to the criticisms supervisors and experts in the relevant profession.

**XVI. RELIABILITY OF THE INSTRUMENT**

The reliability of the instrument was established using pilot study. The instrument was administered to Civil servants in Enugu Urban. The results obtained from the analysis of their responses were used in computing the reliability of the instrument. The reliability was computed using a statistical package for social science (SPSS, version 22)

**XVII. METHOD OF DATA ANALYSIS**

Data were presented using frequency distribution table and analyzed using simple percentage approach.

**XVIII. DATA PRESENTATION AND ANALYSIS OF RESULT**

*What is the impact of window size and orientation in relation to sun direction on indoor heat of office buildings in Enugu urban?*

**Table 3; Analysis on the First Research Question**

S/N		W	SA-----SD				ΣFX	X̄	DECISION
			4	3	2	1			
1	Window size helps in regulating room temperature of office building in Enugu state	F WF	180 720	140 420	40 80	13 13	373 1233	3.30	ACCEPT
2	Window size permits air flow to reduce indoor heat of office building in Enugu state	F WF	145 580	138 414	45 90	45 45	373 1129	3.02	ACCEPT
3	Sun direction determines the indoor heats of office building in Enugu state.	F WF	123 492	154 462	65 130	31 31	373 1115	2.98	ACCEPT
4	Window size and sun direction affected indoor comfort in office building in Enugu state	F WF	144 576	153 459	62 124	14 14	373 1173	3.14	ACCEPT
	<b>Grand mean</b>							<b>3.11</b>	<b>ACCEPT</b>

**Source: field survey computation**

In Table 3, four questionnaire items were used to answer research question one and all the questionnaire items tested have value above the criterion mean of 2.5. The grand mean total is 3.11 which imply that all the instruments listed are ways window size and orientation in relation to sun direction impact on indoor heat of office buildings in Enugu urban



**SECOND RESEARCH QUESTION**

*What is the influence of individual adaptive measure on thermal comfort of office workers in Enugu urban?*

**Table 4; Analysis on the second Objective**

S/N		W	SA-----SD				ΣFX	X̄	DECISION
			4	3	2	1			
5	Individual adaptive measures to thermal comfort helps in regulating mindset towards the indoor comfort.	F WF	151 604	135 405	42 84	45 45	373 1138	3.05	ACCEPT
6	It helps to settle the mind and makes individual feel less about the thermal comfort in the office building	F WF	147 588	115 345	85 170	26 26	373 1129	3.02	ACCEPT
7	Individual adaptive measures helps in regulating the indoor heat	F WF	140 560	112 336	91 182	30 60	373 1138	3.05	ACCEPT
8	It promotes indoor comfort in the office building	F WF	102 408	110 330	101 202	60 60	373 1000	2.68	ACCEPT
<b>Grand Total</b>							2.95	ACCEPT	

Source: field survey computation

In Table 4, four questionnaire items were used to answer research question two. All the items had mean ratings above 2.5. The grand mean rating was 2.95 which is also above the criterion mean. Based on this, we conclude that individual adaptive measure has influence on thermal comfort of office workers in Enugu urban.

**Research question three**

*What is the relationship between indoor comfort and productivity of office workers in Enugu urban?*

**Table 5; Analysis on the third research questions**

S/N		W	SA-----SD				ΣFX	X̄	DECISION
			4	3	2	1			
9	There is significant relationship between indoor comfort and office productivity	F WF	198 792	101 303	46 92	28 28	373 1215	3.25	ACCEPT
10	Indoor comfort determines office productivity	F WF	171 684	114 342	39 78	49 49	373 1153	3.22	ACCEPT



11	An individual with enough indoor comfort performs higher in an office work	F	140	112	91	30	373	2.97	ACCEPT
		WF	560	336	182	30	1108		
12	Indoor comfort promotes workers' performance in the office.	F	101	111	102	59	373	2.68	ACCEPT
		WF	404	333	204	59	1000		
Grand mean								3.03	ACCEPT

Source: field survey computation

In Table 5, four questionnaire items were used to answer research question three, all the questionnaire items tested have value above the criterion mean of 2.5. This implies that in all the instruments listed, there are positive are the relationship between indoor comfort and productivity of office workers in Enugu urban.

**XIX. HYPOTHESES OF THE STUDY**

**Decision rule**

Accept the null hypothesis ( $H_0$ ) if the value of computed test is greater than 0.05 level of significance, otherwise, reject and accept the alternate hypothesis. Hence,

**Hypothesis one**  $H_0$ : window size and orientation in relation to sun direction have no significant influence on natural ventilation and indoor comfort in office buildings in Enugu urban.

**Table 6 One-Sample Test**

Null Hypothesis	Test Value = 0					
	T	Df	Sig.(2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
The window size and orientation in relation to sun direction has no significant influence on natural ventilation and indoor comfort in office buildings in Enugu urban.	0.049	372	.021	113.02000	47.8096	179.2304

Source: SPSS computation (2020)

From the test of hypothesis above using one sample test t-statistics, based on the decision rule, accept null hypothesis if the value of the t-statistics is greater than 0.05, from the result; the value of the t-statistics (0.049) is below 0.05 hence we reject the null hypothesis and conclude that window size and orientation in relation to sun direction have significant relationship with indoor heat comfort of office buildings in Enugu urban.

**Hypothesis two**  $H_0$ : Individual adaptive measures have no significant impact on thermal comfort of office workers in Enugu urban.

**Table 7 One-Sample Test**

Null Hypothesis	Test Value = 0					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Individual adaptive measures have no significant impact on thermal comfort of office workers in Enugu urban.	0.016	373	.000	9.27687	40.7421	173.8116





From the test of hypothesis above using one sample test t-statistics, based on the decision rule, accept null hypothesis if the value of the t-statistics is greater than 0.05, From the result; the value of the t-statistics (0.016) is less than 0.05 hence we reject the null hypothesis and conclude that individual adaptive measure has influence on thermal comfort of office workers in Enugu urban.

**Hypothesis three  $H_0$ :** *Comfort in office building in Enugu urban cannot significantly influence the productivity of the workers*

**Table 8** One-Sample Test

Null Hypothesis	Test Value = 0					
	T	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Human comfort in office building in Enugu urban cannot significantly influence the productivity of the workers	0.031	372	.021	73.02	107.86	48.24

From the test of hypothesis above using one sample test t-statistics, based on the decision rule, accept null hypothesis if the value of the t-statistics is greater than 0.05, from the result; the value of the t-statistics (0.031) is below 0.05 hence we reject the null hypothesis and conclude that human comfort in office building in Enugu urban significantly influence the productivity of the workers.

**XX. DISCUSSION OF FINDINGS**

Research question one sought to know what the impact of window size and orientation, in relation to sun direction, on indoor heat of office buildings in Enugu urban is. The findings showed that window sizes and orientations in relation to sun direction were significant in regulating room temperature and air flow of office buildings and consequently the heat indices of office buildings in Enugu Metropolis. It implied that window size and the Sun’s direction influence indoor comfort in office buildings within the tropics. This is in consonance with the work of Onodugo, Ugwuonah and Ebinne, (2010) who revealed that window size and orientation directly influence each other towards regulating thermal comfort in buildings.

Question two sought to interrogate the influence of individual adaptive measure on thermal comfort of office workers. The findings of this study indicate that Individual adaptive measures to thermal comfort contribute in reorienting mindset towards the indoor comfort, Individual adaptive measures help in regulating the internal heat, It promotes indoor comfort in the office building. which supports the work of Yao, Li, and Liu, (2009), who explored the influence of individual adaptive measures on thermal comfort, the researcher maintained that individual adaptive measures influences thermal comfort of workers.

Question three interrogates the relationship between indoor comfort and productivity of office workers in the study area. Indoor comfort determines office productivity, an individual with maximum indoor comfort performs higher in an office work. This is in accordance with Tanabe, Iwahashi and Tsushima, (2014), who opined that there is significant relationship between indoor comfort and productivity of office workers in Enugu urban.

**XXI. SUMMARY OF FINDINGS**

Table 3: shows the responses on the impact of window size and orientation in relation to sun direction on indoor heat of office building in Enugu urban. Looking at the questionnaire items which answers research question one, item 1,2,3,4, with a mean score of 3.30, 3.02, 2.98 and 3.14 had a mean rating above 2.5 which indicates that window size and orientation in relation to sun direction has impact on indoor heat of office building in Enugu urban. Based on this, we believed that window size and orientation in relation to sun direction has impact on indoor heat of office building.

Table 4: shows the influence of individual adaptive measures on thermal comfort of office workers in Enugu urban, item 5,6,7,8 with a mean score of 3.05, 3.02, 3.05 and 2.68 had a mean rating above 2.5. Research question 2 has a grand mean of 2.95. Based on this, the result showed that individual adaptive measures influences thermal comfort of office workers in Enugu urban.

Table 5: shows the relationship between indoor comfort and productivity of office workers in Enugu, 9, 10, 11 and 12 with the mean score of 3.25, 3.22, 2.97 and 2.68 had a mean rating above 2.5 which indicates that there is relationship between indoor comfort and productivity of office workers in Enugu.

## XXII. CONCLUSION/RECOMMENDATIONS

The findings of this study showed that window size is a significant factor in the regulation of indoor temperatures of office building in the tropics, as was the case in Enugu Metropolis, because window the size permit determines the area of opening through which air flows in and out of the interior spaces. Also the orientation of the office building in relation to the direction of the sun affects indoor heat and, hence, comfortability.

The study also established that adaptive measures to thermal comfort help in mitigating indoor heat for indoor comfort. They help provide mental confidence that indoor comfort in the office is assured. Hence, this sense of indoor comfort provides the motivation and ambience for increased office productivity of workers. Because individuals working in comfortable environments, especially in offices, tend to work longer and better with enhance concentration, it is evident that there is strong relationship comfort and productivity. This is the case with office workers in the tropics, especially in Enugu Metropolis.

- (a) There should be enough sensitization in form of seminars and symposia organized for Stakeholders on the reality climate changes and their effects on daily human activities.
- (b) Adaptation measures to climates should be included into the orientation and work ethics of civil servants. This will transform such measures into becoming part of the responsibilities and consciousness of workers.
- (c) Building designers should adopt all necessary passive design techniques that promote natural ventilation as against dependence on active and mechanical means of achieving indoor comfort.
- (d) There may be need for Government to make budgetary provisions to remodel and rehabilitate old public office spaces, bearing in mind the gains of indoor comfort, in order to improve office workers' comfort and productivity.

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