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EFFECT OF CLIMATE CHANGE ON CONSTRUCTION PROJECT PLANNING IN NIGERIA

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Climate change affects the ecosystems as it creates desertification and serious flooding, and thus, increases the risks associated with embarking on construction project planning. The study assessed the effects of climate change at the first three stages of "the project management cycle" otherwise regarded as project conception planning, project design planning and construction planning. A structured questionnaire was used to obtain responses from eighty-eight (88) construction practitioners representing 73% response rate. Mean and repeated measure ANOVA test was used to establish the average scores and to explore significance differences among variables respectively. Frequent rainfall and extreme air temperatures delaying site preparation activities is the most significant effect of climate change on project conception planning, followed by high insurance costs on projects within flood prone areas. Severe weather events,45 which influence the selection and specification of construction materials, were considered as the greatest impact on project design planning. Too much rain which interfere with construction schedule and mixing of concrete causing newly laid concrete to be destroyed and, high wind which poses danger to life/limbs at the construction sites on building requiring the use of scaffold were ranked very significant effects of climate change on project construction planning. Extreme weather events which influence the structure of site organization plan, and extremely low temperature interference with construction work were outranked in project conception planning and construction planning respectively. The study has provided construction professionals and project managers with useful information and considerations on the effects of climate change on construction project planning.

Keywords: climate change, construction practitioner, Nigeria, project planning

INTRODUCTION

Climate change poses a serious challenge to social and economic development. Developing countries like Nigeria are particularly vulnerable because their economies are generally more dependent on climate-sensitive natural resources, and they are less able to cope with the impacts of climate change (OECD, 2005). Climate change is the result of changes in features of weather conditions, such as temperature, wind patterns, precipitation, and relative humidity. Both natural and artificial factors contribute to climate change but more by anthropogenic factors or human induced activities like burning of fossil fuel, bush burning, deforestation, overgrazing (National Research Council, 2010). In Nigeria, over time, there has been considerable increase in population, which can be considered to have a negative effect on climate

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change. In the report of Oladapo (2010) Nigeria is party to the international effort to reach a new post-Kyoto new climate deal and since 2007, Nigeria has been participating in a series of climate change meetings, talks and negotiations at the regional (Africa, G77+China, ECOWAS) and international levels. United Nations Environment Programme, UNEP (2007) stipulates that climate change is greatly influenced by increase in Green House Gases (GHG). The conversion of Southeast Asian peat forests is estimated to account for 6–7 percent of the total global release of Carbon Dioxide (CO2) into the atmosphere (UNEP, 2007). The Intergovernmental Panel on Climate Change (IPCC) Assessment Report, California (2007) indicates that GHG emissions increased by 70 percent between 1970 and 2004. These gases are primarily emitted through human activities, such as the burning of fossil fuels, with nearly half of worldwide Carbon Dioxide (CO2) emissions produced from buildings. Increased concentration of greenhouse gases (GHGs) in the atmosphere, which traps heat, causes global warming and subsequent rise in sea level. Climate change is a phenomenon that poses a great threat to humanity, the built environment and construction projects (IPCC, 2007).

Achieving construction projects require planning which is a function of management responsible for defining the work to be managed and provide the basis for the performance of other management functions. This according to Arditi (1985) is considered to be the most important management function. Planning of construction projects has been found to be one of the most significant factors for the efficient and effective delivery of projects (Clayton, 1989). Construction project planning has been described as the overall co-ordination and control of a construction project from inception to completion aimed at meeting a client's requirements in order to produce a functionally and financially viable project that will be completed on time within authorized cost and to the required quality standards (Hendrickson, 2008).

Climate change affects the ecosystems; the mangrove and forest zones in Nigeria are affected immensely in that it creates desertification in the Sahel savannahs, and coaster lines could be faced with serious flooding. Flooding makes buildings more expensive to put up as the type of foundation to be employed on an adversely wet soil will have high cost implications (UNEP, 2007). Also, climate change increases the risk of embarking on construction project planning. For instance, during construction of the built facility, extreme weather events and flood risk may hamper construction processes causing delay and extra expense (Hertin, Berkhout, Gann and Barlow; 2003). Similarly, increased extreme weather events and air temperatures affect the health and safety of all site workers and Laborers, particularly those working outdoors on construction sites and this in turn will delay site construction activities and associated costs (Carbon Disclosure Project, 2010). Also extreme weather events may delay transport and delivery of materials affecting site programming and costs, also availability of various construction materials will change as climate change risks, increased regulations and carbon taxes affect the cost feasibility of some materials more than others (CDP, 2010). Hence, this study aims at assessing the effects of climate change on construction project planning.

LITERATURE REVIEW

The construction industry is important in the economy of every nation as it contributes to the process of development. The construction industry comprises a wide range of businesses involved in engineering standards, building design, and the construction of various types of materials and structures. This sector is affected in many ways by

climate change and variability as well as extreme weather events. Knowledge about short-term weather and longer-term climate conditions are essential to adequately design and successfully manage construction projects (National Oceanic and Atmospheric Administration - NOAA, 2010). Long term climate impacts, such as sea level rise, coastal erosion, and drought, and short term weather-related impacts, such as high winds and flooding influence the choice of site construction, building techniques, and materials for construction. The potential risk of inclement weather and climate conditions also influence planning and project completion timelines. Construction projects that require dry conditions, such as laying roads or foundations, may be delayed indefinitely until the weather subsides. This can cost contractors thousands of dollars per day, if not properly planned for in advance (NOAA, 2010). Naoum, Fong and Walker; 2004) describe project planning as one of the tools that stakeholders use to ensure that construction projects are successfully implemented. Hore, Kehoe, McMullan and Penton; 1997) and Faniran (2000) described project planning as the systematic arrangement of project resources in the best way so as to achieve project objectives. Project planning requires that project objectives are defined first and thereafter the strategies to achieve them are formulated. Faniran (1998) observed that the objective of project planning is project performance that is to complete a project within a fixed time, at a previously estimated cost and to specified standards of quality. This assertion implies that the effectiveness of project planning is measured by project performance. Naoum (1991), Ling, Chan and Chong (2004) and Thomas, Macken, Chung, and Kim (2002) also regard project performance as the basis of evaluating the effectiveness of project planning. Dvir, Raz and Shenhar (2003) identifies three levels of project planning namely:

1. The end-user level where planning focuses mainly on the functional characteristics of the project end-product;

2. The technical level which focuses on the technical specifications of project deliverables that are needed to support the functional requirements; and

3. The project management level which focuses on planning the activities and processes that are needed to be carried out to ensure that the technical work proceeds effectively.

These three levels of planning can otherwise be regarded as project conception planning, project design planning and construction planning. Most modern climatologists predict an unprecedented warming period during the next century and beyond, a trend that is increasingly attributed to human-generated greenhouse gas emissions resulting from the industrial processes, transportation, solid waste generation, and land use patterns of the twentieth and twenty-first centuries (IPCC, 2007). Spencer (2007) defines "climate" as the average or typical weather conditions observed over a long period of time, usually at least 30 years, for a given geographic region. Over time, the earth's climate has undergone periodic ice ages and warming periods, as observed in fossil isotopes, ice core samples, and through other

measurement techniques. Recent climate change studies use the historical record to predict future climate variations and the level of fluctuation that might be considered statistically normal given historical trends (IPCC, 2007).

Regardless of the analytic methodology used, global average temperature and sea level are predicted to rise under all scenarios (Alley, 2007). In other words, there is evidence that emission reductions can minimize climate change effects but cannot reverse them entirely. For example, the IPCC predicted that the range of global mean temperature increase from year 1990 to 2100, given different reduction scenarios could range from 1.1°C to 6.4°C (IPCC, 2007).

Nigeria Climate Change (1901 – 2005)

According to Odjugo (2010) the temperature trend in Nigeria since 1901 shows increasing pattern (Fig 1). The increase was gradual until the late 1960s, from which period persistent rise in air temperatures have been recorded to date (Fig 1). The mean air temperature in Nigeria between 1901 and 2005 was 26.6°C while the temperature increase for the 105 years period was 1.1°C.

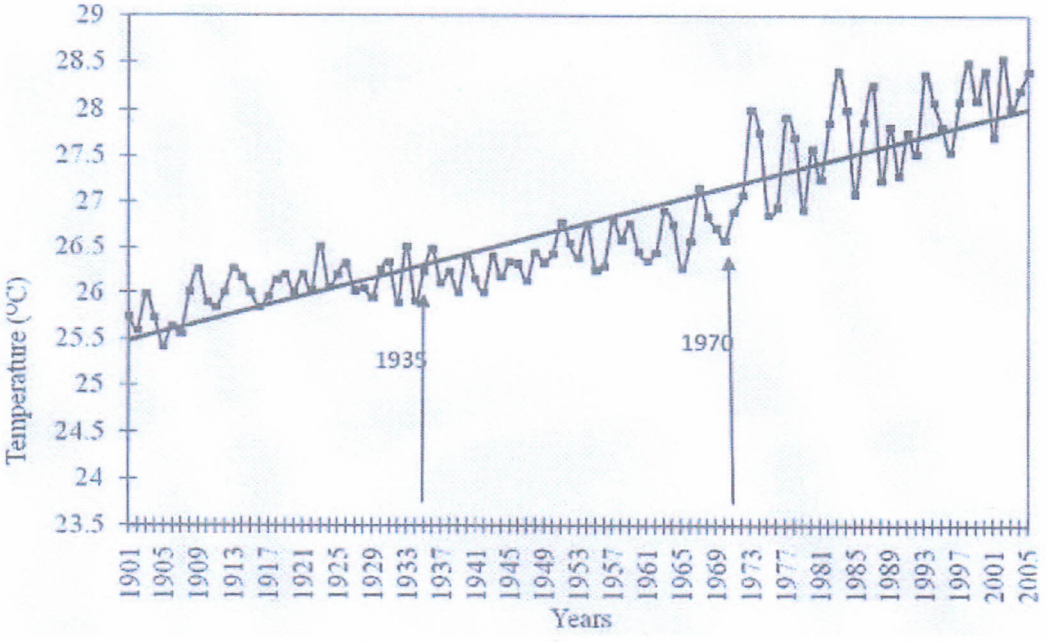

Fig. 1: Air temperature distribution in Nigeria 1901-2005

Source: Odjugo (2010)

This is obviously higher than the global mean temperature increase of 0.74oC recorded since 1860 when actual scientific temperature measurement started. Should this trend continue unabated, Nigeria may experience between the middle (2.5oC) and high (4.5oC) risk temperature increase by the year 2100 (IPCC 2007).

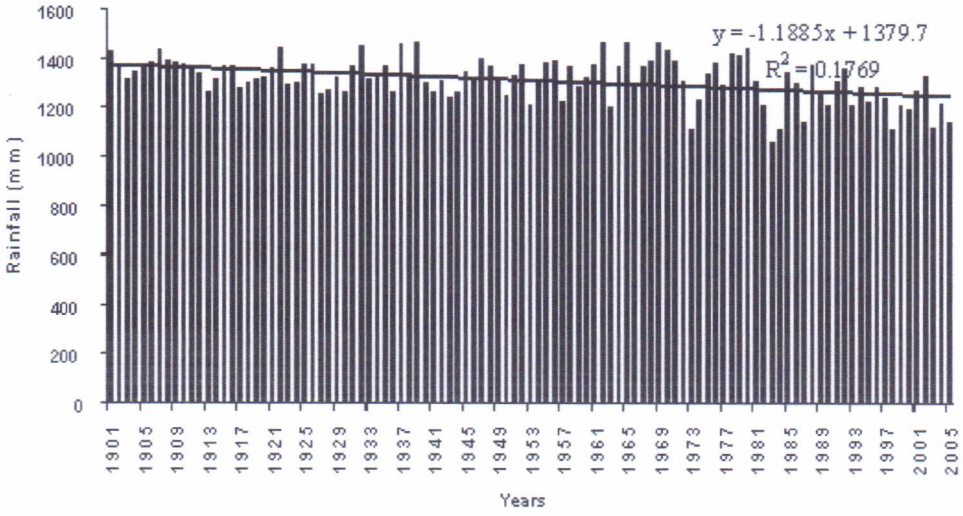

Fig. 2. Rainfall distribution in Nigeria between 1901 and 2005

Source: Odjugo (2010)

Rainfall trend in Nigeria between 1901 and 2005 shows a general decline as shown in Figure 2, as rainfall amount dropped by 81mm within the 105-year period. The declining rainfall became critically significant from the early 1970s, and the pattern has continued till date. This period of drastic rainfall decline corresponds with the period of sharp temperature rise shown in (Fig 3). Odjugo (2010) corroborates IPCC (1996) and NEST (2003) that increasing rainfall in most coastal areas and decreasing rains in the continental interiors are notable impact of climate change. Odjugo (2005, 2007) observe that the number of rain days dropped by 53% in the north-eastern Nigeria and 14% in the Niger-Delta Coastal areas and reported a general decrease in rainfall in Nigeria with the coastal areas of Nigeria like Warri, Brass and Calabar experiencing slightly increasing rainfall in recent times.

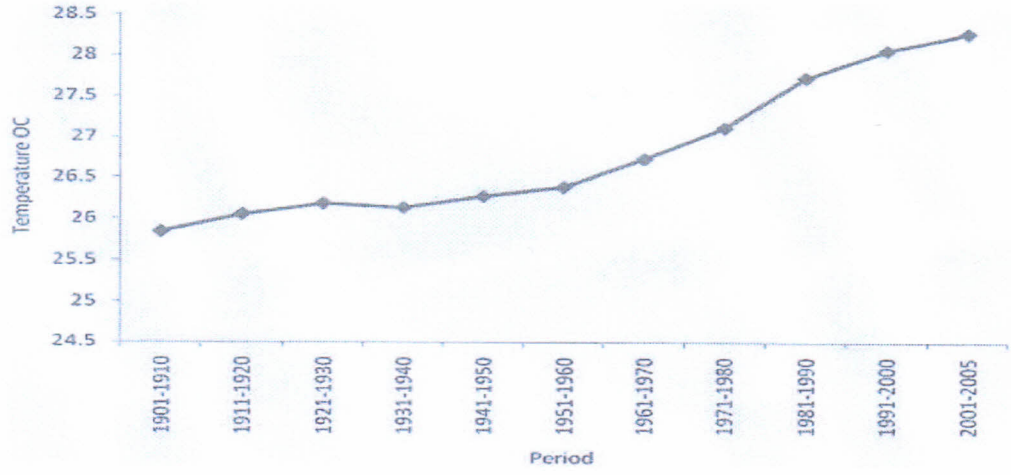

Fig.3 Decadal temperature variation in Nigeria between 1901-2005.

Source: Odjugo (2010)

Odjugo (2005, 2007)

concluded that there are major disruptions in climatic patterns of Nigeria showing evidence of a changing climate.

Effects of climate change on construction project planning

The construction industry may be more vulnerable to climate risk than other sectors due to short term reactions of other stakeholders to perceived risks (Hertin et al, 2003). Risk from flooding due to changes in climate is a combination of the flood hazard coupled with exposure and vulnerability to flooding (Clark, Priest, Treby and Crichton; 2002). According to Clark et al (2002) in the pre-planning stage flood risk affects the suitability of locations for planning construction projects and the conditions under which development is permitted. Commercial viability rests upon considerations such as: possible reduced land price; increased investment in planning consent; increased construction costs; reduced salability, mortgaging and insurability; and long term viability of the built facility. In the planning and design stages flood risk affects the design of the built facility. Under planning conditions specific drainage, building elevation, structural designs and specialized materials may be necessitated. This may represent long term commitments for design and construction companies and importantly their clients. In addition, there are direct financial risks to construction project planning associated with the climate change legislation in terms of changes to local environmental planning guidelines and building standards. Planning guidelines in all the jurisdictions that construction projects operate globally are being amended to reflect climate change risks and adaptation that have direct financial impacts on the value of any construction project. As the standards become more stringent or prescriptive, additional engineering may be required. Besides, expensive building technologies and changes to building standards in line with climate adaptation risks have financial implications on the design, planning and operational costs of construction projects Carbon Disclosure Project (CDP, 2010).

The Carbon disclosure project (2010) also highlighted some of the current and/or anticipated significant physical risks caused by climate change and their various effects on construction project planning as follows:

Severe weather events: resulting in property damage, impact costs associated with transport and delay delivery of construction products and materials, delay site construction activities and programming, increase site construction costs due to increased mitigation measures such as large scale treatment of construction water run-off may result in indirect effects to local economies. Changing weather conditions will also have profound effects on human health (COM, 2009). Increased extreme weather events and air temperatures will directly affect the health and safety of all site workers and Laborers; as diseases such as malaria are likely to have wider ranges (Oladipo, 2010), particularly those working outdoors on construction sites and this in turn will delay site construction activities and associated costs.

Rising sea levels, coastal flooding, and erosion: may increase construction project costs associated with additional site flood mitigation measures in either landscaping, storm water engineering or building design, may prevent construction project approval or undermine existing asset values due to changed sea-level rise mapping, will result in demographic shifts which in turn determine feasibility of construction projects.

Changes in Precipitation: Corresponding to high temperature areas, may cause inadequate water supply. Also, access to adequate water to service construction developments will be the key to determining the feasibility of any proposed construction projects.

Flooding of Low Lying Areas: Flood prone or low lying land in coastal areas like Lagos are affected by increased extreme weather events, rising sea levels, flooding and inundation, and associated demographic shifts. This may comprise land that was historically reclaimed from swamps and river deltas to flood plains and harbor foreshores.

Addressing climate change requires two types of response. Firstly, and importantly, we must reduce our greenhouse gas emissions (GHG) (i.e. take mitigation action) and secondly we must take adaptation action to deal with the unavoidable impacts (COM, 2009). Therefore, governments and policy-makers have a responsibility to understand these climate change impacts and to develop and implement policies that will ensure an optimal level of adaptation.

RESEARCH METHOD

The targeted population comprises managerial staff, project managers and other key personnel involved in project planning in construction firms, consulting firms and client organisations including government ministries and agencies based in Lagos. Purposive sampling technique was adopted for the study due to the comprehensive nature of the required population and limitation on time. One hundred and twenty (120) questionnaires were distributed to respondents, out of which only eighty-eight (88) responses were useful from the ninety-three (93) responses received. Respondents were requested to measure the level of significance they attach to identified factors that determine project managers' perception on climate change and how it affects the planning of construction projects on a five-point Likert scale used to determine the mean score of variables. Analysis of variance (ANOVA) test was performed to explore significant differences in the level of opinion of the respondents. The respondents' backgrounds represent 17% construction project managers, 17% Architects, 19% Builders, 21% Quantity Surveyors, 18% Civil Engineers. 8% represented Meteorologists from the Climate Change Department of the Ministry of Environment, and the Nigerian Meteorological Agency. Also 37 respondents representing 42% of the sample size were consulting organization, 34% contracting organization and 24% represents government organization. The respondents have adequate experience in construction project as 16% of the population have 21-25

years' experience, 21% represents respondents with 16-20 years' experience, 27% represents respondents with 11-15 years' experience, 27% represents respondents with 6-10 years' experience with only 8% in the 1-5 years' experience range. Therefore majority of respondents are qualified in their experience to assess construction project planning issues.

Effects of climate change on construction project Conception planning.

Table 1 reveals that the delay of site preparation activities as a result of frequent rainfall and extreme air temperatures with a mean score of 4.60 has the most significant effect of climate change on project conception planning. This is followed by high insurance cost of flood prone areas with mean rating of 4.40 and force majeure (natural disaster) with mean rating of 4.32. The least ranked effects of climate change on project conception planning as shown in Table 1 is the impact of severe weather events such as sea level rise on the elevation/topography of the site which recorded a mean score of 3.99.

Table 1: Effects of climate change on Project conception planning.

	Mean	Rank
Frequent rainfall and extreme air temperatures may delay site preparation activities.	4.60	1
Flood prone coastal areas may have high insurance cost	4.40	2
Force majeure (natural disaster)	4.32	3
Extreme weather events such as heavy precipitation, drought, excessive flood and erosion may affect the bearing capacity of soil which will determine the type of foundation to be used	4.15	4
Extreme temperature and weather events will influence the choice of site location	4.15	4
Extreme weather events will influence the structure of site organization plan	4.01	5
Severe weather events such as sea level rise will affect the elevation and topography of the site	3.99	6

Table 2:Effects of climate change on Project design planning.

	Mean	Rank
Severe weather events will influence the selection and specification of construction materials	4.44	1
High wind, tides, hurricanes, cyclones may influence the method of construction design	4.16	2
Flood risk affects the design of the built facility	4.00	3
Extreme weather events such as high tides and winds may damage the structural design and stability of the built facility causing high cost implication of remedial works	3.98	4
Extreme weather events will influence asset management strategies	3.88	5
Severe weather events will affect the site layout plan	3.82	6

Table 3: Effects of climate change on construction planning.

	Mean	Rank
Too much rain will interfere with construction schedule and mixing of concrete will be adversely affected. Newly laid concrete will be destroyed and labor will not be fully utilized.	4.59	1
High wind poses danger to life and limbs at the construction sites, especially on building requiring the use of scaffold.	4.50	2
High temperature and humidity will adversely affect the physiological comfort of workers who will not be able to give off their best.	4.44	3
During construction of the built facility extreme weather events and flood risk may hamper construction processes causing delay and extra expense	4.44	3
Extreme weather events may also delay transport and delivery of materials affecting site programming and costs.	4.42	4
Severe weather event results in delay or impact costs associated with transport and delivery of construction products/materials, delay site construction activities/programming and increase site construction costs.	4.41	5
Increased extreme weather events and air temperatures will directly affect the health and safety of all site workers and laborers, particularly those working outdoors on construction sites and this in turn will delay site construction activities and cost.	4.32	6
During the operation of built facilities, flood and extreme weather events cause damage to buildings and contents necessitating remedial work.	4.24	7
In the pre-planning stage flood risk affects the suitability of locations for planning construction projects and the conditions under which development is permitted	4.23	8
Rising sea levels, coastal flooding, and erosion may increase construction project costs associated with additional site flood mitigation measures in either landscaping or building design thereby preventing construction project approval and feasibility.	4.16	9
Flooding of Low Lying Areas such as coastal areas in Lagos are prone to flood/coastal erosion and would in-turn affect transport infrastructures including cost and programming for construction sites and asset maintenance.	4.14	10
Extremely low temperature will interfere with construction work in temperate countries.	3.98	11
Changes in Precipitation corresponding to high temperature areas may cause inadequate water supply and inability to access reliable water utility services in developing countries such as Nigeria would pose challenges to construction project feasibility.	3.88	12
In the planning and design stages flood risk affects the design of the built facility.	3.84	13
Availability of various construction materials will change as climate change risks, increased regulations and carbon taxes affect the cost feasibility of some materials more than others.	3.68	14

The influence of severe weather events on the selection and specification of construction materials which has a mean score of 4.44 was considered as the factor with the highest influence on project design planning. It is followed by High wind, tides, hurricanes, cyclones impacts on the method of construction design and flood risk impacts on the design of the built facility which have 4.16 and 4.00 respectively as shown in Table 2. The factor which ranked least on effect of climate change on

project design planning as indicated in Table 2 was the impact of severe weather events on the site layout plan with a mean of 3.82.

Assessment of respondents' opinion on effects of climate change on construction planning as revealed in Table 3 indicates that too much rain which interfere with construction schedule and mixing of concrete causing newly laid concrete to be destroyed and, high wind which poses danger to life/limbs at the construction sites on building requiring the use of scaffold which have mean scores of 4.59 and 4.50 respectively were ranked very significant effects of climate change on project construction planning. Change in availability of various construction materials as climate change risks increased regulations with carbon taxes affecting cost feasibility of materials which recorded a mean score of 3.68 was found to be the least significant effects of climate change on construction planning. All the factors are within the significant range on the 5-point Likert scale.

Test of hypothesis

There is no significant difference in the effects of climate change on project conception planning, project design planning and construction planning.

Having previously examined the effect of climate change on project conception planning, project design planning and construction planning, a further test was conducted to examine if the effect of climate change differ significantly in these three stages of construction project planning. In order to do this repeated measure analysis of variance was carried out. A one way repeated measures ANOVA was conducted to compare scores on the effect of climate change on project conception planning, project design planning and construction planning. The means and standard deviation are presented in Table 4. There was significant effect of climate change [Wilk's Lambda=0.859, $F(2,86)=7.048$, $p<.005$].

Table 4: Descriptive Statistics for Effects of climate change on construction planning.

Construction Project Planning	N	Mean	
Conception planning	88	4.23	0.22
Design planning	88	4.01	0.22
Construction planning	88	4.18	0.29

The p value is less than .05 therefore we can conclude that there is statistically significant difference in the effect of climate change between the three levels of construction project planning; project conception planning, project design planning and construction planning.

SUMMARY AND CONCLUSIONS

Frequent rainfall and extreme air temperatures which delay site preparation activities rank as the most significant impact on project conception planning. Severe weather events which influence the selection and specification of construction materials have the most significant impact on project design planning. Too much rainfall which interfere with construction schedule and mixing of concrete causing newly laid concrete to be destroyed and extreme weather events/flood risk which hamper construction processes during construction of the built facility causing delay/extra expense are identified in this study as the most significant effects of climate change on construction planning. This corroborates CDP (2010) report that severe weather events resulting in property damage, delay or impact costs associated with transport or delivery of construction products/materials, delay site construction activities and programming as the most significant effects of climate change on construction planning. The findings of the research are obvious as climate change have significant impact on planning of construction projects in the Victoria Island, Ikoyi and Lekki peninsula areas in Lagos metropolis. Several developments at the Bar beach in Victoria Island are being threatened by ocean surge. These areas are close to the Atlantic Ocean and therefore are prone to risk of climate change. Erosion and flooding in particular was identified by project managers as a major challenge to construction works as it requires additional expenses. The weather elements are only fairly predictable now with increasing rainfall and temperature. The concern about the challenge of climate change on construction project has been manifested in this research. This is equally observed in the efforts of the governments of Lagos State and other States in Nigeria rising up to some of the challenges and their resolve to participate and support global action on climate change

The study has provided construction professionals, especially project managers, with useful information about the effects of climate change on construction project planning to help them make guided and informed judgements, and to enable them adopt formal and systematic approach to construction planning which would minimize the impacts of climate change. This is collaborated by the literature review which reiterates that knowledge about short-term weather and longer-term climate conditions are essential to adequately design and successfully manage construction projects. This will enhance the quality of the decisions and ensure that realistic and effective construction planning methods are formulated by the professionals in adapting to climate change. The study provides a platform on which further studies relating to causes and impacts of climate change can be undertaken.

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