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Assessing the Diurnal and Spatial Role of Greenspaces and Concrete Landscapes in Regulating Urban Microclimate

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Abstract

Amidst Dhaka city's rapidly growing urban fabric, Dhanmondi Lake is one of the few remaining natural features that directly impacts the area's microclimate, which is especially relevant to combating the increasing urban heat island phenomenon. This research investigates the lake's diurnal and spatial impact on local temperature and humidity variations between greenspaces and concrete landscapes. Data from 14 monitoring points, collected over two months (March-April 2024), were analyzed using descriptive statistics (mean, median, standard deviation) and inferential statistics (Pearson's correlation coefficient), alongside spatial analysis through Inverse Distance Weighting (IDW) to visualize microclimate patterns. The results demonstrate that during the daytime, temperatures are higher in concrete areas and lower near the lake, with a strong positive correlation between distance from the lake and temperature across the lake ($r = 0.933$, $p = 0.002$). Conversely, at night, temperature decreases as the distance from the lake increases, with a strong negative correlation between them ($r = -0.983$, $p = 0.000$). The recorded nighttime temperature was relatively stable with a small variation (mean = 28.47˚C, SD = 0.21˚C) across the lake, suggesting the lake's ability to retain heat at night. In contrast, the average temperature in the areas near the lake was relatively more stable (mean = 28.59˚C, SD = 0.06˚C). Humidity consistently showed a strong negative correlation with distance from the lake both day ($r = -0.993$, $p = 0.000$) and night ($r = -0.977$, $p = 0.000$), with higher humidity levels near the lake and lower concrete areas. These findings emphasize that distance from the lake and greenspace is a key factor influencing microclimate. The results lead to policy recommendations highlighting integrating natural elements into urban planning to mitigate urban heat island (UHI) effects and enhance thermal comfort.

Keywords

Urban Microclimate, Greenspaces, Concrete Landscapes, Temperature and Humidity Regulation, Diurnal Variation, Spatial Analysis

1. Introduction

Worldwide landscapes have changed fundamentally because of urbanization, where built infrastructure has replaced natural vegetation, resulting in profound shifts in local climate conditions called microclimates (Carlson & Arthur, 2000). In the "Climates in Miniature: A Study of Micro-Climate Environment", "Microclimate" was first introduced as a regional climate that differs from the outside area (Franklin, 2013). Differences in air temperatures, wind patterns, and humidity levels in urban areas due to buildings, pavement, and human activities, represent key characteristics of micro-climatological processes (Salvati & Kolokotroni, 2023). Topography, vegetation, and water bodies also play into these conditions, which can be monitored over hours to years (Al-Hilli et al., 2009). Since urban areas are mostly covered with impervious surfaces that absorb heat immediately, they are often warmer than rural areas (Vujovic et al., 2021).

As urbanization continues, understanding such microclimate dynamics becomes crucial for tackling the problems of thermal comfort and sustainability. Urbanized land uses, and climate modifications enhance the need for greenspaces, e.g., parks, gardens, etc., to overcome the adverse impacts of urbanization (Hoque et al., 2023). Although greenspaces can be any shape or size, more extensive and continuous green spaces have the most significant benefits (Browning et al., 2022). Green areas balance temperature and humidity through shading and evapotranspiration (Piccinini Scolaro et al., 2024).

Lakes produce unique city microclimates with cooling benefits and humidity regulation mechanisms in nearby environments (Manteghi et al., 2015). On the other hand, concrete landscapes intensify heat absorption and inhibit natural cooling processes (Dhakal et al., 2022). Impervious surfaces, such as concrete, significantly increase heating during the day and store this heat at night, causing an Urban Heat Island effect (Uddin et al., 2021). However, the magnitude of those impacts is not constant. They change throughout the day and night, complicating microclimate regulation (Emmanuel, 2021). Studies emphasize the diurnal nature of microclimate; greenspaces are far more effective during the daytime, whereas urban heat retention in built environments at night (Mathew et al., 2018).

However, there is still a lack of knowledge about how temperature and humidity patterns are synchronized at different places and times in urban contexts, with special reference to areas near lakes. The overwhelming majority of works have investigated diurnal or spatial effects separately from each other, while the interaction between both aspects has not been studied before. Filling these two gaps, spatial and diurnal variations in temperature and humidity, and combining both dimensions in one certain analysis is crucial for the effective design and implementation of urban heat relief strategies to reduce thermal stress in Urban areas.

This study aims to investigate the role of greenspaces and concrete landscapes in regulating urban microclimates, focusing on their influence on temperature and humidity fluctuations. Specifically, it seeks to (1) assess the impact of greenspaces and concrete landscapes on microclimate regulation, particularly regarding temperature and humidity patterns during both day and night and (2) identify how distance from these features, particularly lakes, affects microclimate regulation. Through exploring the diurnal and spatial scales, this study aims to offer an effective reference for modifying the current urban planning approaches to promote better thermal comfort and urban sustainability in fast-urbanizing cities.

2. Material and Methods

2.1. Study Area and Site Description

Due to the high population density of more than twenty-one million, rapid urbanization and environmental degradation are some of the big problems that Dhaka faces today (Dewan et al., 2012). Green areas in the urban area represent less than 20% of the total land area and, as a result, promote the UHI that affects the thermal comfort of the city (Zhou et al., 2023). Of all the zones in Dhaka, Dhanmondi has shown a drastic change in land use over the past few years alone (Hasan & Reza, 2022). Dhanmondi, the 49-no. Ward under the Dhaka South City Corporation (DSCC), is the densely populated residential neighbourhood in the Dhaka Metropolitan Area (Nancy & Hafiz, 2023). A unique characteristic of this area is the Dhanmondi Lake, which strictly occupies 16% of Dhanmondi's entire land, still is a primary concern for inhabitants' essential needs and for changing local microclimate (Sharmeen, 2014). Nowadays, Dhanmondi Lake also has an important role in controlling temperature and humidity levels in the area (Sharmeen, 2014).

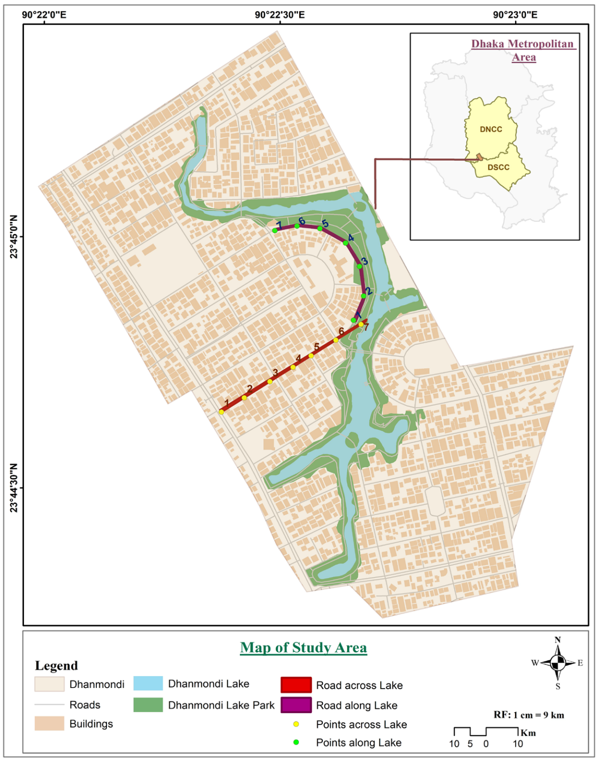
Figure 1. Showing Dhanmondi Lake and its two neighbouring roads (across and along) within 1 km in the Dhanmondi Area, which falls under 49 no. Ward of Dhaka South City Corporation (Source: Authors, 2024).

Figure 2. Displaying selected locations of fourteen points (seven points across the lake and seven points along the lake) to measure microclimatic factors (temperature and humidity) for the study analysis (Source: Authors, 2024).

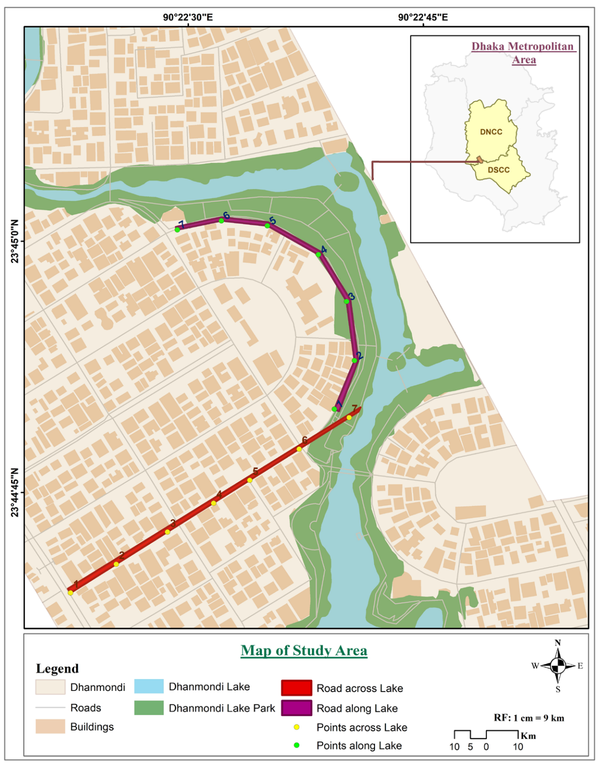
Table 1. (A) & (B) Showing latitude and longitude of seven points across the lake and seven points along the lake.

(A) Absolute Location of Points Across Dhanmondi Lake		
Location	**Latitude**	**Longitude**
Point - 1	23.744167˚	90.372876˚
Point - 2	23.744640˚	90.373688˚
Point - 3	23.745162˚	90.374578˚
Point - 4	23.745627˚	90.375378˚
Point - 5	23.746026˚	90.376052˚
Point - 6	23.746542˚	90.376934˚
Point - 7	23.747028˚	90.377760˚
(B) Absolute Location of Points Along Dhanmondi Lake		
Location	**Latitude**	**Longitude**
Point - 1	23.747203˚	90.377559˚
Point - 2	23.748007˚	90.377918˚
Point - 3	23.748989˚	90.377780˚
Point - 4	23.749766˚	90.377284˚
Point - 5	23.750247˚	90.376382˚
Point - 6	23.750332˚	90.375567˚
Point - 7	23.750184˚	90.374785˚

Dhanmondi has features typical for an urban environment, such as paved areas and some features of the natural environment, especially near the barrier of the Dhanmondi Lake; therefore, the area seems to be suitable for investigating how urban green infrastructures affect the regulation of microclimates.



(A)



(B)

Figure 3. (A) & (B) Overview with both zoomed-out and zoomed-in perspectives of the study area. (Source: Authors, 2024).

The study focused on a 1-kilometer neighboring area of Dhanmondi Lake where both greenspace and concrete landscapes are present. The two roads, across the lake and along the lake, were selected to observe the details of microclimatic change and highlight contrasts in greenspace and concrete coverage, as shown in Figure 1. The monitoring points, detailed in Table 1, between 20 – 618 meters across the lake and within 72 meters along the lake, were selected to capture the varying effects of proximity to the lake on temperature and humidity regulation. The spatial arrangement of these points is illustrated in Figure 2, providing a clear

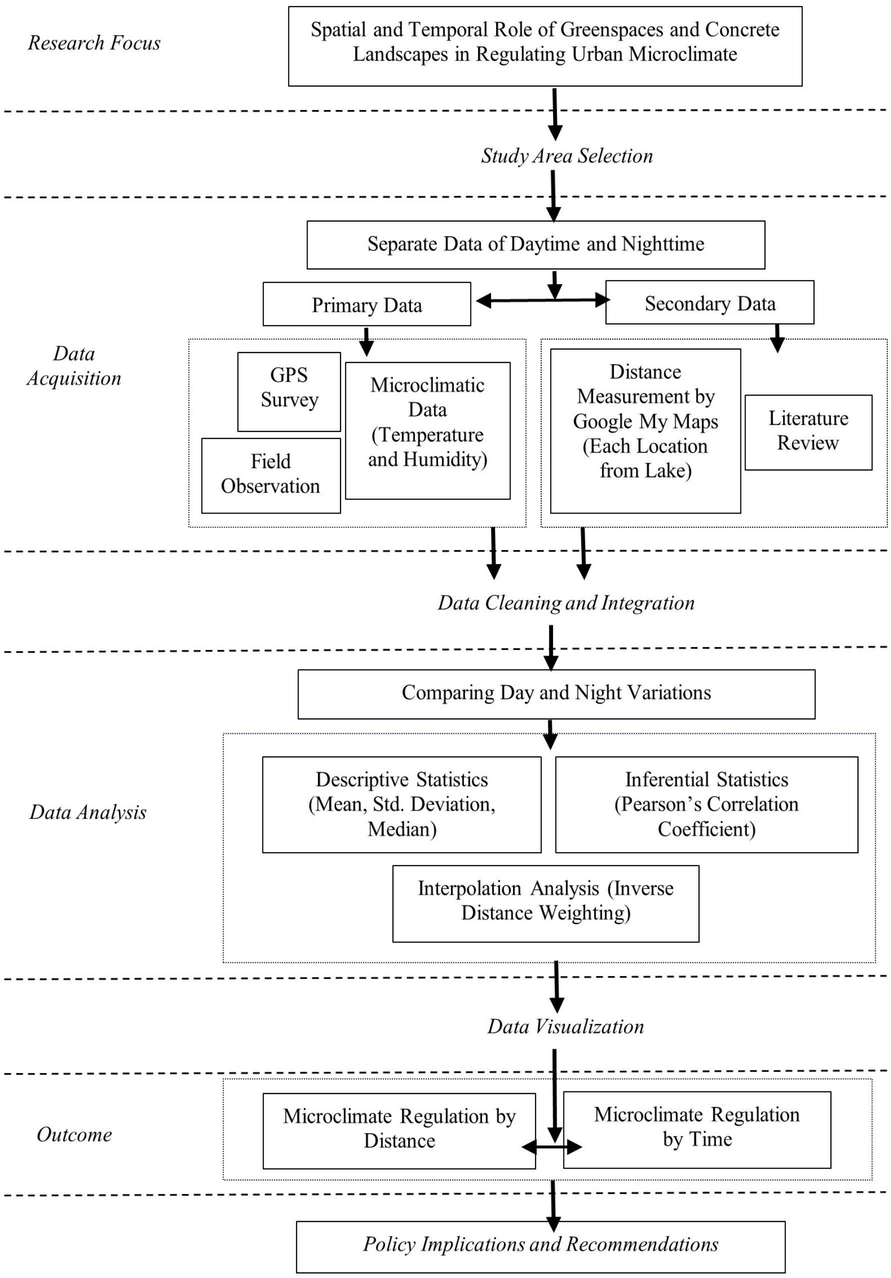


Figure 4. Methodological framework illustrating the step-by-step process of data acquisition, data cleaning and integration, data analysis, and data visualization, ultimately yielding policy recommendations. (Source: Authors, 2024).

depiction of the study layout. Points along the lake, dominated by greenspaces, and points across the lake, reflecting a mix of urban settlements and sparse greenery, allowed for a clear differentiation of microclimatic effects. The zoomed-out and zoomed-in views of the study area, shown in **Figure 3**, further highlight the distinction between these two areas. The points across the lake, such as Point 7 near the lake and Point 1 toward settlement, as well as points along the lake, were crucial in this study for understanding whether there is any impact that greenspace creates in the urban environment or not.

2.2. Data Collection

This study used a spatial-diurnal approach to measure the temperature and humidity at 14 monitoring points by GPS tracking at different distances from Dhanmondi Lake. Data were collected twice daily for two months (March and April 2024) using the Humidity & Temperature Meter AR827. The AR827 is a handheld relative humidity and temperature meter that can measure temperature from −20˚C to 60˚C and relative humidity (RH) from 0% to 100% at the same time, which is suitable for indoor-outdoor uses and also very high-low humid environments. Distances from the lake were calculated using Google My Maps.

Temperature and humidity were selected as microclimate variables due to their sensitivity to land cover changes and relevance in assessing urban thermal and moisture dynamics (Imran et al., 2021). Data collection times were consistent across all days to ensure comparability, with 9:00 AM and 9:00 PM chosen to capture typical diurnal microclimatic variations in Dhaka's urban environment (Lam et al., 2023). March and April months were selected as the pre-monsoon period in Dhaka, marked by high temperatures and low rainfall, providing ideal conditions to observe urban heat and microclimatic impacts of greenspaces and concrete landscapes (Tabassum et al., 2024).

2.3. Data Analysis

Data analysis was carried out through descriptive statistics such as Mean, Standard Deviation, and Median to synthesize microclimate variability amongst different locations using IBM SPSS Statistics 25 and Microsoft Excel. Various types of charts were prepared based on those data. An inferential statistical analysis, Pearson´s Correlation Coefficient, was performed to test the association between distance from the lake and microclimate variables regarding temperature and humidity, as illustrated in the methodological framework of **Figure 4**. The spatial analysis was implemented in ArcMap 10.5 by using the interpolation technique named Inverse Distance Weighting (IDW) to map temperature and humidity fluctuations in the study area and present a realistic view of how lake proximity operates on local climate conditions in detail. In the end, a policy and recommendation framework is given based on the findings from the results to improve the thermal comfort condition in urban environments in a sustainable manner.

3. Results

3.1. Impact of Greenspaces and Concrete Landscapes on Microclimate Regulation: Temperature and Humidity during Day and Night

Field measurements were conducted at 14 locations (7 across the lake and 7 along the lake) during both daytime (9:00 AM) and nighttime (9:00 PM) over two months (March and April). The variables of interest were temperature (˚C) and relative humidity (%). The values were averaged to reduce noise and account for temporary fluctuations. The results are summarized in Table 2(a)-(d), which presents the spatial (across vs. along the lake) and diurnal (day vs. night) microclimate variations.

Table 2. (A)-(D) Microclimate variation at fourteen points across and along the lake during day and night.

(A) Daytime Microclimate Variation Across Dhanmondi Lake (9:00 AM)			
Location	**Distance from Lake (meter)**	**Average Temperature (˚C)**	**Average Humidity (%)**
Point - 1	618	27.13	69.69
Point - 2	520	26.95	70.45
Point - 3	410	26.76	71.19
Point - 4	311	26.60	71.91
Point - 5	233	26.46	72.56
Point - 6	127	26.43	73.21
Point - 7	20	25.61	74.70
Maximum		27.13	74.70
Minimum		25.61	69.69
Standard Deviation		0.49	1.70
Mean		26.56	71.96
Median		26.60	71.91

(B) Nighttime Microclimate Variation Across Dhanmondi Lake (9:00 PM)			
Location	**Distance from Lake (meter)**	**Average Temperature (˚C)**	**Average Humidity (%)**
Point - 1	618	28.22	65.21
Point - 2	520	28.27	65.27
Point - 3	410	28.37	65.37
Point - 4	311	28.46	65.44
Point - 5	233	28.56	65.51
Point - 6	127	28.60	65.54
Point - 7	20	28.83	65.76
Maximum		28.83	65.76
Minimum		28.22	65.21

Continued

Standard Deviation		0.21	0.19
Mean		28.47	65.44
Median		28.46	65.44
(C) Daytime Microclimate Variation Along Dhanmondi Lake (9:00 AM)			
Location	**Distance from Lake (meter)**	**Average Temperature (˚C)**	**Average Humidity (%)**
Point - 1	45	26.48	72.02
Point - 2	37	26.43	72.21
Point - 3	40	26.43	72.12
Point - 4	72	26.60	71.92
Point - 5	60	26.60	71.92
Point - 6	40	26.43	72.12
Point - 7	48	26.48	72.02
Maximum		26.60	72.21
Minimum		26.43	71.92
Standard Deviation		0.07	0.11
Mean		26.50	72.05
Median		26.48	72.02
(D) Nighttime Microclimate Variation Along Dhanmondi Lake (9:00 PM)			
Location	**Distance from Lake (meter)**	**Average Temperature (˚C)**	**Average Humidity (%)**
Point - 1	45	28.60	65.52
Point - 2	37	28.64	65.57
Point - 3	40	28.64	65.57
Point - 4	72	28.50	65.42
Point - 5	60	28.50	65.42
Point - 6	40	28.64	65.57
Point - 7	48	28.60	65.52
Maximum		28.64	65.57
Minimum		28.50	65.42
Standard Deviation		0.06	0.07
Mean		28.59	65.51
Median		28.60	65.52

Descriptive statistics were computed for each dataset: Maximum and Minimum values to identify the range of microclimatic conditions, Mean values to represent the average temperature and humidity among the locations, Median values to understand the central tendency of the data distribution, and Standard Deviation to quantify the variability in microclimate conditions across the study area.

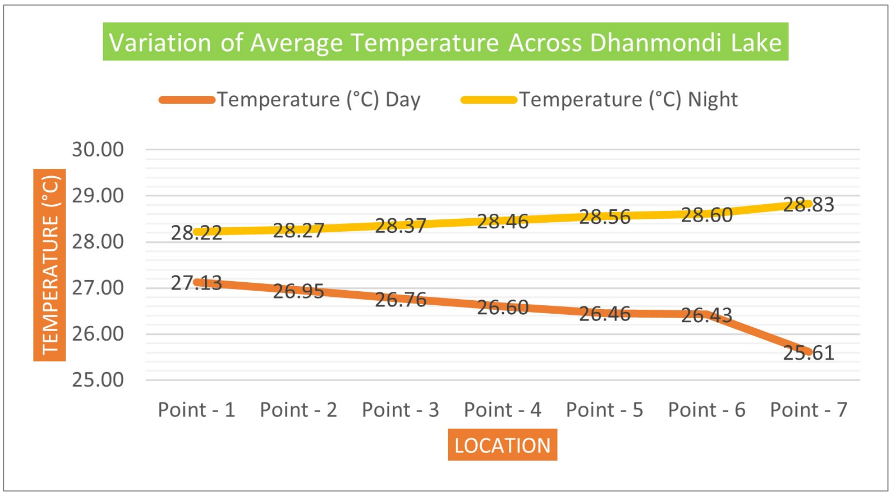
Microclimate Variation Across the Lake

In the daytime, temperature values across the lake ranged from 25.61˚C to 27.13˚C, with a mean temperature of 26.60˚C and a standard deviation of 0.49˚C. Humidity levels ranged from 69.69% to 74.70%, with a mean of 71.96% and a standard deviation of 1.70%. During nighttime, the temperature varied between 28.22˚C and 28.83˚C, where the mean was 28.46˚C, and humidity levels ranged from 65.21% to 65.76%, where the mean was 65.44%.

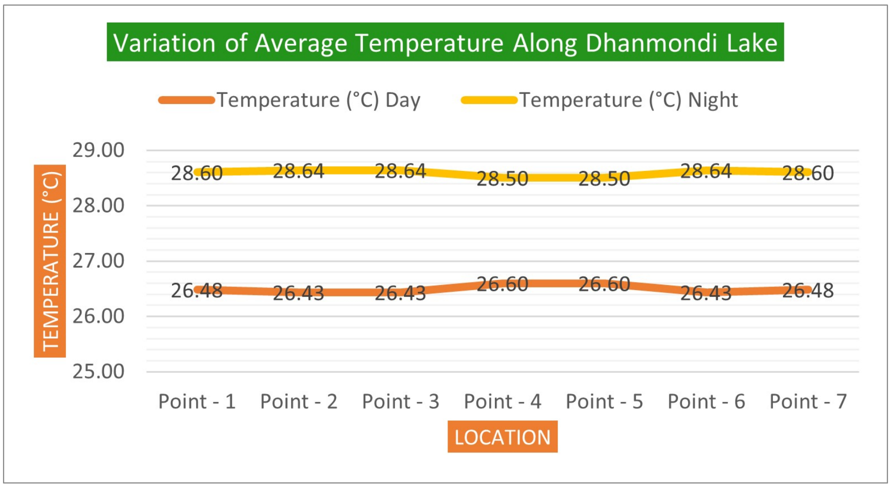
Microclimate Variation Along the Lake

The daytime temperature ranged from 26.43˚C to 26.60˚C, with a mean of 26.50˚C and a low standard deviation of 0.07˚C, indicating minimal temperature fluctuation along the lakeside. Humidity levels showed a similar narrow range, with values between 71.92% and 72.21%, and a mean of 72.05%. During nighttime, the temperature varied between 28.50˚C and 28.64˚C, where the mean was 28.60˚C, and humidity levels ranged from 65.42% to 65.57%, where the mean was 65.52%.

The following charts, shown in Figure 5(A)-(D), illustrate key insights into how temperature and humidity vary across and along Dhanmondi Lake.



(A)



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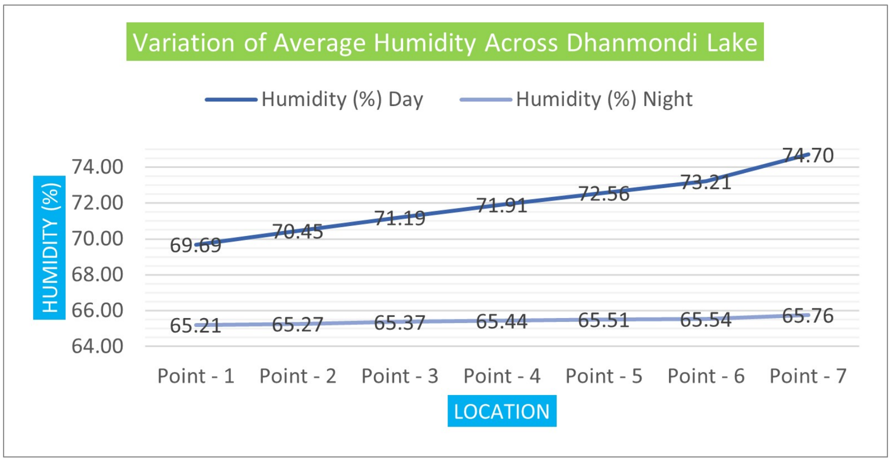
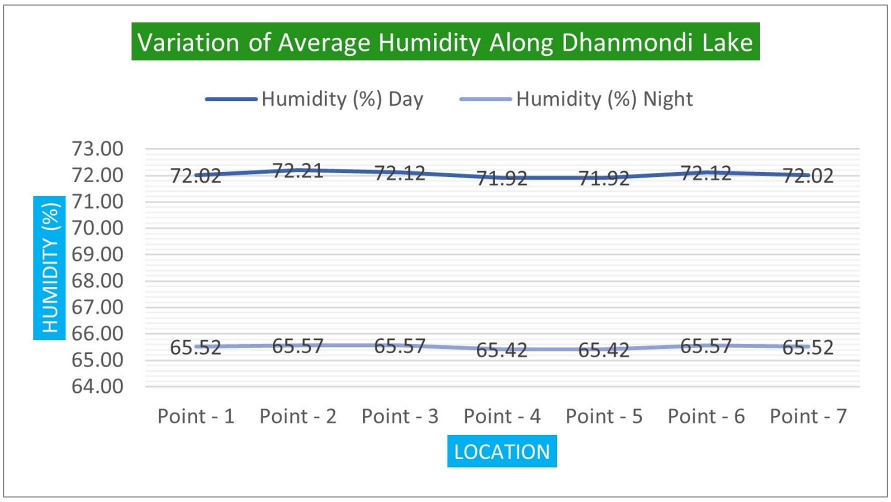


(C)



(D)

Figure 5. (A)-(D) Analysis of the variations in average temperature and humidity at fourteen locations across and along Dhanmondi Lake.

Daytime Temperature Variation Across the Lake: A clear cooling gradient is observed from 27.13˚C at Point 1 to 25.61˚C at Point 7. Temperatures near the lake edge decrease significantly throughout each day.

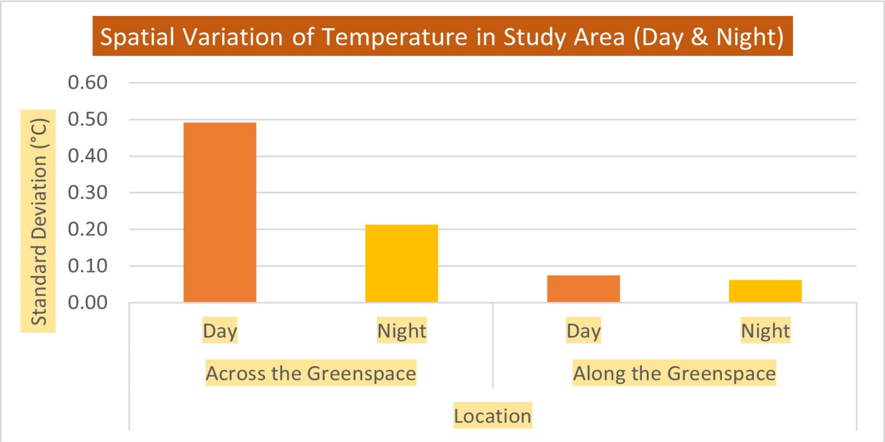
Nighttime Temperature Stability Across the Lake: Nighttime temperatures are stable across all points, with mean values varying narrowly between 28.22˚C and 28.83˚C and less cooling effect during the night.

Temperature Stability Along the Lake (both Day and Night): There is only minimal fluctuation in temperature during both day and night. Daytime mean temperatures fluctuate between 26.43˚C and 26.60˚C, coupled with almost constant nighttime temperatures ranging from 28.50˚C to 28.64˚C.

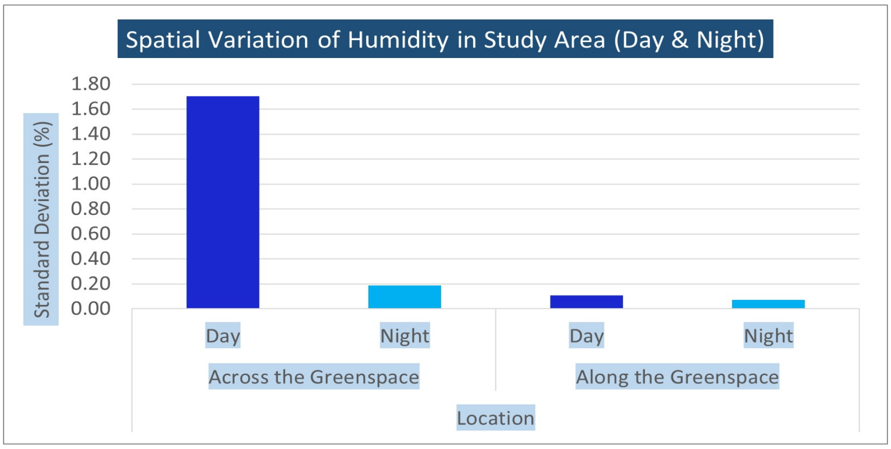
Humidity Increase Across the Lake During Daytime: The daytime humidity rises slightly from 69.69% at Point 1 to 74.70% at Point 7, paralleling the lake's cooling effect.

Nighttime Humidity Stability Across the Lake: Nighttime humidity levels are similar, varying from 65.21% at Point 1 to a maximum of 65.76% at Point 7. Despite the lake's proximity, humidity fluctuates less than during the day.

Consistent Humidity Along the Lake (both Day and Night): Daytime and nighttime humidity levels remain stable throughout the lake. Daytime humidity varies from 71.92% to 72.21%, while nighttime values vary narrowly between 65.42% and 65.57%.



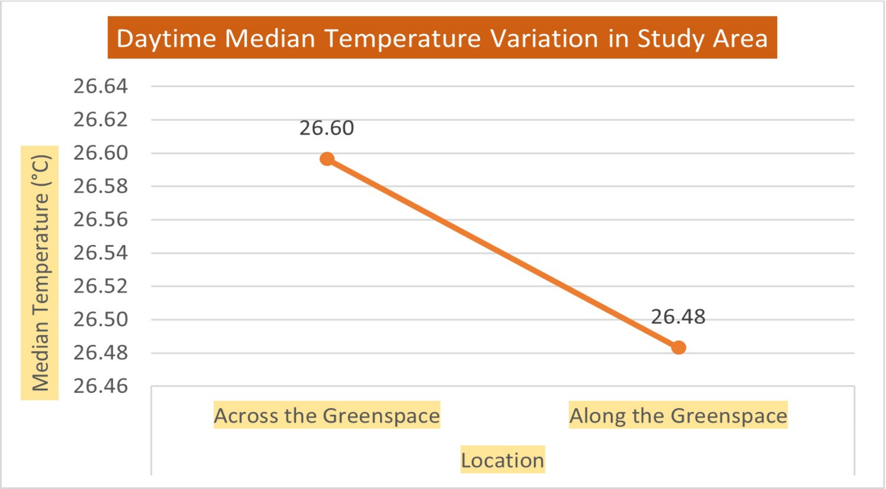
(A)



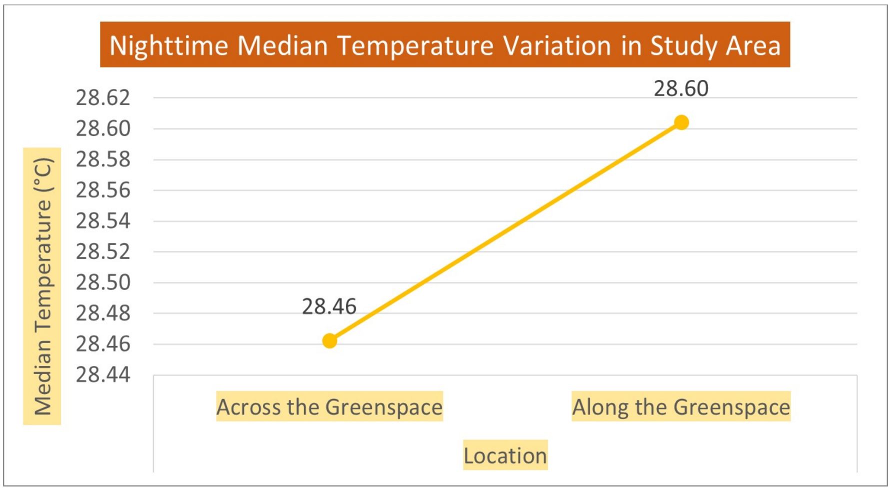
(B)

Figure 6. (A) & (B) Spatial and diurnal variations of microclimatic factors in terms of temperature and humidity in the study area.

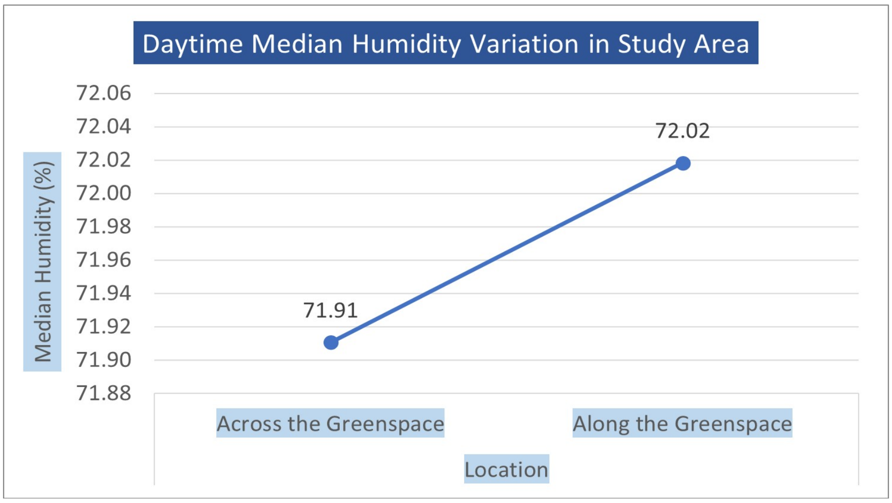
The spatial variation of temperature and humidity in the study area, as depicted in Figure 6 (A) & (B), is more pronounced during the day compared to nighttime, particularly across the lake. The daytime temperature across the lake shows the highest variability, with a standard deviation of 0.49˚C, as illustrated in Figure 6(A), while humidity variability is also significantly higher during the day, with a standard deviation of 1.70%, as shown in Figure 6(B). Conversely, nighttime variations in both parameters are generally lower across the lake, suggesting a more consistent environment after sunset. However, temperature and humidity variations are minimal along the lake during both day and night, with standard deviations remaining below 0.08˚C for temperature and 0.12% for humidity, indicating a stable microclimate near the lake.



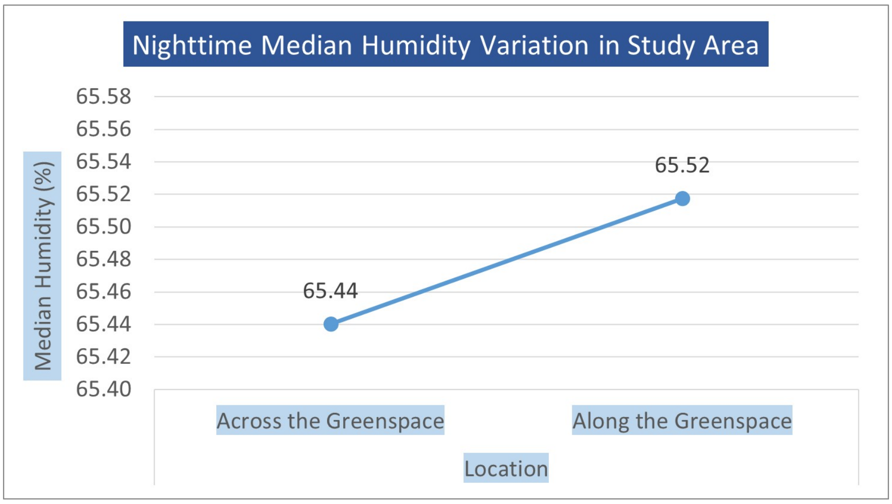
(A)



(B)



(C)



(D)

Figure 7. (A)-(D) Median temperature and humidity fluctuations in the study area during day and night.

During the day, the median temperature is higher across the lake, at 26.60˚C, compared to areas along the lake, where it is 26.48˚C, as depicted in Figure 7(A), while the opposite pattern is observed at night, with higher median temperatures along the lake, at 28.60˚C, than across the lake, where it is 28.46˚C, as shown in Figure 7(B). In terms of humidity, daytime median humidity is slightly higher along the lake, reaching 72.02%, compared to 71.91% across the lake, as illustrated in Figure 7(C), and the same pattern is observed at night, where the median humidity along the lake at 65.52%, exceeding the 65.44% recorded across the lake, as shown in Figure 7(D). These variations, visualized in Figure 7 (A)-(D), suggest that the lake has a more stabilizing influence on the temperature at night and contributes to higher humidity levels along its immediate vicinity throughout the day and night (Zhao et al., 2023).

3.2. Impact of Distance on Microclimate Regulation: Temperature and Humidity

Pearson's Correlation Coefficient was utilized to examine the significance of the data on the association between distance from Dhanmondi Lake and microclimate factors in terms of temperature and humidity, as summarized in Table 3 (A) & (B), Table 4 (A) & (B), Table 5 (A) & (B), and Table 6 (A) & (B).

Daytime Microclimate Regulation Across the Lake

Temperature Regulation: Pearson correlation coefficient: 0.933 ($p = 0.002$), a marked positive correlation, as shown in Table 3(A). The temperature increases with distance, allowing the lake to have a cooling effect (Zhou et al., 2021).

Humidity Regulation: Pearson correlation coefficient: −0.993 ($p = 0.000$), strong negative association outlined in Table 3(B). The further away from the lake, the lower humidity values are noticed, emphasizing how much the lake supports high humidity in neighboring areas (Zhou et al., 2021).

Nighttime Microclimate Regulation Across the Lake

Table 3. (A) & (B) Correlation tables showing the relationships between average temperature and distance from the lake (left) and average humidity and distance from the lake (right) at various points across the lake during the day

(A)

Correlations

		Distance from Lake (meter)	Average Temperature (˚C)
Distance from Lake (meter)	Pearson Correlation	1	0.933**
	Sig. (2-tailed)		0.002
	N	7	7
Average Temperature (°C)	Pearson Correlation	0.933**	1
	Sig. (2-tailed)	0.002	
	N	7	7

(B)

Correlations

		Distance from Lake (meter)	Average Humidity (%)
Distance from Lake (meter)	Pearson Correlation	1	−0.993**
	Sig. (2-tailed)		0.000
	N	7	7
Average Humidity (%)	Pearson Correlation	−0.993**	1
	Sig. (2-tailed)	0.000	
	N	7	7

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4. (A) & (B) Correlation tables showing the relationships between average temperature and distance from the lake (left) and average humidity and distance from the lake (right) at various points across the lake during the night

(A)

Correlations

		Distance from Lake (meter)	Average Temperature (˚C)
Distance from Lake (meter)	Pearson Correlation	1	−0.983**
	Sig. (2-tailed)		0.000
	N	7	7
Average Temperature (˚C)	Pearson Correlation	−0.983**	1
	Sig. (2-tailed)	0.000	
	N	7	7

Continued

(B)			
Correlations			
		Distance from Lake (meter)	Average Humidity (%)
Distance from Lake (meter)	Pearson Correlation	1	−0.977**
	Sig. (2-tailed)		0.000
	N	7	7
Average Humidity (%)	Pearson Correlation	−0.977**	1
	Sig. (2-tailed)	0.000	
	N	7	7

**. Correlation is significant at the 0.01 level (2-tailed).

Temperature Regulation: Pearson correlation: −0.983 (p = 0.000), high negative relationship, as shown in **Table 4(A)**. Nighttime temperatures decrease with distance from the lake, which suggests that heat is retained near the surface (Cosgrove & Berkelhammer, 2018).

Humidity Regulation: Pearson correlation: −0.977 (p = 0.000), substantial negative link outlined in **Table 4(B)**. Further inland humidity is less as the distance from the lake increases, revealing how the lake boosts humidity at night in its vicinity (Chakraborty et al., 2023).

Daytime Microclimate Regulation Along the Lake

Temperature Regulation: Pearson correlation: 0.957 (p = 0.001), demonstrating a strong positive correlation outlined in **Table 5(A)**. As one moves farther along the lake, daytime high temperatures increase slightly, keeping it more relaxed near the water (Piccolroaz et al., 2024).

Table 5. (A) & (B) Correlation tables showing the relationships between average temperature and distance from the lake (left) and average humidity and distance from the lake (right) at various points along the lake during the day.

(A)			
Correlations			
		Distance from Lake (meter)	Average Temperature (˚C)
Distance from Lake (meter)	Pearson Correlation	1	0.957**
	Sig. (2-tailed)		0.001
	N	7	7
Average Temperature (˚C)	Pearson Correlation	0.957**	1
	Sig. (2-tailed)	0.001	
	N	7	7

Continued

(B) Correlations			
		Distance from Lake (meter)	Average Humidity (%)
Distance from Lake (meter)	Pearson Correlation	1	−0.895**
	Sig. (2-tailed)		0.007
	N	7	7
Average Humidity (%)	Pearson Correlation	−0.895**	1
	Sig. (2-tailed)	0.007	
	N	7	7

**. Correlation is significant at the 0.01 level (2-tailed).

Humidity Regulation: Pearson correlation: −0.895 ($p = 0.007$), a strong and negative relationship, as shown in Table 5(B). Lowering humidity during the day with increasing distance from the lake is one key aspect in increasing daytime humidity around its periphery (Gunawardena et al., 2017).

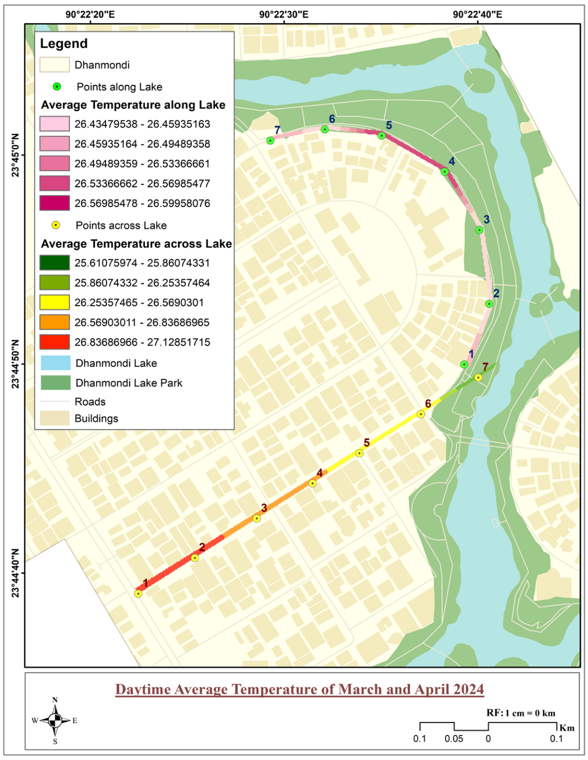
Nighttime Microclimate Regulation Along the Lake

Table 6. (A) & (B) Correlation tables showing the relationships between average temperature and distance from the lake (left) and average humidity and distance from the lake (right) at various points along the lake during the night

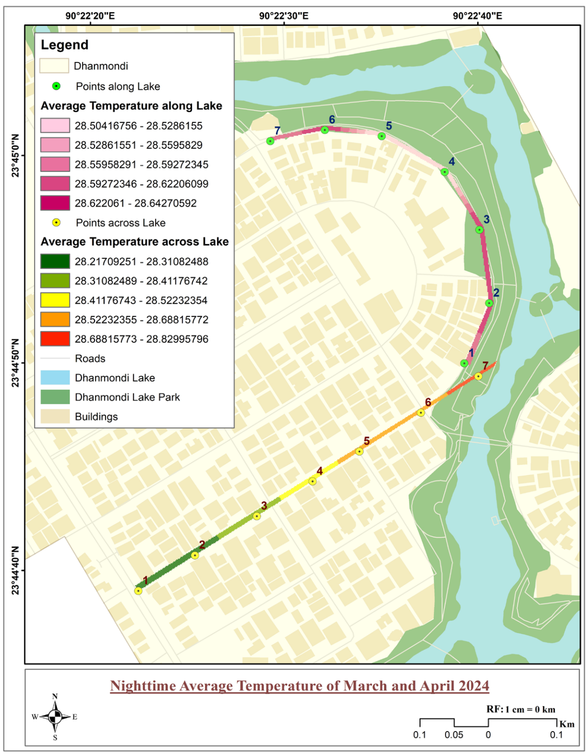
(A) Correlations			
		Distance from Lake (meter)	Average Temperature (˚C)
Distance from Lake (meter)	Pearson Correlation	1	−0.957**
	Sig. (2-tailed)		0.001
	N	7	7
Average Temperature (˚C)	Pearson Correlation	−0.957**	1
	Sig. (2-tailed)	0.001	
	N	7	7

(B) Correlations			
		Distance from Lake (meter)	Average Humidity (%)
Distance from Lake (meter)	Pearson Correlation	1	−0.953**
	Sig. (2-tailed)		0.001
	N	7	7
Average Humidity (%)	Pearson Correlation	−0.953**	1
	Sig. (2-tailed)	0.001	
	N	7	7

**. Correlation is significant at the 0.01 level (2-tailed).

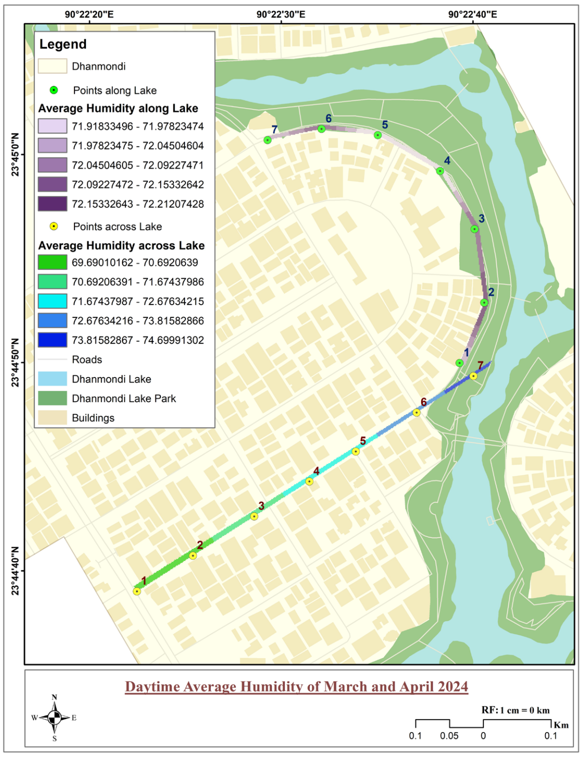


(A)

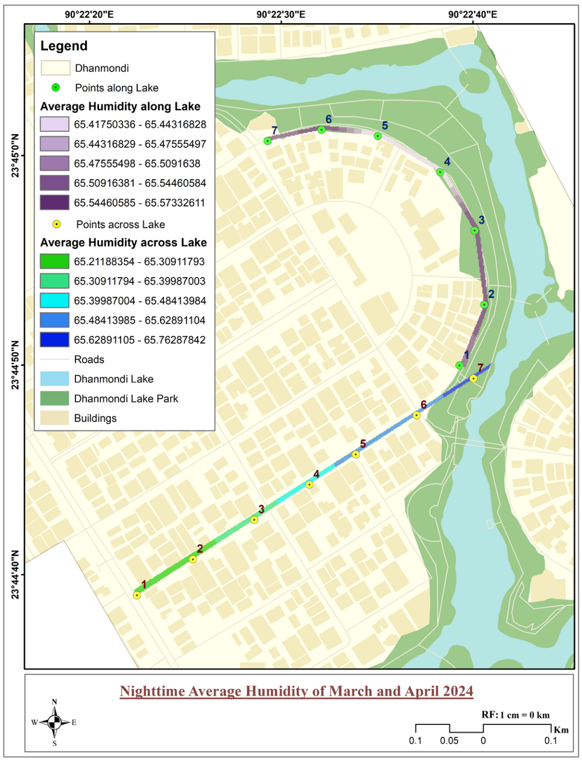


(B)

Figure 8. (A) & (B) Presenting a realistic view of how average temperature fluctuates in the study area between day and night (Source: Authors, 2024).



(A)



(B)

Figure 9. (A) & (B) Presenting a realistic view of how average humidity fluctuates in the study area between day and night (Source: Authors, 2024).

Temperature Regulation: Pearson correlation: −0.957 ($p = 0.001$), strong negative correlation outlined in **Table 6(A)**. Further inland, it is colder at night because the lake gives off heat and warms its vicinity (Jacobs et al., 2020).

Humidity Regulation: Pearson correlation: −0.953 ($p = 0.001$), indicating an inverse strong relationship, as shown in **Table 6(B)**. Nighttime humidity decreases with increasing distance from the lake, reflecting that the lake's moisture levels rise only at night (Ayanlade, 2016).

Dhanmondi Lake helps regulate temperatures and humidity in its vicinity, creating a balanced microclimate in the urban area. The visualized data, presented in **Figure 8** (A) & (B) and **Figure 9** (A) & (B), demonstrates how the distance from the lake affects local climate conditions.

Daytime Temperature and Humidity

Being close to the lake means it is colder most of the day, with a more humid environment. Areas near the waterbody experience a strong cooling effect, which cools the local atmosphere and raises humidity, contrasting with hotter temperatures and lower humidity farther inland. **Figure 8(A)** depicts these daytime temperature variations, while **Figure 9(A)** illustrates the daytime humidity variations.

Nighttime Temperature and Humidity

The lake stabilizes temperature and humidity overnight. Due to the water's heat storage capacity, areas around the lake stay warmer, preventing sudden temperature drops. Lakeside humidity is also somewhat greater, indicating the lake's nighttime impact on moisture levels. **Figure 8(B)** represents these nighttime temperature variations, and **Figure 9(B)** shows the nighttime humidity variations.

4. Discussion

"Water bodies act as heat sinks to warm during the day and emit heat at night" (Jandaghian & Colombo, 2024). The stable temperature at night close to the lake allows it to function as a thermal reservoir. It mitigates the extent of UHI compared to the peak temperatures observed during the day. Significantly higher humidity levels were recorded near the lake, confirming that water bodies may increase local humidity through evapotranspiration. This negative correlation between distance from the water source and humidity levels proves that greenspaces and water bodies make the environment more comfortable by increasing humidity enough to combat the negative effects of UHI. The results further show that proximity to the lake had a strong influence on the temperature and relative humidity, highlighting the cooling and moisture-regulating effect of natural water bodies in the urban environment. It has also been revealed that the area near the lake has a lower temperature during the daytime and higher deviation in concreted zones.

The results highlight the importance of integrating water bodies and greenspaces into the planning and design of cities, especially those experiencing UHI impacts. Lakes, as natural features, have a cooling and moisture-retaining effect and, therefore, have the potential to become efficient indicators of climate adaptation in urban development at a reasonable cost (Yao et al., 2023). As the population densifies, cities should pay more attention to improving and enlarging greenspace to increase their livability and alleviate the pressure of climate change.

The study has a few weaknesses: first, it was carried out with two microclimatic factors, such as temperature and humidity; second, it focused on distance from the lake as a variable affecting the microclimate; and last, it focused on an individual season. However, the study adds important knowledge on how greenspaces and water bodies play a significant role in mitigating UHI impacts and provides useful information for sustainable urban planning. Also, it highlights the need for nature-based solutions as an effective benchmark for green capital, where Dhaka, a fast-growing city facing climate change, is a classic example of this need.

5. Policy Implications and Recommendations

Cities address problems such as thermal discomfort, and this study highlights that features like greenspaces and water bodies, such as Dhanmondi Lake, are important in moderating microclimates in urban areas. Therefore, it becomes crucial to incorporate natural features into the urban layout (Snep & Opdam, 2010). The proposed recommendations are visually summarized in **Figure 10**, which highlights a framework for enhancing urban thermal comfort and sustainability.

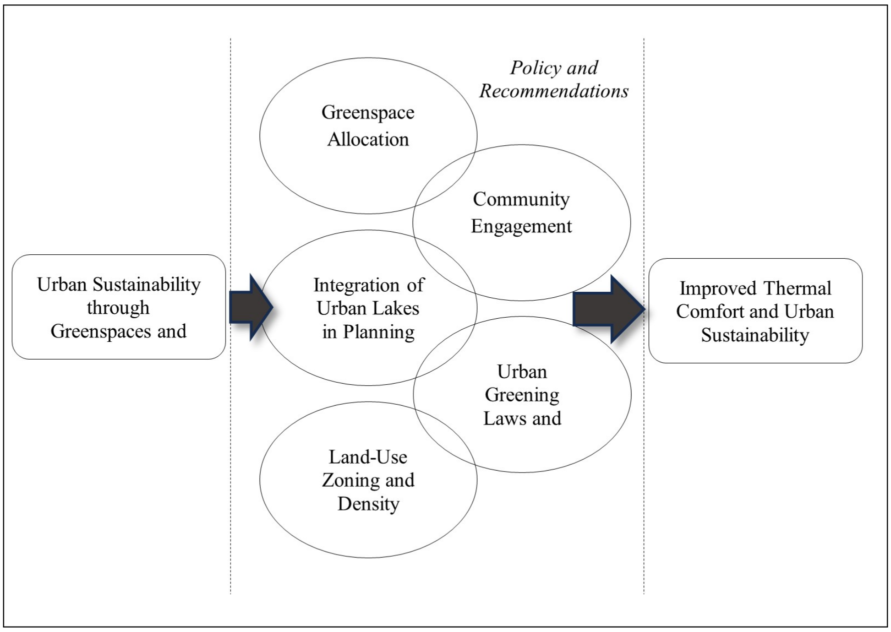


Figure 10. Policy recommendations framework illustrating how thermal comfort and urban sustainability can be enhanced through five specific proposals (Source: Authors, 2024).

To mitigate heat and enhance humidity regulation, sufficient greenspace must be allocated around urban lakes. At least 20% of urban area within 1-kilometer around lakes should be preserved for greenspaces, with protective zones of no less than 50 meters between lakes and construction zones to protect lakes from pollution, support greenery, and preserve water quality by reducing construction impacts (Nawar et al., 2022). Urban lakes should be central to city planning, with efforts to preserve and renature the water reservoirs to avoid their deficit and pollution, and the creation of artificial lakes to enhance the cooling effects (Balaram et al., 2023). Zoning regulations should reflect the cooling benefits of lakes and greenspaces, restricting high-rise development within 100 meters of the periphery of all the lakes, and incorporating at least 30% of greenspace in mixed commercial and residential projects around lakes to maintain microclimate control (Shammi et al., 2023). Community involvement is key to the sustainability of urban greenspaces. Awareness campaigns and local activities, such as - planting trees and cleaning up lakes, can enhance people's knowledge about the benefits of lakes and greenspaces (Burrage, 2011). Policymakers should develop comprehensive strategies for urban greening that include lakes and greenspaces, as the master planning components and formulate laws through legislation to protect natural elements to ensure their incorporation into future urban planning (Vaňo et al., 2021).

Implementing these policy recommendations will boost the cooling and humidifying possibilities of urban lakes, and improve the thermal and sustainability comfort of the urban environment. Using concepts of greenspace and natural features to design urban landscapes helps to create climate change resilience for residents and a healthier living environment for people within metropolitan areas.

6. Conclusion

Dhanmondi Lake, as a greenspace, is a key regulator of temperature and humidity at a microscale within an urban setting, which happens collectively on concrete plains. The results show that during the daytime, areas near the lake are more relaxed and moister and more subject to local thermal inversion around this water body; these conditions stabilize the microclimate in those sites at night. At the same time, concrete areas worsen heat absorption, and the green regions surrounding the lake offer vital cooling effects. The strong correlation with the lake emphasized that urbanization here must be planned extremely carefully. These issues are essential in further studies to make future research learn from the historical flavour and design a more habitable architecture for sustainable cities. Future policy frameworks should include not only the protection of green areas but also the prediction and rational distribution throughout the cities to minimize the adverse impacts of heat stress.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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