QUANTIFYING THE DIURNAL PARK COOL ISLAND EFFECT OF VIHARAMAHADEVI PARK, COLOMBO, SRI LANKA

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Abstract: Rapid urbanisation in Colombo has exacerbated the Urban Heat Island (UHI) effect, yet localised data on mitigation strategies remains scarce. This study quantifies the diurnal Park Cool Island Intensity (PCII) of Viharamahadevi Park, critically analysing the spatial decay of cooling into the surrounding urban fabric. An intensive in-situ measurement campaign was conducted over seven clear-sky days at four synoptic intervals (06:30 AM – 07:30 AM, 12:30 PM – 01:30 PM, 03:30 PM – 04:30 PM, 06:30 PM – 07:30 PM), utilising a fixed interior station and mobile transects extending 350 meters outward.

Results validate a statistically significant cooling effect ($p<0.05$) throughout the diurnal cycle. The PCII peaked from 12:30 PM to 1:30 PM, achieving a maximum intensity of 4.13 °C at a distance of 300 meters. Cooling remained robust in the morning (3.92 °C), but diminished significantly post-sunset (0.76 °C) as urban thermal inertia released stored heat. These findings characterise the park as a vital climate moderator rather than a simple amenity. This study provides essential empirical evidence for Landscape Architects, arguing that preserving large-scale green infrastructure is a significant and essential strategy for ensuring Colombo's thermal resilience.

Keywords: *Urban Heat Island, Park Cool Island Intensity, Tropical Microclimate, Landscape Architecture, Viharamahadevi Park.*

1. Introduction

1.1 THE URBAN CLIMATIC CONTEXT

The global phenomenon of rapid urbanisation has fundamentally altered the thermodynamic properties of the Earth's surface, resulting in the modification of local climates known as the Urban Heat Island (UHI) effect. The UHI is characterised by urban or metropolitan areas exhibiting significantly higher temperatures than their rural surroundings (Oke, 1982). This thermal anomaly is driven by a shift in surface energy balance: natural, porous materials capable of evapotranspiration are systematically replaced by impermeable, high-thermal-admittance materials such as asphalt and concrete. These anthropogenic surfaces possess high thermal storage capacity, absorbing intense solar radiation during the day and re-radiating it as sensible heat, thereby elevating the ambient air temperature (Sailor, 2011; Yuan, 2024).

In tropical climates, where ambient temperatures and relative humidity already approach the margins of human physiological tolerance, the ramifications of the UHI are particularly acute. The addition of anthropogenic waste heat from urban functions (transportation, air conditioning), combined with altered airflow patterns due to complex urban terrain, further exacerbates heat stress. This creates a vicious cycle leading to increased energy costs for mechanical cooling, deterioration of air and water quality, and significant risks to public health and well-being (Emmanuel, 2005).

1.2 THE PROBLEM IN COLOMBO

Colombo, the commercial capital of Sri Lanka, serves as a critical case study for this phenomenon. The city is undergoing rapid morphological transformation, characterised by vertical densification and the reduction of vegetative cover. Meteorological data indicate a worrying trend: while the historical average air temperature of Colombo has hovered around 27 °C, recent decades have shown a warming rate of approximately 0.16 °C per decade (Department of Census and Statistics, 2019). This escalation places the city's population at increasing risk of thermal discomfort and heat-related morbidity.

Within this context, Urban Green Spaces (UGS), specifically large public parks, are increasingly viewed not just as aesthetic amenities, but as essential "nature-based solutions" for climate mitigation. (Bowler et al., 2010). The theoretical mechanism is clear: vegetation reduces air and surface temperatures through the combined physical processes of canopy shading and evapotranspiration, creating a localised anomaly known as the Park Cool Island (PCI) effect (Liao et. al., 2023).

1.3 RESEARCH GAP AND JUSTIFICATION

However, a critical gap exists in the local literature. While the existence of the PCI effect is recognised globally, there is an urgent need to generate localised, quantitative data that reflects the specific climatic and urban conditions of Sri Lanka. Most existing studies focus on temperate climates, and there is a lack of rigorous empirical work quantifying the magnitude, diurnal variation, and spatial extent of the cooling service provided by parks in the Sri Lankan context.

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General assumptions that "parks are cool" are insufficient for evidence-based public decision-making. Landscape Architects and Urban Planners require precise data on '*how much?*' a park cools its surroundings, '*at what time?*' this cooling is most effective, and '*how far?*' this benefit extends into the adjacent urban fabric. Without this granular analysis, arguments for the protection and expansion of green infrastructure lack the technical weight necessary to influence policy in a rapidly developing city.

1.4 RESEARCH OBJECTIVES AND HYPOTHESIS

This research focuses on Viharamahadevi Park, Colombo's largest and most prominent public park, to address this knowledge gap through an empirical assessment of its microclimatic performance.

The primary objective of this study is to quantify the diurnal Park Cool Island Intensity (PCII) of Viharamahadevi Park. This is achieved by rigorously comparing interior park air temperatures with those in the adjacent urban fabric along a defined spatial gradient.

Hypothesis: Viharamahadevi Park acts as a critical thermal sink within the urban heat island, exhibiting a statistically significant diurnal Park Cool Island (PCI) effect. It is hypothesised that the intensity of this cooling is not uniform but exhibits a distinct temporal peak coincident with maximum solar load (midday) and a spatial decay relative to the distance from the park boundary, confirming its function as an active climate modifier rather than a passive open space.

By validating this hypothesis, this study aims to equip Landscape Architects and Policymakers with decisive evidence of the climatic value of urban parks, supporting the argument for the continued protection and planned expansion of Colombo's green infrastructure.

2. Background

2.1 THE THEORETICAL FRAMEWORK OF THE PARK COOL ISLAND (PCI)

The study of the Park Cool Island (PCI) effect is situated within the broader academic discourse on urban climatology and UHI mitigation literature. Conceptually, the PCI effect is a micro-scale inversion of the Urban Heat Island; it represents a "cool spot" of vegetation embedded within a warmer urban matrix. The literature establishes that this phenomenon is not accidental but is the result of complex thermodynamic interactions between the biotic components of the park (vegetation, soil) and the abiotic components of the city (buildings, pavement)(Liao et. al., 2023).

2.2 MECHANISMS OF COOLING: SHADING AND EVAPOTRANSPIRATION

The literature identifies two primary biophysical drivers responsible for the cooling effect of parks: shading and evapotranspiration.

- **Shading:** Tree canopies function as physical barriers that intercept incoming short-wave solar radiation before it strikes the ground surface. Shashua-Bar & Hoffman (2000) demonstrate that shading prevents the heating of surfaces such as pavement and soil, thereby reducing the sensible heat flux into the air. In a tropical context like Colombo, where solar angles are high, the density and coverage of this canopy are critical determinants of cooling potential. (Emmanuel, 2005)

- **Evapotranspiration:** This process comprises evaporation from moist surfaces and transpiration from plant leaves. Jamei et al. (2016) explain that evapotranspiration acts as an active cooling mechanism by consuming latent heat from the surrounding air to convert water from liquid to vapour. This phase change removes energy from the environment, directly lowering the ambient air temperature. The effectiveness of this process is heavily dependent on vegetation attributes, including Canopy Density, Leaf Area Index (LAI), and species composition (Jamei et al., 2016)

2.3 FACTORS INFLUENCING PCI INTENSITY: GEOMETRY AND CONTEXT

The magnitude of the cooling effect is not solely determined by the presence of vegetation; the literature highlights that the geometry and context of the park play significant roles.

- **Park Size:** Cao et al. (2010) indicate a positive correlation between park size and PCI Intensity. Larger parks possess a greater thermal mass of vegetation and soil, allowing them to generate a stable cool air reservoir that is more resistant to the intrusion of hot urban air. This allows the cooling effect to extend further spatially into the surrounding neighbourhoods.

- **Park Shape:** The shape index, or perimeter-to-area ratio, is a critical variable. Chen, Wong & Lin (2012) argue that complex, irregular shapes increase the park's exposure to the surrounding urban fabric. A high perimeter-to-area ratio may facilitate the intrusion of hot air and thermal advection, potentially weakening the internal cooling core of the park. Conversely, compact shapes may retain cool air more effectively.

- **Urban Fabric Interaction:** The literature also suggests that the intensity of the PCI is relative to the surrounding urban morphology. Factors such as the orientation of street canyons, traffic density, and the height-to-width ratio of adjacent buildings influence how effectively the cool air from the park can disperse into the city (Cao et al., 2010; Liao et. al., 2023).

2.4 DIURNAL DYNAMICS OF THE PCI

A critical aspect of PCI research, and one central to this study, is the diurnal variation of cooling intensity. The literature establishes that the PCI is not constant throughout the day. Feyisa, Dons & Meilby (2014) note that the effect typically peaks in the early to mid-afternoon. This temporal peak aligns with the period of maximum solar irradiance, where the differential heating between the transpiring vegetation and the thermal mass of the built environment is greatest.

Conversely, the literature warns that post-sunset dynamics are different. As the sun sets, the PCI effect often diminishes or, in rare cases, reverses. Givoni (1998) attributes this to thermal inertia: the built environment, having high thermal admittance, slowly releases the heat stored during the day, keeping urban temperatures high. The park, lacking this thermal mass, cools rapidly. Therefore, evening PCI is driven less by active cooling and more by the rate of long-wave radiation release from the surrounding urban fabric.

2.5 THE GAP IN TROPICAL RESEARCH

While the mechanisms described above are well-documented in temperate climates, there is a distinct paucity of research in South Asia, and specifically in Sri Lanka. The tropical context, defined by high humidity, low diurnal temperature range, and intense solar radiation, presents a unique set of variables that may alter how PCIs function compared to European or North American models (Hwang et al., 2015). This study aims to bridge this gap by applying a sound empirical approach to the unique case of Viharamahadevi Park. By quantifying the diurnal PCII in this specific locale, this research contributes to the global body of knowledge while providing the formalised evidence necessary for local adaptation frameworks and future urban planning in tropical, warm-humid Colombo.

3. Method

3.1 STUDY AREA JUSTIFICATION

The research centres on Viharamahadevi Park, located in the Cinnamon Gardens precinct of Colombo, Sri Lanka. This site was selected based on three critical criteria relevant to the study of urban microclimates:

1. **Scale and maturity:** As one of the largest and oldest public parks in the city, it possesses a mature, dense tree canopy structure. This significant vegetative mass provides the ideal conditions for generating a stable internal cool air reservoir, necessary for testing the "source-sink" relationship with the city.
2. **Urban context:** The park is embedded within a dense, rapidly changing urban centre. It is surrounded by high-traffic arteries and impermeable built surfaces, creating the high-contrast "Urban Heat Island" conditions required to measure the maximum potential of the cooling effect (Aram et. al., 2019).
3. **Interface:** The park possesses accessible boundaries that allow for unobstructed transect measurements from the green core into the grey infrastructure, facilitating the linear analysis of temperature decay.

3.2 RESEARCH DESIGN

This study employs a quantitative, empirical research design. The core methodological framework is based on the comparative analysis of simultaneous air temperature measurements taken from two distinct environments: the interior of the green space (the park) and the exterior built environment (the urban fabric).

To ensure the data reflects the human experience of thermal comfort, all measurements were recorded at a height of 1.5 meters above ground level. This height corresponds to the average centre of gravity for an adult pedestrian and is the standard protocol for urban microclimate studies, ensuring the results are relevant to public health and walkability discussions.

3.3 DATA COLLECTION PROTOCOL

3.3.1 Temporal Scope

The measurement campaign was conducted over a period of seven days. To control for confounding weather variables, only days with clear, sunny conditions and low wind speeds were selected. These conditions are critical because cloud cover blocks solar radiation (reducing UHI), and high wind speeds mechanically mix the air, dispersing the park's cool island effect. Therefore, selecting calm, clear days ensures the study captures the maximum potential UHI and PCI intensity.

Measurements were synchronised at four specific synoptic intervals to capture the full diurnal hysteresis of the thermal environment:

- **06.30 AM – 07.30 AM (morning):** to observe the residual cooling effects from the night and the initial heating phase.
- **12.30 PM – 01.30 PM (afternoon):** to capture the peak solar load and maximum thermal stress.
- **03.30 PM – 04.30 PM (late afternoon):** to analyse the persistence of cooling as solar angles decline.
- **06.30 PM – 07.30 PM (post-sunset):** to investigate the radiative cooling phase and the urban heat release.

3.3.2 Instrumentation and Traverse Strategy
A dual-node measurement strategy was employed to ensure accuracy:

1. **The control node (fixed):** A datalogger was installed in a central, shaded location within the park interior. This station continuously recorded the baseline reference temperature (T_{park}) throughout the campaign.

2. **The transect nodes (mobile):** A mobile research team conducted linear transects moving outward from the park edge. Measurements were taken at fixed spatial intervals of 50 meters, extending from the park boundary (0m) up to a distance of 350 meters into the surrounding urban fabric (T_{urban}).

All sensors were shielded from direct solar radiation during recording to ensure the measurement of ambient air temperature rather than solar radiation loading.

3.4 DATA ANALYSIS FRAMEWORK
The raw temperature data were processed to calculate the Park Cool Island Intensity (PCII). The PCII is defined as the magnitude of the temperature difference between the urban environment and the park interior. The standard equation applied was:

$$PCII = T_{urban} - T_{park}$$

Where a positive value indicates a functional cooling effect (the park is cooler than the city).

To validate the findings scientifically, the data were subjected to a 'one-sample t-test'. This statistical test was chosen to determine if the observed differences in mean temperatures were statistically significant or merely due to random chance.

The significance level (alpha) was set at $p < 0.05$.

The statistical hypotheses were defined as:

- **Null hypothesis (H_0):** $\mu_{park} = \mu_{urban}$ (there is no significant temperature difference).
- **Alternative hypothesis (H_1):** $\mu_{park} < \mu_{urban}$ (the park is significantly cooler than the urban area).

3.5 SCOPE AND LIMITATIONS
In strict adherence to academic transparency, the following limitations are acknowledged:

1. **Urban mean definition:** The "urban" temperature (T_{urban}) is derived from the transect points extending 350m from the park. The study does not calculate a global mean air temperature for the entire city of Colombo, but rather focuses specifically on the *local* interaction between the park and its immediate context.

2. **Parameter restrictions:** The current scope is limited to air temperature (Ta). While factors such as relative humidity, wind speed, and mean radiant temperature are vital for a complete thermal comfort assessment (e.g., PET indices), they were outside the logistical scope of this specific campaign.

3. **Seasonal variance:** The data represent clear-day conditions during a specific inter-monsoonal window. Seasonal variations, particularly during heavy monsoon rains, may alter these dynamics and merit future longitudinal study.

4. Data analysis

4.1 STATISTICAL VALIDATION OF THE COOLING EFFECT
The primary analytical task was to validate the existence of the park cool island (PCI) effect through statistical testing. The results of the one-sample t-tests confirm that Viharamahadevi Park functions as a significant cold source relative to its context across all measured timeframes.

The statistical output (refer to Table 1) presents indisputable evidence for rejecting the null hypothesis:

Table 1 - Data on the mean variation of air temperature with distance over a 7-day period from the boundary of Viharamahadevi Park. Source - Author

The Variation between Avarage Air temperature & Distance									
	Tpark	0 m	50 m	100 m	150 m	200 m	250 m	300 m	350 m
6.30AM - 7.30AM	27.96	29.10	30.25	31.40	32.05	32.51	32.93	33.02	32.77
12.30PM - 1.30PM	28.76	29.19	31.28	31.84	33.20	33.15	33.20	33.32	33.26
3.30PM - 4.30PM	28.56	28.79	29.40	30.05	30.42	30.30	30.92	31.30	31.25
6.30PM - 7.30PM	26.84	28.14	28.30	28.40	28.53	28.63	28.64	28.76	28.90

06.30 AM - 07.30 AM

```
> summary(Tpark)
Min. 1st Qu. Median Mean 3rd Qu. Max.
27.70 27.85 27.90 27.96 28.05 28.30
```

One-Sample t-test

```
data: X06_30AM_07_30AM$`T - Urban`
t = 43.657, df = 6, p-value = 9.669e-09<0.05
Alternative hypothesis: true mean is not equal to
27.96
95 percent confidence interval:
31.53145 31.95556
Sample estimates:
mean of x
31.7435
```

12.30 PM - 01.30 PM

```
> summary(Tpark)
Min. 1st Qu. Median Mean 3rd Qu. Max.
28.50 28.65 28.70 28.76 28.87 29.10
```

One-Sample t-test

```
data: X12_30PM_01_30PM$`T - Urban`
t = 29.774, df = 6, p-value = 9.519e-08<0.05
Alternative hypothesis: true mean is not equal to
28.76
95 percent confidence interval:
32.01344 32.59608
Sample estimates:
mean of x
32.30476
```

03.30 PM - 04.30 PM

```
> summary(Tpark)
Min. 1st Qu. Median Mean 3rd Qu. Max.
28.30 28.45 28.50 28.56 28.65 28.90
```

One-Sample t-test

```
data: X03_30PM_04_30PM_$`T - Urban`
t = 9.2675, df = 6, p-value = 8.923e-05<0.05
Alternative hypothesis: true mean is not equal to
28.56
95 percent confidence interval:
29.84321 30.76393
Sample estimates:
mean of x
30.30357
```

06.30 PM - 07.30 PM

```
> summary(Tpark)
Min. 1st Qu. Median Mean 3rd Qu. Max.
26.60 26.63 26.70 26.80 26.90 27.20
```

One-Sample t-test

```
data: X06_30PM_07_30PM$`T - Urban`
t = 30.754, df = 6, p-value = 7.846e-08<0.05
Alternative hypothesis: true mean is not equal to
26.8
95 percent confidence interval:
28.39981 28.67638
Sample estimates:
mean of x
28.5381
```

Figure 1 - Results of the Statistical T–Test between the average temperature around Viharamahadevi Park and the temperature inside Viharamahadevi Park. Source - Author

- **Morning (06.30 AM – 07.30 AM):** The temperature difference was statistically significant with a p-value of 9.669* 10^{-9}.
- **Midday (12.30 PM – 01.30 PM):** The peak heating period showed the highest significance, with a p-value of 9.519*10^{-8}.
- **Late afternoon (03.30 PM – 04.30 PM):** Significance persisted with a p-value of 8.923*10^{-5}.
- **Evening (06.30 PM – 07.30 PM):** Even post-sunset, the difference remained significant with a p-value of 7.846*10^{-8}.

In all instances, the p-values were substantially lower than the 0.05 threshold ($p < 0.05$), statistically confirming that the lower temperatures within the park are not random anomalies but the result of consistent microclimatic performance.

4.2 ANALYSIS OF TEMPORAL VARIATIONS (DIURNAL PATTERNS)

The analysis of the mean temperature data reveals a distinct diurnal "pulse" in the park's performance. The data indicate that the cooling intensity is not static but expands and contracts in correlation with solar altitude and urban thermal inertia.

- 07:00 am (morning phase):
  The park exhibits a surprisingly robust cooling effect immediately after sunrise. The mean park temperature was recorded at 27.96 0C, while the surrounding urban mean had already risen to 31.74 0C. This suggests that the park retains cool air accumulated during the night more effectively than the built fabric, which begins heating rapidly as soon as solar radiation strikes the impermeable surfaces.

- 1:00 pm (peak thermal stress phase):
  This interval represents the critical performance window. The park maintained a mean temperature of 28.76 ⁰C, effectively resisting the thermal spike observed in the city, where the mean surged to 32.30 ⁰C. The stability of the park temperature rising only 0.8 ⁰C from morning to midday, compared to the city's steeper rise, demonstrates the high thermal capacity of the vegetation.

- 4:00 pm (transitional phase):
  As solar intensity waned, the park mean settled at 28.56 ⁰C against an urban mean of 30.30 ⁰C. While the gap narrows, the park continues to offer a relief of nearly 2 ⁰C, critical for afternoon commuters.

- 7:00 pm (radiative release phase): Post-sunset, the dynamic shifts. The park cools to 26.80 ⁰C, but the urban fabric, releasing stored heat, remains at 28.54 ⁰C. The cooling intensity is weakest here, confirming that without active solar evaporation, the PCI effect relies on the differential cooling rates of materials.

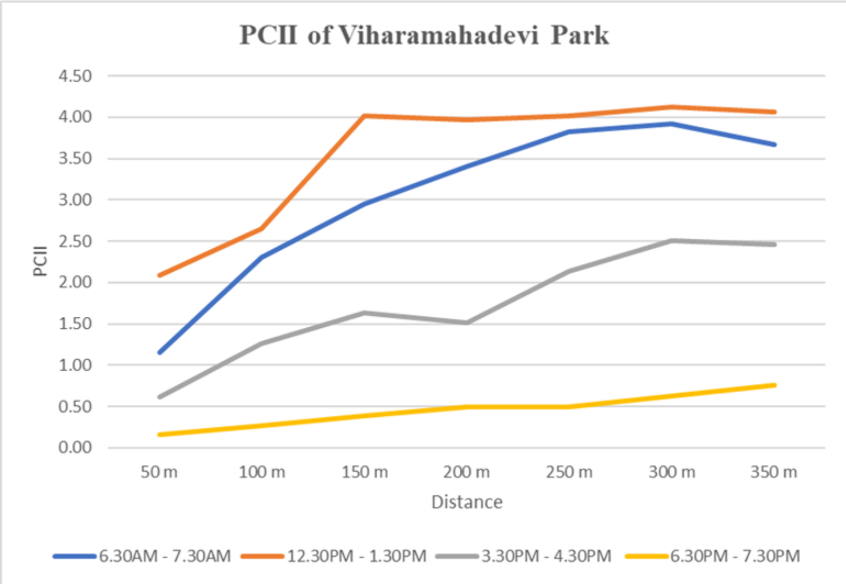

Figure 2 - Result of Park Cool Island Intensity (PCII) with distance around Viharamahadevi Park. Source - Author

4.3 SPATIAL ANALYSIS: THE DISTANCE-DECAY GRADIENT

The most critical finding of this research is the spatial behaviour of the cooling effect, detailed in Table 1 and visualised in Figure 2. The data reveals that the "Cool Air Bubble" does not end abruptly at the park wall but bleeds into the city, degrading over distance.

- The "Edge Effect" (0m - 50m):
  At 13:00, the temperature jump from the park interior (28.76 ⁰C) to the immediate 50m boundary is sharp. However, the PCII at 50m is 2.09 ⁰C. This indicates that the immediate park perimeter benefits significantly from spillover cooling.
- The "Cooling Halo" (100m - 300m):
  Contrary to linear decay, the cooling intensity actually increases or stabilises up to 300 meters in the afternoon. At 13:00, the PCII spikes to 4.01 ⁰C at 150m and peaks at 4.13 ⁰C at 300m. This non-linear anomaly suggests complex airflow patterns or canyon shading effects interacting with the park breeze, creating pockets of maximum relief deep within the urban fabric.
- The "Urban Equilibrium" (350m+):
  By 350 meters, the cooling effect begins to plateau or drop slightly (to 4.07 ⁰C at 13:00). This suggests that the effective "reach" of Viharamahadevi park's cooling influence under these specific conditions is approximately 300-350 meters. Beyond this point, the anthropogenic heat of the city overwhelms the park's influence.

5. Discussion

5.1 INTERPRETATION OF DIURNAL THERMAL DYNAMICS

The empirical results of this study validate the core hypothesis, confirming that Viharamahadevi Park functions as a high-performance thermal sink within Colombo's urban matrix. However, a critical analysis of Figure 2 (the diurnal PCII graph) reveals that this cooling function is not uniform; it exhibits a complex temporal behaviour governed by solar inclination and the differing thermal properties of biotic (vegetation) vs. abiotic (concrete/asphalt) materials.

The peak Park Cool Island Intensity (PCII) observed at 12.30 PM – 01.30 PM (maximum T = 4.13 ^{0}C) aligns with the theoretical maximum of solar irradiance. Currently, the "thermal admittance" mismatch is greatest. The urban fabric, characterised by low albedo and high thermal mass, absorbs incoming short-wave radiation and converts it to sensible heat. Conversely, the park actively consumes this energy through latent heat exchange (evapotranspiration). The magnitude of this midday difference (>4 ^{0}C) is significant for a tropical city, suggesting that the park effectively decouples itself from the regional heating trend of the city during peak stress hours. A notable analytical finding, visible in the morning (06.30 AM – 07.30 AM) curve of Figure 2, is the retention of cool air. The high PCII (3.92 ^{0}C) shortly after sunrise suggests that Viharamahadevi Park acts as a "nocturnal cold reservoir". While the impermeable urban surface heats up rapidly the moment the sun rises (due to low specific heat capacity), the moisture-rich park environment resists this temperature spike. This "thermal lag" is a critical ecosystem service, providing a cool start to the day for commuters and residents.

Conversely, the evening (06.30 PM – 07.30 PM) data reveals the limitations of the PCI effect. The sharp drop in cooling intensity to 0.76 ^{0}C indicates that once the active driver of evapotranspiration (solar energy) is removed, the park's cooling power diminishes. Furthermore, the surrounding urban fabric begins to release its stored heat (long-wave radiation) into the canopy layer. This suggests that while the park is an excellent *daytime* moderator, its passive cooling capacity at night is overwhelmed by the anthropogenic heat flux of the surrounding city.

5.2 ANALYSIS OF SPATIAL GRADIENT AND EDGE EFFECTS

A critical examination of the spatial data in Table 1 and Figure 2 reveals a counter-intuitive "distance-decay" pattern that requires detailed explanation.

Standard theory suggests the cooling effect should be strongest near the park and fade linearly with distance. However, our data shows an inverse spatial curve during the day:

- **The edge anomaly (0m - 100m):** At 12.30 PM – 01.30 PM, the cooling intensity at 50m is only 2.09 ^{0}C, significantly lower than at 300m. This indicates a "transition zone" or boundary layer where hot urban air mixes with the cool park air, diluting the effect. Additionally, the immediate perimeter of Viharamahadevi Park is flanked by high-traffic corridors. The waste heat from vehicles (anthropogenic heat discharge) likely degrades the cooling benefit at the immediate edge.

- **The distant peak (150m - 300m):** the PCII climbs steadily to peak at 300m (4.13 ^{0}C). This finding implies that the "urban" reference points at this distance are experiencing the full brunt of the UHI effect, unmitigated by the park. Therefore, the *contrast* between the deep city heat and the stable park temperature is maximised here. This characterises the park not just as a local cooler, but as a distinct climatic zone that stands in sharp relief against the overheating city.

5.3 IMPLICATIONS FOR LANDSCAPE ARCHITECTURE AND URBAN DESIGN

The data clearly dictate specific design interventions for the profession:

1. **Buffer zone design:** The weaker cooling at the 50m edge suggests that landscape architects must design more robust "buffer zones." The current edge condition allows too much thermal mixing. Future Park perimeters should employ multi-layered vegetation strategies (dense shrubs coupled with high canopy trees) to physically trap cool air inside and block the ingress of vehicular heat, thereby extending the high-performance zone closer to the boundary.
2. **Network connectivity:** Since the cooling effect remains statistically significant ($p<0.05$) but degrades after 350m, this sets a "module" for urban planning. To achieve continuous thermal comfort in Colombo, green spaces should ideally be spaced no more than 600m-700m apart (allowing for a 300-350m cooling radius from each node). This supports a "green network" approach rather than isolated mega-parks.
3. **Species selection:** The high performance during midday confirms the reliance on evapotranspiration. Landscape architects must prioritise species with high transpiration rates and broad leaf area indices (LAI) over purely ornamental species to maximise this latent heat exchange.

5.4 SCOPE AND FUTURE RESEARCH DIRECTIONS

While this study provides a robust baseline, the scope and limitations must be acknowledged to contextualise the findings. The study focused on air temperature (Ta) as the primary metric. However, human thermal comfort is also dictated by humidity and wind. Future research should deploy hygrometers to measure the "humidity index", as the added moisture from trees could potentially increase discomfort in a tropical city if wind flow is blocked. Additionally, the study was limited to clear-sky days; investigating the park's performance during overcast monsoon days would provide a complete annual picture. Finally, correlating these temperature gradients with a specific "Sky View Factor" (SVF) analysis of the surrounding streets would refine the understanding of why the peak occurs specifically at 300m.

6. Conclusion

6.1 SYNTHESIS OF FINDINGS

This research set out to quantify the diurnal Park Cool Island Intensity (PCII) of Viharamahadevi Park, addressing a critical gap in empirical microclimatic data for Colombo, Sri Lanka. Through a statistically validated measurement campaign, the study has moved beyond anecdotal assumptions to provide a precise characterisation of the park's performance.

The results reject the null hypothesis ($p<0.05$), confirming that Viharamahadevi Park functions as a climatic moderator. The study established that the park generates a cooling differential of up to 4.13 ^{0}C during the hours of peak thermal stress (12.30 PM – 01.30 PM). This magnitude of cooling is substantial, verifying that the mature vegetation structure of the park is capable of offsetting the intense solar gains of the tropical urban environment.

6.2 CRITICAL CONTRIBUTIONS

The detailed analytical contribution of this study lies in the identification of the temporal and spatial limits of this cooling:

1. **Temporal:** the park is a "Daytime Warrior." Its efficiency is maximal when the sun is high, driven by active shading and evapotranspiration. Its capacity to cool the city at night is significantly lower (0.76 ^{0}C), limited by the thermal inertia of the surrounding built fabric.
2. **Spatial:** the study identified a "Distance-Decay" curve that is non-linear. The discovery that the cooling contrast peaks at 300m from the edge challenges simplistic design assumptions and highlights the negative impact of vehicular heat flux at the immediate park boundary.

6.3 FINAL STATEMENT

In the face of rapid vertical densification and the associated warming trends in Colombo (0.16 ^{0}C increase per decade), Viharamahadevi Park acts as more than a recreational space; it is a piece of vital thermal infrastructure. This research provides empirical evidence that policymakers need to treat urban greening as a thermal comfort and a public health necessity. For the landscape architect, the directive is clear: design for maximum canopy density, reinforce park edges against thermal intrusion, and advocate for a connected grid of green spaces to overlap these 350m cooling halos, thereby ensuring a resilient, liveable future for Colombo.

7. References

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