



An Assessment of the Variations of Solar Irradiance with Temperature and Relative Humidity of Abuja During the Rainy Season

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ABSTRACT

This study assessed the variation of solar irradiance in relation to atmospheric temperature and relative humidity in Abuja, Nigeria, during the rainy season from April to July 2026. Primary experimental data on solar irradiance, temperature and relative humidity were collected at 30-minute intervals using a digital pyranometer and automatic weather station. The collected data were analysed using daily and monthly averages, correlation analysis and multiple linear regression. The results showed considerable daily variation in solar irradiance, with observed values ranging approximately from 200 to 960 W/m². April recorded the highest individual irradiance value, while July generally exhibited the lowest overall irradiance conditions. Correlation analysis showed a positive relationship between temperature and solar irradiance, with the strongest association occurring in June ($r = 0.7957$). Relative humidity exhibited an inverse relationship with irradiance, with the strongest negative correlation also occurring in June ($r = -0.8091$). Multiple regression analysis indicated that temperature and relative humidity were jointly and significantly associated with solar irradiance, $F(2, 73) = 10.753$, $p < 0.001$. Temperature had a positive regression coefficient of 23.741 W/m² per °C, while relative humidity had a negative coefficient of -7.343 W/m² per percentage point. The model explained 22.52% of the variation in solar irradiance, indicating that substantial variability remained unexplained by the two predictors. The study concludes that temperature and relative humidity are significant atmospheric variables associated with solar-irradiance variability in Abuja during the rainy season, while other factors such as cloud cover, rainfall, atmospheric pressure and aerosol concentration may also contribute substantially to observed variations. The findings provide recent location-specific evidence that can support improved solar-resource assessment and photovoltaic planning in Abuja.

Keywords: Solar irradiance, Temperature, Relative humidity, Rainy season, Abuja, Nigeria

1.0 INTRODUCTION

Solar irradiance is an important measure of the amount of solar energy received at the Earth's surface and is fundamental to the assessment and utilization of solar-energy resources. Solar radiation varies with atmospheric and meteorological conditions, including temperature, relative humidity, cloud cover and other environmental factors (Julius & Balogun, 2022). In Nigeria, variations in solar radiation occur across different climatic zones and seasons because of differences in atmospheric conditions and weather patterns. Julius and Balogun (2022) reported significant spatial and seasonal variations in solar radiation, temperature and relative humidity across Nigeria. Similarly, studies of humid tropical conditions in Nigeria have demonstrated that solar radiation, temperature and relative humidity exhibit clear diurnal and seasonal variations (2022). Recent research has further shown that temperature and relative humidity are important variables in estimating the

relationship between solar radiation and atmospheric conditions in Nigerian locations (Ohiani et al., 2024). In addition, Idogho (2025) incorporated solar irradiation, temperature, humidity and cloud cover in forecasting solar photovoltaic power across different climatic regions of Nigeria, emphasizing the importance of these variables in solar-energy prediction. More recent work by Oyom and Nsa (2026) also examined the combined variations of solar radiation, ambient temperature and relative humidity in selected Nigerian locations.

Despite previous studies examining the relationship between solar radiation and meteorological variables in different parts of Nigeria, limited attention has been given to short-term, high-frequency measurements of solar irradiance in Abuja specifically during the rainy season. Several existing studies have relied on long-term secondary datasets, monthly observations, or solar-radiation estimation models, which may not adequately capture day-to-day atmospheric variability. In addition, few studies have simultaneously examined temperature and relative humidity using recent ground-based measurements and multiple regression during a defined rainy-season period in Abuja. This study therefore addresses this gap by providing experimental evidence from April to July 2026 and quantifying both the individual and combined relationships of temperature and relative humidity with solar irradiance. Previous studies across Nigeria and neighbouring regions have shown that solar irradiance is closely linked to temperature and relative humidity, although the strength and direction of these relationships vary by location and season. In some Nigerian sites, temperature has been reported to increase with solar radiation, while elsewhere an inverse or only weak association has been observed (Ohiani et al., 2024; Akpootu et al., 2021; Oyom & Nsa, 2026). Relative humidity, by contrast, more consistently shows a negative relationship with irradiance, particularly during the wet season when higher atmospheric moisture and cloud cover reduce the amount of solar radiation reaching the surface (Omokungbe et al., 2025; Mari et al., 2026; Ali et al., 2023).

These atmospheric variables have also proved useful for estimating or forecasting solar radiation and photovoltaic output. Models that incorporate temperature, humidity, precipitation and cloud cover have achieved good predictive performance in Abuja and other Nigerian climatic zones (Omeje et al., 2021; Idogho, 2025; Hassan et al., 2022). High-resolution measurements further confirm that rapid changes in irradiance are strongly tied to cloudiness and diurnal shifts in temperature and humidity (Bawa & Sarsah, 2026; Ndiaye et al., 2025; Alemu et al., 2025).

Despite these advances, most existing work has relied on long-term secondary datasets, monthly averages or predictive models rather than short-term, high-frequency ground measurements. Consequently, the day-to-day variability of solar irradiance and its simultaneous relationship with temperature and relative humidity during the rainy season in Abuja remain poorly documented. The present study addresses this gap by analysing primary half-hourly observations collected from April to July 2026.

The reviewed studies generally demonstrate that solar irradiance is closely associated with atmospheric conditions, particularly temperature, relative humidity, cloud cover and rainfall. However, the direction and strength of these relationships vary across geographical locations and seasons. Studies conducted in Nigeria have reported both positive and negative relationships between temperature and solar radiation, while relative humidity has more frequently demonstrated an inverse relationship, particularly during wet-season conditions. Most previous investigations have also relied on long-term secondary datasets or predictive models, with comparatively limited experimental evidence based on high-frequency measurements in Abuja during the rainy season. The present study addresses this limitation by using primary measurements collected at 30-minute intervals over four consecutive months and applying both monthly correlation and multiple regression analysis.

2.0 METHODOLOGY

2.1 Study Area: Abuja, Nigeria

Abuja is located in the central part of Nigeria within the Federal Capital Territory (FCT), approximately between latitudes 8.25°–9.20°N and longitudes 6.45°–7.39°E. The FCT covers approximately 7,315 km² and is characterised by undulating terrain, hills and elevated areas that influence its local climatic conditions. Abuja has a tropical wet-and-dry climate, with the rainy season occurring from April to October and a dry season from November to March. A short Harmattan period normally occurs during the dry season and is associated with dry air, dust haze and reduced atmospheric moisture. The vegetation of Abuja is predominantly Guinea savanna, consisting mainly of grasses, shrubs and scattered trees, although patches of forest vegetation also occur in some parts of the FCT. The rainy season is characterised by increased cloud cover, rainfall and atmospheric humidity, conditions that can influence the amount of solar radiation reaching the Earth's surface.

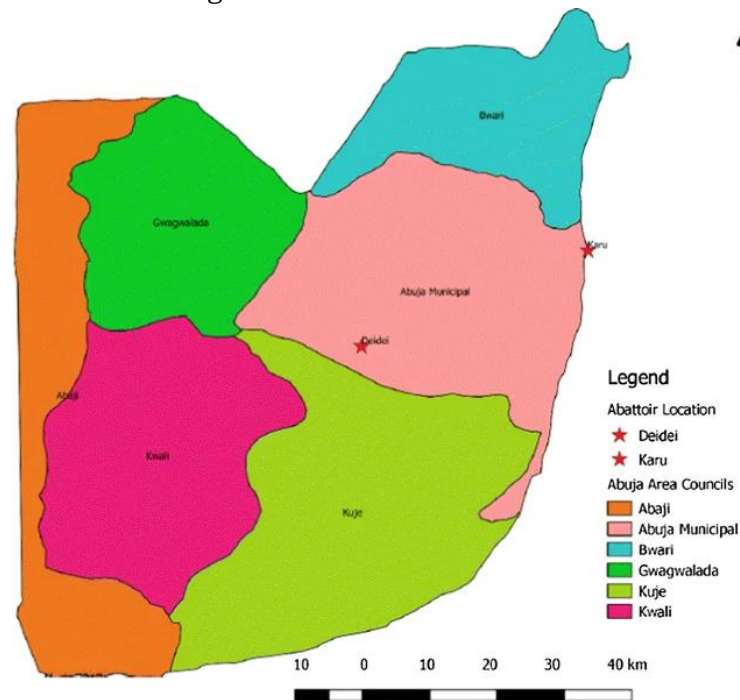


Figure 1: Map of Abuja (Source: Aworh et al., 2017)

2.2 Materials

The study utilised an automatic weather station, a portable digital pyranometer, a stopwatch, and Python software for data collection and analysis. Primary data were collected for three atmospheric and solar-radiation variables: atmospheric temperature (°C), relative humidity (%), and solar irradiance (W/m²).

2.3 Research Method

The study adopted an experimental research design. The experimental equipment was installed at a selected location in Abuja, Nigeria, on Latitude 8.9609° N and Longitude: 7.3615° E and average elevation of around 350 meters, and maintained at the same location throughout the study period to ensure consistency in the measurement conditions. Atmospheric temperature and relative humidity were measured using an automatic weather station of model WS 1007 10.1, while solar irradiance was measured using a portable digital pyranometer of model SM206 with the resolution of 0.1 W/m², 0.1 Btu/(ft²-h), Error range of +/-10%R+2dgts) Readings, temperature error of +/-0.38 W/m²/°C, drift of less than +/-1.5%/year, measuring range of 0.1 – 1999.9 W/m², incidence angle normal direction of less than +/-45 degree, wavelength range of 340 – 1100nm, and sampling time of 2.5st/s. The

weather station consisted of an indoor receiving unit that displayed the measured atmospheric parameters, including temperature and relative humidity.

Atmospheric temperature, relative humidity and pressure were measured using an automatic weather station (model WS 1007). The temperature sensor operated over a range of $-40\text{ }^{\circ}\text{C}$ to $65\text{ }^{\circ}\text{C}$ with an accuracy of $\pm 1\text{ }^{\circ}\text{C}$, the relative-humidity sensor over 10–99 % with an accuracy of $\pm 10\text{ }%$, and the pressure sensor over 700–1100 hPa with an accuracy of $\pm 1\text{ hPa}$. For each measurement, the pyranometer was properly positioned and directed toward the sun manually to obtain the corresponding solar-irradiance reading. This was to enable it measure only Direct Normal Irradiance (DNI), thus, capturing only the beam from the sun.

Data collection was carried out at 30-minute intervals from 9:00 a.m. to 6:00 p.m. daily. The experiment covered the rainy season from April 1 to July 31, 2026. A total of 19 observations were obtained daily for each of the three measured variables. The recorded observations were subsequently organised and processed to obtain half hourly and daily averages for the variables.

Before statistical analysis, the collected observations were examined for missing, inconsistent and abnormal values. Measurements were checked against the expected operating ranges of the instruments, and incomplete observations were excluded from the corresponding analysis. The remaining observations were organised according to date and measurement time before calculation of daily and monthly averages. This procedure was used to minimise the influence of recording errors and incomplete measurements on the statistical results.

Correlation analysis was performed to determine the strength and direction of the relationship between solar irradiance as the dependent variable and atmospheric temperature and relative humidity as the independent variables. Multiple regression analysis was also conducted using 76 observations gotten from the 19 mean average half hourly data of the four months (April to July) to determine the combined influence of temperature and relative humidity on solar irradiance and to obtain the coefficient of determination (R^2). The original half-hourly observations ($\approx 2,300$ points) were aggregated into monthly time-of-day means to capture the typical diurnal relationship between solar irradiance, temperature and relative humidity during the rainy season. For each of the 19 half-hour intervals (09:00–18:00), averages were calculated across all days of each month, yielding 76 representative observations (19 means $\times$ 4 months). This approach reduced day-to-day weather noise while preserving the characteristic diurnal cycle, clearly revealed the consistent temperature–irradiance and humidity–irradiance associations, and follows standard practice in solar-resource studies that focus on typical atmospheric behaviour rather than short-term fluctuations.

The R^2 value was used to determine the proportion of variation in solar irradiance jointly explained by the two atmospheric variables. The statistical significance of the individual independent variables was evaluated using their corresponding probability values (p -values). In addition, the overall significance of the regression model was assessed using analysis of variance (ANOVA) and the F-test. The ANOVA result was used to determine whether temperature and relative humidity, when considered together, significantly predicted variations in solar irradiance. All data processing, statistical analysis, and graphical presentations were performed using Python software.

3.0 RESULTS AND DISCUSSION

3.1 Interpretation of Average Daily Solar Irradiance from April to July 2026

The graph (fig. 2) shows the variation in average daily solar irradiance (W/m^2) from April to July 2026. The results demonstrate substantial day-to-day fluctuations in solar irradiance across all four months, with values ranging approximately from $200\text{ W}/\text{m}^2$ to $960\text{ W}/\text{m}^2$. This indicates that the availability of solar radiation varied considerably throughout the study period, which may be associated with changing atmospheric conditions during the rainy season, particularly variations in cloud cover, rainfall, and atmospheric moisture.

April recorded relatively high irradiance values on many days, generally ranging between approximately 300 and 960 W/m². The highest value in the entire graph occurred in April, reaching approximately 960 W/m² around day 17. This indicates that April experienced the highest individual daily solar irradiance during the period. However, irradiance also decreased considerably on some days, reaching approximately 300 W/m², demonstrating substantial within-month variability.

May also showed considerable daily fluctuations, with irradiance reaching approximately 810 W/m² around day 3 and remaining above 700 W/m² on several days during the first half of the month. However, the month also recorded relatively low values, including approximately 210 W/m² around day 6. Thus, May experienced both high and low irradiance conditions, with a generally moderate-to-high level during much of the first half of the month.

June displayed a different pattern, with relatively low values at the beginning and middle of the month but higher values during the latter half. The lowest value shown for June was approximately 210 W/m² around day 17, while irradiance increased to approximately 780 W/m² around day 19 and remained around 600–700 W/m² on several subsequent days. This indicates a considerable improvement in solar radiation after the middle of the month.

July showed the greatest frequency of low-to-moderate irradiance values, particularly from approximately day 18 onward. Although the month recorded a relatively high value of about 780 W/m² around day 4, several days recorded values between 300 and 500 W/m². Consequently, July can generally be regarded as the month with the lowest overall solar irradiance pattern, despite having some isolated high-radiation days.

In summary, April had the highest individual daily irradiance value, while July generally exhibited the lowest overall irradiance conditions. May and June showed intermediate and highly variable conditions. The pronounced daily fluctuations across all four months indicate that solar irradiance during the rainy season was not consistent and could change substantially from one day to another. This variability is important for solar-energy applications because it implies that photovoltaic power generation during the rainy season may fluctuate considerably depending on daily atmospheric conditions.

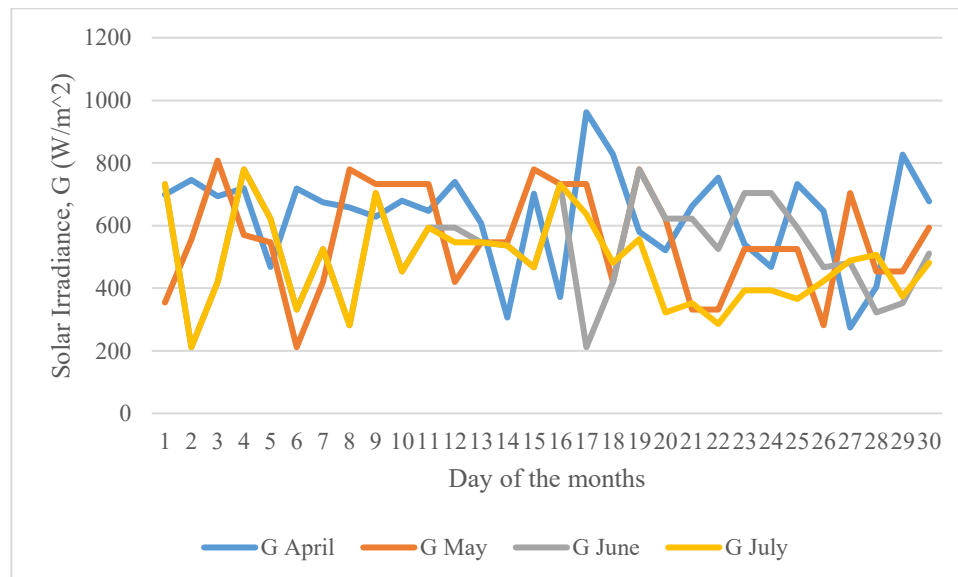


Figure 2: Average daily solar irradiance for each of the four months

3.2 Monthly Correlation between Solar Irradiance, Temperature and Relative Humidity

Fig. 3 shows the correlation of solar irradiance with temperature and relative humidity by month.

It was observed that in April, temperature had a relatively weak positive correlation with solar irradiance ($r = 0.2701$), indicating that increases in temperature were only weakly associated

with increases in irradiance. Relative humidity showed a very weak negative correlation ($r = -0.0889$), suggesting that RH had almost no linear relationship with solar irradiance during this month. However, the relationship became considerably stronger in May, when temperature recorded a moderate positive correlation ($r = 0.4699$), while relative humidity showed a strong negative correlation ($r = -0.7710$). This indicates that higher temperatures tended to occur alongside higher irradiance, whereas higher humidity was strongly associated with reduced irradiance.

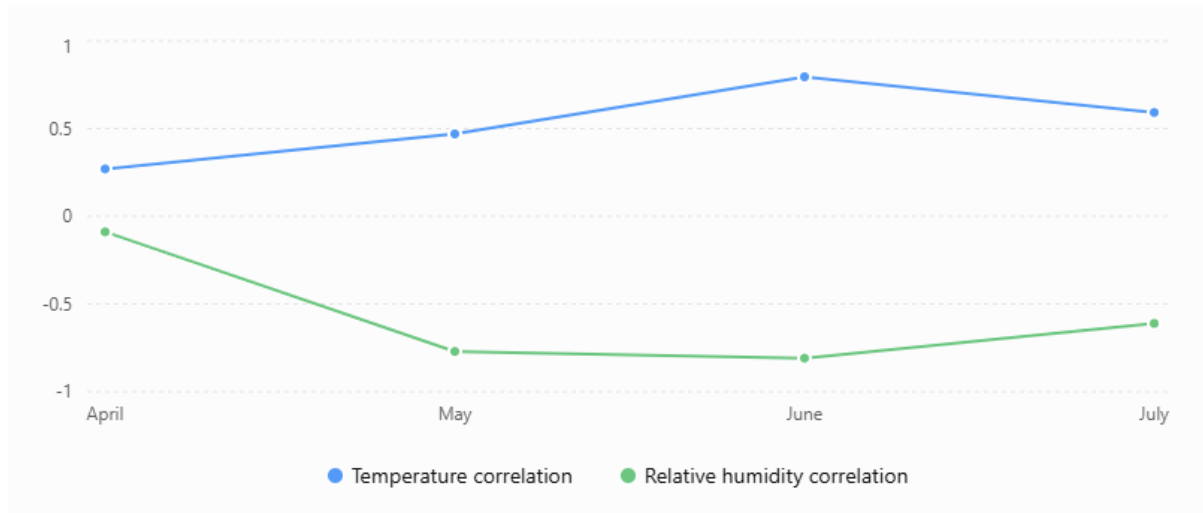


Figure 3: Monthly correlation of solar irradiance with temperature and relative humidity

The strongest temperature relationship occurred in June, with a correlation coefficient of 0.7957, representing a strong positive association between temperature and solar irradiance. During the same month, RH recorded a correlation of -0.8091 , indicating a very strong inverse relationship. This suggests that June experienced a particularly clear contrast between the two atmospheric variables: higher temperatures were associated with greater solar irradiance, while higher relative humidity was associated with substantially lower irradiance. In July, temperature maintained a moderate-to-strong positive correlation ($r = 0.5923$), while RH remained strongly negatively correlated with irradiance ($r = -0.6109$). In all, it can be seen that, the monthly results indicate that temperature generally had a positive relationship with solar irradiance, while relative humidity consistently had a negative relationship. The strength of both relationships varied considerably across the four months, with June showing the strongest associations for both variables.

The particularly strong negative RH correlations from May to July suggest that atmospheric moisture may have played an important role in limiting the amount of solar radiation reaching the surface during the rainy-season period. Conversely, the increasing positive temperature correlations from April to June indicate that temperature was more closely aligned with changes in solar irradiance as the rainy season progressed. These findings support the broader regression results and demonstrate that the influence of atmospheric conditions on solar irradiance varies from month to month.

Table 1: Monthly Correlation coefficients between solar irradiance and atmospheric temperature and relative humidity from April to July, 2026

Monthly Correlation coefficients values				
Variables/Month	April	May	June	July
Temp	0.2701	0.4700	0.7957	0.5922
RH	-0.0889	-0.7710	-0.8091	-0.6109

Table 2 presents the estimated regression coefficients, standard errors, t-statistics and corresponding p-values for temperature and relative humidity. The regression model was developed to assess the relationship between solar irradiance, temperature, and relative humidity during the rainy season in Abuja. The resulting equation, is given as;

$$G = 249.498 + 23.741T - 7.343RH \quad (1)$$

where G = Solar Irradiance (W/m^2), T = Temperature ($^{\circ}\text{C}$), and RH = Relative Humidity (%),

Equation (1) indicates that temperature and relative humidity jointly explain variations in solar irradiance. The results (Table 2.0) show a Multiple R of 0.4745, indicating a moderate overall positive relationship between the observed solar irradiance values and those predicted by the two atmospheric variables. This suggests that temperature and relative humidity provide a measurable, although moderate, explanation of changes in solar irradiance. The R^2 value of 0.2252 further shows that the two variables jointly explain approximately 22.52 % of the variation in solar irradiance (W/m^2) during the rainy season in Abuja. Their combined explanatory power is therefore relatively limited, with the remaining 77.48 % of the variation attributable to other atmospheric and environmental factors such as cloud cover, rainfall, atmospheric pressure, aerosol concentration, water vapour and solar position.

The Adjusted R^2 of 0.2042 confirms that, after accounting for the number of independent variables and the sample size, temperature and relative humidity collectively explain about 20.42 % of the variation. The small difference between the R^2 and Adjusted R^2 values indicates that the model's explanatory power is not substantially inflated by the inclusion of the predictors. Overall, the regression model provides a reasonable, although limited, explanation of solar-irradiance changes based on the selected meteorological variables.

In addition, the regression model has a standard error of 116.41 W/m^2 , which represents the typical magnitude of the difference between the observed solar irradiance values and the values predicted by the regression model. In practical terms, the model's predictions of solar irradiance may differ from the actual measured values by approximately 116.41 W/m^2 on average. This relatively large prediction error indicates that considerable variability in solar irradiance remains unexplained by temperature and relative humidity alone. Although these variables provide useful information for predicting irradiance, solar radiation is affected by several other atmospheric and environmental conditions that are not represented in the model. Consequently, incorporating additional relevant predictors, particularly cloud cover, and other weather parameters, could potentially improve the predictive accuracy of the regression model.

The Analysis of Variance (ANOVA) results provide an overall assessment of whether the regression model significantly explains variations in solar irradiance. From the table, the results show an F-statistic of $F(2, 73) = 10.753$, with a corresponding Significance F value of 0.0000795. Since the probability value is considerably smaller than the conventional significance level of 0.05 ($0.0000795 < 0.05$), the null hypothesis that temperature and relative humidity jointly have no linear relationship with solar irradiance is rejected. Therefore, the regression model is considered statistically significant. This significant F-test shows that temperature and relative humidity, when considered together, provide meaningful information for explaining variations in solar irradiance (W/m^2). However, statistical significance does not necessarily imply that the model explains a large proportion of the total variation, as indicated by the relatively modest Adjusted R^2 value of 0.2042. Rather, it demonstrates that the relationship observed between the predictors and solar irradiance is unlikely to have occurred solely as a result of random sampling variation. Furthermore, the p-value of 0.0000795, equivalent to approximately 0.00795%, provides further evidence of the statistical significance of the model. Consequently, the null hypothesis is rejected at the 5% significance level, providing strong evidence that temperature and relative humidity jointly contribute to explaining variations in solar irradiance.

Table 2: Regression analysis results**SUMMARY OUTPUT****Regression Statistics**

Multiple R	0.474537
R Square	0.225185
Adjusted R Square	0.204244
Standard Error	116.4146
Observations	76

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	2	291466.2	145733.1	10.75333	7.95E-05			
Residual	73	1002875	13552.37					
Total	76	1294341						

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	249.4978	116.8978	2.134324	0.036129	16.57382	482.4218	16.57382	482.4218
Ave Half Hourly Temp	23.74109	5.122436	4.634726	1.5E-05	13.53441	33.94777	13.53441	33.94777
Ave Half Hourly RH	-7.34334	2.272443	-3.23148	0.001839	-11.8713	-2.8154	-11.8713	-2.8154

3.3 Temperature–Irradiance Relationship

The regression coefficient for average half-hourly temperature is $\beta = 23.74109$ W/m² per °C. The positive sign of this coefficient indicates a positive relationship between temperature and solar irradiance, after controlling for the effect of relative humidity. Specifically, the coefficient implies that for every 1°C increase in average half-hourly temperature, solar irradiance is expected to increase by approximately 23.74 W/m², provided that relative humidity remains constant. For example, an increase in temperature from 30°C to 31°C would be associated with an estimated increase of approximately 23.74 W/m² in solar irradiance. Similarly, a 5°C increase in temperature would correspond to an estimated increase of approximately 118.71 W/m², assuming that relative humidity remains unchanged.

The statistical significance of the temperature coefficient is further demonstrated by its standard error of 5.122, t-value of 4.635, and p-value of 0.000015. Since $p = 0.000015 < 0.05$, the temperature–irradiance relationship is statistically significant. This means that there is strong statistical evidence that temperature contributes to explaining variations in solar irradiance independently of relative humidity. The 95% confidence interval, ranging from 13.534 to 33.948 W/m² per °C, is entirely above zero. This indicates that the estimated effect of temperature is consistently positive within the 95% confidence level. In other words, the analysis provides strong evidence that increases in temperature are associated with increases in solar irradiance under the conditions represented by the dataset. The temperature p-value of 0.000015, equivalent to approximately 0.0015%, indicates an extremely low probability of obtaining a temperature coefficient as large as the observed coefficient purely because of random variation if no underlying linear relationship existed. Therefore, the results provide very strong evidence of a positive association between temperature and solar irradiance, even after controlling for relative humidity. These findings suggest that temperature is an important predictor of solar irradiance in the regression model, although its effect should be interpreted as an association rather than proof of direct causation. However, the positive temperature–irradiance association should not be interpreted as evidence that warmer air directly causes higher solar irradiance. Both variables respond strongly to cloud state and the diurnal cycle of solar forcing; clearer days raise both irradiance and temperature, while cloudy conditions reduce both simultaneously.

3.4 Relative Humidity–Irradiance Relationship

The regression coefficient for average half-hourly relative humidity (RH) is $\beta = -7.34334 \text{ W/m}^2$ per percentage point of RH. The negative sign of the coefficient indicates an inverse relationship between relative humidity and solar irradiance after controlling for the effect of temperature. Specifically, the coefficient indicates that for every 1 percentage-point increase in relative humidity, solar irradiance is expected to decrease by approximately 7.34 W/m^2 , assuming that temperature remains constant. For instance, if relative humidity increases from 60% to 61% while temperature remains unchanged, the regression model predicts an approximate decrease of 7.34 W/m^2 in solar irradiance. Similarly, a 10 percentage-point increase in relative humidity would be associated with an estimated decrease of approximately 73.43 W/m^2 in solar irradiance, provided that temperature remains constant.

The statistical significance of the relationship is demonstrated by the coefficient's standard error of 2.272, t-value of -3.231 , and p-value of 0.001839. Since the p-value is considerably lower than the 5% significance level ($0.001839 < 0.05$), the null hypothesis that relative humidity has no linear relationship with solar irradiance, after controlling for temperature, is rejected. Therefore, the relationship between relative humidity and solar irradiance is statistically significant. The negative t-value is consistent with the negative regression coefficient, confirming that increases in relative humidity are associated with reductions in solar irradiance.

The 95% confidence interval for the relative humidity coefficient ranges from -11.871 to -2.815 W/m^2 per percentage point of RH. Importantly, the entire confidence interval lies below zero, providing additional evidence that the effect of relative humidity is negative. This means that, within the 95% confidence level, the estimated reduction in solar irradiance associated with a one-percentage-point increase in relative humidity is expected to fall between approximately 2.82 and 11.87 W/m^2 , assuming temperature is held constant.

The p-value of 0.001839, equivalent to approximately 0.1839%, indicates that if there were truly no linear relationship between relative humidity and solar irradiance in the population after controlling for temperature, there would be only about a 0.184% probability of obtaining a relationship as strong as the one observed due to random variation alone. This provides strong statistical evidence that higher relative humidity is associated with lower solar irradiance during the rainy season. The finding is also physically plausible because higher atmospheric moisture is often associated with increased cloud formation and atmospheric scattering or absorption, which can reduce the amount of solar radiation reaching the Earth's surface. However, the regression result establishes a statistical association rather than direct causation. The negative RH–irradiance relationship should also be interpreted cautiously. While higher moisture can increase cloudiness and attenuate radiation, part of the association simply reflects the inverse diurnal relationship between temperature and relative humidity rather than attenuation by atmospheric water alone.

The positive temperature–irradiance relationship observed in this study is consistent with earlier Nigerian findings. Ododo et al. (1995) identified maximum air temperature as an important parameter in solar-radiation estimation, while Abdullahi et al. (2017) also reported a positive association between temperature and global solar radiation in Ikeja. The negative RH–irradiance relationship recorded from May to July likewise agrees with Omokungbe et al. (2025), who noted reduced solar radiation under wet-season conditions of higher humidity and cloud cover. These results further align with Idogho (2025), who highlighted the combined importance of temperature, humidity, cloud cover and solar irradiation for photovoltaic prediction across Nigerian climatic regions.

In summary, the findings demonstrate that higher temperature tends to be associated with higher solar irradiance, whereas higher relative humidity tends to be associated with lower solar irradiance during the rainy season in Abuja. Although temperature and RH make statistically significant contributions to explaining irradiance variability, they do not fully

account for the changes observed. The results therefore highlight the importance of considering a broader range of meteorological and atmospheric variables in future studies to improve the understanding and prediction of solar irradiance in Abuja.

4.0 CONCLUSION

The results of this study show that solar irradiance in Abuja experienced considerable daily and monthly variations during the rainy season from April to July 2026. The observed irradiance values varied widely, with April recording the highest individual daily value of approximately 960 W/m², while July generally showed the lowest overall irradiance conditions. The monthly correlation analysis further revealed that temperature maintained a positive relationship with irradiance, with the strongest correlation occurring in June ($r = 0.7957$), whereas relative humidity showed a strong negative relationship, particularly in May, June and July. The regression results indicate that temperature and relative humidity are significant atmospheric variables associated with solar irradiance in Abuja. Temperature showed a positive and statistically significant relationship, while relative humidity showed a significant negative relationship. The regression model was statistically significant ($F(2,73) = 10.753$, $p < 0.001$), with temperature and RH jointly explaining 22.52% of the variation in irradiance. This indicates that although temperature and humidity contribute meaningfully to changes in solar irradiance, other factors such as cloud cover, rainfall, atmospheric aerosols and solar position may influence the amount of radiation reaching the Earth's surface.

It can be concluded that solar irradiance in Abuja exhibited substantial daily and monthly variability between April and July 2026. Temperature and relative humidity were statistically associated with irradiance but jointly explained only 22.52 % of its variance. The regression model is therefore incomplete without additional information on cloud cover, rainfall, aerosols and solar geometry.

4.1 Limitations of the Study

This study was limited to measurements collected at a single experimental location in Abuja and covered only the April–July 2026 rainy-season period. Consequently, the findings may not represent conditions across all locations within the Federal Capital Territory or the entire year. In addition, the regression model considered only temperature and relative humidity, while other factors such as cloud cover, rainfall intensity, atmospheric pressure, wind speed, aerosol concentration and solar geometry may also influence solar irradiance. The use of a relatively limited number of observations for the regression analysis may also constrain the generalisation of the findings. Future studies should therefore employ longer observation periods, multiple measurement locations and a wider range of meteorological variables. Also, Solar zenith angle and clear-sky irradiance were not controlled for in the present analysis. Consequently, part of the observed relationships between temperature, relative humidity and solar irradiance may reflect the common diurnal cycle driven by solar elevation rather than purely atmospheric effects. In addition, formal regression diagnostics (variance inflation factor, residual normality, heteroscedasticity and temporal autocorrelation) were not reported. These omissions are acknowledged as limitations; future work should incorporate clear-sky normalisation and full residual diagnostics to strengthen the statistical interpretation.

4.2 Recommendations

It is recommended that continuous monitoring of temperature, RH, cloud cover and rainfall should be encouraged in Abuja for solar-resource assessment. Also, similar research should be done in dry season for the same study area.

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