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Impacts of Climate Variability on Construction Project Performance in South-South, Nigeria

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Abstract **Original Research Article**

The impact of climate variability on construction project performance has become increasingly significant, particularly in regions like South-South Nigeria, where weather conditions can be extreme and unpredictable. This study investigates how climate elements such as rainfall, temperature, humidity, and wind affect key project performance parameters, including productivity, delivery time, quality, safety, cost, and profitability. Utilising a quantitative survey approach, data were collected from registered construction professionals across selected states in the region. The analysis, employing inter-rater reliability and relative importance index methods, revealed that rainfall predominantly impacts project delivery time and quality, while high temperatures contribute to safety risks and decreased productivity. Humidity was shown to exacerbate construction challenges by creating unstable work conditions, while high winds disrupt material handling and pose risks to structural integrity. Findings indicate that effective mitigation strategies, such as the adoption of renewable energy, afforestation, public education on reducing emissions, and climate-adaptive project planning, are essential to counteract these challenges. Key recommended measures include the adoption of alternative energy sources such as solar power to reduce reliance on fossil fuels, afforestation initiatives to absorb carbon and moderate temperature fluctuations, and educational campaigns to raise public awareness about emission reduction practices. This study underscores the need for comprehensive policy development and investment in climate-responsive infrastructure to enhance construction resilience.

Keywords: Climate Variability, Construction Project Performance, Mitigation Strategies, Project Delays and Productivity, South-South Nigeria.

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INTRODUCTION

The Nigerian construction industry has not been left out of the emphasis on the impacting phenomenon of climate variability through research studies. Among them is a study by Bello and Ogunsanmi (2012) in Lagos State which assessed the effects of climate change at the first three stages of construction project planning vis-à-vis conception, design, and construction. Ede, Adeyemi and Joshua (2014) analytically employed rainfall, temperature and structural failure data from Lagos State and postulated their impacts on constructed facilities in Lagos Cosmopolitan urban area. Also in Lagos State, a study by Ede and Oshiga (2014) focused on the consequences of global climate change on the road infrastructure network and its mitigation strategies. Gana and Aliyu (2015) carried out research to examine climate and engineering construction practices in Nigeria, causes and sources of climate variability, the effects of climate change, and engineering responses to the effects of climate change. Ebele and Emodi (2016) reviewed some existing literatures to derive information on policies, and data on climate change in Nigeria and its impacts on the various sectors of the economy. Odjugo (2010) explained the general overview of climate change impacts in Nigeria. Akanni, Oke and Akpomiemie (2015) researched on the impact of environmental factors on building project performance in Delta State, Nigeria. It is obvious that most of these studies have only been centred on reviews and majorly around the South-Western area of the country.
According to Oruc *et al*. (2024), weather consists of a variety of elements, including temperature, wind, rain, hail, snow, humidity, flooding, thunderstorms, and heat waves. In contrast, climate refers to the long-term patterns of weather in a specific region. Discussions about climate often involve analysing patterns or cycles of variability, such as changes in temperature, humidity, precipitation, and ocean surface temperature (Neal *et al*., 2016; Werndl

et al., 2016). The variability in the patterns of changes in climate is referred to as climate variability in this study. It suffices to say that impacts of climate variability need be investigated in environment such as South-South of Nigeria where it has been reported that there are many disruptions to labour productivity and material waste generation on building sites due to variabilities of weather conditions (Adewuyi *et al*., 2014; Odesola, 2012). Moreso, it has been reported by Umah and Adewuyi (2023) that some elements of climate variability impact on project activities which in turn might impact on the performance of affected construction projects.

Considering the foregoing, the imperativeness of this study is anchored on the fact that there has been an overwhelming challenge on the impacting nature of climate variability on the performance of the construction projects in Nigeria. There are limited citations of this kind of study in South-South, Nigeria. Hence, to fill the gap in knowledge due to dearth of studies in this area, this study seeks to investigate the impact of climate variability on the performance of the construction projects in South-South, Nigeria with a view to achieving an improved project delivery and a safe working environment in the construction industry. The following objectives were set to guide this study.

i.) Determine the impact of climate variability on performance of construction projects in the South-South region of Nigeria.

ii.) Assess the strategies for mitigating the impacts of climate variability on construction project performance in the region.

Climate Variability Impact on Construction Project Performance

Construction projects, in general, are executed in an outdoor environment, and therefore are affected by climatic conditions. It has been said that delays as a result of weather conditions are significant risk factors in the contract delivery process, but construction managers are often unable to reliably predict delays as a result of them (Thorpe and Karan, 2008). Therefore, it should not seem strange that climate and weather conditions are often reported as one of the main causes of project delays and unscheduled changes. The climate variability impact on construction activities can be in the form of reduced labour productivity and/or work stoppage. Reduced labour productivity is generally attributed to reduced human performance due to the combined effect of temperature, humidity, and wind velocity. The weather-related work stoppage is attributed either to the inability of construction personnel to work under severe weather conditions such as heavy rain, heat wave, and gusting winds, or simply to the compliance with safety regulations in such adverse weather conditions. Ballesteros-Pérez (2015) reiterated that while it may be nearly impossible to establish an exact link between individual or combined weather events and specific construction activities, construction managers should nonetheless implement measures to enhance their current estimates of activity-specific non-working days caused by weather conditions. It depicts the fact that climate variability is recognized as a significant contributor to labour productivity.

Lim *et al.* (2017) highlighted the impact of severe weather on labour stress and productivity. Similarly, Durdyev *et al.* (2018) identified adverse weather conditions as a key external factor negatively affecting labour productivity. Ghoddousi *et al.* (2015) ranked weather as the 16th most influential, among 32, factors impacting construction labour productivity. El-Rayes and Moselhi (2001) examined rainfall's effect on productivity in highway construction projects and proposed a predictive system for its impact. Furthermore, high temperatures have been noted to significantly influence labour productivity in Bahrain and Oman (Jarkas, 2015) and in Nigeria (Ekung *et al*., 2021). Similarly, Umah and Adewuyi (2023) reported twenty-nine (29) critical construction activities impacted by climate variability. Thus, it is understood that extreme climatic condition is one of the main determinants of labour productivity, project delivery time, cost overrun, quality, profitability and safety on construction site which are parameters of project performance. The study of labour productivity considering weather conditions is important for many reasons. Changes in weather and different climate conditions contribute to variances in productivity. Determining the impact of weather facilitates accurate project planning and estimation of workers' performance (Al Refaie *et al.*, 2020). With the accelerated climate variability and global warming, it is expected that hot weather might have more influence on labour productivity. Heat stress, as one of the consequences of global warming, causes fatigue, dizziness or even death at extremely high temperatures (Kovats *et al.*, 2008; Setyaningsih *et al.*, 2018). It was predicted that global warming may have greater impact on productivity in many countries around the world (Shan *et al*., 2015).

Research on climate change impact and construction project performance have been carried out in different parts of the world. The study of Pasquire (1999) in the United Kingdom identified the broad environmental issues and legislation affecting the construction industry in the UK and placed the environment firmly on the construction agenda, highlighting the major issues for concern. Another study in the UK by Hertin, Berkhout, Gann and Barlow (2003) were done to explore how climate change could affect the UK house-building sector, focusing on the question of how companies can adapt to changing climatic conditions. It presented the results of in-depth interviews in five house-building companies in the UK. In Sweden, a study by Gustavsson, Dodoo and Sathre (2015) reported on methodological issues in determining the climate change effects over the lifecycle of a building. In New Zealand, a study by Camilleri (2000) was done to assess the implications of climate change for construction projects. Also in New Zealand, Camilleri, Jacques and Isaacs (2001) carried out a study to identify what impacts climate variability may have on buildings, how serious they are, and what action (if any) could be taken to ensure that future building performance is not compromised. El-Sawalhi and Mahdi (2015) in Gaza, provided a platform of knowledge for the construction management practitioners about the impacts of climate variability on the construction projects lifecycle, identified the most dangerous climate variability factors on the construction project lifecycle, and identified the most affected phase by climate variability factors through the construction projects lifecycle. Pravin, Murali and Shanmugapriyan (2017) carried out a study in India to assess the climate change and its effect on building construction projects. In South Africa, du Plessis, Irurah and Scholes (2003) provided an appraisal of research/policy and national strategy frameworks/gaps with regard to mitigation and adaptation in response to the projected climate change in South Africa with specific focus on the built environment. Then in Ghana, Twerefou, Adjei-Mantey and Strzepek (2014) researched on the economic impact of climate change on road infrastructure using the stressor-response methodology. Umah and Adewuyi (2023) determined the drivers of climate variability in the South-South region of Nigeria and inclusively verified the critical construction activities impacted upon by climate variability. With these inexhaustible studies in climate variability and the construction project, it is crucial to have a critical study through a well-designed scientific inquiry on the impact of climate variability on construction project performance, with a view to achieving an improved project delivery and a safe working environment in the construction industry.

METHODOLOGY

This research is a component part of other studies (Umah, 2023; Umah and Adewuyi, 2023) on climate variability impact on construction project activities and performance. Hence, it shares the same research design, population, sampling method and sample size with the said previous studies but different focus and analyses. It is quantitative survey research with the study population drawn from registered construction professionals, such as Architects, Builders, Engineers (Civil, Structural and Services) and Quantity Surveyors. The study area covered the South-South geopolitical zone of Nigeria. The study area was stratified into three, comprising two States each to add up to the six States in the South-South geopolitical zone. The stratification was based on the similarity of culture and geographical settings shared by each stratum. For instance, during the administration of the first military regime after independence in Nigeria, the country was divided into twelve (12) States for administrative purpose. The section of Nigeria referred to as South-South geopolitical zone presently comprised three States (Bendel, Rivers and South-Eastern States). These States were subdivided into two each by the subsequent military regimes. Bendel was subdivided into Edo and Delta States, Rivers into Rivers and Bayelsa States, and South-Eastern into Cross River and Akwa Ibom States. This study, therefore, based the stratification of the study population in the region on the old set up and randomly selected one State each from the three strata to represent the region on convenience basis. Hence, Delta State represents the old Bendel State, Rivers represents the old Rivers State, and Akwa Ibom represent the old South-Eastern State. The population of this study is as reflected in the first component of the inclusive study as presented in Table1.

Table 1: Sample size of Each Component of the Population Frame

Registered Professionals	**Akwa Ibom**			**Delta**			**Rivers**		
	N	**n_1**	**n_i**	**N**	**n_2**	**n_i**	**N**	**n_3**	**n_i**
Architects	63	146	41	66	150	42	95	186	52
Builders	42		27	45		29	36		20
Engineers	70		45	80		51	126		68
Quantity Surveyors	53		34	48		31	88		48
Total	**228**		**147**	**239**		**153**	**345**		**188**

n_1, n_2 and n_3 are the stratified sample size based on State; n_i is the stratified sample size based on profession.
Source: Umah and Adewuyi (2023)

The determination of sample size was done with the use of Taro Yamane formula which yielded a total population of four hundred and eighty-two (added up as 146 + 150 + 186 = 482) professionals, applying the expression in Equation 1. The sample were distributed across the three selected States of Akwa Ibom, Delta and Rivers.

$$n = \frac{N}{1 + N(e)^2} \qquad (1)$$

where:

n is the sample size;
N is the finite population;
e is the level of significance, and 1 is unity.

Subsequently, to capture all significant sub-population and precision, the proportionate type of stratified random sampling, which was used by Adewuyi and Umoren (2020), the expression in Equation 2 was adopted for stratifying the sample size into their respective professions in the respective State. The application of the expression in Equation 2, for further stratification into sub-population, slightly increased the sample size to four hundred and eighty-eight (added up as 147 + 153 + 188 = 488).

$$n_i = \frac{nS}{N} \qquad (2)$$

where:

n_i is the sample size in each State;
n is the total sample size derive from Equation 1;
S is the corresponding population of

professionals in the respective State;
N is the total finite population in each State.

The questionnaire was prepared with the reflection of the respondent's demographic characteristics in the first section and the parametric focus of the study in the second segment. Fifty-five (55) measured variables of project performance were incorporated into the questionnaire which were stratified into six (6) latent variables of project performance vis-à-vis productivity, delivery time, quality, safety, cost and profitability. Likert scale ratings of 1 to 5 were assigned to the respondent's ratings of the variables, with 1 and 5 interpreted as lowest and highest point, respectively. The criterion-related reliability test of the questionnaire was measured using Cronbach's alpha. The derived data were analysed descriptively to obtain the standard deviation and subsequently the variance of each variable towards the derivation of the criticality of the variable with the use of the expression in Equations 3 and 4.

$$RWG = 1 - \frac{S_x^2}{\sigma_E^2} \qquad (3)$$

where:

S_x^2 = the observed variance on the variable X;
σ_E^2 = the variance expected when there is a complete lack of agreement among the judges; and

$$\sigma_E^2 = \frac{A^2 - 1}{12} \qquad (4)$$

where:

A = number of response option in the scale; and
S_x^2 = the observed variance.

The expression in Equation 3 is referred to as inter-rater agreement (IRA) scoring which was expounded by LeBreton and Senter (2008). Estimations of IRA was necessary to authenticate whether the rating provided by a respondent is interchangeable or equivalent in complete terms, meaning that IRA is a perfectly reasonable technique for estimating ratters' similarity. IRA is usually represented by **RWG** (rating weighted agreement). This analysis is incorporated into this study based on Pareto's principle of 80:20 rule of extricating the important few from the trivial many to focus attention on the key variables as explained in Ekanem *et al.* (2020).
The interpretation of inter-rater analysis adopted from LeBreton and Senter (2008) which denoted 0.00 - 0.30 as lack of agreement; 0.31 - 0.50 as weak agreement; 0.51 - 0.70 as moderate agreement; 0.71 - 0.90 as strong agreement; and 0.91 - 1.00 as very strong agreement. The IRA is unique in finding critical index parameters for exploring consensus using the variance in respondents' judgment rather than mean score seen in other techniques. A high or significant interrater score means that the appraisers are applying essentially the same standard when assessing the samples. The rules adopted is such that a moderate agreement among the appraisers ($0.50 \leq RWG \leq 1.00$) connotes criticality of the variable.
The second rung of data analyses espoused the impact weighting method which was adopted by Ekanem *et al.* (2020). The impact weighting formula was patterned after relative importance index (RII) formula as presented in Equation 5, while the adapted expression for deriving relative impact index of the individual variable is presented in Equation 6. The interpretation of the impact weighting (IW) is in percentages.

$$IW = \frac{RI_mI}{\sum_i^n RI_mI} \qquad (5)$$

where:

IW = Impact Weighting;
RI_mI = Relative Impact Index of individual variable; and

$$RI_mI = \frac{\sum_1^5 n_i k_i}{N * Rh} \qquad (6)$$

where:

n_i = number of respondents choosing ki;
k_i= constants 1-5 (on Likert scale) with 1 = lowest and 5 = highest;
N = Total number of questionnaires collected or analysed; and
Rh = the highest value in rating order.

Findings and Discussion of Results

The retrieved questionnaires were perused, leading to the abstraction of three hundred and eight usable ones, which represent about sixty-three percent (63.11%) of the distributed number. Relying on the submissions of Assaad *et al*. (2020) and many other survey-based construction studies certifying response rate of 20-30%, the response rate of this study was adjudged adequate for this survey-based construction field research. Hence, the extracted data were analysed with the resultant findings and respective discussions. Furthermore, the analyses were carried out according to the purposively selected four elements of climate variability vis-à-vis rainfall, temperature, humidity, and wind speed.

Respondents' Demography

The profiles of the respondents of this study were analysed and the breakdown was constricted into a spider radar as shown Figure 1 to justify the reliability of the data derived from their responses.

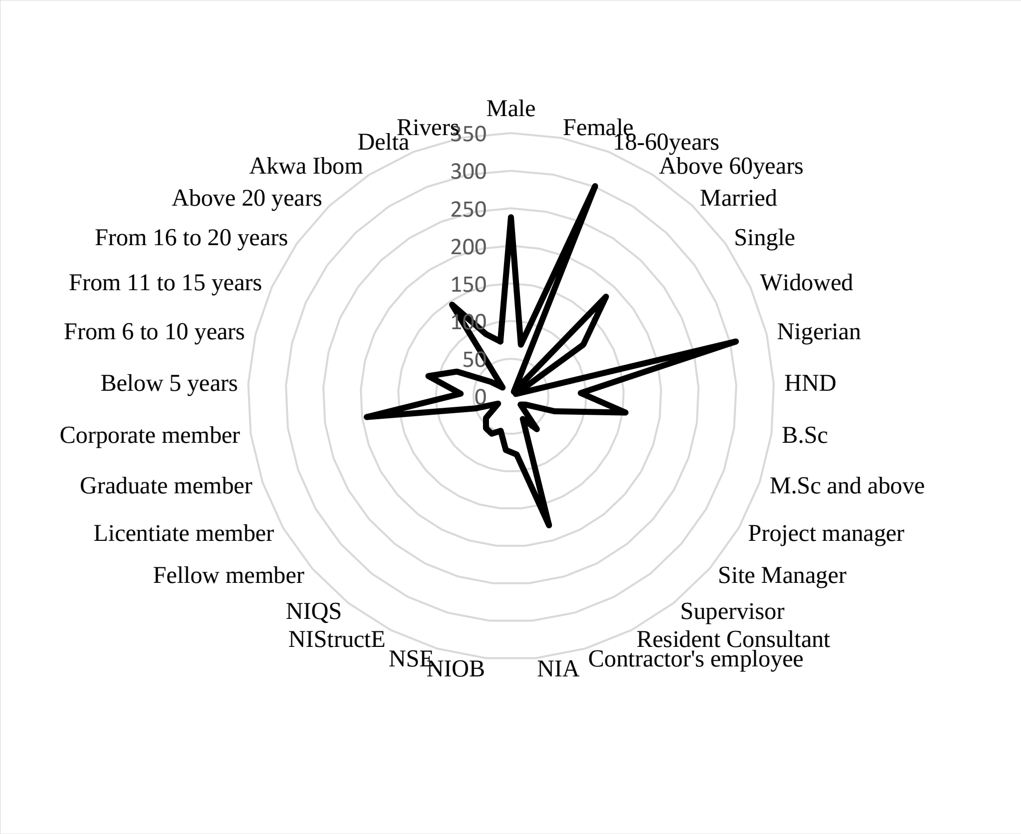

Figure 1: Respondents' Demographic Characteristics

In Figure 1, the academic qualifications of the respondents show that 19.8% possess M.Sc. or higher degree, 50.0% hold B.Sc. degree, and 30.2% have HND certificate, indicating a strong literacy level, sufficient to understand and accurately complete the questionnaire. In terms of professional roles, 41.8% of the respondents are project managers, site managers, site supervisors, or resident consultants, positioning them in upper or middle management level of their organisations, which supports the reliability of their insights. The remaining 58.2% are engineers and other construction professionals such as builders, quantity surveyors, and architects employed by contractors. This composition underscores a balanced representation from various tiers of the industry, reflecting high engagement and dependable data.
The professional affiliations of respondents reveal that 25.3% are Architects, 23.4% are Builders, 33.8% are various types of Engineers, and 17.5% are Quantity Surveyors. This diverse professional mix illustrates their relevance in the construction sector and supports confidence in their responses. The professional competence displayed affirms their qualifications, enhancing the credibility of the survey outcomes.
Regarding experience, 41.5% of the respondents have over a decade of experience, 36.7% have six to ten years, and the remainder have fewer than five years. This distribution implies that the majority have substantial experience, providing them with the insight needed to understand the impacts of climate variability on construction activities. Geographically, 47.1% of respondents are based in Akwa Ibom State, 28.9% in Delta State, and 24.0% in Rivers State, showing an even spread and comprehensive coverage across the study region.

Impact of Rainfall on Project Performance

The determination of the impact of rainfall, as an element of climate variability, on project performance commenced with the spotting of the critical measured variables of project performance. The expression in Equations 3 and 4 were applied to analyse the collected data to derive the critical ones. The rule for selection of critical variables was based on $0.51 \leq RWG \leq 1.00$ which represents at least moderate agreement among the respondents. The variables were stratified into the various latent dimensions of project performance.
Furtherance to determining the criticality of the variables, the impact on project performance were verified. The results of the analyses are presented in Table 2. The analysis adopted relative impact index (RI_mI) method, with the subsequent calculated impact weighting (IW) of each variable, as described in the method of data analysis in the methodology section of this study. The results were ranked based on the percentage of impact of each of the variables. Fifty-five (55) measured variables of project performance were presented to the respondents for evaluation but were captured under six latent variables for measuring construction project performance. The parameters (latent variables) include productivity, delivery time, quality, safety, cost, and profitability. The results in Table 2, which presents the impact of rainfall on construction project performance, were carefully examined to understand the highest rated measured variable among the variables captured under each latent variable. The first three

critically rated measured variables across the various parameters of project performance in South-South, Nigeria include work may get cancelled or postponed until later time, lead to water encroachment, and affect the duration that labourers can work outside, with impact weighting (IW) of 3.68%, 3.68%, and 3.53 %, respectively. The first three highly rated measured variables occurred in order of the latent variables of delivery time, quality, and productivity. It implies that rainfall as an element of climate variability can impact the duration, quality and workers' productivity of construction projects.

Table 2: Critical Variables of Impact of Rainfall on Project Performance in South-South, Nigeria

LVPP	Measured Critical Variables of Impact of Rainfall on Project Performance	Criticality Analysis			Impact Weighting Analysis			
		Var.	RWG	Dec.	RImI	IW	%Ip	R
Productivity	Worker's exposure to uncomfortable working environment	0.458	0.77	SA	0.876	0.034	3.42	9
	Affect the duration that labourers can work outside	0.387	0.81	SA	0.905	0.035	3.53	3
	Unavailability of plants and equipment	0.970	0.52	MA	0.795	0.031	3.10	23
	Make excavation and earthwork more difficult	0.504	0.75	SA	0.893	0.035	3.48	7
Delivery Time	Influence flash flood which put the equipment at risk	0.731	0.63	MA	0.765	0.030	2.98	27
	Delay due to bad road	0.722	0.64	MA	0.807	0.031	3.15	19
	Delay due to unexpected weather events	0.931	0.53	MA	0.803	0.031	3.13	20
	Leads to unnecessary legal actions by both parties	0.726	0.64	MA	0.716	0.028	2.79	29
	Increase the time to complete a task	0.639	0.68	MA	0.825	0.032	3.22	16
	Cause delay to construction program completion	0.552	0.72	SA	0.855	0.033	3.34	11
	Causes shortage of labour and equipment	0.796	0.60	MA	0.773	0.030	3.01	26
	Work may get cancelled or postponed until later time	0.289	0.86	SA	0.943	0.037	3.68	1
Quality	Impact strength and workability of construction materials	0.756	0.62	MA	0.775	0.030	3.02	25
	Affect performance and application of painting finishes	0.632	0.68	MA	0.834	0.033	3.26	15
	Affect the rate of concrete hardening	0.643	0.68	MA	0.818	0.032	3.19	17
	Causes materials to swell and shrink as they take on and lose water	0.480	0.76	SA	0.879	0.034	3.43	8
	Affect the process of concrete casting and workability	0.729	0.64	MA	0.797	0.031	3.11	22
	Make a reduction in bond strength between the mortar and bricks	0.561	0.72	SA	0.851	0.033	3.32	12
	Increase the risk of collapse.	0.674	0.66	MA	0.840	0.033	3.28	14
	Lead to water encroachment	0.296	0.85	SA	0.943	0.037	3.68	1
	Causes dampness on most parts of the building	0.387	0.81	SA	0.903	0.035	3.52	4
	Mold growth and deterioration of the structural integrity of the wall	0.518	0.74	SA	0.803	0.031	3.13	20
Safety	Lead to unsafe work conditions and leaves the workers at higher risk	0.919	0.54	MA	0.711	0.028	2.77	30
	Turn ground into mud which pose its own risks to the health of workers	0.790	0.61	MA	0.682	0.027	2.66	31
	Make several tasks to be riskier to accomplish	0.788	0.61	MA	0.726	0.028	2.83	28
	Lead to unpredicted accident during the course of work	0.645	0.68	MA	0.811	0.032	3.16	18
	Causes the risk of poor visibility through frozen windscreen	0.587	0.71	SA	0.848	0.033	3.31	13
Cost	Require additional maintenance works after completion of project activities	0.640	0.68	MA	0.792	0.031	3.09	24
	Cause disputes between contractors, subcontractors, suppliers	0.544	0.73	SA	0.903	0.035	3.52	4
Profitability	Cause project estimated time to exceed initial estimated time which in turn reduces profit margin	0.368	0.82	SA	0.899	0.035	3.51	6
	Cause damages to material and equipment which result in extra expenses	0.562	0.72	SA	0.863	0.034	3.37	10
		∑RImI = 25.631						

LVPP = Latent Variables of Project Performance; N = 308; Var. = Variance; RWG = Rating Weighted Agreement; Dec. = Decision; RImI = Relative Impact Index; IW = Impact Weightings; %Imp = Percentage of Impact; R = Rank; SA = Strong Agreement; MA = Moderate Agreement

Similarly, the fourth and sixth critically rated measured variables are that climate variability may cause disputes between contractors, subcontractors, suppliers, and may cause project estimated time to exceed initial estimated time which in turn may reduce profit margin, with impact weighting (IW) of 3.52%, and 3.51 %. The two variables fall under cost and profitability as project performance parameters. Summarily, the result connotes that duration, quality, workers' productivity, cost and profitability of construction project are predisposed to impact of climate variability.

To capture the impingements of rainfall impact on project performance, the cumulative impact weightings of the latent variables are compressed into a spider radar plot as shown in Figure 2. Radar plots, also known as spider charts, are effective tools for visualizing multivariate data (Duan *et al.*, 2023; Allen *et al.*, 2021). They provide an intuitive way to assess the relative strengths and weaknesses across various categories briefly (Al-Ghuwairi *et al.*, 2023). In this context, using a radar plot enables project managers to observe how climate variability elements, such as rainfall, temperature humidity and wind, disrupt different aspects of construction project performance. It is revealed from Figure 2 that the quality of construction project is much more impacted by rainfall with duration or delivery time in the next rank.

Figure 2: Cumulative Impact of Rainfall on Project Performance

Impact of Temperature on Project Performance

The critical variables of impact of temperature on construction project performance and the impact weightings of the variables were determined with similar procedures to the impact of rainfall. The result of the analysis is shown in Table 3. The first three critically rated measured variables across the various parameters of project performance in South-South, Nigeria include damages to material and equipment which result in extra expenses, unpredicted accident during the course of work, and unsafe work conditions and leaves the workers at higher risk, with impact weighting (IW) of 3.67%, 3.54%, and 3.48%, respectively. The first three highly rated measured variables occurred in order of the latent variables of profitability and safety. It implies that temperature as an element of climate variability can impact the profitability and safety of construction project.

Concisely, this study explored how temperature, as elements of climate variability, influence construction project performance, especially in South-South Nigeria. By identifying the specific variables affected by these climate conditions, the analysis offers insights into the primary challenges that arise in construction projects due to weather impacts.

The results of the findings showed how temperature can significantly disrupt construction projects, hence impacting project performance. For example, high temperatures or sudden rainfall can damage construction materials or machinery, increasing expenses as teams must repair or replace items. Equally, workers are at a greater risk of accidents due to weather fluctuations. Extreme temperatures might lead to heat stress, while rain creates slippery surfaces, both of which can contribute to unpredicted accidents (Setyaningsih *et al.*, 2018; Amoadu *et al.*, 2023). Unstable weather can create hazardous environments, leaving workers exposed to higher risks, such as slips, trips, or health impacts from temperature extremes, resulting in unsafe working conditions. Delays might occur due to damaged materials or waiting due to unsafe weather conditions, thereby increased the delivery time of the construction project. Poor handling conditions due to extreme temperatures or rainfall could compromise the quality of work. Worker efficiency may decline as adverse conditions make tasks more physically demanding or risky with an implication of reduced productivity.

Table 3: Critical Variables of Impact of Temperature on Project Performance in South-South, Nigeria

LVPP	Measured Critical Variables of Impact of Rainfall on Project Performance	Criticality Analysis			Impact Weighting Analysis			
		Var.	RWG	Dec.	RImI	IW	%Ip	R
Productivity	Workers' exposure to uncomfortable working environment	0.694	0.65	MA	0.502	0.0196	1.96	14
	Unavailability of workers	0.799	0.60	MA	0.458	0.0178	1.78	36
	Low morale at workplace	0.596	0.70	MA	0.460	0.0179	1.79	32
	Affect the duration that labourers can work outside	0.721	0.64	MA	0.461	0.0180	1.80	31
	Lead to slower work and more mistakes	0.526	0.74	SA	0.479	0.0187	1.87	16
	Unavailability of plants and equipment	0.648	0.68	MA	0.460	0.0179	1.79	32
	Make excavation and earthwork more difficult	0.586	0.71	SA	0.466	0.0182	1.82	27
	Leads to insubordination by lower cadet	0.632	0.68	MA	0.490	0.0191	1.91	15
	Affect the choice of site location	0.739	0.63	MA	0.472	0.0184	1.84	21
	Cause machinery not to operate correctly	0.562	0.72	SA	0.457	0.0178	1.78	36
Delivery Time	Influence flash flood which put the equipment at risk	0.666	0.67	MA	0.460	0.0179	1.79	32
	Delay due to bad road	0.661	0.67	MA	0.472	0.0184	1.84	21
	Delay due to unexpected weather events	0.62	0.69	MA	0.451	0.0176	1.76	40
	Lead to strike by labour force	0.614	0.69	MA	0.446	0.0174	1.74	44
	Leads to unnecessary legal actions by both parties	0.595	0.70	MA	0.476	0.0186	1.86	17
	Increase the time to complete a task	0.573	0.71	SA	0.512	0.0199	1.99	12
	Cause delay to construction program completion	0.733	0.63	MA	0.472	0.0184	1.84	21
	Causes shortage of labour and equipment	0.681	0.66	MA	0.455	0.0177	1.77	38
	Delay assembling of crane and other equipment	0.601	0.70	MA	0.476	0.0186	1.86	17
	Work may get cancelled or postponed until later time	0.534	0.73	SA	0.475	0.0185	1.85	20
Quality	Leads to error on cost estimate	0.518	0.74	SA	0.464	0.0181	1.81	30
	Impact strength and workability of construction materials	0.586	0.71	SA	0.466	0.0182	1.82	27
	Affect performance and application of painting finishes	0.583	0.71	SA	0.468	0.0182	1.82	27
	Affect the rate of concrete hardening	0.684	0.66	MA	0.470	0.0183	1.83	25
	Causes materials to swell and shrink as they take on and lose water	0.63	0.69	MA	0.455	0.0177	1.77	38
	Affect the process of concrete casting and workability	0.455	0.77	SA	0.450	0.0175	1.75	42
	Make a reduction in bond strength between the mortar and bricks	0.791	0.60	MA	0.460	0.0179	1.79	32
	Cause after completion unexpected problems and defects in the structure.	0.397	0.80	SA	0.450	0.0175	1.75	42
	Increase the risk of collapse.	0.446	0.78	SA	0.405	0.0158	1.58	46
	Lead to water encroachment	0.621	0.69	MA	0.451	0.0176	1.76	40
	Cause some materials that are prone to heat to expand	0.614	0.69	MA	0.446	0.0174	1.74	44
	Causes dampness on most parts of the building	0.595	0.70	MA	0.476	0.0186	1.86	17
	Leads to misaligned join when material expand	0.573	0.71	SA	0.512	0.0199	1.99	12
	Causes discolouration on painted surface due to intense heat	0.733	0.63	MA	0.472	0.0184	1.84	21
	Mold growth and deterioration of the structural integrity of the wall	0.684	0.66	MA	0.470	0.0183	1.83	25
Safety	Lead to unsafe work conditions and leaves the workers at higher risk	0.504	0.75	SA	0.893	0.0348	3.48	3
	Affect the use of tower, cranes and scaffoldings	0.518	0.74	SA	0.803	0.0313	3.13	9
	Lead to unpredicted accident during the course of work	0.373	0.81	SA	0.908	0.0354	3.54	2
Cost	Cause disputes between contractors, subcontractors, suppliers	0.756	0.62	MA	0.775	0.0302	3.02	11
	Influence unexpected price raises for labour	0.632	0.68	MA	0.834	0.0325	3.25	7
	Influence unexpected price raises for materials	0.643	0.68	MA	0.818	0.0319	3.19	8
Profitability	Cause project estimated time to exceed which in turn reduces profit margin	0.48	0.76	SA	0.878	0.0342	3.42	4
	Supplies needed to complete a project do not come with consistent price tag.	0.729	0.64	MA	0.797	0.0311	3.11	10

	Delay transport and delivery of materials causing more cost	0.561	0.72	SA	0.851	0.0332	3.32	5
	Leads to challenges in resolving variations	0.674	0.66	MA	0.840	0.0327	3.27	6
	Cause damages to material and equipment which result in extra expenses	0.299	0.85	SA	0.942	0.0367	3.67	1
					∑RImI = 23.870			

LVPP = Latent Variables of Project Performance; N = 308; Var. = Variance; RWG = Rating Weighted Agreement; Dec. = Decision; RImI = Relative Impact Index; IW = Impact Weightings; %Imp = Percentage of Impact; R = Rank; SA = Strong Agreement; MA = Moderate Agreement

To illustrate the effects of temperature on project performance, the cumulative impact weightings of the latent variables are presented in a spider radar plot, as shown in Figure 3. It is revealed from Figure 3 that the quality of construction projects is much more impacted by temperature with productivity and delivery time in the next rank.

Figure 3: Cumulative Impact of Temperature on Project Performance

Impact of Humidity on Project Performance

The critical variables related to humidity's impact on construction project performance, along with their impact weightings, were identified using similar procedures to those applied for rainfall. The analysis results are displayed in Table 4. In South-South of Nigeria, the top three critical variables affecting project performance resulting from undue humidity conditions include exposure to cold temperatures which affects the skin, muscles, and internal organs; turns ground into mud which pose its own risks to the health of workers, and causes project estimated time to exceed proposed duration which in turn reduces profit margin, with impact weightings (IW) of 4.71%, 4.62%, and 4.32%, respectively. These highly rated variables align with the latent variables of safety, and cost of the project. This indicates that humidity, as a climate variability factor, can influence the safety of workers on construction sites, and the cost of construction projects.

Table 4: Critical Variables of Impact of Humidity on Project Performance in South-South, Nigeria

LVPP	Measured Critical Variables of Impact of Rainfall on Project Performance	Var.	RWG	Dec.	RImI	IW	%Ip	R
Productivity	Workers' exposure to uncomfortable working environment	0.290	0.86	SA	0.304	0.0157	1.57	42
	Unavailability of workers	0.452	0.77	SA	0.343	0.0177	1.77	26
	Low morale at workplace	0.232	0.88	SA	0.258	0.0133	1.33	46
	Affect the duration that labourers can work outside	0.000	1.00	VSA	0.200	0.0103	1.03	47
	Lead to slower work and more mistakes	0.000	1.00	VSA	0.200	0.0103	1.03	47
	Unavailability of plants and equipment	0.320	0.84	SA	0.290	0.0150	1.50	43
	Make excavation and earthwork more difficult	0.379	0.81	SA	0.290	0.0150	1.50	43
	Leads to insubordination by lower cadet	0.447	0.78	SA	0.358	0.0185	1.85	19

	Affect the choice of site location	0.290	0.86	SA	0.316	0.0163	1.63	40
	Cause machinery not to operate correctly	0.261	0.87	SA	0.319	0.0165	1.65	38
Delivery Time	Influence flash flood which put the equipment at risk	0.313	0.84	SA	0.319	0.0165	1.65	38
	Delay due to bad road	0.313	0.84	SA	0.310	0.0161	1.61	41
	Delay due to unexpected weather events	0.260	0.87	SA	0.321	0.0166	1.66	37
	Lead to strike by labour force	0.224	0.89	SA	0.332	0.0172	1.72	31
	Leads to unnecessary legal actions by both parties	0.294	0.85	SA	0.325	0.0168	1.68	35
	Increase the time to complete a task	0.264	0.87	SA	0.323	0.0167	1.67	36
	Cause delay to construction program completion	0.289	0.86	SA	0.336	0.0174	1.74	29
	Causes shortage of labour and equipment	0.335	0.83	SA	0.349	0.0180	1.80	22
	Delay assembling of crane and other equipment	0.248	0.88	SA	0.330	0.0171	1.71	32
	Work may get cancelled or postponed until later time	0.339	0.83	SA	0.347	0.0179	1.79	24
Quality	Leads to error on cost estimate	0.348	0.83	SA	0.343	0.0177	1.77	26
	Impact strength and workability of construction materials	0.294	0.85	SA	0.361	0.0187	1.87	18
	Affect performance and application of painting finishes	0.318	0.84	SA	0.355	0.0184	1.84	20
	Affect the rate of concrete hardening	0.275	0.86	SA	0.340	0.0176	1.76	28
	Causes materials to swell and shrink as they take on and lose water	0.274	0.86	SA	0.344	0.0178	1.78	25
	Affect the process of concrete casting and workability	0.320	0.84	SA	0.290	0.0150	1.50	43
	Make a reduction in bond strength between the mortar and bricks	0.248	0.88	SA	0.330	0.0171	1.71	32
	Cause after completion unexpected problems and defects in the structure.	0.327	0.84	SA	0.357	0.0184	1.84	20
	Increase the risk of collapse.	0.650	0.68	MA	0.408	0.0211	2.11	16
	Lead to water encroachment	0.605	0.70	MA	0.423	0.0219	2.19	13
	Cause some materials that are prone to heat to expand	0.668	0.67	MA	0.432	0.0223	2.23	10
	Causes dampness on most parts of the building	0.615	0.69	MA	0.426	0.0220	2.20	12
	Leads to misaligned join when material expand	0.660	0.67	MA	0.433	0.0224	2.24	9
	Causes discolouration on painted surface due to intense heat	0.666	0.67	MA	0.460	0.0238	2.38	8
	Mold growth and deterioration of the structural integrity of the wall	0.561	0.72	SA	0.422	0.0218	2.18	15
Safety	Lead to unsafe work conditions and leaves the workers at higher risk	0.733	0.63	MA	0.472	0.0244	2.44	6
	Affect the use of tower, cranes and scaffoldings	0.684	0.66	MA	0.470	0.0243	2.43	7
	Turn ground into mud which pose its own risks to the health of workers	0.504	0.75	SA	0.893	0.0462	4.62	2
	Make several tasks to be riskier to accomplish	0.518	0.74	SA	0.803	0.0416	4.16	4
	Exposure to cold temperatures affects the skin, muscles, and internal organs	0.372	0.81	SA	0.910	0.0471	4.71	1
Cost	Influence unexpected price raises for materials	0.756	0.62	MA	0.775	0.0401	4.01	5
	Cause project estimated time to exceed which in turn reduces profit margin	0.632	0.68	MA	0.834	0.0432	4.32	3
Profitability	Supplies needed to complete a project do not come with consistent price tag.	0.650	0.68	MA	0.408	0.0211	2.11	16
	Delay transport and delivery of materials causing more cost	0.605	0.70	MA	0.423	0.0219	2.19	13
	Extra work to the project can sink a budget	0.668	0.67	MA	0.432	0.0223	2.23	10
	Leads to challenges in resolving variations	0.289	0.86	SA	0.336	0.0174	1.74	29
	Cause damages to material and equipment which result in extra expenses	0.335	0.83	SA	0.349	0.0180	1.80	22
	Unexpected damage on part of the project requires drastic correction	0.249	0.88	SA	0.329	0.0170	1.70	34
		∑RimI = 19.329						

LVPP = Latent Variables of Project Performance; N = 308; Var. = Variance; RWG = Rating Weighted Agreement; Dec. = Decision; RImI = Relative Impact Index; IW = Impact Weightings; %Imp = Percentage of Impact; R = Rank; VSA = Very Strong Agreement; SA = Strong Agreement; MA = Moderate Agreement

The findings reveal the effect of humidity on construction project performance in South-South of Nigeria, highlighting that high humidity levels contribute to adverse working conditions, project delays, and increased costs. The analysis identified three main challenges, each with a notable impact on the safety, health, and cost-efficiency of construction projects. By exploring these factors further, several practical implications can be deduced for project managers, planners, and workers, especially in humid regions like South-South, Nigeria. These include health and safety risks from humidity-induced conditions, project delays and cost overruns. Some deductions can be made from the findings of this study explaining the impacts of humidity on construction project performance.

The analysis shows that undue humidity exposes workers to cold conditions, which can harm the skin, muscles, and internal organs, making prolonged outdoor exposure risky. Research suggests that continuous work in high-humidity, low-temperature conditions can lead to musculoskeletal problems and heightened vulnerability to respiratory infections and skin issues (Almaskati *et al*., 2024; Karthick *et al*., 2022). This is especially relevant in the construction sector, where outdoor labour is significant, and workers have limited shelter from such conditions.

Humidity can turn construction sites into muddy, unstable terrain, creating tripping, slipping, and musculoskeletal injury risks. For instance, wet, muddy grounds make it difficult for heavy equipment to manoeuvre and for workers to carry out tasks safely, leading to increased chances of injury (Lingard, 2013; Osei-Asibey *et al*., 2021). This instability can halt work or force project managers to implement additional safety measures, raising costs and slowing productivity.

Figure 4: Cumulative Impact of Humidity on Project Performance

High humidity levels slow construction processes, as muddy grounds and health risks may compel project managers to limit or stop work during adverse conditions. This delay is critical as it can cause projects to extend beyond estimated timelines, negatively impacting profit margins. A study on construction delays found that climate factors such as humidity are major contributors to time overruns, which add indirect costs like extended labour and rental fees for equipment (Doloi *et al*., 2012).

To assess how humidity affects construction project performance, cumulative weightings of variables such as quality, safety, and cost effectiveness were visually compressed using a spider radar plot as shown in Figure 4. This visualization helps to compare impacts across dimensions and highlights which aspects are most affected. Figure 4 reveals that construction quality suffers the most under high humidity, followed closely by safety.

Effective humidity control, through dehumidifiers, ventilation, and climate monitoring, can mitigate these risks. Proactive management strategies help keep projects on track and protect the structural integrity and durability of materials, which can prevent costly repairs or adjustments later in the project lifecycle. As the effects of climate change intensify, construction projects will likely need to adopt more robust strategies for humidity and overall weather management.

Impact of Wind on Project Performance

The determination of the impact of wind, as an element of climate variability, on project performance was carried out like that of rainfall. The rule for selection of critical variables was based on $0.51 \leq RWG \leq 1.00$ which represents at least moderate agreement among the respondents, as was done in the analysis of other latent variables of project performance. The variables were stratified into the various latent dimensions of project performance. The analysis results are displayed in Table 5.

The top three critical variables affecting project performance resulting in the effects of wind are wind causes delay to construction programme completion, causes shortage of labour and equipment availability on site, and increases the time to complete a task, with impact weightings (IW) of 6.31%, 6.19%, and 6.18%, respectively.

The unpredictability of wind patterns can lead to disruptions in scheduling, particularly for activities sensitive to wind, like exterior painting, facade installation, or roofing. Planners must incorporate weather forecasts into scheduling to mitigate risks, yet unexpected changes in wind speed may still cause delays. High winds can also pose serious safety risks on construction sites, especially where cranes, scaffolding, or tall structures are involved. Wind can make it dangerous for workers operating at heights, leading to an increased risk of falls or accidents with swinging or moving equipment. As a result, construction activities may need to be halted temporarily, impacting project timelines (Schuldt *et al*., 2021). Wind can also impact the drying and curing of materials like concrete. Strong winds accelerate the evaporation of moisture from freshly poured concrete, leading to uneven curing and potentially weakening the final structure. This impact can be particularly detrimental in areas that require high structural integrity, potentially leading to rework or quality issues (Schuldt *et al*., 2021). Variable wind speeds can cause issues with material handling and storage. Lightweight materials, such as insulation, plastic sheeting, and roofing components, can be blown away or damaged, requiring replacements and leading to increased costs and delays. Moreover, high winds can hinder the use of large equipment or cranes, as lifting materials in such conditions could lead to accidents or damage to the equipment itself.

Table 5: Critical Variables of Impact of Wind on Project Performance in South-South, Nigeria

LVPP	**Measured Critical Variables of Impact of Rainfall on Project Performance**	**Var.**	**RWG**	**Dec.**	**RImI**	**IW**	**%Ip**	**R**
Productivity	Workers' exposure to uncomfortable working environment	0.436	0.78	SA	0.423	0.0315	3.15	11
	Unavailability of workers	0.462	0.77	SA	0.401	0.0299	2.99	15
	Lead to slower work and more mistakes	0.77	0.62	MA	0.408	0.0304	3.04	14
	Unavailability of plants and equipment	0.496	0.75	SA	0.329	0.0245	2.45	24
	Make excavation and earthwork more difficult	0.814	0.59	MA	0.399	0.0297	2.97	18
	Leads to insubordination by lower cadet	0.642	0.68	MA	0.390	0.0290	2.90	21
	Affect the choice of site location	0.963	0.52	MA	0.427	0.0318	3.18	10
Delivery Time	Increase the time to complete a task	0.746	0.63	MA	0.830	0.0618	6.18	3
	Cause delay to construction program completion	0.813	0.59	MA	0.847	0.0631	6.31	1
	Causes shortage of labour and equipment	0.792	0.60	MA	0.832	0.0619	6.19	2
Quality	Affect performance and application of painting finishes	0.696	0.65	MA	0.377	0.0280	2.80	22
	Affect the rate of concrete hardening	0.719	0.64	MA	0.394	0.0293	2.93	19
	Cause some materials that are prone to heat to expand	0.771	0.61	MA	0.779	0.0580	5.80	7
	Causes dampness on most parts of the building	0.61	0.70	MA	0.322	0.0240	2.40	25
	Causes discolouration on painted surface due to intense heat	0.702	0.65	MA	0.818	0.0609	6.09	4
	Mold growth and deterioration of the structural integrity of the wall	0.68	0.66	MA	0.782	0.0583	5.83	6
Safety	Lead to unsafe work conditions and leaves the workers at higher risk	0.599	0.70	MA	0.401	0.0299	2.99	16
	Affect the use of tower, cranes and scaffoldings	0.545	0.73	SA	0.421	0.0314	3.14	12
	Turn ground into mud which pose its own risks to the health of workers	0.589	0.71	SA	0.413	0.0307	3.07	13
	Make several tasks to be riskier to accomplish	0.66	0.67	MA	0.433	0.0322	3.22	9
	Causes the risk of poor visibility through frozen windscreen	0.66	0.67	MA	0.354	0.0263	2.63	23
Cost	Require additional maintenance works after completion of project activities	0.833	0.58	MA	0.734	0.0547	5.47	8
Profitability	Supplies needed to complete a project do not come with consistent price tag.	0.704	0.65	MA	0.390	0.0291	2.91	20
	Delay transport and delivery of materials causing more cost	0.81	0.60	MA	0.806	0.0600	6.00	5
	Cause damages to material and equipment which result in extra expenses	0.762	0.62	MA	0.401	0.0299	2.99	17
	Unexpected damage on part of the project requires drastic correction	0.465	0.77	SA	0.317	0.0236	2.36	26
		∑RimI = 13.431						

LVPP = Latent Variables of Project Performance; N = 308; Var. = Variance; RWG = Rating Weighted Agreement; Dec. = Decision; RImI = Relative Impact Index; IW = Impact Weightings; %Imp = Percentage of Impact; R = Rank; SA = Strong Agreement; MA = Moderate Agreement

To evaluate the influence of wind on the performance of construction projects, various key variables, namely, quality, safety, and cost-effectiveness, were cumulatively weighted and represented using a spider (radar) plot, as demonstrated in Figure 5. This graphical representation allows for a comprehensive comparison across different performance dimensions, making it easier to identify which project performance dimensions are most impacted by wind conditions. According to Figure 5, construction quality is the most negatively affected by strong wind, with safety being the second most impacted aspect. Research has shown that wind can compromise material handling and structural stability, leading to quality control issues (Ruan *et al*., 2023). Additionally, wind poses significant safety hazards, heightening the risk of accidents and equipment failure (Karanikas, 2021).

Figure 5: Cumulative Impact of Wind on Project Performance

Strategies for Mitigating the Impact of Climate Variability

This study established the strategies adopted to mitigate the impact of climate variability on construction project performance in the study area. The summary of the analysis of the assessed strategies against the impact of climate variability is presented in Table 6. The assessment employed the use of relative importance index as a descriptive analytical tool to rank the various strategies according to the perceptions of the respondents from the selected State in South-South geopolitical zone of Nigeria.

The first highly rated strategy for curbing the impact of climate variability is using alternative energy such as solar in our homes, with RII of 0.919, and for construction activities to reduce emissions from fossil fuels. This is akin to the findings of Tunji-Olayeni *et al.* (2019) revealing that construction activities, especially in developing countries, rely heavily on fossil fuels as an alternative energy source, which significantly contributes to greenhouse gas (GHG) emissions. The second and the third strategies include encouraging afforestation and tree planting campaigns; and switching to sustainable transportation system, with RII of 0.912 and 0.828, respectively.

Table 6: Strategies for Mitigating the Impact of Climate Variability in South-South, Nigeria

Strategies for Mitigating the Impact of Climate Variability	Sum	RII	Rank
Using alternative energy such as solar in our homes	1415	0.919	1
Encouraging afforestation and tree planting campaigns	1404	0.912	2
Switch to sustainable transportation system	1275	0.828	3
Educate the public on the need to reduce carbon emission	1259	0.818	4
Communities' awareness campaign to desist from bush burning	1253	0.814	5
Make climate variability a compulsory subject from secondary school level	1241	0.806	6
Investment in renewable energy	1208	0.784	7
Restore nature to absorb carbon	1207	0.784	7
Waste management agencies should work towards discouraging waste burning	1204	0.782	9
Government at all levels should create opportunities in rural areas to discourage	1178	0.765	10

migration to urban centers			
Engages in capturing the amount of carbon emission into the atmosphere	1177	0.764	11
Discouraging the act of deforestation	1164	0.756	12
Create carbon tax and emission market	1154	0.749	13
Stop gas flaring and keep fossil fuels in the ground	1151	0.747	14
Construction stakeholder's engagement on routine awareness campaign	1109	0.720	15
Keep to international best practice (Kyoto protocol) for carbon reduction	1061	0.689	16
Use of alternative building materials with low carbon emission	1033	0.671	17
Organize seminars and workshop on way forward to curb the issue of climate variability	997	0.647	18

RII = Relative Importance Index; N= 308

The three least rated strategies for curbing the impact of climate variability in South-South keeping to international best practice (Kyoto protocol) for carbon reduction; use of alternative building materials with low carbon emission; organize seminars and workshop on way forward to curb the issue of climate variability with RII of 0.689, 0.671 and 0.647 respectively. Realistically, the three least rated strategies appear to depend more on regulating activities of construction industry through enactment of such regulations by the appropriate authority.

Conclusions and Recommendations

This study highlighted the significant impact of climate variability on construction project performance in South-South Nigeria. The analysis showed that climatic factors such as rainfall, temperature, humidity, and wind affect critical aspects of project execution, including productivity, delivery time, quality, safety, cost, and profitability. The data revealed that extreme weather events contribute to delays, reduced labour productivity, material damage, and increased project costs. The findings emphasized that rainfall most notably affects project delivery time and quality, while temperature extremes heighten the risk of accidents and stress, impacting worker safety and overall productivity. The use of inter-rater reliability and relative importance index methods ensured robust analysis of the impacts, underscoring the critical variables of each climate element on project performance. It is recommended that construction stakeholders should prioritize the use of renewable energy, such as solar power, to reduce dependency on fossil fuels, minimizing greenhouse gas emissions. Tree-planting campaigns to enhance carbon absorption and create microclimates that mitigate temperature fluctuations should be encouraged. Public education and awareness, down to the community levels, to inform the public about practices that reduce carbon emissions should be implemented, emphasizing the need to desist from environmentally harmful actions such as bush burning. Equipping construction projects with technologies like weather-monitoring tools to anticipate adverse weather conditions and allow pre-emptive scheduling adjustments should be prioritised. Construction managers should enhance on-site safety protocols and worker training to handle extreme weather conditions effectively, focusing on protecting workers from heat stress and ensuring safe operational practices during heavy rain or high winds. Policymakers should consider integrating climate variability adaptation strategies into construction regulations, including making climate education compulsory in schools and mandating periodic climate risk assessments for projects.

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