

## Assessing the Environmental Impacts of Titiwangsa and Shah Alam Lake Gardens on Their Surrounding Urban Areas

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### ABSTRACT

*Urban parks play a crucial role as green spaces amidst the bustling urban environment. Rapid development in urban areas seeks to accommodate the growing demand for residential, commercial, and institutional spaces, which has led to the formation of urban heat islands. The urban heat island effect affects densely populated cities, and urban parks are essential for regulating microclimate conditions. This study examines three microclimatic parameters—temperature, relative humidity, and wind speed—to determine how Titiwangsa Lake Garden and Shah Alam Lake Garden affect the neighbouring metropolitan regions. The impact of vegetation and water bodies on microclimatic control is evaluated in this study using in-situ field data and ENVI-met simulation software. Data was gathered over the course of two 24-hour periods from eight key locations inside each park. Model accuracy was guaranteed by validation approaches such as RMSE, MAPE, and MAD. The findings demonstrate that both parks considerably reduce urban heat, but Titiwangsa exhibits a larger temperature drop because of its closer proximity to water bodies and denser tree canopy. Heat accumulation was higher in Shah Alam, which is encircled by tall buildings. The results back contemporary urban planning techniques that promote climate-sensitive urban design and maximize green infrastructure. These findings will aid in future microclimate planning for urban settings in Klang Valley cities area, while provide valuable insights for developing microclimate-responsive urban designs for urban planners and designers.*

*Keywords: Urban park; urban heat island; vegetation; microclimate; ENVI-met*

### INTRODUCTION

Environmental impacts refer to any changes to the physical, chemical, or biological properties of the environment caused by human activities or natural events. These changes can be beneficial, such as the restoration of ecosystems, or detrimental, like pollution, habitat destruction, or biodiversity loss. They are typically evaluated in terms of their scope, magnitude, duration, and reversibility.

Urban Heat Island (UHI) is a phenomenon where temperature in urban areas is higher than that of in rural areas (Asmadi et al. 2024; Brahimy et al. 2023). The environmental impacts of the UHI effect extend beyond temperature rise, influencing local climate patterns, air quality, and biodiversity. Elevated temperatures exacerbate energy demands for cooling, contributing to higher greenhouse gas emissions and amplifying climate change

(Johnson et al. 2019). Moreover, the increased heat can disrupt local ecosystems, threatening flora and fauna sensitive to temperature changes (Carter et al. 2021). Water resources are also impacted as urban heat accelerates evaporation rates, potentially intensifying drought conditions in nearby areas (Buyadi et al. 2013). Efforts to mitigate the UHI effect have focused on implementing strategies such as increasing urban greenery, using reflective building materials, and promoting sustainable urban design (Taylor et al. 2024).

Urban parks play a crucial role in enhancing urban sustainability by providing ecological, social, and health benefits to the surrounding areas (Chiesura, 2004). As cities grow and densify, these green spaces serve as vital components in mitigating urban challenges such as air pollution, noise, and heat islands (Zakaria et al. 2020). Studies have consistently demonstrated that urban parks contribute to improved air quality, biodiversity preservation,

and noise reduction, though the extent of these benefits can vary based on park size, design, and location.

However, there is still a lack of local studies on how urban parks affect the microclimate in tropical areas, even though global research shows that green spaces help the environment (Senwen et al. 2023). Many studies also make broad conclusions without considering specific factors like plant density, city layout, and park design. This study helps fill those gaps by comparing the microclimate effects of two parks.

In Malaysian cities like Kuala Lumpur and Shah Alam, the rapid rate of urbanisation has exacerbated the impacts of urban heat islands (UHI), leading to higher temperatures, disturbed wind patterns, and decreased humidity (Harun et al. 2020). As climatic regulators, urban parks provide a natural remedy to combat these unfavourable circumstances (Zhiqiao et al. 2024). However, a number of elements, including design, spatial position, and the type of neighbouring developments, influence how beneficial they are.

Thus, this study aims to measure the impacts of temperature changes and their impacts on surrounding areas, which is essential for effective urban planning and environmental management. The objectives are to analyse and contrast the wind speed, temperature, and relative humidity in Shah Alam Lake Gardens and Titiwangsa, to evaluate how water bodies and plants affect the regulation of the microclimate. Hence, to determine the parks' ability to lessen the effects of urban heat.

The selection of these two parks was based on their stark differences in urban environments. Located in the centre of Kuala Lumpur, Titiwangsa features sizable green spaces with water features. On the other hand, Shah Alam Lake Garden is encircled by large structures and is located in a more suburban region. This study offers practical suggestions for sustainable urban planning in tropical areas.

## METHODOLOGY

### STUDY AREA

Figure 1 shows the key and location plan of the study areas, Titiwangsa, Kuala Lumpur and Shah Alam, Selangor, Malaysia. The site's study is located in the hot and humid Tropical Climate of Malaysia. Taman Tasik Titiwangsa was also chosen due to its strategic location in a highly urbanised area, offering an opportunity to study microclimatic variations influenced by both natural and built elements. Taman Tasik Shah Alam was selected for its unique urban setting, which was close compared with Taman Tasik Titiwangsa's urban environment.

### TAMAN TASIK TITIWANGSA, KUALA LUMPUR

Taman Tasik Titiwangsa is an Urban Park in the centre of Kuala Lumpur (Figure 2). The site is located at the longitude and latitude of  $3^{\circ}10'40''$  N and  $101^{\circ}42'25''$  E respectively. It is known that this site is one of Kuala Lumpur's most iconic recreational parks, known for its scenic lake and lush greenery. The area also features diverse land uses, including nearby residential, and institutional zones, making it a prime location in an urban park setting.

### TAMAN TASIK SHAH ALAM SEKSYEN 14, SELANGOR

Figure 3, Taman Tasik Shah Alam is the second selected site at the longitude and latitude  $3^{\circ}04'25''$  N and  $101^{\circ}30'52''$  E each. This park is part of Shah Alam's urban fabric and is a well-loved public space featuring several lakes, themed gardens, and community facilities. Known for its extensive greenery and tranquil environment, Taman Tasik Shah Alam is an urban park featuring interconnected lakes and themed gardens.



FIGURE 1. Key plan and location plan the study area

### OVERVIEW OF STUDY AREA AND MEASURING POINTS

Figures 4-5 illustrate the spatial arrangement of the study locations, clearly showing how softscape features such as lawn areas, shrub clusters, and tree canopies interact with nearby residential neighbourhoods and open green spaces.

This clarity enhances our understanding of how microclimatic variables differ across the area. Eight measurement stations were carefully selected to capture a wide range of environmental variables. Their locations were chosen based on proximity to important features like residential neighbourhoods, pedestrian pathways,

recreational areas, and landscaped regions, ensuring coverage of both shaded and sunny spots.

In-situ measurements were conducted at each station to assess key microclimatic parameters, including air temperature, relative humidity, and wind flow. These parameters were selected for their importance in influencing thermal comfort and understanding the effect of softscape features on the local microclimate.

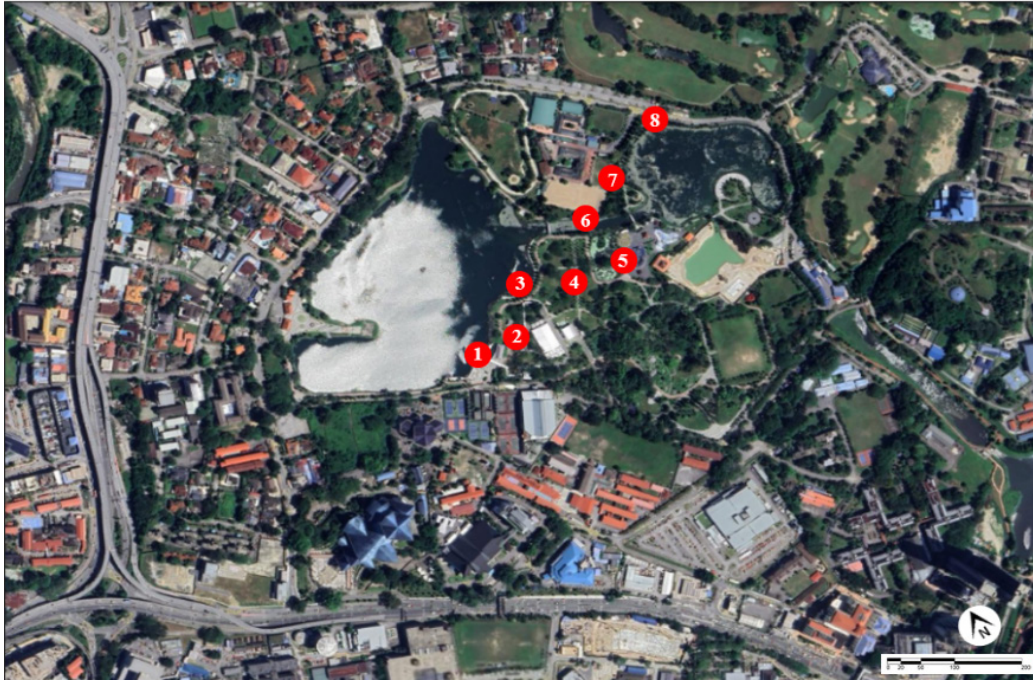


FIGURE 2. Site study location Taman Tasik Titiwangsa

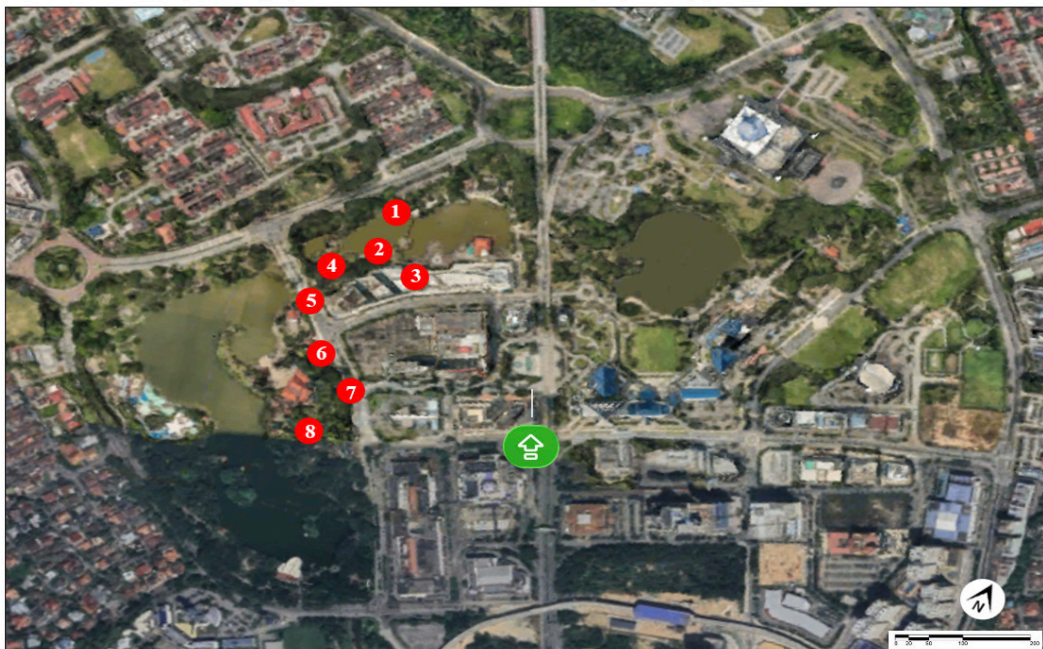


FIGURE 3. Site study location Taman Tasik Shah Alam

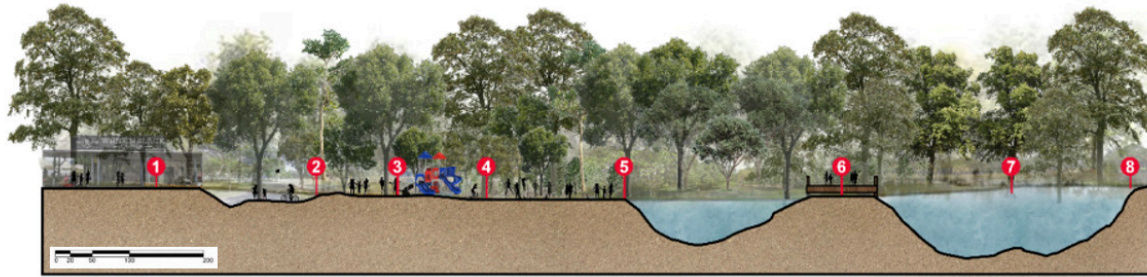


FIGURE 4. Section of points 1 to 8 of measuring climate data at Taman Tasik Titiwangsa

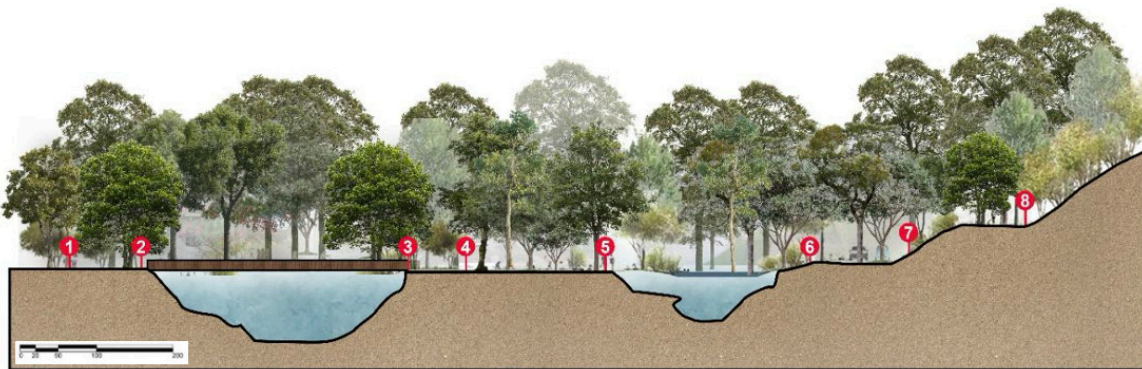





FIGURE 5. Section of points 1 to 8 of measuring climate data at Taman Tasik Shah Alam

### ENVI-MET AND LEONARDO: FUNDAMENTAL ELEMENTS OF THE ENVIRONMENTAL MODEL

ENVI-met model is a sophisticated 3D environmental simulation tool that is frequently used to evaluate microclimatic conditions and how they interact with urban settings (Misni et al, 2019; Kusumastuty et al. 2018). Within ENVI-met, Leonardo is a sophisticated toolkit that provides improved data analysis and visualisation features (Peter et al. 2018). Taman Tasik Titiwangsa and Shah

Alam’s foundations were the Master the art of digitisation using Spaces (grid-based tool Spaces) to produce three-dimensional models that accurately depicted the state of environmental impacts in the research area (Yu et al. 2025). Following model validation, Leonardo, a potent toolkit for data visualisation and analysis, is used to improve ENVI-met results (Figure 6). In order to ensure that the simulations are accurate and useful, Leonardo transforms complicated simulation data into graphical formats that are simple to understand and permit iterative model modifications (Wanlu et al. 2022; Tsoka et al. 2018).

TABLE 2. Meteorological measuring instruments

Parameters	Symbol	Unit	Instrument	Range	Accuracy	Probe type
Air temperature	Ta	°C	Lutron LM-8010	-20 to +70 °C	±0.5 °C	
Relative humidity	RH	%	Lutron LM-8010	0 to 100%RH	+(1.0%Rh +0.7% of mv) 0 to 90%RH (1.4%Rh +0.7% of mv) 90 to 100%RH-	
Wind speed	Va	m/s	Swevy 6086	+0.10 to 15.00 m/s	±(0.1 m/s +1.5% of mv)	

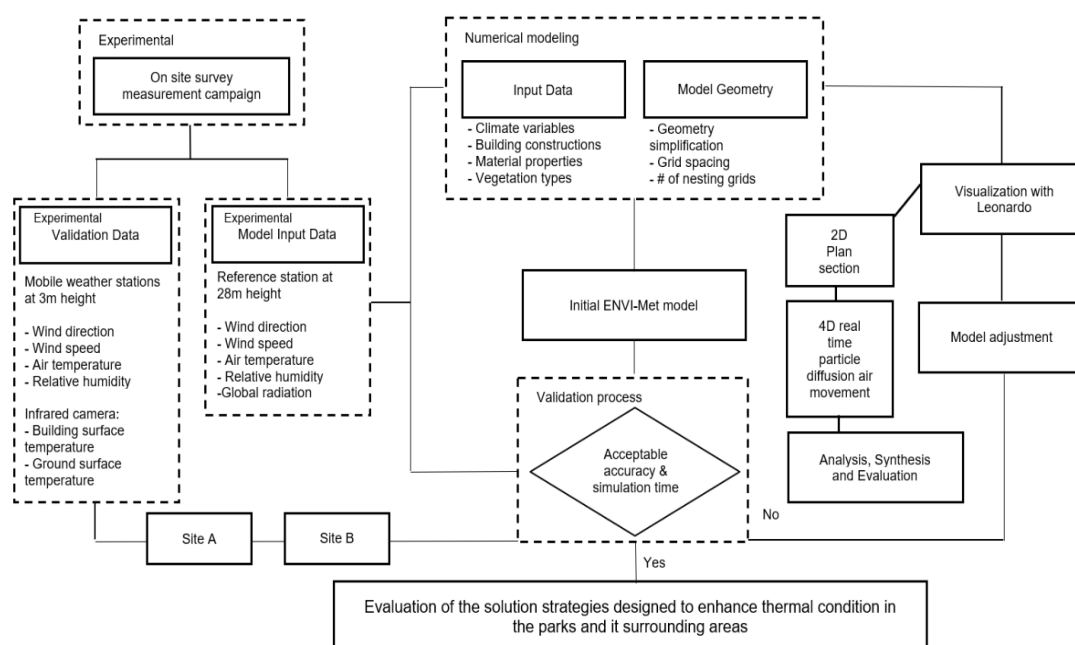


FIGURE 6. Methodology conceptual framework of data structure of ENVI-met

TABLE 3. Input data and initial settings for the ENVI-Met model and Leonardo

Model Location	Site A	Site B
Name of location	Titiwangsa, Kuala Lumpur	Shah Alam, Selangor
Position (Latitude)	101°42'25"E	101°30'52"E
Position (Longitude)	3°10'40"N	3°04'25 N
Model geometry		
Domaine size	92,520m x 92,520m	88,350 m x 88,350m
Model dimension	X-Grid =50 Y-Grid=50 Z Grid=29	X-Grid =60 Y-Grid=60 Z Grid=30
Size of grid cell	dx + 2m dy + 2m dz + 1m	dx + 2m dy + 2m dz + 1m
Model rotation out of grid from north	16°	348°
Height of 3D model TOP	25m	20m
Differences model top to highest point	30m	30m

Three meteorological data were measured in the field: wind speed ( $V_a$ ), relative humidity (RH), and air temperature ( $T_a$ ) using instruments (Table 2). Data Collection Field data were obtained using devices. All of the devices were positioned at least one meter away from adjacent structures and installed 1.0–1.5m above the ground to reduce the impact of surrounding surfaces on the recorded data at eight carefully selected locations within each park. These points reflected a range of vegetation densities and exposure types. Environmental parameters were recorded every 30 minutes over two full 24-hour monitoring sessions at eight representative points at Taman Tasik Titiwangsa and Taman Tasik Shah Alam each, the investigation

concentrated on the hours between 7:00am (November 30, 2024) until 7:00am (December 1, 2024) at Taman Tasik Shah Alam and 7:00am (December 8, 2024) until 7:00am (December 9, 2024) when people are most likely to engage in outdoor activities. The positions of the two location points inside the research area are shown in Table 3.

## SIMULATION SETTING

Simulation Model ENVI-met version 5.0 was utilized to simulate microclimatic conditions under two different scenarios: with existing vegetation and in its absence. The

model was chosen for its detailed spatial and temporal capabilities, making it particularly suitable for analysing small-scale urban climates. Starting at 7:00am on Sunday, November 30, and finishing at 7:00 am on Monday, December 1, 2024, the simulation was run for 24 hours using the ENVI-Met (Tables 4 and 5). The MMD in Kuala Lumpur and Selangor provided the meteorological information that was utilised to calculate the temperature, wind, and humidity. Tables 3 outlines the input data and basic settings used in the simulation. The justification for the simulation scenario involves aligning the 24-hour simulation period with times that reflect realistic human activity patterns. Conducting the simulation over a

complete 24-hour cycle allows the observation of environmental conditions and their impacts throughout different times of the day.

TABLE 4. Setting of ENVI-Met simulation of Taman Tasik Titiwangsa, Kuala Lumpur

Simulation setting	
Start date	November 30, 2024
Start time	7:00am
Total simulation time (h)	24h
Air temperature (°C)	24h cycle / CSV Data
Relative humidity (%)	24h cycle
Wind speed (m/s)	3.2

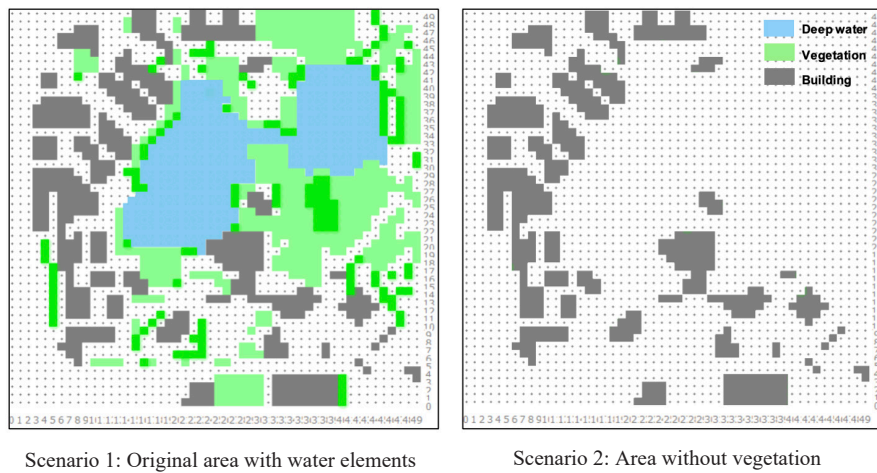
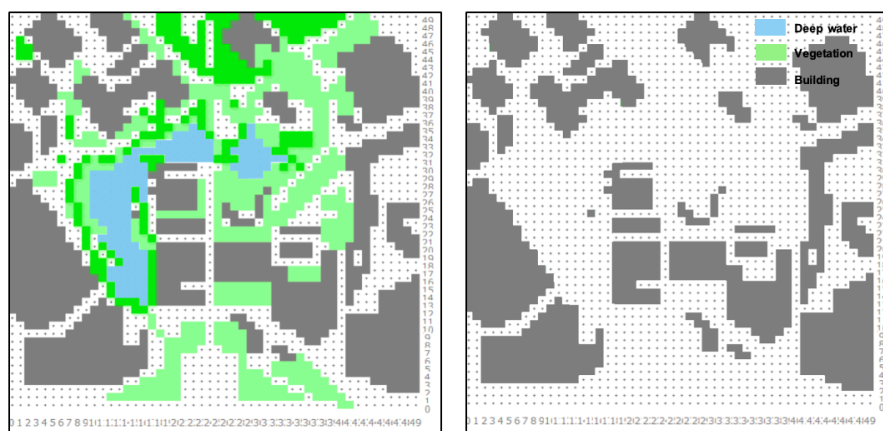


FIGURE 7. Various scenarios investigated in the study - Taman Tasik Titiwangsa

TABLE 5. Setting of ENVI-Met simulation of Taman Tasik Shah Alam Seksyen 14, Selangor

Simulation setting	
Start date	December 8, 2024
Start time	7:00 AM
Total simulation time (h)	24h
Air temperature (°C)	24h cycle / CSV Data
Relative humidity (%)	24h cycle
Wind speed (m/s)	2.1



Scenario 1: Original area with green elements

Scenario 2: Area without green elements

FIGURE 8. Various scenarios investigated in the study - Taman Tasik Titivangsa

### SCENARIO 1: ORIGINAL AREA WITH VEGETATION AND WATER ELEMENTS

This major scenario simulates the current conditions in the case study area, including the existing microclimate (Figure 8). It utilizes identical meteorological data, topographic features, urban structures, and vegetation types. The goal is to create an accurate representation of the area as it currently exists. This approach enables a comprehensive understanding of the microclimate and thermal comfort parameters influenced by natural environmental factors and existing urban features.

### SCENARIO 2: AREA WITHOUT VEGETATION AND WATER ELEMENTS

In the second scenario, the research area is cleared of all vegetation, and pavement is used in place of the grass (Figure 8).

Assessing the effects of adding or removing vegetation enables researchers to determine the direct impact of urban greenery on its surroundings. They can also examine how specific vegetation characteristics influence the urban microclimate and outdoor thermal comfort in the area.

### SIMULATION SCENARIOS

Figure 9 illustrates two scenarios simulated using ENVI-Met software. By comparing both sites, we can analyse how vegetation and soft scaping influence the urban microclimate and outdoor thermal comfort. The simulation started with a specific configuration of buildings and layouts, considering material types and building heights. It then included elements such as water features, vegetation (including trees and ground cover), and essential on-site characteristics like concrete, asphalt, soil types, and others.

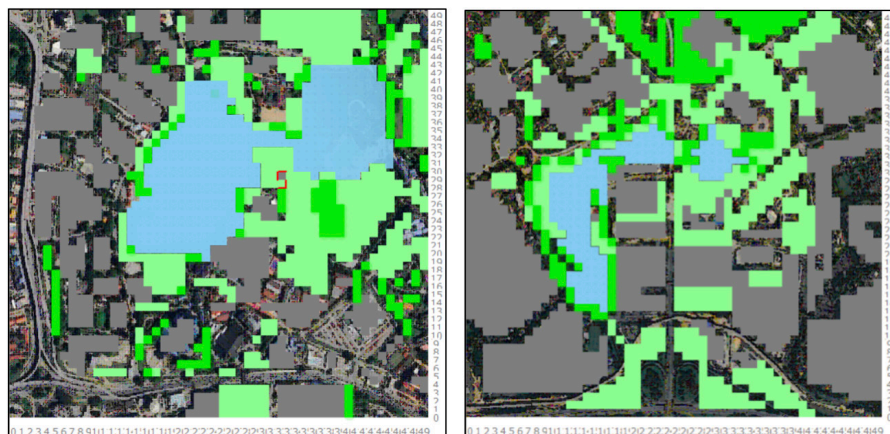


FIGURE 9. Site simulation using ENVI-met for Taman Tasik Titivangsa (left), and Taman Tasik Shah Alam (right)

## LANDUSE

The majority of Taman Tasik Titiwangsa's land use is urban commercial, including urban plazas, dense commercial structures, and institutional land use. Because of the density of the terrain, vegetation covers less than 35% of the land. However, in the Taman Tasik Shah Alam, the urban feature has more evenly distributed urban elements. An estimated 25% of the area is made up of greenland. By natural shading and evapotranspiration, it can improve the microclimate and contributes to cooling. Taman Tasik Shah Alam has the grid pattern, created better-spaced streets and appropriate ventilation, lowers heat retention.

## SOIL TYPE

The soil features a distinctive reddish hue with a high content of iron and aluminium oxides. (Alfred & Minasny, 2014), is the primary soil type in Taman Tasik Titiwangsa and Shah Alam. Usually permeable and well-draining, this type of soil facilitates effective water circulation. On the other hand, Taman Tasik Shah Alam benefits from the presence of flora, which can assist in moderate temperature increases because it has a larger share of green spaces. Taman Tasik Titiwangsa laterite soil and vegetation work together to improve moisture retention and foster a more varied plant life, which helps with localized cooling through evapotranspiration and shade.

## VEGETATION

Vegetation in urban parks acts as a natural cooling mechanism by providing shade and enabling evapotranspiration (Zhou, 2024; Misni, 2024). The presence of dense tree canopies and grass in both Taman Tasik Titiwangsa and Shah Alam contributes to the reduction of surface temperatures and air temperatures, mitigating the UHI effect. The simulated scenarios for both sites demonstrate that areas have higher vegetation density and expansive water elements. In Taman Tasik Shah Alam, the combined influence of vegetation and water features has a pronounced effect due to the park's spatial configuration, characterized by interconnected green spaces and proximity to large water bodies.

## WATER ELEMENT

Water bodies, such as lakes and ponds present in these sites, regulate temperatures through evaporative cooling (Jandaghian & Colombo, 2024). This process effectively lowers ambient air temperatures and creates a more comfortable thermal environment. The cooling effects from water evaporation are particularly evident in Taman Tasik Shah Alam, where larger water surfaces result in broader cooling zones.

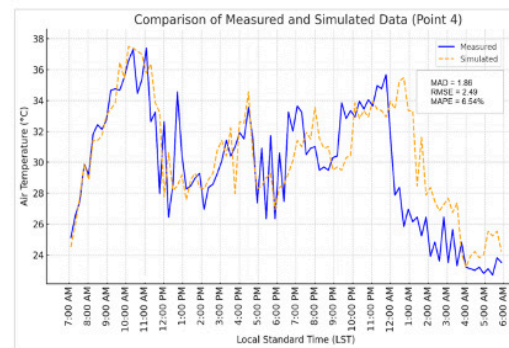
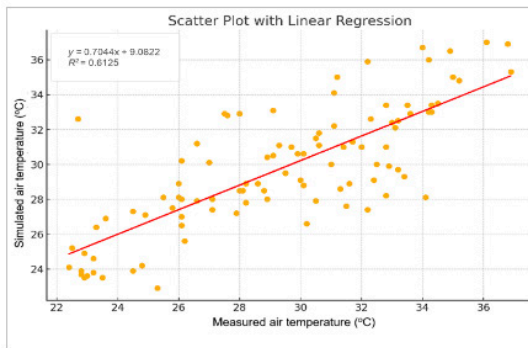
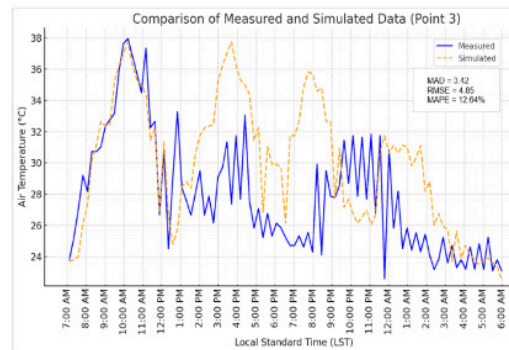
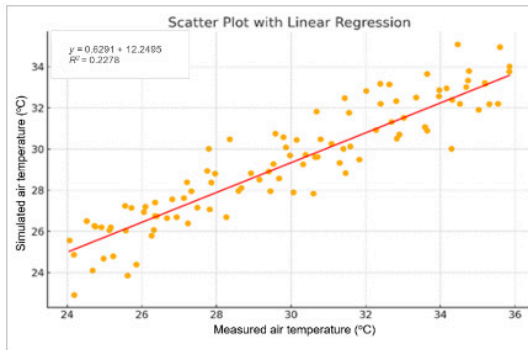
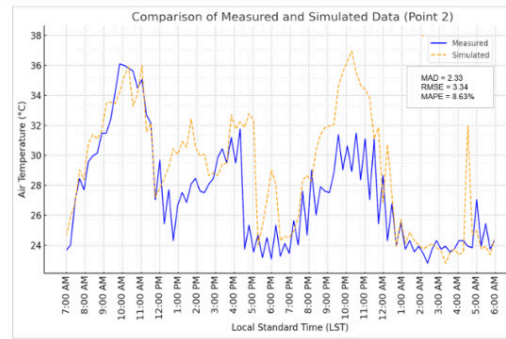
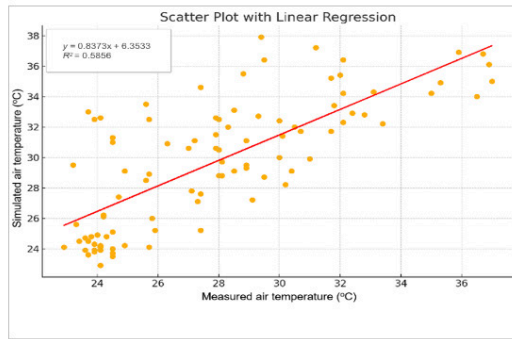
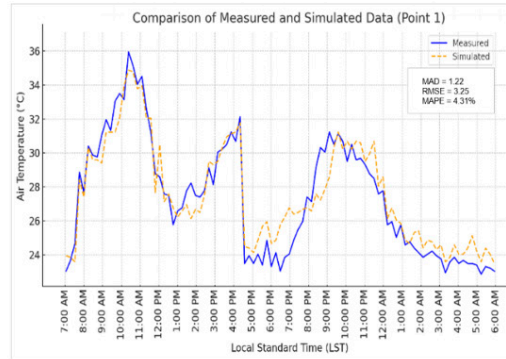
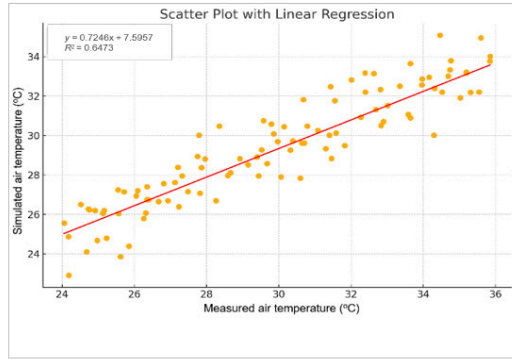
The inclusion of vegetation and water elements in urban parks like Taman Tasik Titiwangsa and Shah Alam emphasizes the need for sustainable design strategies that prioritize natural cooling.

## BUILDINGS SURROUNDING PARK

In towns and cities, the layout of buildings has a big impact on the microclimate, especially on temperature. Although Taman Tasik Titiwangsa and Shah Alam, with its surrounding urban structure, allows for some wind flow, the area is densely populated due to building height variances, which reach a height of 42 meters. This layout could create heat-trapping canyons that restrict airflow and worsen the UHI issue (Setaih et al. 2013). Gridiron urban layout has lower and more uniform structures, even though the higher and closer buildings may make it harder for wind to get through. Generally, the design of buildings in Taman Tasik Titiwangsa and Taman Tasik Shah Alam demonstrates how urban planning has a big influence on the microclimate.

## RESULTS AND DISCUSSION

The graphs below are the results of microclimate data gathered from ground data and the MMD to help in the temperature analysis of the chosen locations in Shah Alam and Taman Tasik Titiwangsa. Temperature, wind speed, and humidity are among the key meteorological factors that can be obtained from this data.



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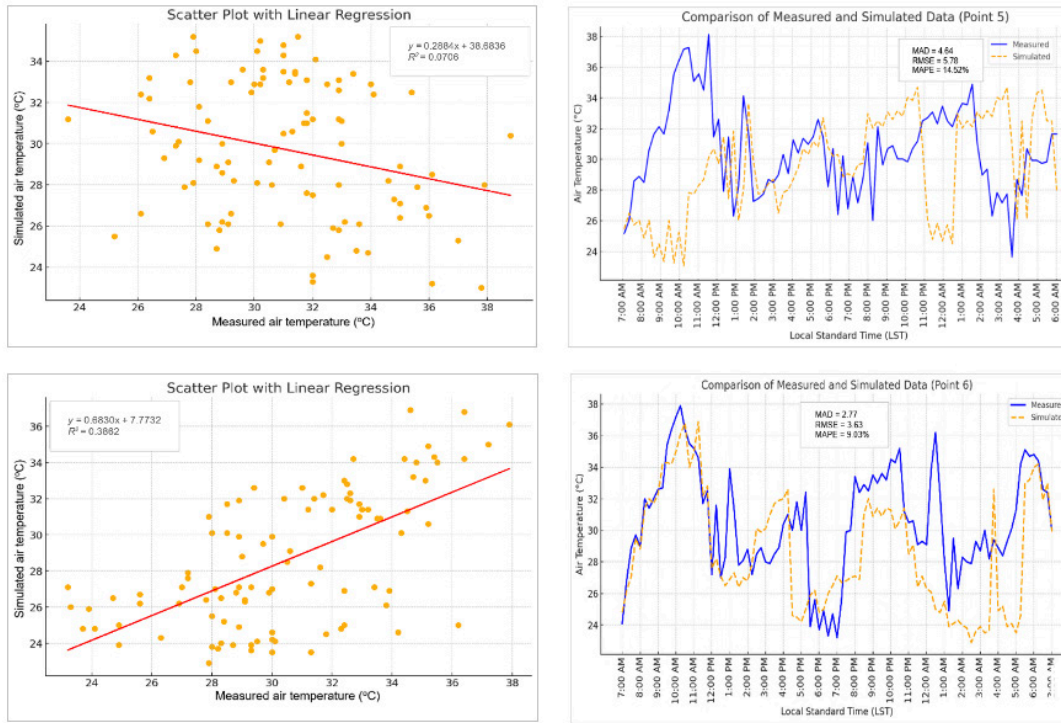
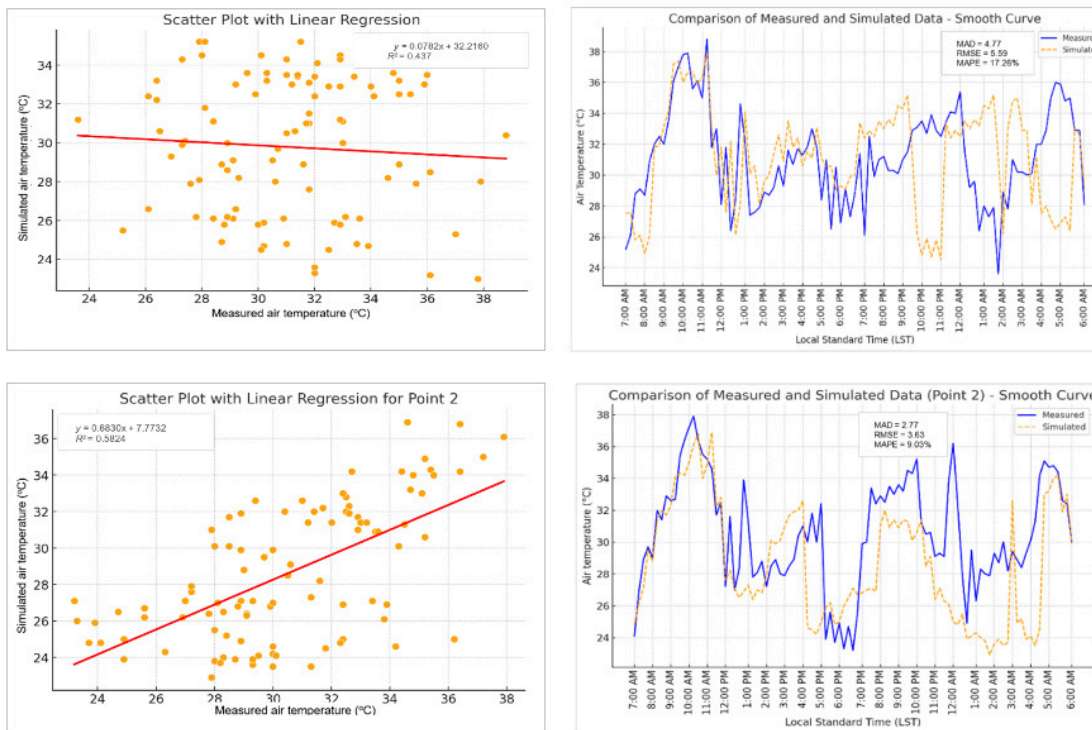
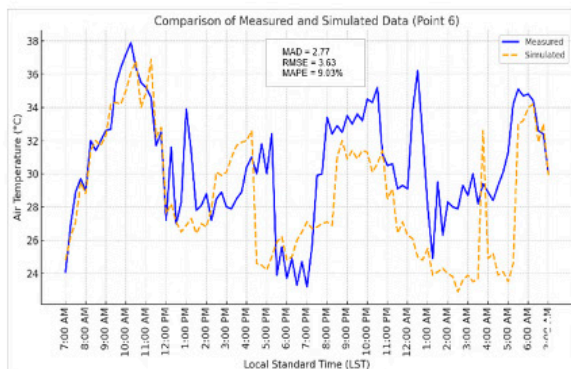
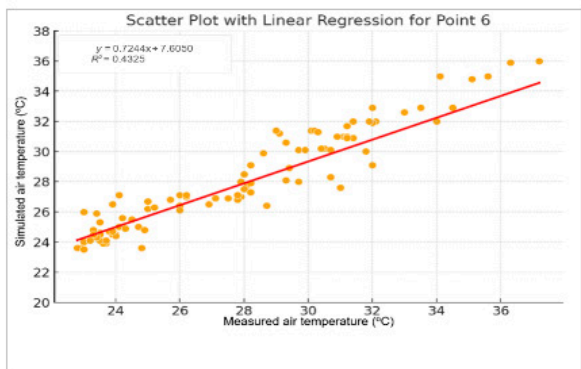
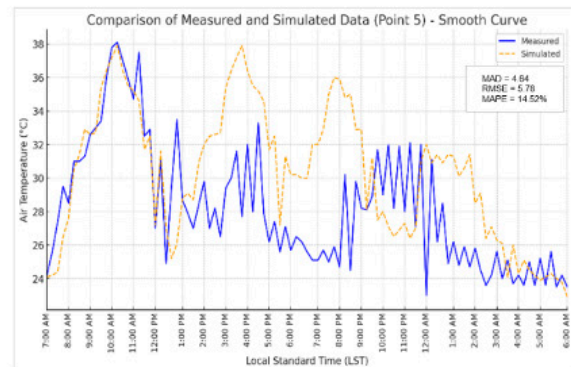
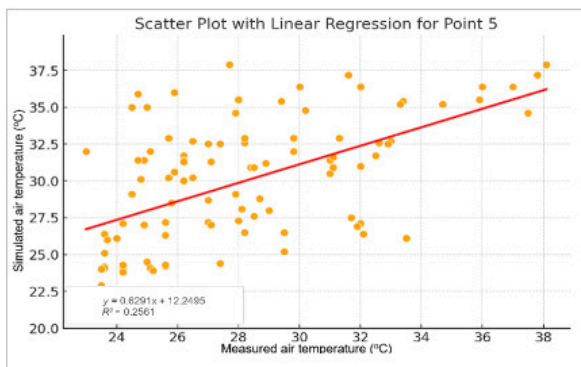
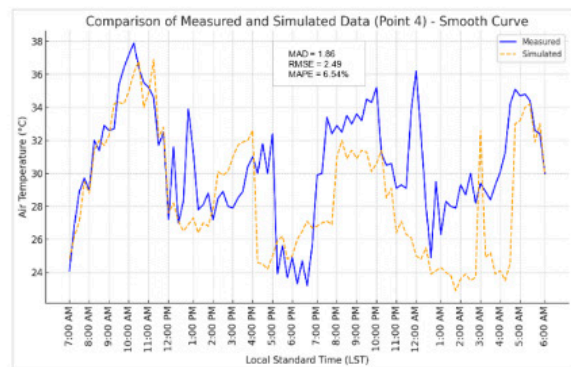
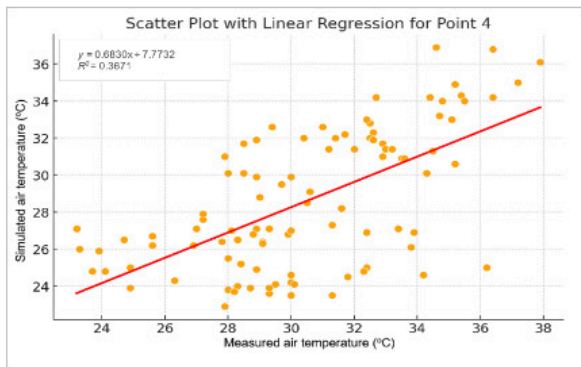
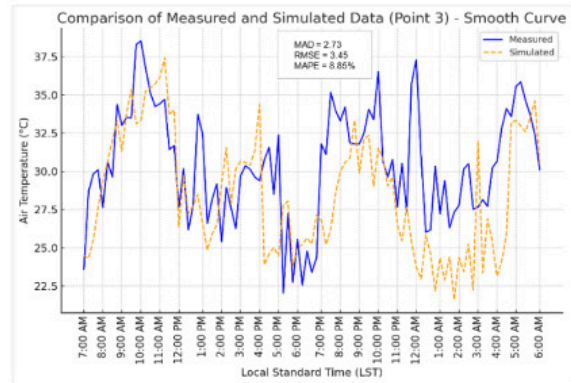
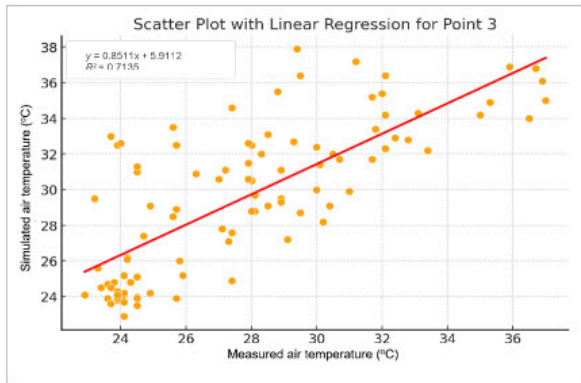


FIGURE 10. Microclimate data from MMD and ENVI-met for 24 hours in Taman Tasik Titiwangsa



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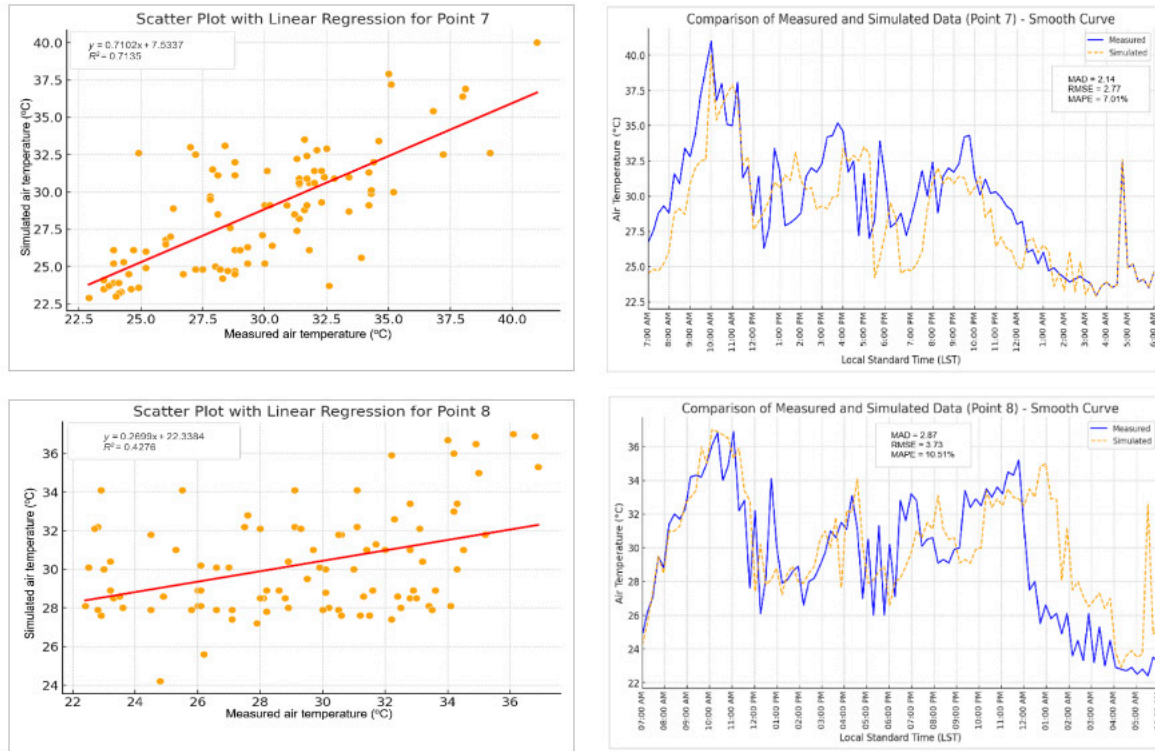


FIGURE 11. Microclimate data from MMD and ENVI-met for 24 hours in Taman Tasik Shah Alam

Below is the equation for a linear fit regression model.

$$y = b_0 + b_1x_1 + b_2x_1^2 + b_2x_1^3 + \dots b_nx^n \quad (1)$$

Where:

$y$  = is the dependent variable

$x$  = is the dependent variable

$b_0$ - $b_n$  = are the parameters that can optimize

Figure 10 shows that the  $R^2$  values are in category of 0.3-0.7, mean moderate connection, mean the variation in the outcome in moderate level of explanatory power—it's meaningful and valid even not very strong (Turney, 2023). Additionally, Figure 11 shows how the ENVI-met model was validated using in situ measurements. Numerical findings and air temperature measurements at eight typical locations within the survey area (07:00am to 07:00am) are compared: (a) Air temperature correlation between simulation and measurement. (b) ENVI-met model calibration MAD, RMSE, and MAPE. We performed a calibration by computing important metrics including the Mean Absolute Deviation (MAD), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE) in order to further guarantee the accuracy of the ENVI-met simulation model (Myttenaere et al. 2016). These metrics are commonly used to quantify the agreement between simulated and observed data. The calculations are detailed as follows:

$$MAPE = \frac{1}{n} \sum_{k=1}^n \left( \frac{|T_{mes} - T_{sim}|}{T_{mes}} \right) \times 100\% \quad (2)$$

$$MAD = \frac{1}{n} \sum_{k=1}^n |T_{mes} - T_{sim}| \quad (3)$$

$$RMSE = \sqrt{\frac{1}{n} \sum_{k=1}^n (T_{mes} - T_{sim})^2} \quad (4)$$

Where:

$T_{mes}$  = air temperature measured in °C

$T_{sim}$  = air temperature simulated in °C

$n$  = the total number of data being considered

As shown in Table 6 and Figure 10, the MAD accuracy (0.68-1.42°C) for points 1, 2, 4, 6, and 7. RMSE accuracy (0.82-1.56°C) for point 2 only and MAPE accuracy (2.08-4.13%) was none (all values exceeded the range). Table 7 and Figure 10 also reveal that these results show that the numerical model is highly accurate, particularly in MAD (97.02%), RMSE (96.20%), and MAPE at 89.58%, showing reliable performance in predicting temperature deviations. The results indicate that the numerical model is accurate and has been properly validated.

## VALIDATION OF ENVI-MET SIMULATIONS

Since air temperature is a critical metric for evaluating the thermal conditions of a particular place, we mainly used it to compare simulated and observed data, in keeping with earlier studies carried out for this purpose. A number of variables, including ventilation, the amount of shade in the area, and the thermal properties of nearby natural and artificial surfaces affect fluctuations in ambient air temperature. The modelling findings and the observations made at five representative points (07:00am and 07:00am) showed a significant correlation, as seen in Figures 10. The simulated results and the measured results were largely consistent with each other, as indicated by the correlation coefficient ( $R^2$ ), which varied ranges 6.3231-0.7513.

TABLE 6. Calibration of ENVI-met model and MAD, RMSE, and MAPE. Site A – Taman Tasik Titiwangsa

	Points	MAD (°C)	RMSE (°C)	MAPE (%)
1	dx = 150 dy = 37 k = 5	1.22	3.25	4.31
2	dx = 140 dy = 36 k = 6	2.33	3.34	8.63
3	dx = 130 dy = 35 k = 7	3.42	4.85	12.64
4	dx = 120 dy = 34 k = 8	1.86	2.49	6.54
5	dx = 110 dy = 33 k = 9	4.64	5.78	14.52
6	dx = 100 dy = 32 k = 10	2.77	3.63	9.03
7	dx = 90 dy = 31 k = 11	2.14	2.77	7.01
8	dx = 80 dy = 37 k = 12	2.17	2.86	7.33

TABLE 7. Calibration of ENVI-met model and MAD, RMSE, and MAPE. Site B – Taman Tasik Shah Alam

	Points	MAD (°C)	RMSE (°C)	MAPE (%)
1	dx = 150 dy = 37 k = 5	4.77	5.59	17.26
2	dx = 140 dy = 36 k = 6	2.50	3.25	8.15
3	dx = 130 dy = 35 k = 7	2.73	3.45	8.85
4	dx = 120 dy = 34 k = 8	1.86	2.49	6.54
5	dx = 110 dy = 33 k = 9	4.64	5.78	14.52
6	dx = 100 dy = 32 k = 10	2.31	3.31	8.54
7	dx = 90 dy = 31 k = 11	2.14	2.77	7.01
8	dx = 80 dy = 37 k = 12	2.87	3.73	10.51

## EVALUATION OF THE ENVIRONMENTAL IMPACTS ON TAMAN TASIK TITIWANGSA AND TAMAN TASIK SHAH ALAM

**Data Validation** The simulation results were validated using statistical methods such as mean absolute deviation (MAD), root mean square error (RMSE), and mean absolute percentage error (MAPE). Air temperatures ranged from 24.8°C to 41.5°C (07:00am to 07:00am), with the highest reported temperature at 12.45 pm, according to the ENVI-met simulation results for Site A. The notable temperature variations during the day are depicted in Figure 12. The temperature peaks at over 37°C at sized regions and those exposed to strong direct sunshine were consistently shown to be the “heat stress zone”. Higher Physiological Equivalent Temperature (PET) index values than at Site A resulted from the heat accumulation exacerbated by the lack of significant shade components and a cooling water body. Although higher error margins were detected in certain locations within Shah Alam, the overall model performance was consistent with established ENVI-met applications.

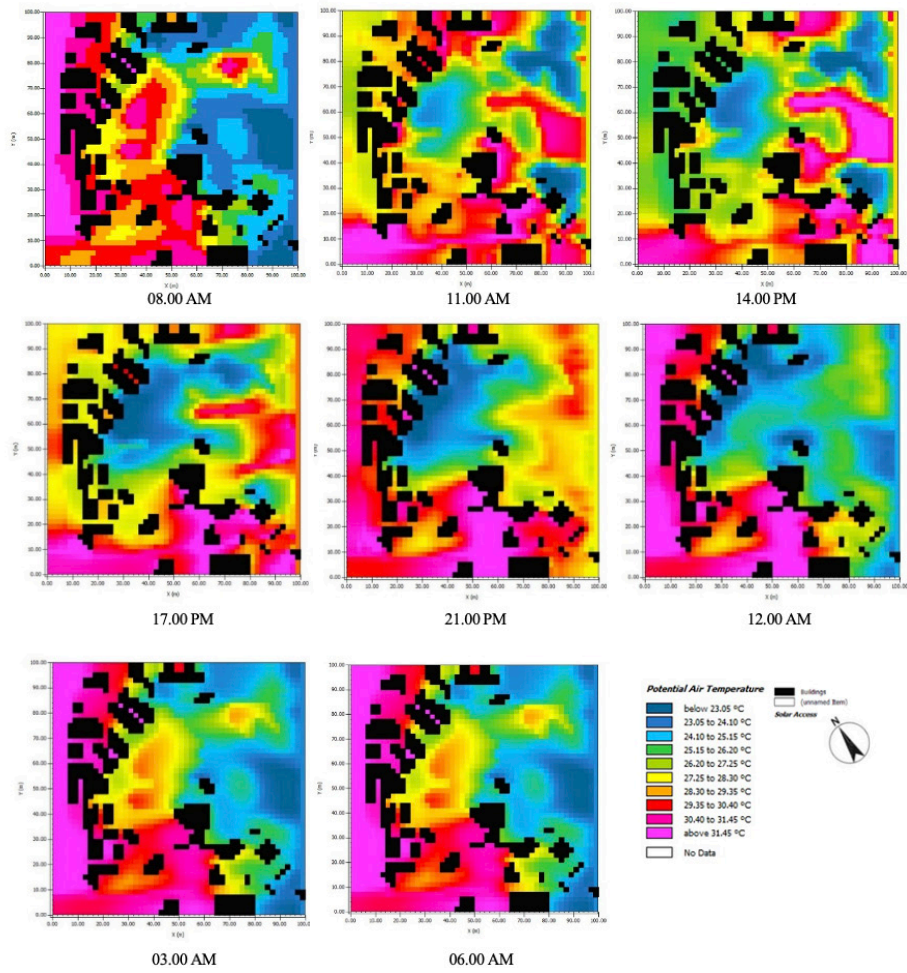
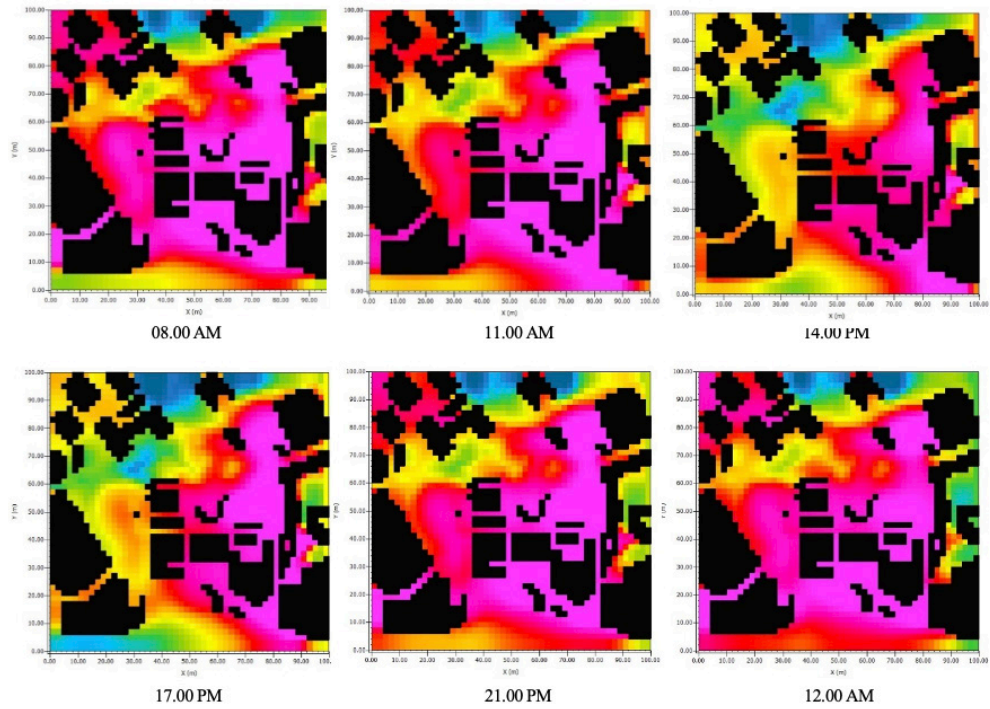


FIGURE 12. Air temperature outputs from the simulation at 24 hours periods of the



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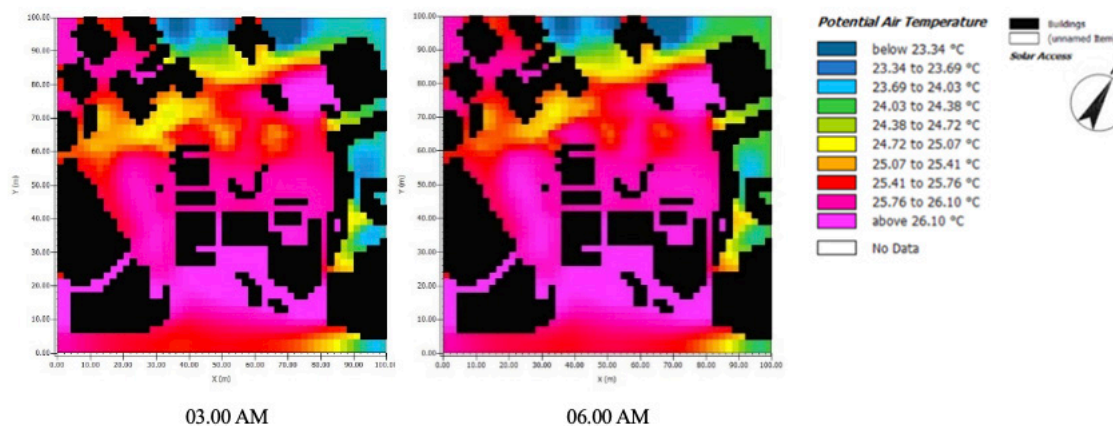


FIGURE 13. Air temperature simulation at three distinct periods of the day

## COMPARISON BETWEEN TAMAN TASIK TITIWANGSA AND TAMAN TASIK SHAH ALAM

Determining the impact of plants on thermal conditions is challenging since a number of elements, such as building materials, urban morphology, and plants, influence the thermal environment of metropolitan areas. Taman Tasik Titiwangsa and Taman Tasik Shah Alam are two locations in Selangor that were compared in order to examine an alternate simulation. In comparison to Taman Tasik Titiwangsa, the Taman Tasik Shah Alam site has the least amount of vegetation cover, according to the 10%. The impact of vegetation can be evaluated by comparing these two locations on the same day. Variations in the PET index and climatic conditions are mostly caused by the presence or absence of the plant element.

According to the PET index comparison, Site B needed more vegetation and shaded structures to improve visitor comfort because of its higher thermal exposure. At the same time, Site A continuously provided better thermal comfort because of its well-balanced combination of green spaces and water elements. To create a sustainable and comfortable outdoor space, these findings highlight the crucial role of park design, landscape composition, and vegetation density in influencing microclimatic conditions.

They also suggest that future urban parks include more tree canopies, shaded pathways, and water bodies. Particularly in the city of Titiwangsa, Kuala Lumpur, and the city business district at Shah Alam, the results of this study will assist in future microclimate planning in urban areas, as well as in retrofitting landscape projects and city environments. The outcomes demonstrate how important urban parks are in reducing the UHI effect and how they may support sustainable urban growth. In the commercial

districts of Titiwangsa, Kuala Lumpur, and Shah Alam, the study offers important insights for future microclimate-responsive urban design, retrofitting landscaping techniques, and developing climate-resilient urban environments.

### AIR TEMPERATURE

According to the ENVI-met simulation results for the first scenario (the basic case), air temperatures ranged from 22.8°C to 41.5°C between 7:00am and 7:00am the following day, with the highest temperature observed at 12:40pm. These statistics represent the simulation outcomes for three distinct time periods throughout the day. Figure 11 illustrates significant temperature variations occurring throughout the day. At noon, temperatures rise above 37°C, reaching up to 40°C by 1:00pm, with a daily maximum of 37.9°C. The “heat stress zone” was regularly located in the most populated areas, especially those exposed to intense direct sunlight, particularly at point 8. Figure 13 displays the 24-hour temperature results for Taman Tasik Titiwangsa on November 30, 2024, as calculated with the ENVI-met software.

The temperature was recorded as being at its lowest at 8:00am and rising somewhat at 10:12am. At 12:46pm the highest recorded temperature was 38.2°C. Despite the high relative humidity, the temperature in Titiwangsa stayed high at 29.8°C at 09:11pm. High relative humidity may limit the cooling of the air at night. Because moisture in the air stores heat and inhibits its dispersion, it can contribute to warmer evening temperatures.

The ENVI-met software’s 24-hour temperature result for Taman Tasik Shah Alam on December 8, 2024, is displayed in Figure 12. The temperature was measured to be at its lowest at 3:00am and to be somewhat higher by

06:00am. At 13:00pm, the highest recorded temperature was 38.5°C. Despite the high relative humidity, the temperature in Shah Alam stayed high at 31.5°C at 10:00pm. High relative humidity may limit the cooling of the air at night. Because moisture in the air stores heat and inhibits its dispersion, it can contribute to warmer evening temperatures.

In comparison to nearby urban areas, Titiwangsa Lake Garden showed a noticeable cooling impact, with average daily temperatures dropping by 2 to 3°C. Due to its sparser vegetation and the overpowering presence of surrounding high-rise structures, Shah Alam Lake Garden, on the other hand had a less significant cooling benefit.

### RELATIVE HUMIDITY

Figure 14 shows the relative humidity (RH) results from the ENVI-met software for a 24-hour period on November 30, 2024, in Taman Tasik Titiwangsa. The RH peaks around 8:00am because the cooler temperatures reduce the air's

capacity to hold moisture. During the afternoon, RH reaches its lowest point due to the highest recorded temperatures 41.5°C. This is consistent with the principle that warmer air can hold more moisture, lowering RH even if absolute moisture remains constant. Elevated nighttime temperatures may slightly alter this typical pattern by slowing the cooling process, demonstrating the interaction between temperature, time, and humidity in the study area.

Figure 15 displays the relative humidity (RH) values obtained from the ENVI-met software after a 24-hour period on December 8, 2024 in Taman Tasik Shah Alam. The humidity levels are higher in most parts of the area, as shown by the dominant green shades in the early morning at 08:00am. The pattern suggests a strong correlation between temperature and RH, with higher temperature reducing humidity and cooler periods increasing it. While the lowest during the afternoon 03:00pm. Hence, at 10:00pm humidity begins to recover as temperature drops and areas shift back to green and yellow shades.

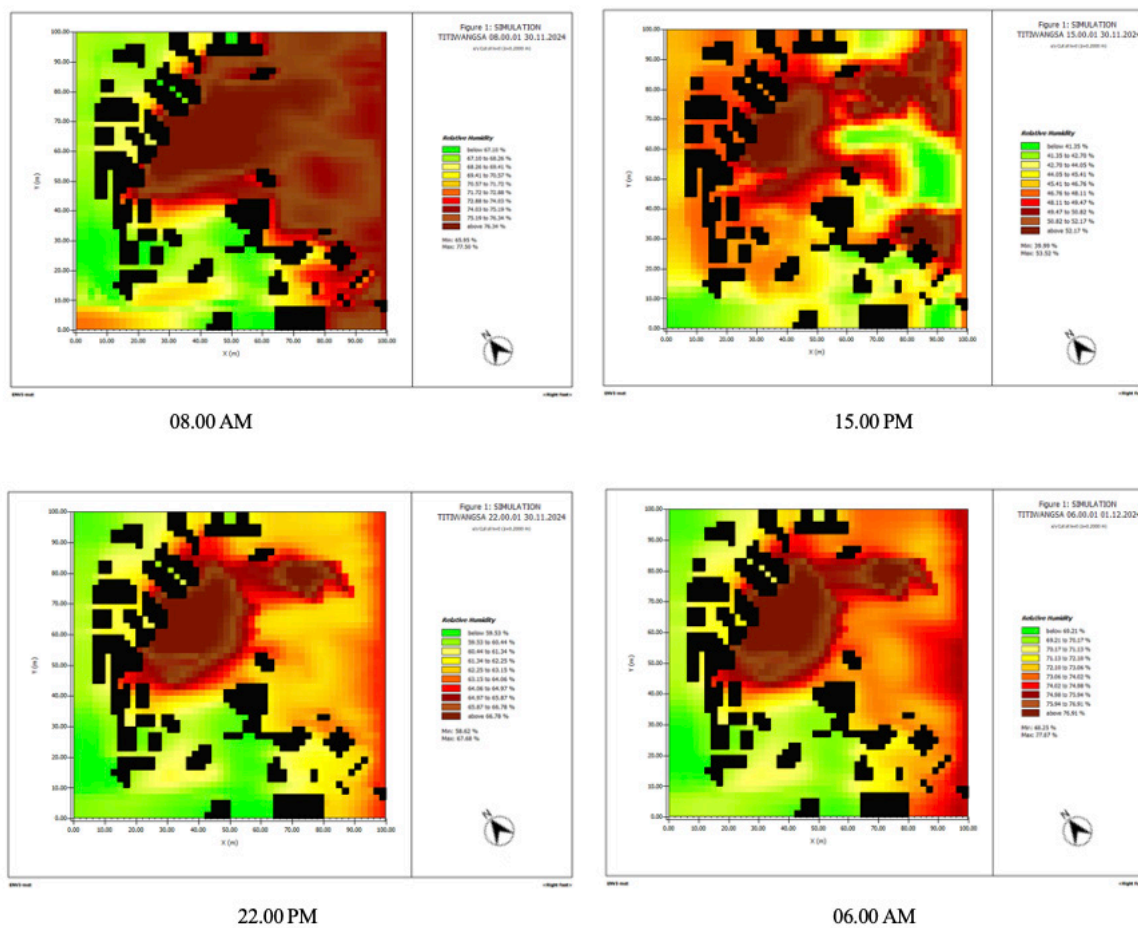


FIGURE 14. RH map in Taman Tasik Titiwangsa

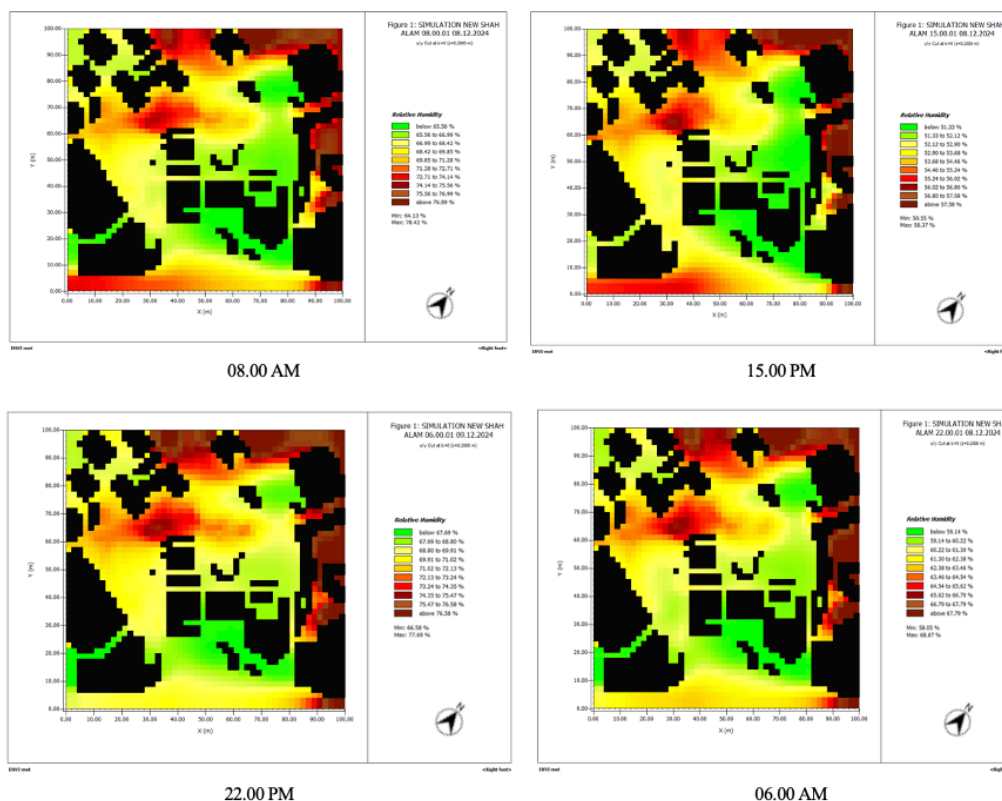
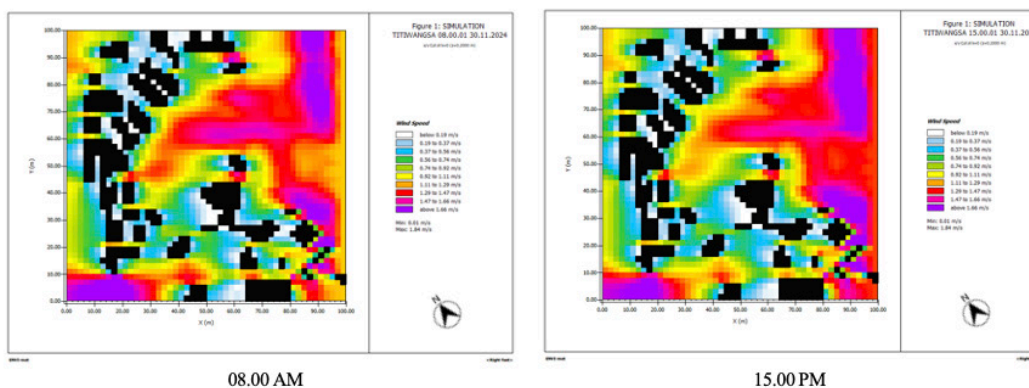


FIGURE 15. RH model in Taman Tasik Shah Alam

WIND SPEED

Wind speed significantly affects outdoor thermal comfort, influencing how individuals perceive temperature and overall comfort in outdoor environments. Wind speed is a vital factor in determining outdoor thermal comfort, with its effects varying by climate and context. While it plays a cooling role, its influence is often overshadowed by other environmental factors, particularly solar radiation. Figures 15-16 show the wind speed result from the ENVI-met software for 24 hours for the two site studies, which is

wind speeds are lowest during pre-sunrise at 7:00-8:00am due to solar-induced thermal turbulence. Displays slightly lower wind speed and a more significant reduction in RH during the afternoon. Wind speed drops again at 10.00pm as the atmosphere stabilizes with cooling temperatures. The surrounding environment, with possible vegetation and open spaces, could lead to lower thermal convection and airflow in certain areas. Lastly, Shah Alam shows stronger urban heat effects with higher wind speed and slower recovery of humidity at night due to heat retention from urban surfaces.



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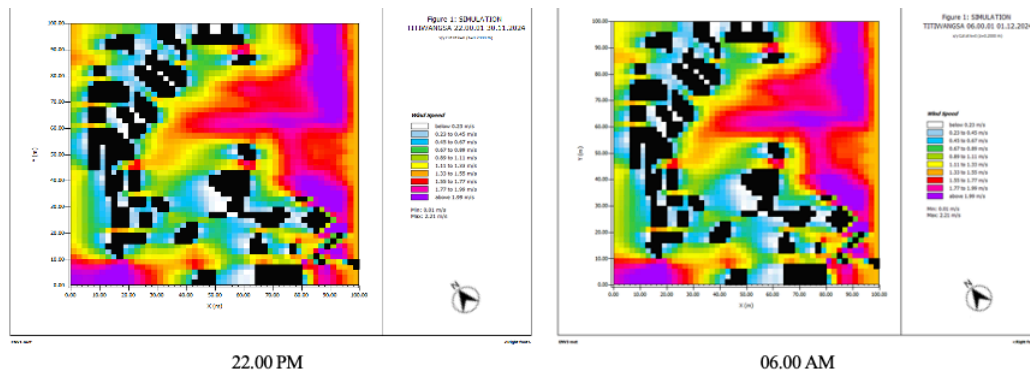


FIGURE 16. Wind speed model in Taman Tasik Titiwangsa

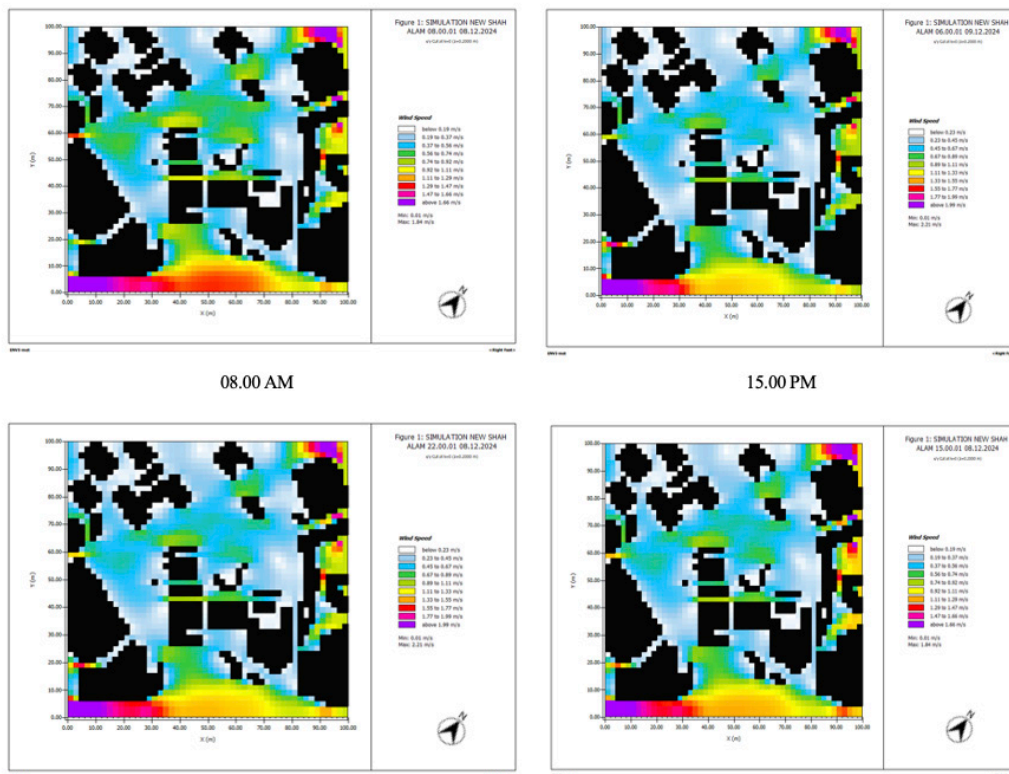


FIGURE 17. Wind speed model in Taman Tasik Shah Alam

Figure 17 illustrates a graph of microclimate data collected from the MMD in Petaling Jaya on December 26, 2024, to assist in analyzing temperature at the designated study sites of Taman Tasik Titiwangsa and Taman Tasik Shah Alam. Hence, the findings from the microclimate simulation and observational data, the MMD temperatures readings appear more stable likely due to the averaging effects of broader spatial parameters. The lower temperature data reading during the evening and early morning significantly contribute to cooling through RH. With ENVI-met data indicating higher humidity levels in the morning and night but showing a significant decrease

during midday which is peak temperature. The RH between 10:00am and 4:00pm align with increased higher evapotranspiration rates from the lake and surrounding greenery.

The successful validation of the ENVI-met model against MMD data further highlights the importance of microclimate simulation in urban planning and environmental sustainability effort. Daily variations in temperature and RH trends from the ENVI-Met and MMD data for Sites A and B can be compared. The simulation findings agree with the actual environmental conditions, as seen by the small disparities between the measured

(MMD) and modelled (ENVI-Met) data. With greater daytime and lower night-time temperatures, its swings follow a typical Malaysian urban park pattern. Similarly, RH rises at night and falls as temperatures rise. Wind speeds were significantly lower in Shah Alam due to structural

barriers created by dense building arrangements. These results support the model's accuracy in simulating real-world settings by indicating that the microclimate behaviour of the examined urban park is consistent with typical urban parks in Malaysia.

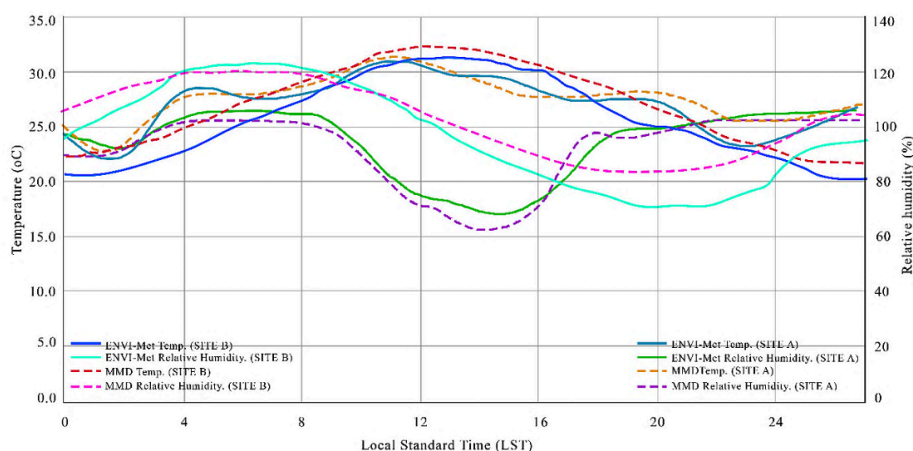


FIGURE 18. Comparison of temperature for Taman Tasik Titiwangsa (Site A), and Taman Tasik Shah Alam (Site B)

### TEMPERATURE PATTERN CHANGE IN TAMAN TASIK TIIWANGSA AND TAMAN TASIK SHAH ALAM

The main finding of the temperature patterns observed at Taman Tasik Shah Alam was consistently higher. This can be attributed to several local environmental factors influencing the temperature fluctuations at each site. From the recorded data, Taman Tasik Shah Alam exhibited a temperature that was higher by 2.3°C, especially during the midday period between 12:30pm and 15:43pm.

One of the key factors influencing this difference is the land cover, vegetation density and surrounding saturated development. Taman Tasik Shah Alam, where increased built-up areas, concrete surfaces, and medium vegetation result in higher heat absorption and retention. In contrast, Taman Tasik Titiwangsa, located in an urban setting, has one of the significant factors affecting the temperature difference between the two parks, which is the surrounding low-density land cover and vegetation density, which can profoundly influence the experience of nature.

#### LANDCOVER

The quantity of sunlight reflected or absorbed by various land cover types determines their albedo effects. Taman Tasik Titiwangsa's land cover is primarily composed of impermeable surfaces, such as asphalt and concrete, which are typical in cities with heavy pedestrian traffic. Medium

to higher temperatures are the result of these surfaces' absorption and retention of heat. Darker surfaces, like asphalt, absorb more heat than lighter ones, like grass. Shah Alam was then classified as an urban park that has an impact on the surrounding area, including the business centre and the city, which is packed with densely populated structures. The Taman Tasik Shah Alam region experiences scorching temperatures and takes a long time because of the amount of green land cover that does not exceed the RH minimum.

#### VEGETATION

Taman Tasik Shah Alam has a higher density of green cover, however the dense development surrounding it increases heat retention making the area more susceptible to the UHI effect. In contrast, Taman Tasik Titiwangsa benefits from a higher percentage of vegetation and lower development around, which aids in cooling the environment by promoting better air circulation and reducing heat absorption. Street trees and well-distributed greenery in Taman Tasik Titiwangsa further contribute to lower temperatures, providing a comfortable environment for visitors while supporting biodiversity.

#### WATER ELEMENT

Water bodies significantly influence microclimate conditions by regulating temperature. Increasing RH and reducing heat accumulation in urban areas. However,

Taman Tasik Shah Alam water elements such as lakes and fountains help mitigate the heat absorbed by surrounding built surfaces. However, the overall impact is limited due to dense urbanisation. Meanwhile, Taman Tasik Titiwangsa integrates larger water bodies that act as natural cooling systems that enhance air movement and maintain lower surrounding temperatures. The cooling effect of water elements in Taman Tasik Titiwangsa complements its vegetation creating a balanced ecosystem that improves visitors' environmental quality and thermal comfort.

#### URBAN LAYOUT AND SETTING

The urban layout and setting justify the arrangement of buildings and roads impact environmental factors like temperature, wind speed and humidity. Building height and density in Taman Tasik Shah Alam are taller and denser buildings 42m high, creating heat-trapping canyons that hinder airflow and can increase the UHI effect. Its building density may create slightly more heat retention. In contrast, Taman Tasik Titiwangsa has low rise buildings and is surrounded by land, such as residential and institutional, that promotes better air circulation, dispersing heat and maintaining lower temperatures. Taman Tasik Titiwangsa grid pattern allows for organised urban sprawl, reducing traffic congestion and enhancing air quality with proper street plantations.

#### HUMAN MOVEMENT AND TRAFFIC

Human movement and traffic congestion frequently take place in buildings that need HVAC systems, which can release heat into the surrounding air, particularly during peak time of the day. Human movement at Taman Tasik Titiwangsa attracts heavy traffic, especially during peak recreational times. This human activity can slightly increase localised heat through body heat and movement. However, the presence of vast greenery and urban parks mitigates these effects by dissipating heat and improving airflow. Commercial buildings around Titiwangsa such as restaurants typically operate during the daytime and early evening. These operations often utilize HVAC systems which emit heat into the environment. Taman Tasik Shah Alam similarly draws significant human activity. The lake and surrounding greenery help absorb and counteract heat generated by crowds. Business near the lake gardens may operate longer hours particularly during evening when visitors frequent the area.

#### BUSINESS OPERATION

Business operations play a crucial role in shaping the environmental conditions of urban parks particularly in

terms of heat generation and energy consumption. Commercial establishments such as restaurants and business facilities frequently utilise HVAC systems contributing to localised heat emissions. Moreover, for Taman Tasik Shah Alam the concentration of commercial activities near the lake gardens resulting in extended operational hours was also leading to prolonged energy usage and increased heat retention. Conversely, Taman Tasik Titiwangsa benefits from a more dispersed business layout with integrated greenery which helps regulate temperature and improve air circulation. The combination of water elements and vegetation in Taman Tasik Titiwangsa mitigates the heat generated by lower temperature creating a more comfortable environment while supporting sustainable urban cooling strategies.

#### CONCLUSION

The analysis and comparison of Taman Tasik Titiwangsa and Taman Tasik Shah Alam reveal important insights into how urban planning, natural features and human activities influence the environmental conditions of recreational areas and their surroundings. To enhance sustainability, both parks can adopt additional measures like increasing tree density, incorporating green roofs in nearby buildings and optimizing business energy consumption to further reduce the UHI. The surrounding urban areas could improve environmental conditions and create more liveable cities and urban parks. Both parks can use additional strategies, such as boosting tree density, adding green roofs to surrounding buildings, and encouraging energy-efficient business practices to enhance environmental resilience.

The outcomes demonstrate how important urban parks are in mitigating the UHI effect and how they may support sustainable urban growth. In the commercial districts of Titiwangsa, Kuala Lumpur, and Shah Alam, Selangor, the study offers important insights for future microclimate-responsive urban design, retrofitting landscaping techniques, and developing climate-resilient urban environments.

In conclusion the microclimatic conditions in urban areas can be significantly improved by urban parks like Titiwangsa and Shah Alam Lake Gardens. Climate responsiveness should be given top priority in their design and incorporation into city planning, particularly as urbanization and climate change increase environmental stress. This study provides empirical support for the idea that green infrastructure might improve urban resilience.

## ACKNOWLEDGEMENT

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## DECLARATION OF COMPETING INTEREST

None.

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