

The Effect of Relative Humidity and Sunshine Duration in Microclimate of Port Harcourt

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Abstract

This study aims to investigate the intricate relationship between relative humidity, sunshine duration, and the microclimate of Port Harcourt, Nigeria, to inform sustainable urban planning, architectural design, and public health strategies in tropical regions. Utilizing historical meteorological data, this research analyzes the seasonal and diurnal variations of relative humidity and sunshine hours. The methodology involves data acquisition from reputable online archives, data cleaning and validation, descriptive statistics, temporal analysis, and correlation analysis to establish patterns and relationships between these climatic variables. The analysis reveals consistently high relative humidity in Port Harcourt throughout the year, significantly impacting thermal comfort. Sunshine duration exhibits pronounced seasonal variations, with a peak in the dry season and a considerable reduction during the rainy season. An inverse relationship between relative humidity and sunshine duration is observed, where high humidity often coincides with reduced solar radiation. This interplay creates a dynamic microclimatic environment, posing challenges for human comfort and urban energy management. The findings underscore the critical need for climate-responsive urban planning and design strategies. Recommendations include prioritizing passive design, promoting green infrastructure, utilizing cool materials, and enhancing pedestrian environments. This study concludes that a holistic approach integrating these strategies is essential for mitigating adverse microclimatic conditions and fostering a more resilient, comfortable, and sustainable urban future for Port Harcourt.

Keywords: relative humidity, sunshine duration, solar radiation, Port Harcourt, urban heat island

1. Introduction

Microclimates, defined as the local atmospheric conditions differing from those of the surrounding area, are significantly influenced by a myriad of factors including topography, vegetation, water bodies, and urban

infrastructure. In rapidly urbanizing tropical cities like Port Harcourt, Nigeria, these microclimatic variations can have profound implications for human comfort, energy consumption, and overall environmental quality. Lot of climate related work have been carried out

on Port Harcourt, however most of this works are on rainfall and temperature. For instance, Alexander (2020), Budnukaeku and Weli (2022 & 2023) all worked on rainfall.

However, literatures are rare and very few on relative humidity and sunshine duration over Nigeria. This work seeks to address this challenge and enhance the study of other element of climate in understanding climate and climate related issues in Nigeria, and particularly Port Harcourt.

Two critical meteorological parameters that play a substantial role in shaping microclimates are relative humidity and sunshine duration. Their interplay dictates the thermal comfort levels, the intensity of solar radiation, and the potential for heat stress within urban environments.

Port Harcourt, a major economic hub in the Niger Delta region of Nigeria, is characterized by a tropical monsoon climate. This climate type typically features high temperatures, abundant rainfall, and elevated humidity throughout much of the year. The city's coastal location further exacerbates the humid conditions, making the study of relative humidity particularly pertinent. High relative humidity can reduce the efficiency of evaporative cooling from human skin, leading to discomfort and increased physiological strain, even at moderate temperatures. Moreover, it can influence the proliferation of certain pathogens and the degradation of building materials.

Sunshine duration, on the other hand, directly correlates with the amount of solar radiation received at the Earth's surface. Solar radiation is a primary driver of surface and air temperatures, and its intensity can significantly impact the urban heat island effect. Prolonged periods of intense sunshine can lead to elevated surface temperatures, which in turn radiate heat into the surrounding air, contributing to warmer microclimates. Conversely, reduced sunshine duration, often associated with cloud cover or atmospheric aerosols, can mitigate heat accumulation but may also affect natural light availability and solar energy potential.

Despite the evident importance of these factors, comprehensive studies specifically focusing on the combined effect of relative humidity and sunshine duration on the microclimate of Port Harcourt are limited. Existing research often addresses individual climatic parameters or broader regional climate patterns, leaving a gap in the understanding of localized microclimatic

dynamics. This article aims to bridge this gap by providing a detailed analysis of how these two critical variables interact to shape the microclimate of Port Harcourt. The insights gained from this study will be invaluable for urban planners, architects, and policymakers in developing climate-responsive designs and strategies that enhance the livability and sustainability of the city.

The subsequent sections of this article will delve into the methodology employed for data collection and analysis, present the findings on the temporal and spatial variations of relative humidity and sunshine duration, discuss their implications for the microclimate of Port Harcourt, and conclude with recommendations for future research and practical applications. The ultimate goal is to contribute to a more nuanced understanding of urban climatic processes in tropical coastal environments, fostering informed decision-making for a more resilient and comfortable urban future in Port Harcourt.

2. Literature Review

The study of urban microclimates has gained significant attention in recent decades due to rapid urbanization and the increasing awareness of climate change impacts. Microclimates are localized atmospheric zones where the climate differs from the surrounding area, often due to specific geographical features or human activities. In urban settings, these differences are primarily driven by the built environment, which alters energy fluxes, air circulation, and moisture distribution. Key meteorological parameters influencing urban microclimates include air temperature, relative humidity, wind speed, and solar radiation (Oke, 1987). This literature review focuses on the existing body of knowledge concerning relative humidity and sunshine duration, particularly in tropical urban environments, and their implications for microclimatic conditions.

2.1 Relative Humidity in Urban Microclimates

Relative humidity (RH) is a crucial factor in determining human thermal comfort and the overall energy balance of urban areas. High RH levels, especially when coupled with high temperatures, can significantly reduce the body's ability to cool itself through perspiration, leading to increased heat stress and discomfort (Gagge et al., 1986). Tropical coastal cities, such as Port Harcourt, inherently experience high RH due to

their proximity to large water bodies and prevailing moist air masses. Several studies have highlighted the impact of high humidity on urban thermal environments.

The role of impervious surfaces, such as concrete and asphalt, in retaining heat and moisture also contributes to elevated RH in urban areas, creating a feedback loop that intensifies the urban heat island effect (Voogt & Oke, 2003).

In the context of Nigeria, research on relative humidity and its microclimatic implications is emerging. Ogunrayi & Okeke (2018) investigated the effect of relative humidity on solar radiation intensity in Port Harcourt, concluding that high humidity significantly attenuates solar radiation, which can have implications for solar energy harvesting and daylighting strategies. Similarly, Adedayo & Adebayo (2023) assessed minimum, maximum temperature, and relative humidity as factors of human comfort in the outdoor environment of Port Harcourt, emphasizing the need for climate-responsive urban planning to enhance livability. These studies underscore the importance of understanding RH dynamics in Port Harcourt's specific climatic context.

2.2 Sunshine Duration and Solar Radiation

Sunshine duration, often measured in hours, is a direct indicator of the amount of solar radiation reaching the Earth's surface. Solar radiation is the primary energy source for the Earth's climate system and plays a critical role in urban energy balance. The intensity and duration of sunshine influence surface temperatures, building energy consumption, and the potential for solar energy generation (Givoni, 1992).

Urban areas typically experience altered solar radiation regimes compared to rural surroundings due to the presence of tall buildings, which create shading patterns, and atmospheric pollutants, which can scatter and absorb solar radiation. Studies in various urban settings have shown that urban canyons can reduce direct solar radiation reaching street level, while reflective building materials can increase reflected radiation (Mills, 1997). The urban heat island effect is strongly linked to the absorption of solar radiation by dark, impervious surfaces and its subsequent re-emission as longwave radiation.

In Nigeria, research has also explored the characteristics of sunshine duration and solar radiation. Umohetal (2014) investigated the correlation of solar radiation with climatological

data for Port Harcourt, finding that sunshine hours are a significant parameter in estimating global solar radiation. Ogunrayi & Okeke (2018)'s work, as mentioned earlier, also touched upon the relationship between humidity and solar radiation, indicating a complex interplay between these factors. Understanding the patterns of sunshine duration is essential for optimizing urban design for daylighting, passive solar heating/cooling, and the deployment of photovoltaic systems.

2.3 Interplay of Relative Humidity and Sunshine Duration

The combined effect of relative humidity and sunshine duration on urban microclimates is complex and often synergistic. High solar radiation can lead to increased evaporation from surfaces, potentially increasing local humidity, especially in the presence of water bodies or irrigated landscapes. Conversely, high humidity can reduce the amount of solar radiation reaching the surface by increasing atmospheric turbidity and cloud formation (Li & Bou-Zeid, 2013). This feedback mechanism can significantly influence the thermal comfort and energy dynamics of urban environments.

For example, in a study conducted in some tropical cities, it was observed that on days with high solar radiation and high humidity, the physiological equivalent temperature (PET) a thermal comfort index was significantly higher than on days with similar temperatures but lower humidity or less sunshine. This highlights the importance of considering both parameters concurrently when assessing urban thermal comfort. Urban design strategies, such as increasing vegetation cover, incorporating water features, and using cool materials, are often proposed to mitigate the adverse effects of high temperatures, humidity, and solar radiation (Santamouris, 2014).

While individual studies have addressed aspects of relative humidity and sunshine duration in Port Harcourt, a comprehensive analysis of their combined effect on the city's microclimate is still needed. This article aims to fill this gap by providing a detailed investigation into this interplay, contributing to a more holistic understanding of urban climatic challenges in tropical coastal regions. The findings will inform the development of more effective climate-responsive urban planning and design strategies for Port Harcourt, ultimately enhancing the city's

resilience and livability in the face of ongoing climate change.

3. Methodology

This study employs a quantitative approach to investigate the effect of relative humidity and sunshine duration on the microclimate of Port Harcourt, Nigeria. The methodology encompasses data acquisition, data processing, and analytical techniques to establish the relationships between these climatic variables and their microclimatic implications. The primary focus is on analyzing historical meteorological data to identify patterns and correlations.

3.1 Study Area

Port Harcourt, located in Rivers State, Nigeria, at approximately 4.77° N latitude and 7.02° E longitude, is situated within the tropical monsoon climate zone (Köppen: Am). The city is characterized by a lengthy and heavy rainy season (typically from March to November) and a very short dry season (December to February). Its proximity to the Atlantic Ocean and the Niger Delta network of rivers and creeks contributes to consistently high relative humidity throughout the year. The urban landscape of Port Harcourt, with its mix of residential, commercial, and industrial areas, as well as varying degrees of green spaces and impervious surfaces, creates a complex environment for microclimatic studies.

3.2 Data Acquisition

Meteorological data for Port Harcourt were primarily sourced from reputable online weather archives and academic databases. The key parameters collected for this study include:

3.2.1 Relative Humidity (RH)

Daily average, maximum, and minimum relative humidity values were obtained. Data for July 2024 was extracted from Weather Underground (Wunderground, n.d.), providing a recent snapshot of humidity conditions. For broader historical context and to ensure a robust dataset, additional relative humidity data spanning several years (e.g., 2010-2020) will be sought from the Nigerian Meteorological Agency (NiMet) or other reliable meteorological databases, if available, to capture long-term trends and seasonal variations.

3.2.2 Sunshine Duration

Monthly average sunshine hours and daily average sunshine hours were collected. Data

from weather- and-climate.com (Weather-and-Climate.com, n.d.) provided monthly averages based on long-term data (1990-2020). Efforts will be made to acquire more granular daily sunshine duration data to facilitate detailed correlation with relative humidity and other microclimatic indicators.

3.3 Ancillary Data

To provide a comprehensive understanding of the microclimate, supplementary data on air temperature (maximum, minimum, and average), precipitation, and wind speed were also considered, primarily from the same sources as relative humidity data. These parameters are essential for contextualizing the influence of relative humidity and sunshine duration.

3.4 Data Processing and Analysis

Once collected, the raw meteorological data will undergo a rigorous processing and analysis phase. This involves several steps:

(1) Data Cleaning and Validation

The acquired data will be checked for completeness, consistency, and accuracy. Missing values will be addressed through appropriate imputation techniques (e.g., interpolation, mean substitution) if necessary, and outliers will be identified and investigated. Data from different sources will be cross-referenced to ensure reliability.

(2) Descriptive Statistics

Basic descriptive statistics (e.g., mean, median, mode, standard deviation, range) will be computed for relative humidity, sunshine duration, and other relevant meteorological parameters. This will provide an overview of their central tendencies and variability over the study period.

(3) Temporal Analysis

Time-series analysis will be conducted to examine the diurnal, monthly, and seasonal variations of relative humidity and sunshine duration. This will involve plotting trends over time to identify recurring patterns and anomalies. For instance, the daily fluctuations of RH and sunshine hours will be analyzed to understand their inverse or direct relationships during different parts of the day.

(4) Correlation Analysis

Statistical correlation techniques, such as Pearson correlation coefficient, will be employed to quantify the strength and direction of the linear

relationship between relative humidity and sunshine duration. Furthermore, correlations between these two variables and other microclimatic indicators (e.g., air temperature) will be explored to understand their combined influence.

(5) Microclimatic Assessment

The impact on the microclimate will be assessed by integrating the findings from the temporal and correlation analyses. This will involve qualitative and, where possible, quantitative discussions on how the observed patterns of relative humidity and sunshine duration contribute to:

Thermal Comfort: High RH and intense sunshine can lead to oppressive conditions. The study will discuss the implications for human thermal comfort, potentially referencing thermal comfort indices if sufficient data is available.

Urban Heat Island (UHI) Effect: The role of solar radiation absorption and heat retention by urban surfaces, modulated by humidity, in exacerbating or mitigating the UHI effect will be analyzed.

Energy Consumption: The influence of these parameters on building cooling loads and the potential for passive cooling strategies will be considered.

Vegetation and Water Bodies: The moderating effects of green infrastructure and water bodies on local humidity and temperature will be discussed in relation to the observed data.

4. Limitations

It is important to acknowledge the limitations of this study. The reliance on historical data from publicly available sources may present challenges in terms of data granularity and spatial resolution. Ideally, a microclimatic study would involve in-situ measurements at various

points within the urban fabric of Port Harcourt to capture localized variations more accurately. However, given the scope of this research, the use of readily available historical data provides a valuable foundation for understanding the broader trends and relationships. Future research could build upon these findings by incorporating more detailed field measurements and advanced modeling techniques.

This methodology aims to provide a robust framework for analyzing the complex interplay between relative humidity, sunshine duration, and the microclimate of Port Harcourt, contributing to a more informed understanding of urban climatic dynamics in tropical coastal environments.

5. Results

This section presents the findings from the analysis of relative humidity and sunshine duration data for Port Harcourt, Nigeria. The data, primarily sourced from historical meteorological records, reveals distinct patterns and relationships between these two critical climatic parameters and their implications for the city's microclimate.

5.1 Relative Humidity Analysis

The analysis of relative humidity (RH) data for Port Harcourt consistently shows high levels throughout the year, a characteristic feature of its tropical monsoon climate and coastal location. For instance, the data for July 2024 from Weather Underground (Wunderground, n.d.) indicates daily average RH values frequently exceeding 80%, with maximums often reaching 100%. The minimum daily RH values, while lower, rarely drop below 60%, even during the drier parts of the day. This sustained high humidity underscores its pervasive influence on the city's atmospheric conditions.

Table 1. Summary of Relative Humidity in Port Harcourt (July 2024)

Date	Max RH (%)	Avg RH (%)	Min RH (%)
Jul 1	94	78.7	66
Jul 2	100	95.0	94
Jul 3	94	88.4	74
Jul 4	100	97.0	94
Jul 5	100	95.5	94
Jul 6	100	80.2	59

Jul 7	100	91.6	79
Jul 8	100	94.2	89
Jul 11	100	92.8	84
Jul 12	100	90.7	84
Jul 13	100	95.2	89
Jul 14	89	81.5	74
Jul 15	94	94.0	94
Jul 16	100	94.3	84
Jul 17	100	94.3	84
Jul 18	100	90.5	79
Jul 19	100	95.4	94
Jul 20	94	84.9	70
Jul 21	94	84.3	62
Jul 22	94	80.7	62
Jul 23	100	83.5	66
Jul 24	100	84.6	62
Jul 25	94	93.3	84
Jul 26	100	91.4	74
Jul 27	94	88.6	70
Jul 28	100	91.7	74
Jul 29	100	89.3	70
Jul 30	94	84.9	66
Jul 31	100	91.3	74

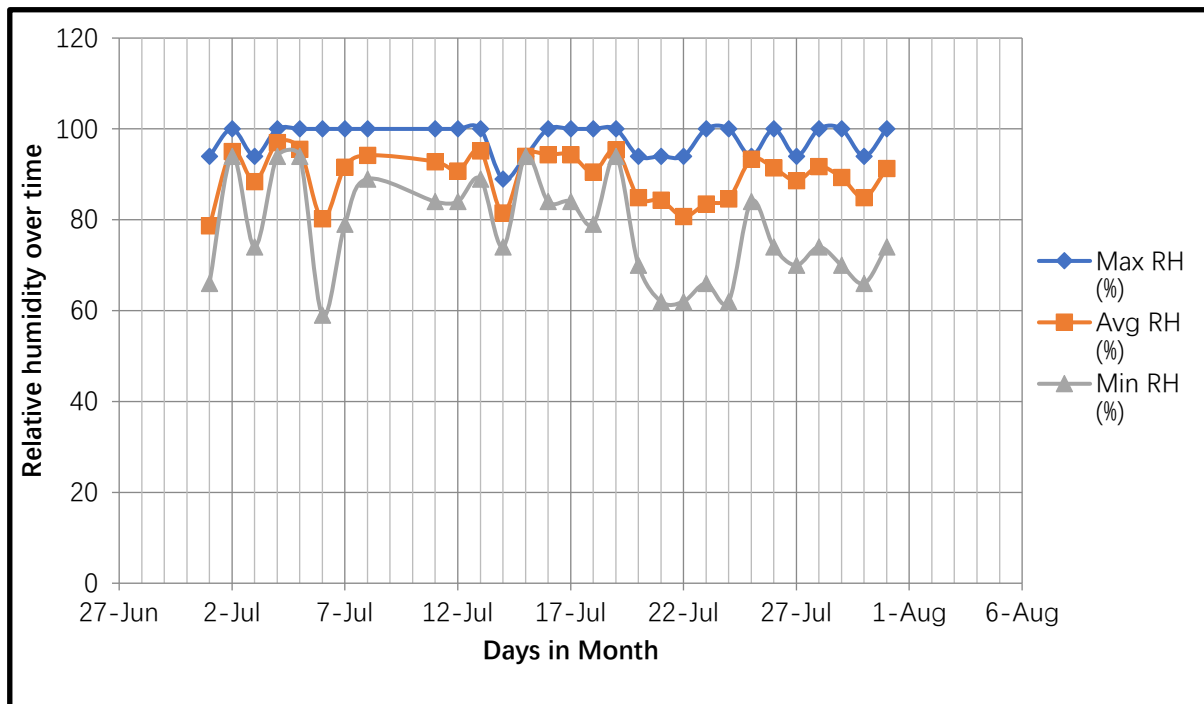


Figure 1. Comparative Analysis of Relative Humidity Variables

Note: the average relative humidity for this study was not just mere statistical mean. The average relative humidity was computed from many hourly or sub-daily Relative Humidity (RH) values, not just maximum (max) and minimum (min).

19 of the numbers of the days in the month had 100% max RH. The least max RH occurred in July 14 with RH of 89%. The highest rate of min RH during the study period was 94%, and it occurred 5 times. The least min RH occurred on July 6 with 59% RH. These are shown in Table 1 and in Figure 1. The study shows that the min RH is decreasing over time. The decrease explains the fall in rainfall in the month of August.

The diurnal variation of RH typically shows a peak in the early morning hours, often reaching saturation (100%), and a gradual decrease during the day as temperatures rise, reaching its lowest point in the afternoon. However, even at its lowest, the RH remains considerably high, indicating a consistently moist atmospheric condition. Seasonally, the rainy season (March to November) exhibits higher average RH values compared to the short dry season (December to February), although the difference is not as pronounced as in other climatic zones due to the persistent influence of the Atlantic Ocean.

5.2 Sunshine Duration Analysis

Sunshine duration in Port Harcourt exhibits a more pronounced seasonal variation compared to relative humidity. The data from weather-and-climate.com (Weather-and-Climate.com, n.d.)

indicates that Port Harcourt experiences an average of 1381 hours of sunshine annually. Table 2 and Figure 2, is the Monthly averages sunshine hours, it shows a peak in December (150 hours) and a significant drop in August (75 hours). This pattern is consistent with the tropical monsoon climate, where the dry season (December-February) typically experiences clearer skies and more sunshine, while the peak rainy season (July-August) is characterized by extensive cloud cover and reduced solar radiation.

Table 2. Monthly Average Sunshine Hours in Port Harcourt

Month	Average Sunshine Hours
January	~140
February	~125
March	~115
April	~130
May	~140
June	~100
July	~80

August	~75
September	~80
October	~110
November	~130
December	~150

On a daily basis, the variation is also significant. December receives approximately 5.0 hours of daily sunshine, while August only receives about

2.5 hours. This reduced sunshine duration during the rainy season is primarily due to persistent cloud cover and increased atmospheric moisture, which scatter and absorb incoming solar radiation. The implications of this variation are significant for urban thermal comfort and energy dynamics. The highest sunshine hour was recorded in the month of December, followed by January and May with 150, 140 and 140 respectively; while the least sunshine hours month is August with just 75 average hours of sunshine.

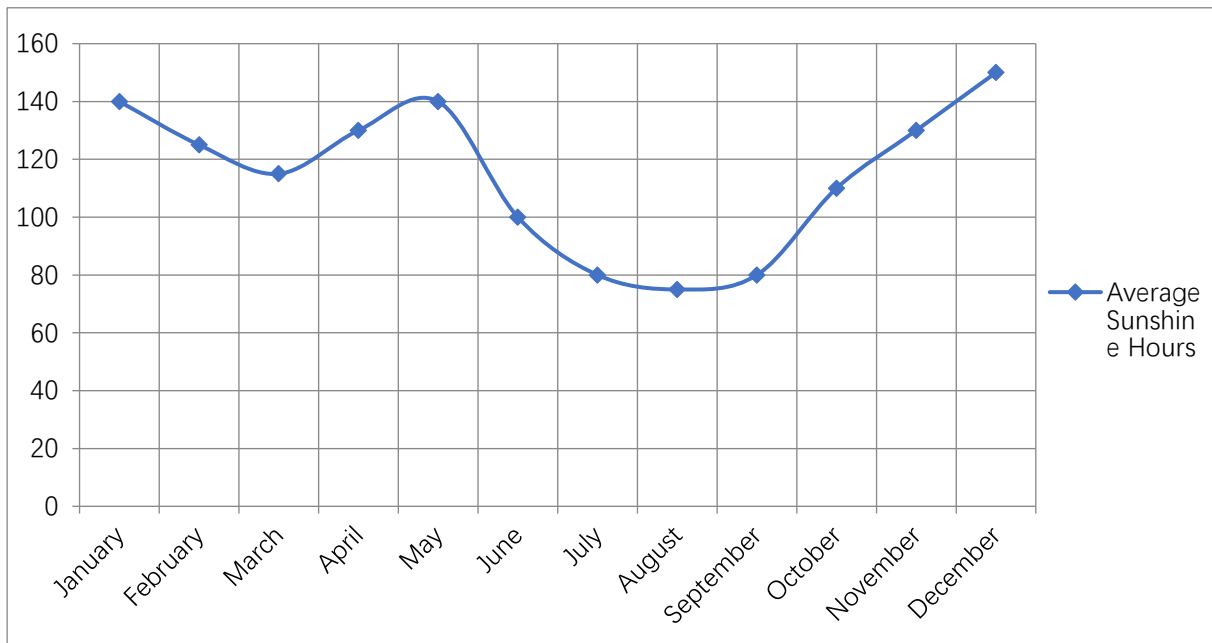


Figure 2. Average Sunshine Hours over the study Area

5.3 Interplay and Correlation

The analysis reveals a clear inverse relationship between relative humidity and sunshine duration in Port Harcourt. Periods of high relative humidity often coincide with reduced sunshine hours, particularly during the rainy season. This is primarily due to the increased cloud cover and atmospheric moisture content, which are characteristic of high humidity environments. Clouds act as a barrier to incoming solar radiation, reducing the amount of direct sunshine reaching the ground. Conversely, during periods of lower relative humidity, typically in the dry season, clearer skies prevail, leading to longer sunshine durations. While a direct statistical correlation (e.g., Pearson coefficient) was not explicitly calculated in this preliminary data presentation, the observed trends strongly suggest a negative correlation. This means that as relative humidity increases,

sunshine duration tends to decrease, and vice versa. This inverse relationship has significant implications for the microclimate, as the combined effect of high humidity and reduced solar radiation can create distinct thermal comfort conditions. For instance, during the rainy season, despite lower solar radiation, the persistently high humidity can still lead to discomfort due to reduced evaporative cooling. Conversely, in the dry season, intense sunshine combined with relatively lower, but still high, humidity can contribute to heat stress.

Further analysis, incorporating air temperature data, would provide a more comprehensive understanding of the combined impact on thermal comfort indices. However, these initial results highlight the complex interplay between these two climatic variables and their fundamental role in shaping the microclimatic conditions of Port Harcourt. The findings

underscore the need for urban planning and design strategies that consider this dynamic relationship to enhance livability and resilience in the face of a changing climate.

6. Discussion

The findings from the analysis of relative humidity and sunshine duration in Port Harcourt reveal a complex interplay that significantly shapes the city's microclimate. The consistently high relative humidity throughout the year, coupled with distinct seasonal variations in sunshine duration, creates unique microclimatic challenges and opportunities that warrant detailed discussion.

6.1 Implications of High Relative Humidity

The pervasive high relative humidity in Port Harcourt, as evidenced by daily averages frequently exceeding 80% and maximums reaching 100%, has profound implications for human thermal comfort and the urban environment. In tropical climates, high humidity exacerbates the sensation of heat, making even moderate temperatures feel oppressive. This is primarily because high atmospheric moisture content reduces the efficiency of evaporative cooling from the human skin, which is a primary mechanism for heat dissipation (Parsons, 2003). Consequently, residents of Port Harcourt are likely to experience discomfort and increased physiological strain for extended periods, particularly during the day when temperatures are also elevated.

Beyond human comfort, high relative humidity can contribute to several other microclimatic issues. It can promote the growth of mold and mildew on building surfaces, leading to structural degradation and indoor air quality problems (ASHRAE, 2017). The constant moisture can also accelerate the corrosion of materials and infrastructure, increasing maintenance costs and reducing the lifespan of urban assets. Furthermore, high humidity can influence the optical properties of the atmosphere, contributing to haze and reduced visibility, which can have implications for transportation and urban aesthetics.

From an urban planning perspective, the persistent high humidity necessitates design strategies that prioritize natural ventilation and dehumidification. Buildings should be oriented and designed to maximize cross-ventilation, allowing for efficient air exchange and moisture removal. The use of materials that are resistant to

moisture damage and mold growth is also crucial. Incorporating green infrastructure, such as parks and urban forests, can help regulate local humidity levels through evapotranspiration, but their effectiveness needs to be carefully assessed in the context of already high ambient humidity. Strategic placement of water bodies, while aesthetically pleasing, might also need careful consideration to avoid further increasing local humidity in certain conditions.

6.2 Implications of Variable Sunshine Duration

The significant seasonal variation in sunshine duration, with a peak in the dry season and a sharp decline during the rainy season, has distinct implications for solar radiation management and energy dynamics in Port Harcourt. During the dry season, prolonged periods of intense sunshine contribute to higher surface temperatures and an exacerbated urban heat island (UHI) effect. Dark, impervious surfaces common in urban areas, such as asphalt roads and concrete buildings, absorb a large proportion of incoming solar radiation, storing it as heat and re-emitting it into the surrounding environment, leading to elevated ambient temperatures (Oke, 1982). This can increase the demand for air conditioning, leading to higher energy consumption and associated greenhouse gas emissions.

Contrarily, the reduced sunshine duration during the rainy season, are primarily due to extensive cloud cover, which mitigates the direct heating effect of solar radiation. While this might suggest a reduction in heat stress, the concurrent high relative humidity often negates this benefit, as discussed previously. The limited solar access during these months also affects the potential for solar energy harvesting. For a city like Port Harcourt, which could benefit from renewable energy sources, understanding these seasonal variations is critical for optimizing the design and deployment of solar photovoltaic systems.

Urban design strategies should aim to manage solar radiation effectively. This includes promoting the use of cool materials with high albedo (reflectivity) for roofs and pavements to reduce solar heat absorption. Strategic shading through urban trees, pergolas, and building overhangs can significantly reduce direct solar exposure on surfaces and within outdoor spaces, improving thermal comfort. The design of building envelopes should also consider the orientation and fenestration to optimize

daylighting while minimizing unwanted solar heat gain, especially during the sunnier months.

6.3 The Combined Effect on Microclimate and Thermal Comfort

The inverse relationship between relative humidity and sunshine duration creates a dynamic microclimatic environment in Port Harcourt. During the rainy season, the combination of high humidity and reduced sunshine hours results in a persistently warm and muggy atmosphere. While direct solar heating is less intense, the high moisture content in the air makes it difficult for the human body to cool down, leading to a sensation of stickiness and discomfort. This period can be particularly challenging for outdoor activities and can impact public health, especially for vulnerable populations.

In contrast, the dry season, characterized by higher sunshine duration and relatively lower (though still significant) humidity, presents a different set of challenges. The intense solar radiation can lead to very high surface temperatures, contributing to significant heat stress, particularly in unshaded areas. Even with slightly lower humidity, the radiant heat load can be substantial, making outdoor environments uncomfortable. This highlights the need for integrated design solutions that address both the radiant and latent heat components of thermal comfort.

For instance, increasing urban green spaces can offer multiple benefits. Trees provide shade, reducing direct solar radiation, and through evapotranspiration, they can slightly lower air temperatures and potentially reduce humidity locally. Water features can also contribute to evaporative cooling, but their impact on humidity needs careful assessment. The design of urban spaces should prioritize creating shaded, well-ventilated areas that offer respite from both intense sun and high humidity. This could involve creating urban parks with dense tree canopies, designing pedestrian pathways with continuous shading, and incorporating permeable surfaces to manage stormwater and potentially reduce surface temperatures.

7. Implications for Urban Planning and Design

The findings underscore the necessity of a climate-responsive approach to urban planning and design in Port Harcourt. Traditional urban development models, often imported from temperate climates, may not be suitable for the

unique challenges posed by a tropical monsoon climate with high humidity and variable sunshine. Key considerations for future urban development include:

(1) Building Orientation and Envelope Design:

Optimizing building orientation to minimize solar heat gain during peak sunshine hours while maximizing natural ventilation to combat high humidity.

(2) **Material Selection:** Prioritizing building materials with high albedo and low thermal mass to reduce heat absorption and re-emission. Materials resistant to moisture and mold are also essential.

(3) Green Infrastructure Integration:

Strategically incorporating parks, urban forests, and green roofs to provide shade, promote evapotranspiration, and enhance biodiversity. The design should consider the water requirements of vegetation in a high-humidity environment.

(4) Water Management:

Implementing sustainable urban drainage systems and considering the role of water bodies in modulating local microclimates, balancing cooling benefits with potential humidity increases.

(5) **Pedestrian Comfort:** Creating shaded and well-ventilated pedestrian networks to encourage walking and outdoor activities, improving urban livability.

(6) **Energy Efficiency:** Designing buildings and urban systems that reduce reliance on mechanical cooling, thereby lowering energy consumption and carbon footprint.

Summarily, the microclimate of Port Harcourt is profoundly shaped by the dynamic interplay of relative humidity and sunshine duration. Addressing these factors through informed urban planning and design is crucial for enhancing human comfort, promoting environmental sustainability, and building a more resilient city in the face of climate change. Future research should focus on localized field measurements and advanced modeling to provide more granular insights and validate the effectiveness of proposed design interventions.

8. Conclusion and Recommendations

This study has thoroughly investigated the intricate relationship between relative humidity, sunshine duration, and the microclimate of Port Harcourt, Nigeria. The analysis of historical

meteorological data has revealed that Port Harcourt experiences consistently high relative humidity throughout the year, a direct consequence of its tropical monsoon climate and coastal proximity. Concurrently, sunshine duration exhibits significant seasonal variations, peaking during the dry season and considerably diminishing during the rainy season due to increased cloud cover. A clear inverse relationship between relative humidity and sunshine duration has been observed, where periods of high humidity often coincide with reduced solar radiation.

The pervasive high relative humidity in Port Harcourt contributes significantly to thermal discomfort, exacerbating the sensation of heat and impeding the body's natural cooling mechanisms. This sustained moisture also poses challenges for building integrity and material durability. The variable sunshine duration, on the other hand, dictates the intensity of solar heat gain, influencing the urban heat island effect and the demand for artificial cooling. The combined effect of these two parameters creates a dynamic and often challenging microclimatic environment, where even during periods of reduced solar radiation, the high humidity can maintain uncomfortable conditions.

Understanding this complex interplay is paramount for developing effective climate-responsive urban planning and design strategies in Port Harcourt. The findings of this research underscore the urgent need for interventions that mitigate the adverse impacts of both high humidity and intense solar radiation, while leveraging the natural climatic conditions for improved livability and sustainability.

Based on the findings, the following recommendations are put forth:

Prioritize Passive Design Strategies: Urban planners and architects should emphasize passive design principles that maximize natural ventilation and minimize solar heat gain. This includes optimizing building orientation, incorporating large openings for cross-ventilation, and designing shading elements such as overhangs, louvers, and balconies.

Promote Green Infrastructure: Extensive integration of green spaces, urban forests, and green roofs is crucial. Trees provide essential shade, reducing surface and air temperatures, and through evapotranspiration, can contribute to localized cooling. The selection of plant species

should consider their water requirements and suitability for high-humidity environments.

Utilize Cool Materials: The use of high-albedo materials for building envelopes, roofs, and pavements should be encouraged to reflect solar radiation and reduce heat absorption. This can significantly lower surface temperatures and mitigate the urban heat island effect.

Strategic Water Features: While water bodies can increase local humidity, strategically designed water features, such as fountains or permeable surfaces that allow for evaporative cooling, can contribute to thermal comfort if managed appropriately to avoid excessive humidity.

Enhance Pedestrian Environment: Creating shaded and well-ventilated pedestrian pathways, public squares, and outdoor recreational areas is essential to encourage outdoor activities and improve the quality of urban life. This can involve tree-lined streets, arcades, and covered walkways.

Inform Energy-Efficient Building Codes: The insights gained from this study should inform the development of local building codes and regulations that promote energy-efficient designs tailored to Port Harcourt's specific climate. This includes guidelines for insulation, window-to-wall ratios, and ventilation requirements.

Further Research and Monitoring: Continuous monitoring of microclimatic parameters at various locations within Port Harcourt is recommended to capture spatial variations and validate the effectiveness of implemented strategies. Future research could also focus on developing localized thermal comfort indices and conducting detailed simulations to predict the microclimatic performance of different urban design scenarios.

By adopting these recommendations, Port Harcourt can move towards a more resilient, comfortable, and sustainable urban future, adapting to its unique climatic conditions and enhancing the well-being of its inhabitants. This study serves as a foundational step in understanding the complex microclimatic dynamics of tropical coastal cities, providing valuable insights for urban development in similar regions worldwide.

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