EFFECTS OF CLIMATE CHANGE ON BUILDING CONSTRUCTION AND MAINTENANCE COST IN ENUGU STATE, NIGERIA

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ABSTRACT
Climate change affects building. This causes some worry and discomfort. The effects include: dust, smoke, acidic rain, flood, loss of life and properties, building failure and collapse. As a result of this, the cost of construction and maintenance has increase to an alarming point. The research aims at analyzing the effects of climate change on construction and maintenance cost on buildings in Enugu state, Nigeria, therefore proffered remedial measures to these effects. The study adopted survey design, this involves the use of well-structured question, interview and literature review. The data analyses was done using simple percentages and descriptive analytical tool such as tables in analyzing and presenting the result. The data realized from NiMet was analyzed using time series analysis and presented in tables and charts. The research developed a mathematical model of relationship between known climatic variables against construction and maintenance cost. The clusters mean value of 3.9, slightly above the lickert average of 3.0 and associated standard deviation of 0.65 (lickert standard deviation) indicates that there are reasons for variations in the cost of construction and maintenance of buildings.The research recommends;the need for use of overhangs in building located within Enugu and environs to minimize the impacts of wind driven rain on the exterior of buildings. Thus, for buildings without this, landlords and house owners should install overhangs over openings like windows and doors.

KEYWORDS: Climate Change, Building, Construction, Maintenance, Enugu State

INTRODUCTION
The climate is changing globally and its evidence is clear to all. It is a current issue.Some changes in the climate parameters bear more impact on building than others, this includes rainfall, wind speed, wind direction and temperature which affect the internal environment of a building (Harman, 2004). To ignore the effect of climate change while designing is taking a big risk. Some of these changes are seen in the form of dust, smoke, acidic rain and flood which drastically affects the building envelop.

The effect of climate change on buildings manifest in diverse forms and degrees: accelerated deterioration, risk of failure, collapse, increased running cost. Climate agents contributes immensely to the deterioration of building fabrics (Johns and Fedeski, 2017). For the sustainability of optimum performance of any building structure, a sound maintenance culture is inevitable (Iheama, Alinta-Able and Ezeokoli, 2017). This menace caused by climate change can be handled by improved maintenance on the building structure.

A building basically is required to provide comfort and protection from all external hazards (Pretlove and Oreszezyn, 1996). This diverse pressure from the external environment affects its expected load bearing capacity (Steenbergen, Geurts and Bentum 2006). It therefore, requires other techniques which have been developed over the years to adapt the changing climate.

The building designers should be well informed of the future effects of these climate parameters and the degree to which the building structure can withstand it. It is also appropriate to inform the building users of the expected weaknesses and possible maintenance measures to ensure continuous functionality.

Scott *et al* (2014), while examining the impacts of future climate variability on the energy consumption, peak energy demand and energy costs at NASA's John C. Stennis Space Center (SSC) in southern Mississippi also found that the high impact scenario projects potentially disruptive increases in cooling peak demand and resulting peak electric demand. This is due to sizable projected increases in both peak dry-bulb and wet-bulb temperatures. Thermal storage technologies may offer increased value by providing methods to ride-through longer and more frequent peak demand events, which is higher cost of management and maintenance. Specifying larger capacities for these systems, in particular for campus distribution systems, should be considered during upgrades and new construction (when smaller incremental costs are incurred).

Considering that climate change is a continuous event which has started from the existence of man on earth and extending to an unknown period. It calls for a continuous research from different walks of life to address this issue. Since no research has been carried out on assessment of the impact of climate change on building maintenance in Nigeria, Enugu State precisely, this researchtherefore analyzes the effects of climate change on building in Enugu state, therefore proffer remedial measure to these effects.

LITERATURE REVIEW

Ackerman and Stanton (2008), in their review on the cost of climate change noted that global warming comes with a big price tag for every country around the world. The 80 percent reduction in U.S. emissions that will be needed to lead international action to stop climate change may not come cheaply, but the cost of failing to act will be much greater. New research shows that if present trends continue, the total cost of global warming will be as high as 3.6 percent of gross domestic product (GDP). Four global warming impacts alone: hurricane damage, real estate losses, energy costs, and water costs; will come with a price tag of 1.8 percent of U.S. GDP, or almost $1.9 trillion annually (in today's dollars) by 2100.

Ackerman and Stanton (2008), in their report, noted that it is difficult to put a price tag on many of the costs of climate change: loss of human lives and health, species extinction, loss of unique ecosystems, increased social conflict, and other impacts extend far beyond any monetary measure. But by measuring the economic damage of global warming in the United States, we can begin to understand the magnitude of the challenges we will face if we continue to do nothing to push back against climate change. Curbing global warming pollution will require a substantial investment, they also noted that the cost of doing nothing will be far greater. Immediate action can save lives, avoid trillions of dollars of economic damage, and put us on a path to solving one of the greatest challenges of the 21st century.

Hallegatte (2009), in studying strategies to adapt to uncertain climate change, opined that new infrastructure will have to be able to cope with a large range of changing climate conditions, which will make design more difficult and construction more expensive. According to the study, it is essential to consider both negative and positive side-effects and externalities of adaptation measures as the cost implication is unavoidable. The research recommended that adaptation–mitigation interactions need integrated design and assessment of adaptation and mitigation policies, which are often developed by distinct communities.

High temperatures and heat waves will cause internal building temperatures to increase, particularly when combined with the urban heat island effect in cities. This may result in heat stress, health problems, and loss of productivity for those who inhabit the buildings(USAID Fact Sheet, 2012). More humid weather will affect buildings in warm weather climates, with the effect being glaring for instance, Sea level rise could permanently inundate homes, workplaces, or service centers. Flooded coastal health centers could hamper delivery of critical health services amongst many other effects. These effects have

their economic implications especially with respect to cost of maintenance of the affected buildings, cost of rehabilitation and reconstruction of these buildings and the change in design of future buildings to accommodate the impact of these changes in the climate element.

Nigeria, being a part of the global community is not immune to the impacts of climate change. The climate condition of Nigeria is tropical, which basically is influenced by two winds; South-West wet monsoon which blows across the Atlantic ocean and brings with it rainfall and the North-East wind which blows across Sahara desert and brings along; dust, dry season and harmattan (Okereke, 2003).The increasing frequency and intensity of these extreme weather events, and the associated natural disasters, bear negative impacts on the cost of construction and maintenance of buildings.

Research Methodology

This study adopted survey design, this involves the use of well-structured question, interview and literature review. The data analyses was done using simple percentages and descriptive analytical tool such as tables in analyzing and presenting the result. The data realized from NiMet was analyzed using time series analysis and presented in tables and charts.

Regression Analysis

To investigate the relationship between the climatic parameters and their combined strength on variations in construction and maintenance cost, multiple regression analysis was performed to determine the strength of these relationships. The dependent variables were regressed on the climatological variables (independent variables). From this multiple regression model, the rate of change (increase or decrease), as indicated by the regression coefficients.

Data Analysis and Presentation

The data collected from the questionnaire distributed was analyzed using simple percentages and descriptive analytical tool such as tables in analyzing and presenting the result. The data realized from NiMet will be analyzed using time series analysis and presented in tables and charts. For the hypotheses test, the lickers scale questions will be subjected to a mean calculation to get the cut off point for the responses of each question. The research examined the responses of the respondents on the effects of climate on the cost of construction and maintenance cost. The responses are presented in table 2.1.

Table 1.0: Perceptions of Effects of Climate on the Cost of Construction and Maintenance

Question Items SA=5, A=4, UD=3, D=2, SD=1	**SA**	**A**	**UD**	**D**	**SD**	**Statistics**	
						Mean	**STD**
The cost of construction has increased over the past five decades	287	23	15	0	0	**4.8**	**1.24**
The cost of building maintenance has increased over the past five decades	249	68	8	0	0	**4.7**	**1.07**
The increase is as a result of the present day recession	143	71	24	63	24	**3.8**	**0.49**
Climate change has affected the cost of building construction	15	62	77	125	46	**2.6**	**0.41**
Climate change has caused buildings to be deteriorated without living out their life span	108	147	16	54	0	**4.0**	**0.62**
climate change is the cause of changes in	111	138	41	35	0	**4.0**	**0.57**

building color shortly after painting							
High rainfall affects the cost of building construction and maintenance	111	133	29	52	0	**3.9**	**0.56**
Temperature change affects cost of construction and maintenance	59	133	66	52	15	**3.5**	**0.43**
Wind variations affects cost of construction and maintenance	85	131	70	23	16	**3.8**	**0.47**
Cluster Means and Standard Deviations						**3.9**	**0.65**

The responses on table 1.0 show that despite the fact that most respondents agreed that construction cost and maintenance cost have increased over the years, they attributed these to economic situations particularly the recession. Thus majority of the respondents, about 125 strongly disagreed that changing climate conditions has affected the construction and maintenance cost of building. Also, about 77 of the respondents were undecided on this question while only 62 and 15 of the respondents agreed and strongly agreed respectively that climate change has affected cost of construction and maintenance. Contrarily, these respondents still believed that variations in climatic parameters have caused deteriorations in buildings. On this, 108 and 147 strongly agreed and agreed that this position is true as they gladly emphasized that climate factors are reducing the life span of most of the buildings. These climatic factors were also believed by the respondents to have been the reason why colours of paints on buildings change and easily deteriorate. About 111 of the respondents strongly agreed that rainfall affects the cost of maintaining buildings in the study area as well as the cost of construction.

On the other hand, 133 agreed and supported the assertion that rainfall is one climatic parameter affecting cost if construction and maintenance of buildings in the study area. Similarly, 59 and 133 of the respondents strongly agreed and agreed the temperature, as a climate parameter, also influence cost of construction and maintenance. In the same vein, the respondents also agreed that wind also affects greatly the cost of maintaining buildings as well as actual construction. In support of this, the clusters mean value of 3.9, slightly above the lickert average of 3.0 and associated standard deviation of 0.65 (lickert standard deviation) indicates that there are reasons for variations in the cost of construction and maintenance of buildings.

The results of the Poisson Regression are presented in tables below.

Table1.1:Perceptions of the Respondents on Time Variations in Aspects of Building Considered.

Month	**Cost of Maintenance**
January	11
February	16
March	37
April	29
May	35
June	31
July	41
August	27
September	17
October	41
November	13
December	27

Table 1.2:Poisson Regression of Cost of Maintenance (as dependent variable) against Rn, Sl, Tmax, Ws, Tmin, Rh and Eff. Rn

Coefficients	Estimate	Std. Error	Z Value	Pr(>|z|)
(Intercept)	-11.011463	5.740199	-1.918	0.05507 .
Rn	-0.008974	0.003851	-2.331	0.01977 *
Sl	-0.215216	0.181035	-1.189	0.23452
Tmax	0.697005	0.256868	2.713	0.00666 **
Ws	0.536338	0.267109	2.008	0.04465 *
Tmin	-0.893465	0.275905	-3.238	0.00120 **
Rh	0.129563	0.049981	2.592	0.00954 **
Eff.Rn	0.021145	0.008463	2.499	0.01247 *

From table 1.2, it is clear that the only one factor that does not affect cost of maintenance of building in the study area is; Sunshine Intensity. The rest of the factors; Rainfall, Maximum Temperature, Wind speed, Minimum temperature, Relative humidity and Effective Rainfall all did affect cost of maintenance of building.
The model corresponding to this table is given by

$$\eta_i = -11.011463 - 0.008974X_1 + 0.697005X_3 + 0.536338X_4 - 0.893465X_5 + 0.129563X_6 + 0.021145X_7$$

. (1.0)

Table1.3: PCA Analysis of Perceptions on the effects of climate change on the cost of construction and Maintenance (KMO and Bartlett's Test).

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.907
Bartlett's Test of Sphericity	Approx. Chi-Square	5359.774
	Df	36
	Sig.	.000

From table 1.3, we see that the Kaiser–Meyer–Olkin Measure of Sampling Adequacy is 0.907, while the Bartlett's Test of Sphericity has a p–value of 0.000. The values of these show that we can go ahead with the PCA.

Table 1.6:Communalities on Analysis of Perceptions on the effects of climate change on the cost of construction and Maintenance.

	Initial	Extraction
The cost of construction has increased over the past five decades	1.000	.551
The cost of building maintenance has increased over the past five decades	1.000	.771
The increase is as a result of the present day recession	1.000	.890
Climate change has affected the cost of building construction	1.000	.768
Climate change has caused buildings to be deteriorated without living out their life span	1.000	.922
climate change is the cause of changes in building color shortly after painting	1.000	.946
High rainfall affects the cost of building construction and maintenance	1.000	.940
Temperature change affects cost of construction and maintenance	1.000	.902
Wind variations affects cost of construction and maintenance	1.000	.924

Extraction Method: Principal Component Analysis.

Table 1.4:Total Variance Explainedon Analysis of Perceptions on the Effects of Climate Change on the Cost of Construction and Maintenance

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.615	84.612	84.612	7.615	84.612	84.612
2	.604	6.706	91.318			
3	.319	3.546	94.865			
4	.189	2.097	96.962			
5	.100	1.113	98.075			
6	.076	.844	98.919			
7	.049	.541	99.461			
8	.032	.360	99.821			
9	.016	.179	100.000			

Extraction Method: Principal Component Analysis.

The PCA extracted about 84.612% of the total variance.

Table1.5:Component Matrix Analysis of Perceptions on the Effects of Climate Change on the Cost of Construction and Maintenance.

	Component
	1
The cost of construction has increased over the past five decades	.742
The cost of building maintenance has increased over the past five decades	.878
The increase is as a result of the present day recession	.943
Climate change has affected the cost of building construction	.877
Climate change has caused buildings to be deteriorated without living out their life span	.960
climate change is the cause of changes in building color shortly after painting	.973
High rainfall affects the cost of building construction and maintenance	.970
Temperature change affects cost of construction and maintenance	.950
Wind variations affects cost of construction and maintenance	.961

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Table 1.6: Component Matrix Analysis of Perceptions on the Effects of Climate Change on the Cost of Construction and Maintenance

	Component
	1
Energy need in buildings in Enugu metropolis varied over the last three decades.	.967
The variation in energy needs of buildings in Enugu is a product of climate variations	.947
Does temperature change/increase affect the energy need of a building?	.970
Does amount and intensity of rainfall affect the energy need of a building?	.973
Does wind direction affect the energy need of a building?	.960
Does Humidity and Cloud Cover affect the energy need of a building?	.963
Does sunshine intensity affect the energy need of a building?	.955
Heating up of the building increases the energy need in building	.974
Cooling down of the building increases the energy need in building	.972

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

DISCUSSION

The cluster mean value of 3.9 and the associated standard deviation of 0.65 indicates that there are reasons for variations in the cost of construction and maintenance of buildings. The most contributing parameter is rainfall. Climate parameters have caused deteriorations in buildings and reducing the life span of these buildings.
Thus, there is rising cost of maintenance on these buildings. For instance, paints on buildings are easily destroyed due to the impact of wind driven rains. The principal component is strongly correlated with all the original variables.

This component can be viewed as a measure of increases the energy need in building as the heating up in the building takes place.The model (equ. 1.0) is in line with the listed factors that affect cost of maintenance, together with the intercept.
This component can be viewed as a measure of the quality of these variables;

1. High rainfall affects the cost of building construction and maintenance,
2. Wind variations affects cost of construction and maintenance,
3. Climate change has caused buildings to be deteriorated without living out their life span,
4. Temperature change affects cost of construction and maintenance,
5. The cost of building maintenance has increased over the past five decades,
6. Climate change has affected the cost of building construction and
7. The cost of construction has increased over the past five decades.

CONCLUSION AND RECOMMENDATION

Based on the outcome of the research, it is clear that climate change affects construction and maintenance cost on buildings in Enugu. This was explained by the established relationship given by the regressive model (equ. 1.0)

There is need for use of overhangs in building located within Enugu and environs to minimize the impacts of wind driven rain on the exterior of buildings. Thus, for buildings without this, landlords and house owners should install overhangs over openings like windows and doors.

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