EVALUATING THE EFFECTS OF OUTDOOR MICROCLIMATE IN AN URBAN PARK THROUGH LANDSCAPE

A Thesis

Submitted in partial fulfillment of the requirements for the award of
Master of Architecture degree in Sustainable Architecture

by

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MAY 2021

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BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **REWANTH INFANT S (39890014)** who carried out the Thesis entitled "**EVALUATING THE EFFECTS OF OUTDOOR MICROCLIMATE IN AN URBAN PARK THROUGH LANDSCAPE"** under our supervision from January 2021 to May 2021.

Sheetal. A.

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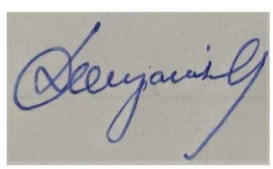

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Submitted for Viva voce Examination held on 31.05.21

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Internal Examiner **External Examiner**

DECLARATION

I **REWANTH INFANT S (39890014)** hereby declare that the Thesis Report entitled "**EVALUATING THE EFFECTS OF OUTDOOR MICROCLIMATE IN AN URBAN PARK THROUGH LANDSCAPE**" done by me under the guidance of **Ar. SHEETAL AMROATKAR** (Internal) and **Ar. BALAMURUGAN RAJKUMAR, Principal Architect -Proton Ateliers**/ **Ar. P.S. GANESH, Principal Architect – GREENVIRON /** (External) at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Master of Architecture degree in Sustainable Architecture.

DATE:

PLACE: **SIGNATURE OF THE CANDIDATE**

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I wish to express my thanks to all Teaching and Non-teaching staff members of the Department of Architecture who were helpful in many ways for the completion of this Thesis.

ABSTRACT

The outdoor human comfort in an urban environment has been affected by many physiological factors like air, wind, temperature, relative humidity and solar radiation.

This Thesis explains and indulges in the study of these physiological factors and reveals the integrated effects of these physiological factors to the perception and overall comfort of human in an residential township.

The study concentrates on the changes in the level of comfort due to the variation in the urban landscape and the change it creates on the urban heat island effect. Various onsite and offsite features are studied and the conclusion of the change in the microclimate is conceived through the landscape with both field measurements and simulations.

The observed study findings are applied to iterated proposals and the findings from these proposals are postulated for future references.

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LIST OF SYMBOLS AND ABBREVIATIONS

T_a	-	Air Temperature
T_{mrt}	-	Mean Radiant Temperature
V	-	Wind Speed
RH	-	Relative humidity
PET	-	Physiological equivalent temperature
SVF	-	Sky view factor
U value	-	Thermal Transmittance
R value	-	Thermal Resistance
CSEB	-	Compressed Stabilized Earth Blocks

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

In an outdoor space, people are involved in many activities, like sitting, standing, playing, etc. They experience various sensations (Thermal Sensation, Humidity Sensation, Wind Sensation) .while carrying out these activities. In order to continue these activities, they need to feel comfortable. To understand the behavior of people in these spaces and in order to design comfortable outdoor spaces, it is very important to understand the microclimate of that place in detail.

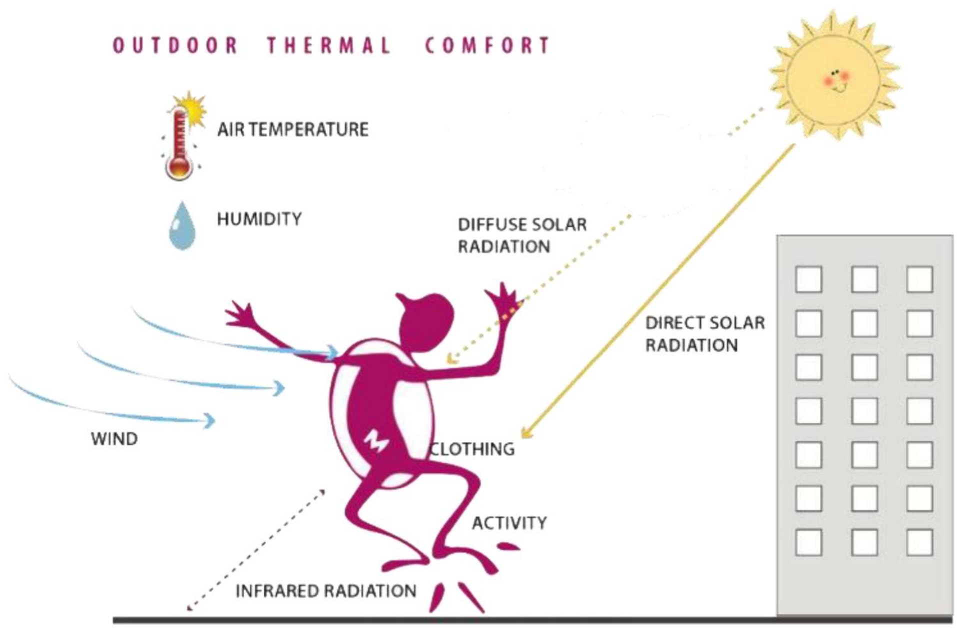


Fig 1

For that, it is necessary to understand two important factors as follows:-
Aspects of Outdoor Thermal Comfort
Landscaping elements that influence the microclimate of any place

1.2.Aim
The aim of this research Thesis is to review the influence of landscape in semi-outdoor spaces and analyze the thermal variation it imparts on the building by formulating different landscape strategies.

1.3.Objectives involved
- To identify the outdoor thermal comfort parameters and indices.
- To study the different landscape elements and develop strategies for outdoor spaces.
- To quantify the value of outdoor thermal comfort in specified areas through simulations from Envi-Met.
- To find out critical point from the about analysis and formulate solutions through strategies.

1.4.Scope
The scope of the Study involves both subjective and objective approach towards the development of new sustainable landscape strategies in the area of outdoor thermal comfort(OTC).

1.5.RESEARCH QUESTION

- How to find out the critically underperforming areas in the outdoor spaces of the building ?
- How to comparatively strategize the solution and bring out the best possible outcome of the simulation?

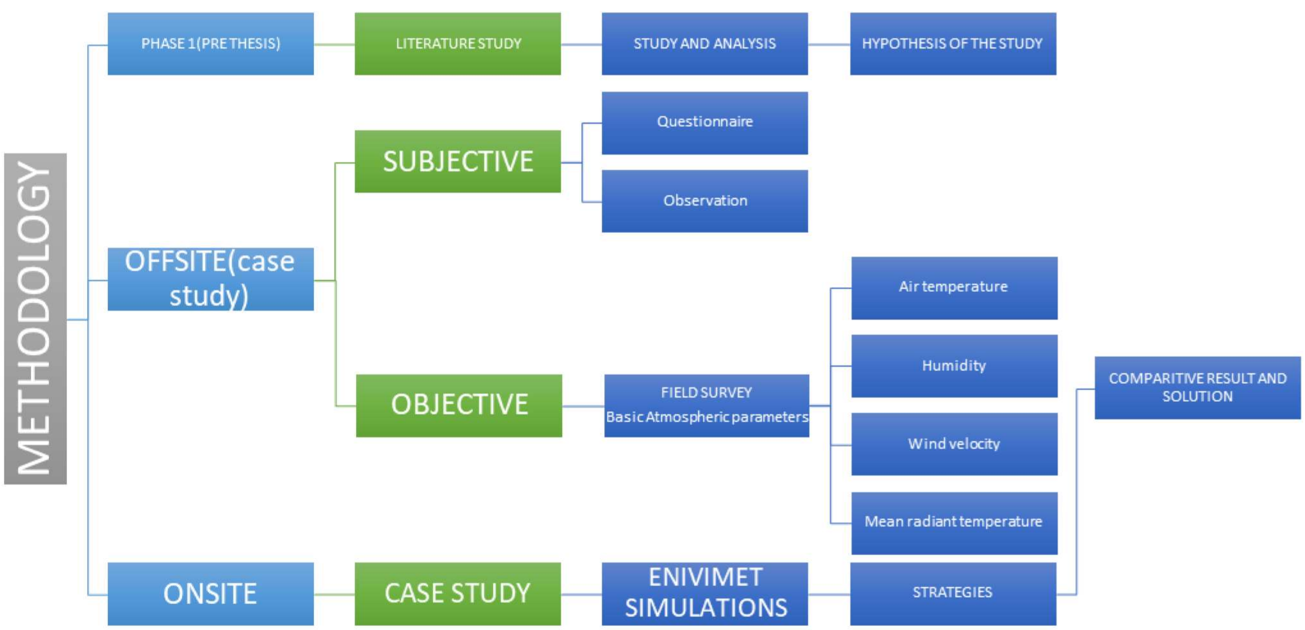
1.6.Limitations

Due to the effect of landscape on the building the scope of the research will be restricted to the open spaces like

COURTYARDS
VERANDAS
CORRIDOR
PATHWAYS
OAT

These spaces notice a major impact when landscaping comes into effect and these spaces actually affect the thermal comfort of the indoors too.

Methodology



2.CASE STUDY 1: "Effects of Landscape Design on Urban Microclimate and Thermal Comfort in Tropical Climate"

Abstract

A climate-responsive landscape design can create a more livable urban microclimate with adequate human comfortability. This paper **aims to quantitatively investigate the effects of landscape design elements of pavement materials, greenery, and water bodies** on urban microclimate and thermal comfort in a high-rise residential area in the tropic climate of Singapore.

A comprehensive field measurement is undertaken to obtain real data on microclimate parameters for calibration of the microclimate-modeling software ENVI-met 4.0. With the calibrated ENVI-met, **seven urban landscape scenarios are simulated** and their **effects on thermal comfort** as measured by physiologically equivalent temperature (PET) are evaluated. It is found that the maximum improvement of PET reduction with suggested landscape designs is about 12℃, and high-albedo pavement materials and water bodies are

not effective in reducing heat stress in hot and humid climate conditions. The combination of shade trees over grass is the most effective landscape strategy for cooling the microclimate. The findings from the paper can equip urban designers with knowledge and techniques to mitigate urban heat stress.

2.1STUDY AREA

- The study area is two residential quarters at Bedok in southeast Singapore as shown in Figure 1. Bedok is an urban residential zone for new development in Singapore.

2.1.1.Field Measurements

Field measurements were conducted at the study area from 13 April to 06 June 2012. The purpose of field measurements is to validate ENVI-met modeling results and also help define the initial conditions of the general model of ENVI-met.

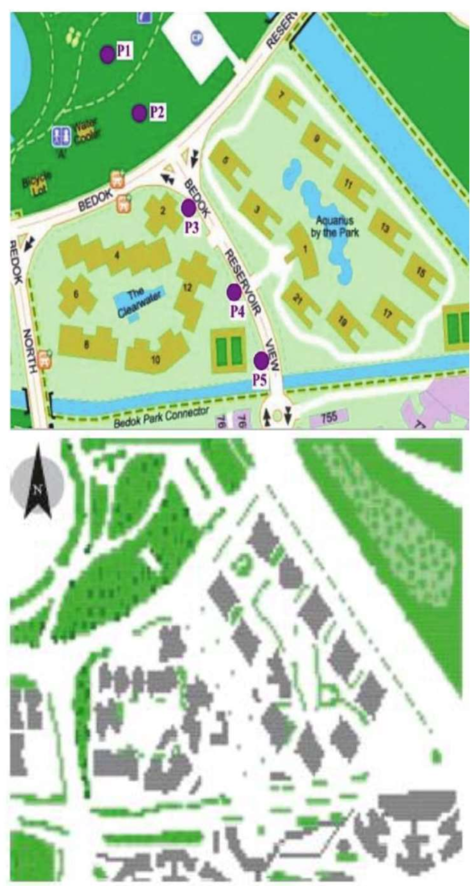
TABLE 1: Equipment used for field measurement.

Variable	Instrument	Accuracy
Air temperature/ relative humidity	HOBO U12-012 Temp/RH Data Logger	±0.35°C from 0°C–50°C to a maximum of ±3.5%
Globe temperature	HOBO Thermocouple Data Logger, U12-014 with Type-T Copper-Constantan thermocouple sensors and 40 mm diameter ping pong ball	±1.5°C
Wind speed	Onset Wind Speed Smart Sensor, S-WSA-M003	±1.1 m/s or ±4% of reading, whichever is greater
Short- and long-wave radiation	Kipp & Zonen, CNR 4 with integrated pyranometer, pyrgeometer, Pt-100, and thermistor	Pyranometer: <5% uncertainty (95% confidence level) Pyrgeometer: <10% uncertainty (95% confidence level) Pt-100/thermistor: ±0.7°C

The parametric study consists of a base case and seven design scenarios. The base case was constructed according to the actual conditions of the study area. The model domain covers the entire area of the study area and is expanded to the surrounding buildings, streets, and an urban park.

TABLE 2: Boundary conditions and initial setting of the ENVI-met model.

Location	Singapore 103°51′E, 1°18′N
Climate	Tropical climate
Date/time simulated	From 04:00 to 22:00 (18 h) on 30 April 2012
Model domain	Bedok: 150 × 98 × 30 grids $\Delta x = \Delta y = \Delta z = 4$m Note: vertical grid with the equidistant method
Meteorological inputs	Air temperature and relative humidity: hourly data from the measurement on-site Wind speed and direction: hourly data from the meteorological station Specific humidity (2500 m) = 7 g/kg
Initial soil temperature and relative humidity	Upper layer (0–20 cm): 305 K/30% Middle layer (20–50 cm): 307 K/40% Deeper layer (below 50 cm): 306 K/50%
Building conditions	Inside temperature = 293 K (constant) Heat transmission walls = 1.94 W/m^2·K Heat transmission roofs = 6 W/m^2·K Albedo walls = 0.2 Albedo roofs = 0.3
Plants	Trees: 10 m dense, leafless base Trees: 20 m dense, leafless base Grass: 20 cm average dense



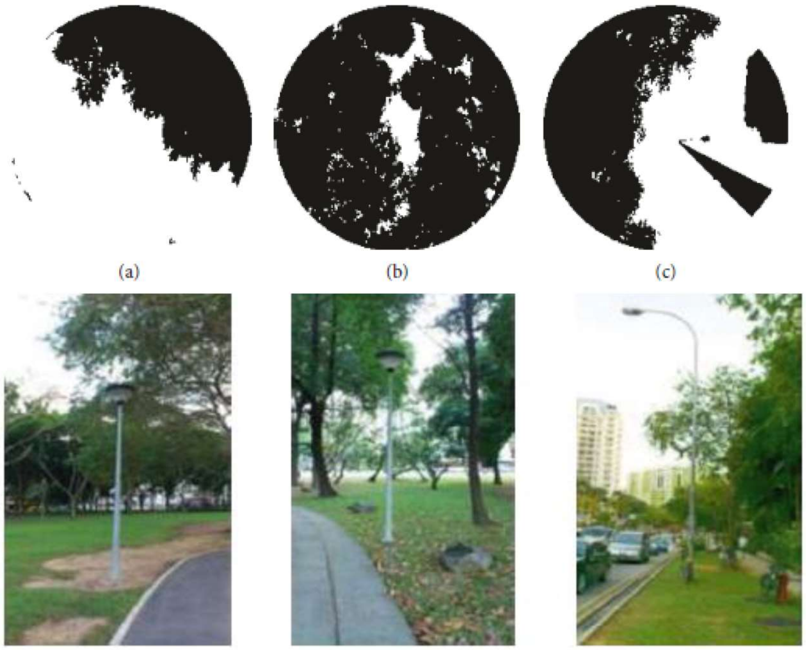
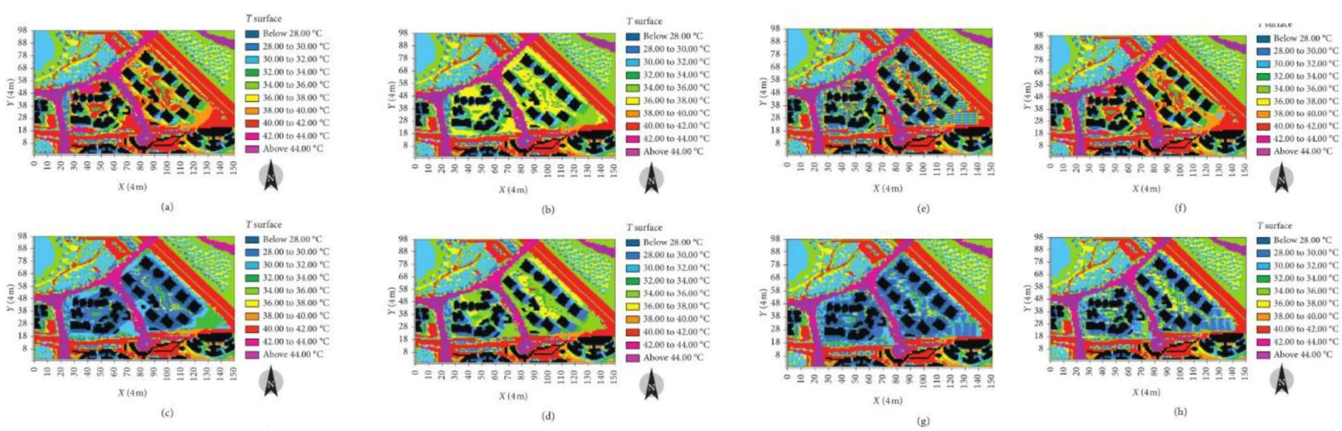


Figure 3: Photos and fisheye photos for each location (measurements were taken at 2.0 m above the ground level).

(a) Point 1 (SVF - 0.61)

(b) Point 2 (SVF - 0.17).



Simulated surface temperature for all design scenarios.
(a) Base case. (b) Scenario 1 (wooden boards). (c) Scenario 2 (light-color granite). (d) Scenario 3 (grass surface). (e) Scenario 4 (more trees). (f) Scenario 5 (more water bodies). (g) Scenario 6 (light-color granite + more trees). (h) Scenario 7 (grass surface + more trees).

2.1.2.Inference – Surface temperature

The differences in surface temperatures are obvious. Pavement with light-color granite (Scenario 2) has the lowest surface temperature, with a maximum reduction of 12°C compared with the base case.
Surface temperature reduction by grass surfacing (Scenario 3) and adding more trees (Scenario 4) is also obvious, with a reduction by up to 8°C for grass and 10°C for trees.
Surface temperature reduction by applying wood pavement (Scenario 1) can be up to 6°C. Not much difference in surface temperature can be found by adding more water bodies.

Both Scenario 6 (combination of light-color granite and adding more trees) and Scenario 7 (combination of grass surfacing and adding more trees) resulted in a significant reduction of surface temperature. However, Scenario 6 is more effective in reducing the surface temperature than Scenario 7.

TABLE 3: Different design scenarios for Bedok.

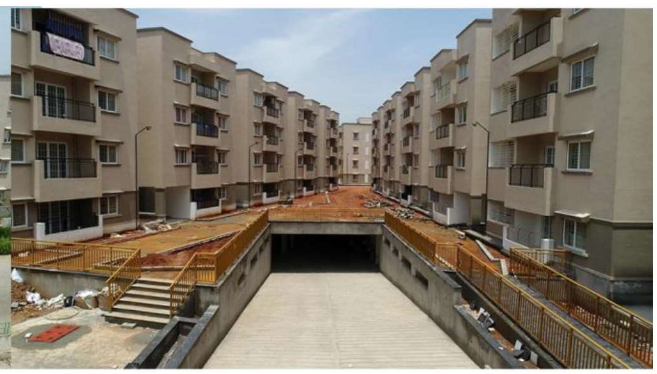
Design scenario	Pavement materials	Vegetation and water body
Base case	Red brick (ID: KK) and concrete pavement (ID: PP)	Sparse trees and grass Small area of water bodies ($30\,m^2$)
Scenario 1	Wooden boards (ID: WD)	As base case
Scenario 2	Light-color granite (ID: G2)	As base case
Scenario 3	Grass surface	As base case
Scenario 4	As base case	Add more trees (increase by 200%)
Scenario 5	As base case	Add more water bodies (increase by 200%)
Scenario 6	Light-color granite (ID: G2)	Add more trees (increase by 200%)
Scenario 7	Grass surface	Add more trees (increase by 200%)

3.0.BOLLINENI HILLSIDE PHASE 2

Bollineni Hillside is an integrated residential township spread across 92 acres, with about 50% open space. The first phase is spread over 52 acres with 1300 dwelling units.Bollineni Hillside phase 2 is an integral part of Bollineni Hillside Township. It is spread on 6.5 acres abetting our 50 feet road and Perumabakkam main road. It has 383 units of 1, 2, 2.5 & 3 BHK apartments variant with G + 3 structures.

Location : Arasankalani,sithalapakkam Chennai
Total no of houses : 382 units
Typology of houses: 1,2,2.5&3 bhk
Neighbourhood blocks

Four point of study are selected and these enclosed landscape areas are measured for the influence they are impacting on the neighboring building. The study areas are assessed for typology of landscapes used and the nature of pavement which is enclosed by the buildings.


3.1.Study area Description

Site area - 10,039.08 m²

The study area is bollineni hillside park 2 which is located in between 3 major residential blocks on three sides and a empty site to the eastern side .The southern part consists of G+1 ,whereas the western side there is a G+4 apartment block and in the northern side there is a club house and recreation center. The site has 2 major open entrances one on the northern side and other on the western side.

The side is abutted by 30 ft roads on all side. Pavements on both sides with trees on either side which shades the pavement all along.

Field measurements

Four point of study is identified in the site to justify the distinctness of the space and the material. The HOBO weather station device is placed in the open grass lawn which identifies the data for air temperature and humidity reading for an interval of 1 min.

Point 1 - Open Grass lawn

Point 2 - Shaded seating area

Point 3 - Concreted Basket ball Court

Point 4 - Amphitheater

Site Justification

STRENGTH

The park socially and climatologically connects the residents where 3000+ habitants are living and a need for social connectivity is an important role.

WEAKNESS

The site is having very scare vegetation planning so the park doesn't perform fine hence the southern radiation directly heats up the park and the neighbouring spaces.

OPPORTUNITIES

The sites location being in a large residential township, a change in the landscape would influence the microclimate drastically and also gives an opportunity for landscape design to alter the space.

Threat

The site is located in a warm and humid place hence a thorough study of landscape is required to not raise the level of humidity in the space.

References

- **References-** to be arranged in alphabetical order with respect to 1st author with the initials at the end for all the authors.)

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Follow APA format for paper reference and citations

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ANNEXURE