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**ASSESSMENT OF SEASONAL VARIABILITY ON THE ARTISANAL PRODUCTIVITY ON  
CONSTRUCTION SITES: A CASE STUDY OF MINNA, NORTH-CENTRAL ZONE OF NIGERIA**

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**ABSTRACT**

Globally, the issue of seasonal variability and its effect on the productivity of artisans in construction sites cannot be over-emphasized. Infact, many construction stakeholders planned alongside the climatic information released by the meteorologists before embarking on a major construction activity. This paper assesses the effect of the thermal variability prevailing in Minna, the capital of Niger state on the productivity of tilers and plasterers on construction sites. The objectives of the paper are (i) to determine the output of the tilers and plasterers during indoor and outdoor operations and (ii) to determine the relationship between the temperature and the output of tilers and plasterers. Data were collected from the tilers and plasterer's unions in Minna metropolis to determine the population of the registered tilers and plasterers out of which 60 tilers and 60 plasterers were randomly sampled respectively and 10 residential buildings undergoing construction were purposively sampled. Structured questionnaires were prepared that cover the profile of the selected tilers and plasterers. Interviews and records of intensity of sun both in the morning and afternoon periods were taken using thermometer device. The data collected were subjected to regression analysis and analysis of variance (ANOVA). The results of the finding show Coefficient of determination ( $R^2$ ) of 0.2% and 0.5% respectively which indicates that there is no significant relationship between the variables tested, it is concluded that construction stakeholders should mitigate the thermal effects on the operatives during outdoor operations.

**Keywords:** Productivity, seasons, tilers, construction, variability.

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**INTRODUCTION**

Construction workers are constantly exposed to a variety of outdoor weather factors, which affect their thermal comfort, health, and productivity (Hwang et al., 2023). Adverse weather conditions reduce output, cause project delays and financial losses, and

provide legitimate grounds for deadline extensions. The extent to which weather variables impact construction activities depends on the technologies, equipment, materials, and procedures applied; the exposure of the site; the frequency of unusual weather; and the regional or national definition of average conditions. Operations conducted under adverse weather inevitably incur productivity losses, with their magnitude influenced by both the type of activity and the level of protection provided. These effects also vary considerably by geographic location as noted by Schuldt et al., (2021).

Adverse weather, an unavoidable reality for contractors, often compels work under unfavorable conditions, yet adequate planning for such challenges is frequently lacking. Understanding the role of weather in construction progress is therefore essential for effective planning and successful project delivery. Projects can mitigate risks from weather conditions if relevant weather information is incorporated during the planning phase. Proper decision-making at the planning stage can substantially reduce project time, cost, and effort. Decision-makers must model weather events to predict their impact on construction tasks (Sopic et al., 2025). Quantifying the weather impact is valuable to contractors for preparing realistic timetables, cost estimates, and reliable bids. Determining the impact of weather on labour productivity and health enables more accurate project preparation and the implementation of appropriate measures to enhance worker comfort and efficiency at the construction site. However, when calculating the duration of activities, contractors mostly ignore the impact of adverse weather conditions, which results in an incorrect estimate of the project duration. This is largely because tender periods are often too short and essential site-specific data are frequently unavailable at that phase.

In their view, Moohialdin et al., (2020), expressed productivity as the ratio of outputs (e.g., quantity) to inputs (e.g., labour hours) in a given activity and it plays a decisive role in the successful delivery of construction projects, directly determining the achievement of targeted timeframes and budgets. As a central concern for managers, investors, and researchers alike, construction productivity significantly contributes to the gap between planned investments and actual costs. Improving productivity enhances resource utilization, economic value, and the quality of deliverables.

#### **STATEMENT OF THE PROBLEM**

Claims and counterclaims from the clients and contractors on the reduction of the productivity levels of plasterers and tilers on construction sites leading to litigation without adequate considerations of the effect of adverse weather on the output of these operatives is a problem common and rampant in Nigerian building industry. Among the building developers, the general opinion is that workers on site do deliberately delay the progress of work while some are of the opinion that external forces could be responsible. Hence this paper attempts to assess the effect of thermal variability on the output of tilers and plasterers on site.

## **AIM**

The aim of this paper is to assess the effects of weather variability (thermal) on the productivity and output of tilers and plasterers in the Nigerian construction sites taking Minna metropolis as the case study.

## **OBJECTIVES**

The Objectives of the paper are:-

- (i) To identify the variability in the temperature that the tilers and plasterers are subjected to on the construction sites
- (ii) To determine the outputs of both the tilers and plasterers working on residential building sites
- (iii) To determine the relationship of temperature of the sites and the outputs of tilers and plasterers on construction sites.

## **RESEARCH QUESTIONS**

Based on the above, the following are the research questions:-

- (i) What is the minimum and maximum temperature prevailing on the construction sites in the area of study?
- (ii) What is the output of a gang of tiler and plasterer?
- (iii) What is the relationship between the temperature and the output of the operatives?

## **LITERATURE REVIEW**

Sopic et al., (2025) explained that weather conditions have a significant impact on construction projects and play a crucial role in the determination of a project's success. Therefore, understanding and minimizing the hazards associated with severe weather conditions are highly crucial in a setting where even modest disturbances can have wide-ranging results

In addition, environmental factors, such as weather conditions, introduce an additional level of intricacy to construction projects. In contrast to internal variables like resource allocation or project scope, weather is outside the influence of project managers but can significantly affect project results. Empirical evidence indicates that weather-related disturbances frequently result in project delays and cost overruns within the construction sector.

In construction activities, output of artisan cannot be discussed extensively without referring to productivity level (Dong et.al 2026). The most common adverse weather events leading to work stoppages, productivity losses, cost overruns, and project delays in construction are precipitation (heavy rainfall or snowfall), extreme temperatures (high and low), and intense winds as observed by Larsson et al., (2023). Among these, rainfall and extreme temperatures are considered the most impactful weather

difficulties. Different types of construction work are affected by weather in different ways, since each involves distinct materials and equipment.

According to Al Refaie et al., (2021), quantifying the weather impact is valuable to contractors for preparing realistic timetables, cost estimates, and reliable bids. Determining the impact of weather on labour productivity and health enables more accurate project preparation and the implementation of appropriate measures to enhance worker comfort and efficiency at the construction site. However, when calculating the duration of activities, contractors mostly ignore the impact of adverse weather conditions, which results in an incorrect estimate of the project duration. This is largely because tender periods are often too short and essential site-specific data are frequently unavailable at that phase.

In Nigeria, extreme temperatures, whether hot especially in the northern region or cold weather in the southern region and some part in the north-central zone particularly in Jos, Plateau state, exert physical and psychological effects on construction workers, thereby diminishing their productivity. Physiologically, exposure to hot weather can cause heat stress or stroke, whereas cold temperatures may result in tissue damage or numbness in extremities, all of which may psychologically affect a worker to the point of demoralization and reduced productivity. Productivity remains largely unaffected between 10 °C and 20 °C, but drops significantly at temperatures exceeding 25 °C or falling below 0 °C as postulated by Larsson et al., (2023). For each 1 °C increase above 28 °C, worker productivity can drop by up to 57%. Concrete works and asphalt paving are canceled when the minimum temperature is  $\leq 0$  °C, earthworks, steelworks, and exterior painting are canceled when the mean temperature is  $\leq 0$  °C, and at temperatures  $\geq 40$  °C, concrete works, steelworks, and asphalt paving are canceled. Work must stop entirely when temperatures fall below  $-23.3$  °C or rise above 43.3 °C, since efficient construction operations are not feasible under such conditions.

In their view, Schuldt et al., (2021) opined that weather events directly impact the ability to complete construction tasks, which is called task feasibility. Effects on task feasibility range from complete work stoppage to reduced worker productivity and ultimately delays the project schedule. The delay of any project has financial implications, which are shared by the contractor, owner, and external stakeholders. The inclusion of specific language concerning the calculation of permissible delays, based on abnormal or unforeseeable weather, and which weather conditions constitute an excusable delay, have been shown to reduce the number of delay disputes that arise in a project. Events like lightning and high winds pose significant threats to workers, slow worker productivity, or require work stoppages, but proper planning and coordination can mitigate risk

Productivity is usually taken to mean labour productivity, that is, units of work placed or produced per man-hour. The inverse of labour productivity, man-hours per unit (unit rate), is also commonly used. Productivity is the ratio of output to all or some of the resources used to produce that output. Output can be homogenous or heterogeneous

and resources comprise of labour, capital, energy, raw materials. Sharma (2026) opined that for a project to be more efficient, cut costs, and finish on time, workers must be more productive. Workforce performance improvement is even more important now that the world needs more buildings, especially for infrastructure and population. Low output can lead to higher costs, delays, and problems with quality, which can hurt consumers and the image of the business.

**HYPOTHESIS**

For the purpose of this paper, two null hypotheses were formulated. These are -:

- (i) There is no significant relationship between the morning temperature of the site and the outputs of the tilers and plasterers working on a residential building at superstructural level
- (ii) There is no significant relationship between the afternoon temperature of the site and the outputs of the tilers and plasterers

**RESEARCH METHODOLOGY**

For the purpose of this study, quantitative research approach was adopted, whereby ten residential construction sites were purposively sampled and 120 structured questionnaires were prepared and administered to randomly selected 60 tilers and 60 plasterers who are registered members of tiler and plasterer unions. The profile of the respondents ranges from (i) age (ii) number of years of experience and (iii) educational qualification. 42 responses out of 60 respondents (tilers) and 48 responses out of 60 respondents (plasterers) were returned. In the same vein, site temperature during the morning session and afternoon session were collated using thermometer device and the outputs of the gang were also recorded as work progresses. The data collected were subjected analysis of variance (ANOVA) and linear regression analysis.

Table 1.0 shows the average outputs of a gang of plasterer (1 plasterer and 2 unskilled labourers) during the morning and afternoon period.

**Table 1.0 Average Output in Plastering for Wall Exceeding 300mm wide in Superstructure**

HEIG HT	AV. AREA	AVG TIME	AV.OUT P	AV.MO RN	AV.AR EA	AVG TIME	AV. AFTN	AV. AFTN	TOTAL	AVG DIST	AVG. PROD
	COVERED		PRODT VT	TEMP	COVERED		PRODT VT	TEMP	AV.TI ME		PER HOUR
metre	M2	hr	m2/hr	(°C)	M2	Hrs	m2/hr	(°C)	SPENT	metres	
<b>1</b>	13	3.12	4.13	26.4	10.2	3.06	3.33	34.2	6.18	5.5	7.46
<b>2</b>	11.6	2.89	3.93	26.3	10.4	3.02	3.43	34.8	5.91	5.9	7.36
<b>3</b>	10.5	3.09	3.37	26.35	11.3	3.17	3.53	34.6	6.27	6	6.9

Source: Researcher’s Fieldwork (2025)

Output figures from the Table 1.0 shows progressive reduction in the morning session as the height of work increases at an average temperature of 26.3°C. The highest

productivity level was achieved in the morning period with a value of 4.13 m<sup>2</sup>/hr whereas, the highest productivity value in the afternoon period stood at 3.53m<sup>2</sup>/hr. In the same vein, the average output of a gang of tiler (1 tiler and 2 unskilled labourer) is tabulated below showing both the morning and afternoon periods. In this case, the average productivity level in the morning period was 2.68m<sup>2</sup>/hr for an area not wider than 3sq.m while the productivity level in the afternoon stood at 2.19m<sup>2</sup>/hr. This implies that productivity falls as temperature increases from 26.28°C to 33.96°C.

**Table 2.0 Average Output For Tiling on Wall exceeding 300mm wide Excluding Backing**

MORNG PERIOD						AFTN PERIOD						
HEIG HT	AV. AREA	AVG TIME	AV.OU TP	AV.MO RN	AV.AR EA	AVG TIME	AV. AFTN	AV. AFTN	TOTA L	AVG DIST	AVG TOTAL	AVG. PROD
	COVERD		PROD TVT	TEMP	COVERD		PROD TVT	TEMP	AV.TI ME		OUTPU T	PER HOUR
metr e	M2	hr	m2/hr	(°C)	M2	hrs	m2/hr	(°C)	SPEN T	metre s	M2	
<b>3</b>	6.23	2.5	2.68	26.28	6.58	3.02	2.19	33.96	5.52	5.2	<b>12.81</b>	4.87

Source: Researcher’s Fieldwork (2025)

The relationship is further subjected to the analysis of variance (ANOVA) whereby the mean output of a gang of tiler in the morning and afternoon periods as seen in Table 3.0 was analysed. The F calculated shows a value of 2.451 and Ftab shows a value of 4.00. Hence, no relationship exists between the variables tested.

**Table 3.0 ANOVA between**

Variables				Observations				Inferences				
				Type of Model	Mean Values	F cal	Ftab	P values	LOS	Rema rk	Action On Hypothe sis	
	Analysis No.	X1	X2									
	1.	Mean output wall Tiling mornin g	Mean output wall Tiling Afternoon	One- way ANO VA	X1=3.11 53 X2=3.44 07	2.45 1	4.00	0.1 2	0.0 5	NSV	Accept Ho	

Source: Author’s Analysis (2025)

Further analyses were made to determine the relationship of the variables through linear regression analysis and the results are as shown in Table 4.0. The results of relationship between the variables tested in both periods of the day shows no significant relationship as Coefficient of Determination (R<sup>2</sup>) shows a value of 0.5% in the morning and 0.2% in the afternoon period. Hence, null hypothesis (Ho) is accepted.

**Table 4.0: Summary Of Regression Results For Plastering For Wall Exceeding 300mm Wide In Superstructure (Plain Finish)**

Analysis NO	X	Y	Type of Model	Regression Equation	R2 (%)	F cal	Ftab	P values	Strength of Relationship	Remark	Action On Hypothesis
1	Morg Temp Plastrg in wall plain finish	Morg outpt Plastrg plain finish	linear simple	$Y=4.629-0.031X$	0.5	0.15	4.20	0.70	Weak	NS	Accept Ho
2	Aftn Temp Plastrg plain finish	Aftn outpt Plastrg plain finish	linear simple	$Y=4.04-0.017X$	0.20	0.067	4.20	0.80	Weak	NS	Accept Ho

Source: Author’s Analysis, (2025),  
NS= Not Significant

The relationship between the morning and afternoon outputs were regressed against the temperature of the site and results indicated that the coefficient of determination ( $R^2$ ) was 9.4% in the morning and 0.2% in the afternoon respectively while P values was 0.10 and 0.83 for both periods, hence the null hypothesis is accepted as shown in Table 5.0

**Table 5.0 Summary of Regression Results for Wall Tiles**

Analysis NO	Variables		Type of Model	Observations					Inferences		
	X	Y		Regression Equation	R2 (%)	F cal	Ftab	P values	Strength of Relationship	Remark	Action On Hypothesis
1	Morg Temp wall tiles	Morg outpt wall tiles	linear simple	$Y=-2.401+0.193X$	9.4	2.911	4.20	0.10	Weak	NS	Accept Ho
2	Aftn Temp Wall Tiles	Aftn outpt wall tiles	linear simple	$Y=2.736-0.016X$	0.20	0.045	4.20	0.83	Weak	NS	Accept Ho

KEY: NS= Not Significant  
Source: Researcher’s Data Analysis (2025).

The Table 6.0 below shows the summary of regression equation for the floor tiles and denotes the relationship between the variables. The morning and afternoon temperature Coefficient of determination ( $R^2$ ) values denote 0.4% and 0.2% respectively. These results show a weak relationship between the temperatures and the output of a gang of tiler.

**Table 6.0 : Summary Of Regression Results For Floor Tiles**

Analysis NO	Variables		Type of Model	Observations					Inferences		
	X	Y		Regression Equation	R2 (%)	F cal	Ftab	P values	Strength of Relationship	Remark	Action On Hypothesis
1	Morg Temp floor tiles	Morg outpt floor tiles	linear simple	$Y=3.388+0.004X$	0.4	0.121	4.20	0.730	Weak	NS	Accept Ho

Analysis NO	Variables		Type of Model	Observations					Inferences		
	X	Y		Regression Equation	R2 (%)	F cal	Ftab	P values	Strength of Relationship	Remark	Action On Hypothesis
2	Aftn Temp Floor Tiles	Aftn output floor tiles	linear simple	Y=3.32+0.033X	0.20	0.055	4.20	0.82	Weak	NS	Accept Ho

Source: Researcher’s Data Analysis (2025)

NS= Not Significant

### CONCLUSION

This article paper examines how weather especially temperature of a construction sites affects the output of a gang of tiler and a gang of plasterer. From the results of analyses conducted above, it is seen that temperature of the site when taking in the morning and afternoon period did not exert significant pressure on the output of the operatives sampled as none of the Coefficient of determination values shows significant relationship. This could be as a result of the fact that most the operations done were indoor operations where significant thermal effect may not have direct impact. However, from the study, the outputs and productivity levels reduced drastically as temperature of the site rises. Therefore, efforts should be made by construction stakeholders to imbibe mitigating measures where necessary when considering major outdoor operations.

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