

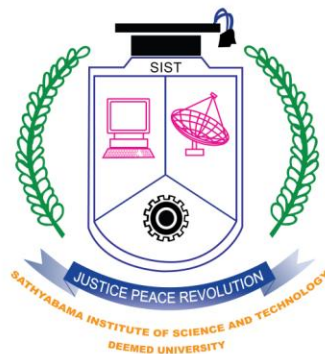
EFFECTS OF THE URBAN STREETS REDEVELOPMENT ON MICROCLIMATE AND THERMAL COMFORT IN CHENNAI

A Thesis

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

by

DEEPIKA A (40890004)



**DEPARTMENT OF ARCHITECTURE
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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600 119**

MAY 2022



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BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **DEEPIKA A (40890004)** who carried out the Thesis entitled "**EFFECTS OF THE URBAN STREETS REDEVELOPMENT ON MICROCLIMATE AND THERMAL COMFORT IN CHENNAI**" under our supervision from January 2022 to May 2022.

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I **DEEPIKA A** hereby declare that the Thesis Report entitled “**EFFECTS OF THE URBAN STREETS REDEVELOPMENT ON MICROCLIMATE AND THERMAL COMFORT IN CHENNAI**” is done by me under the guidance of **Ar. SHEETAL AMRAOTKAR** (Internal) and **AR.R.BALAMURUGAN** (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:

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ABSTRACT

Although the urban morphology can significantly affect local microclimates, planning of street development largely ignores opportunities to design for improved thermal environments. Because of the complex connections between air temperature, relative humidity, wind speed, and micro-scale landscape factors, the urban microclimate both influences and is influenced by human behaviour and decision-making. With an increase in population, there is a rapid change in urban growth, while its impact on the microclimate is widely neglected. The urban settlement pattern determines the outdoor microclimate condition which affects the building's energy demand. Policies governing urban development should take into account the impact of urban heat islands and thermal comfort on climate change. This study aims to compare the impact of the urban street before and after the redevelopment can have on microclimatic conditions and thermal comfort in outdoor urban spaces. The objective is to highlight the relationship between street design criteria and the thermal comfort of the area. To study how the microclimate is influenced by the urban street design and to rank design parameters based on their influence on pedestrian comfort indices. Analyzing and comparing the results will aid in setting guidelines for the new development rules, considering microclimate.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The streets are redeveloped to cater to the needs of all users and activities, through equitable allocation of road space. A Complete Streets Policy prioritizes the creation of walking and cycling infrastructure in the city while simultaneously redressing the focus from private motor vehicle infrastructure. (1)

1.2 AIM

To compare the impact of the urban street before and after the redevelopment can have on microclimatic conditions and thermal comfort in outdoor urban spaces.

1.3 RESEARCH QUESTION

- How the urban street design influence the microclimate?
- In what ways design strategies aided in mitigating the microclimate?
- How the microclimate is changed after the redevelopment?

1.4 OBJECTIVE

- To highlight the relationship between street design criteria and thermal comfort of the area.
- To study how the microclimate is influenced by the urban street design.
- To compare the UHI impact between before and after the redevelopment.
- To rank design parameters based of their influence on pedestrian comfort indices.

1.5 NEED OF THE STUDY

A complete street promotes sustainable modes of transport and has the scope to improve local climatic conditions. Trees and plants on streets help absorb pollutants and reducing heat. Well-designed complete streets also help properly capture and channelize rainwater. (1)

The creation of complete streets need to be sustained and long-term, by setting the necessary aspects for the city to achieve. The city will also improve liveability by improving outdoor scenario.

1.6 LIMITATIONS

The simulation and field measurement is limited to summertime.
The study does not include street services such as transformer, storm water drainage and any other utilities below the road surface.

1.7 RESEARCH METHODOLOGY

PHASE 1

Background study – Pedestrian Redevelopment
Literature Case Study

Case Study – Live:

Analysis of redevelopment
User Map analysis
Creating existing scenario 1 Model (after redevelopment).
Simulation on peak hours – extreme temperature – Envimet tool.
Comparative analysis simulated scenario.
Parameters – AT, RH, MRT,TS,WS, UTCI (Environmental Parameters selected from Pre-thesis study)

PHASE 2

FIELD STUDY – SITE

Field measurement during peak hours.
Comparison with simulated results of existing scenario – 12 Location on site.
Iteration development from Base Case - Reference to Case study

PHASE 3

DESIGN DEVELOPMENT

Planning Strategies – By ITDP
UHI Mitigation Strategies
Creating mitigation scenario with combination of strategies applicable

PHASE 4

RESULT & CONCLUSION

Evaluation of each design parameters affecting the microclimate.
Recommendation for new redevelopment of Pedestrian mall proposed by CMA.

CHAPTER 2 BACKGROUND STUDY

2.1 NON-MOTORISED TRANSPORT PLAN

The CMP envisions Chennai as a city with a general sense of well-being, based on the creation of a **quality and dignified environment** in which people are encouraged to walk and cycle, equitable allocation of public space and infrastructure, and equitable access to opportunities and mobility for all Chennai residents.

Aim to **increase the use of cycling and walking** by creating a **safe and pleasant NMT network** of footpaths, cycle tracks, greenways, and other facilities to serve all citizens.

2.2 The proposals under Non-Motorized Transport (NMT) Plan for Chennai are

- Development of Footpath facilities.
- Development of Cyclist-Friendly streets.
- Area-Wise NMT Recommendations.

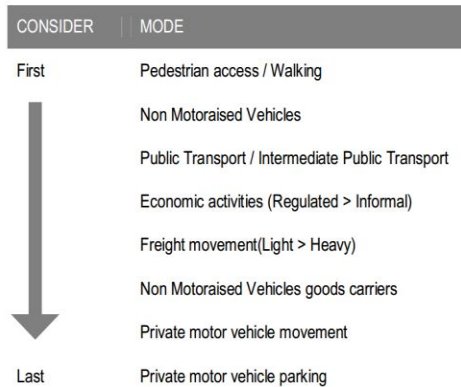


Fig 2.1 Mode hierarchy

S.No	Travel Mode	2008	2018
1	Walk	28.0%	25.1%
2	Bicycle	6.0%	2.9%
3	Auto-rickshaw	4.0%	7.1%
4	Car/van	6.0%	7.1%
5	Two-wheeler	25.0%	29.6%
6	Bus	26.0%	22.6%
7	Train	5.0%	5.6%
	Total	100%	100%

Fig 2.2 Travel mode 2008vs2018

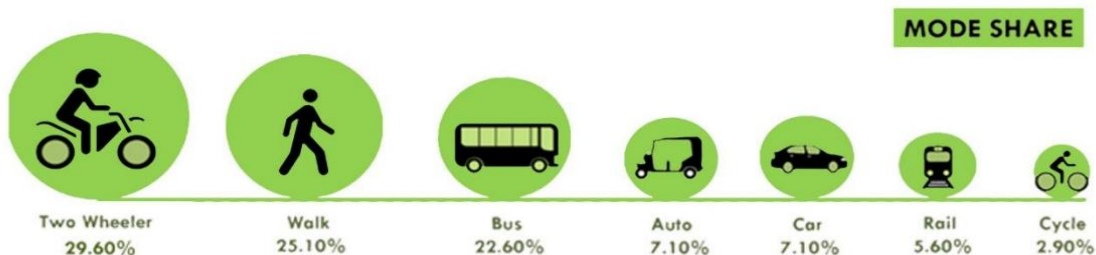


Fig 2.3 Mode share

2.3 COMPLETE STREET

A street designed to cater to the needs of all users and activities, through equitable allocation of road space.

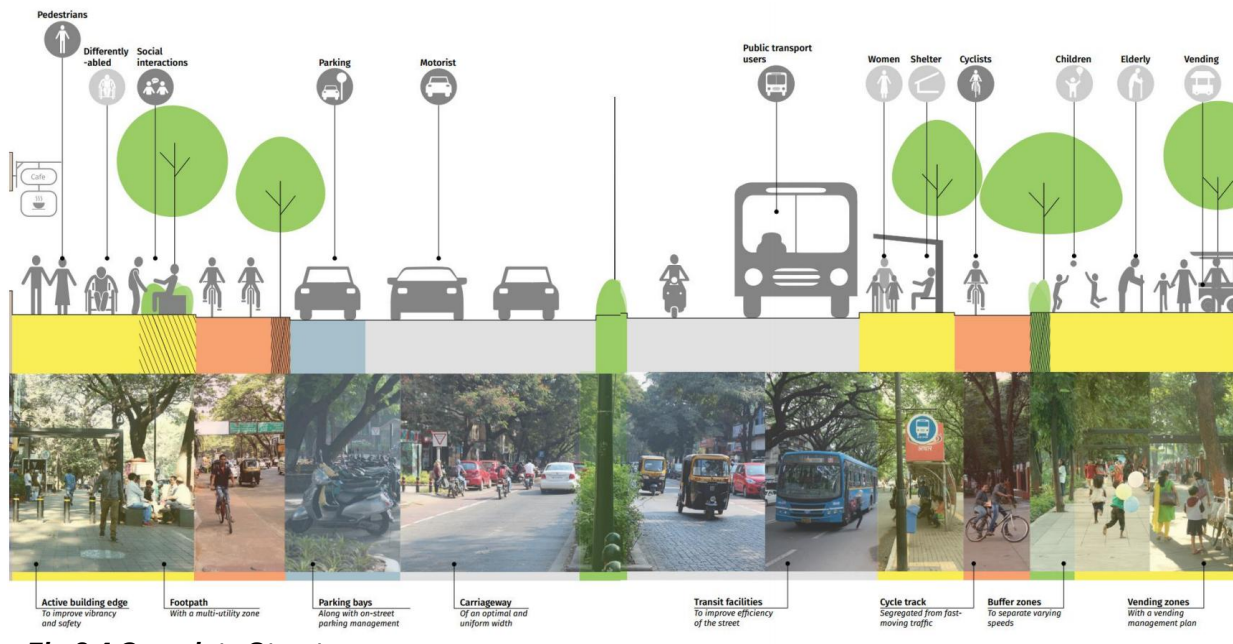


Fig 2.4 Complete Street

STREET SURFACE MATERIAL



Source: Complete Streets Design Guidelines - ITDP

Fig 2.5 Surface Material

CHAPTER 3 LITERATURE CASE STUDY

3.1 Can urban heat be mitigated in a single urban street? Monitoring, strategies, and performance results from a real scale redevelopment project | Carlos Bartesaghi-Koc, Shamila Haddad, Gloria Pignatta, Riccardo Paolini, Deo Prasad, Mattheos Santamouris

The study demonstrates that outdoor thermal comfort can be improved in a single street by decreasing ambient (T_a) and surface (T_s) temperatures by implementing innovative and traditional heat mitigation strategies.

This study focuses on a realistic setting that corresponds to a single street located in the central area of Parramatta, a Local Government Area of the Greater Western Region in Sydney, Australia.

Selection of area based on

- The substantial urban development that has been experiencing in recent years.
- The prolonged urban overheating as sea breezes cannot always reach the west.
- The increasing interest of the local government to improve the thermal comfort conditions in the area due to the pressing challenges that local communities face because of climate change and urban warming.

The local microclimate is generally influenced by the close proximity to the river (causing a wind channeling effect), the geographic distance to the coast, the specific synoptic weather conditions of the region, and the predominant compact urban form and presence of impervious materials.



Fig 3.1 Plan

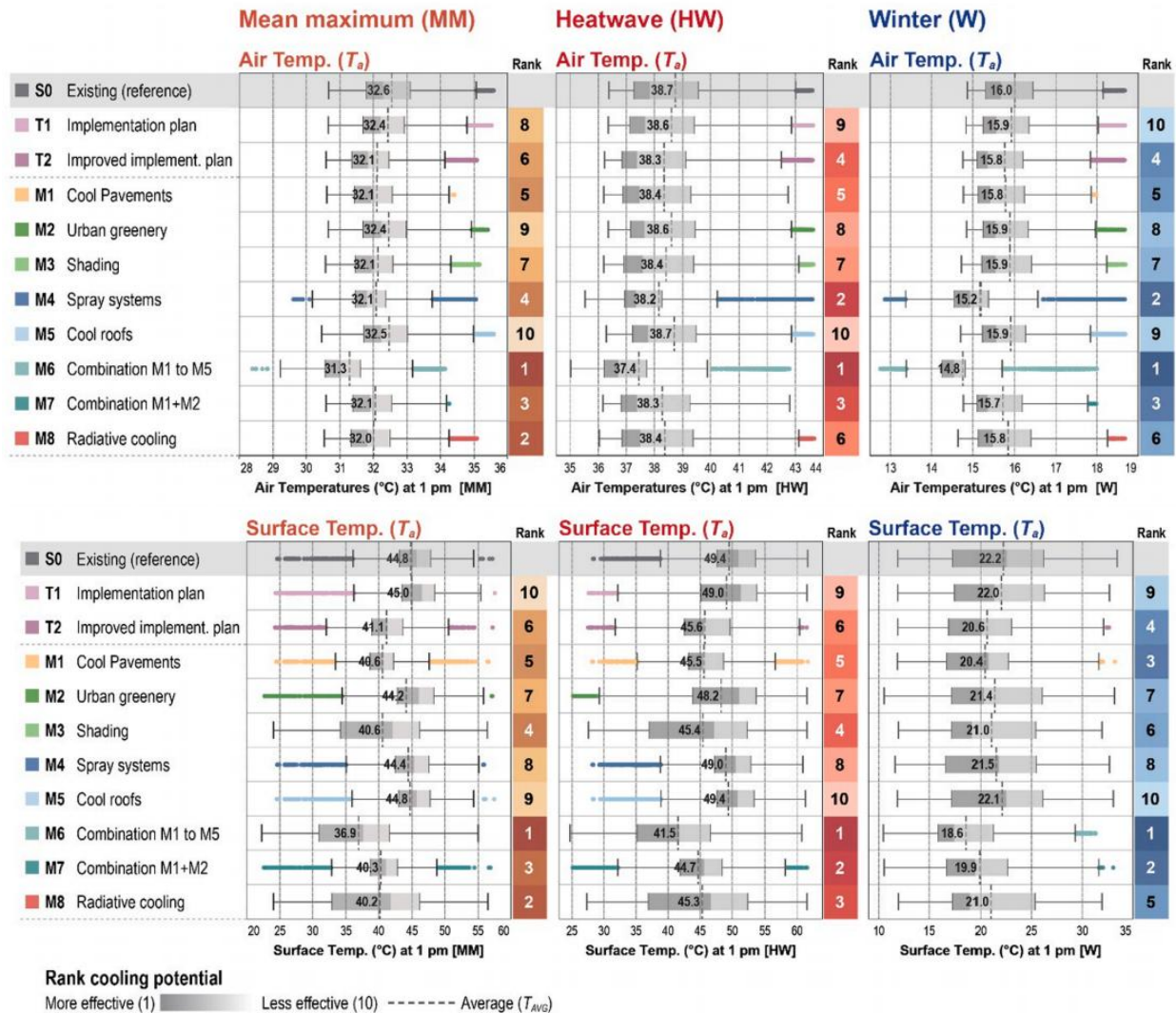


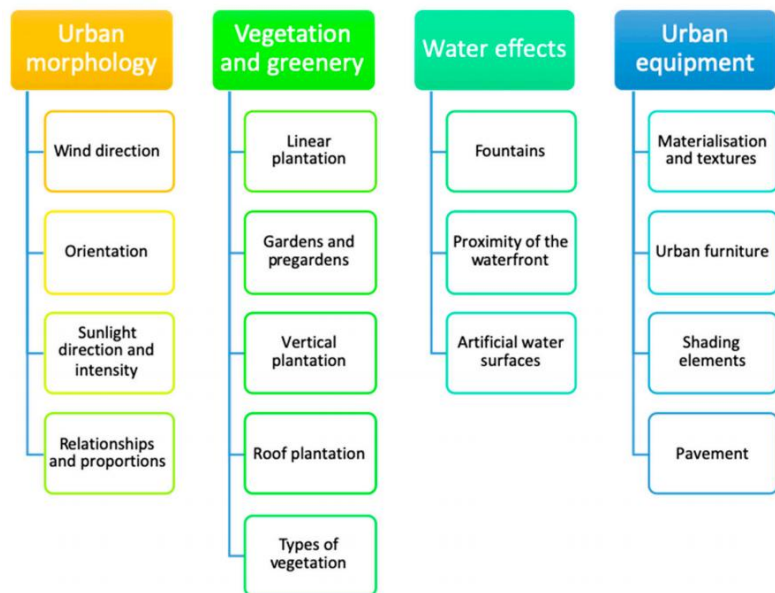
Fig 3.2 Strategies Ranking

- The application of reflective pavements (M1) resulted in a moderate decrease of both T_a and T_s in all climatic conditions by up to 1.0 °C and 10.7 °C respectively.
- Observed that temperature reductions are higher in areas with high H/W ratio as this can be attributed to shading from buildings.
- The **increment of urban greenery in combination with increased albedo of pavements** and roads (T2 and M7) can result in additional T_a and T_s reductions of up to 0.2 °C and 3.6 °C, respectively.
- **Photonic radiative coolers (M8)** applied to shading structures **offered a thermal comfort improvement** comparable to the scenario implementing **multiple strategies (M6)**.
- **Trees** mostly provide a **pleasant thermal environment** immediately below or the immediate surroundings that **varies throughout the day** and **depends on the extent of shaded areas**.

3.2 The Improvement of the Comfort of Public Spaces as a Local Initiative in Coping with Climate Change | Milena Vukmirovic, Suzana Gavrilovic, Dalibor Stojanovic

The aim of this study is to observe the actual state of the public space network and to define a future scenario of its development in line with climate change challenges.

LOCATION: BELGRADE, SERBIA



- The first scale level covers the analysis of the public space network and the degree of establishment of green infrastructure.

- The second scale level will cover qualitative and quantitative analysis of public space elements such as paving, urban equipment, greenery, lighting, water facilities, etc.

Fig 3.3 Open public space comfort clusters and indicators

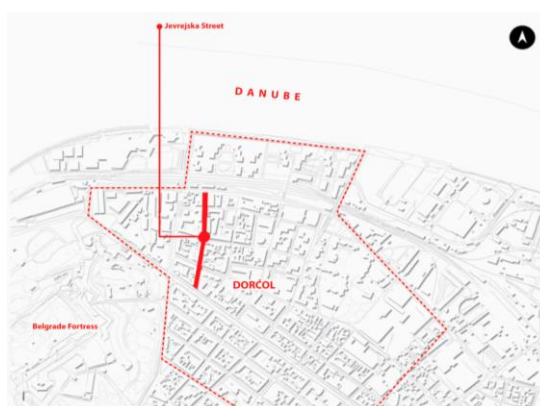


Fig 3.4 Research area and the position of Jevrejska Street

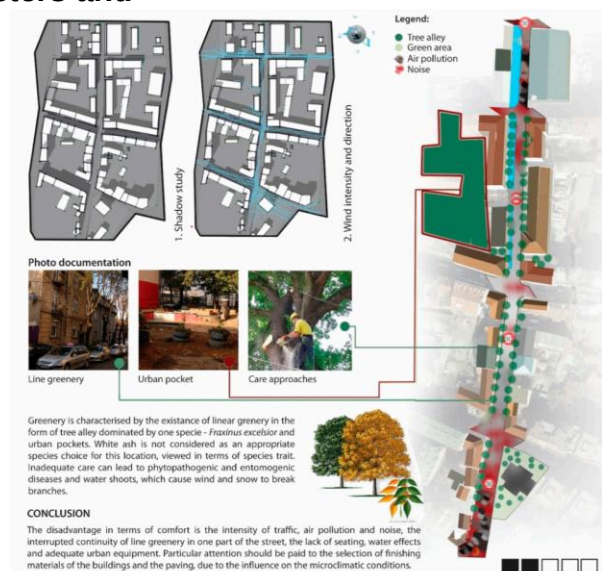


Fig 3.5 Comfort of Jevrejska Street, Belgrade

High Greenery

- A saturated ambient environment - during hot summer days.

Installation of a water fountain, urban furniture (benches and litterbins) and urban equipment (lighting)

- To create places for sitting, communicating and relaxing.

Padding of the light, natural pavement

- Light granite - sidewalks;
- Stone cubes - reduce the absorption of solar radiation, partially reduce the traffic speed-providing the sense of security and user comfort.

Provision of levelling and curves

- Slow down the traffic and reduce traffic noise



Fig 3.6 Existing and proposed state

AIR TEMPERATURE

- The air temperature of the **existing state** of open public space amounts from **37 to 38^a C.**
- The **modified materialization** and the use of vegetation and grassy areas can **reduce the temperature by approximately 2° C.**

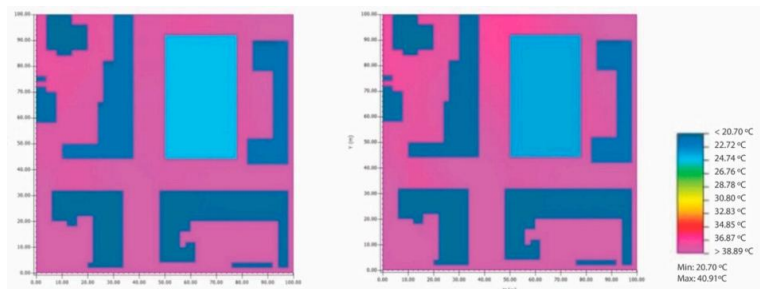


Fig 3.7 Air temperature simulation

RELATIVE HUMIDITY

- Relative humidity in the simulation of the existing state is approximately 50 per cent as opposed to the planned state.
- **Greenery** in open public space can **contribute to the humidity by between 5 % and 10 %.**

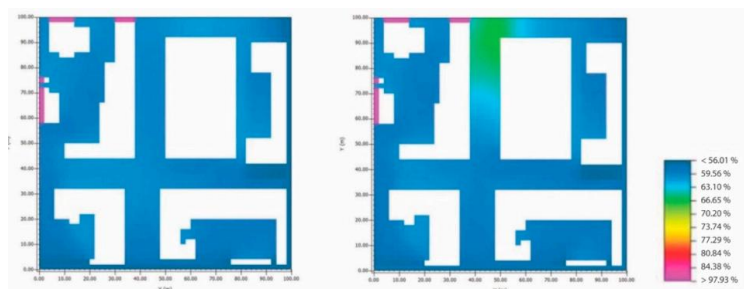


Fig 3.8 Relative humidity

WIND SPEED AND DIRECTION

- According to the **Beaufort scale**, this wind speed of **6.9 m/s** is rated **4**, as a **moderate breeze**.
- The introduction of the **tree alley** **does not alter the wind direction**, but partially slows down the wind by a total of 0.72 m/s.

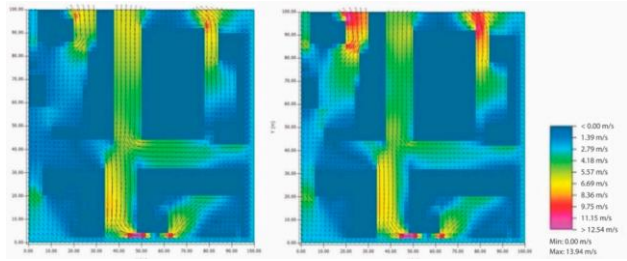


Fig 3.9 Wind speed and direction

SOLAR RADIATION

- Solar radiation in case of the existing situation is **very intensive**, almost up to **223 W/m²** during the noon period.
- In case of the design scenario, the **tree alley** can contribute to the extensive reduction of solar radiation during the noon period, which is even up to **161 W/m²**

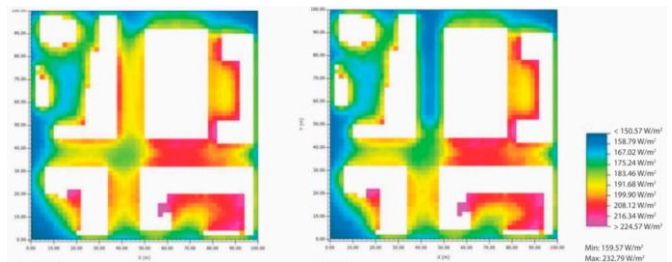


Fig 3.10 Solar Radiation

SUN EXPOSURE AND SHADE POSITION

- Using the **leafy vegetation** in open public space design proposals **improves the microclimatic characteristics** of the space.
- The **air temperature in the shade is lowered** and suitable for staying outdoors, while **during the winter**, after the **fall of leaves**, the **required sun exposure is enabled**.

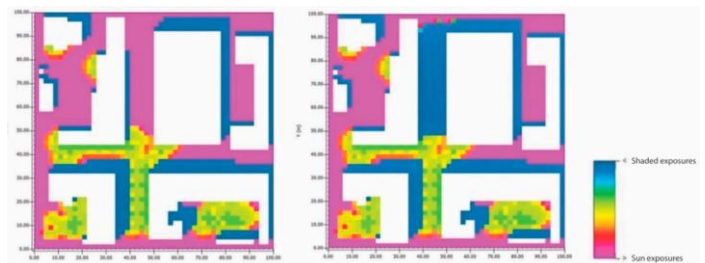


Fig 3.11 Sun exposure

3.3 The Influence Of Bioclimatic Urban Redevelopment On Outdoor Thermal Comfort| Karakounos I., Dimoudi A., Zoras S.,

- The emphasis of this work is to analyze how mitigation techniques in a dense urban environment affect microclimate parameters and outdoor thermal comfort.
- The main bioclimatic interventions concern the **application of cool paving materials, the increase of vegetated areas and the creation of water surfaces.**
- The evaluation of outdoor thermal comfort conditions is conducted using the **index PMV (Predicted Mean Vote), adapted for outdoor conditions.**

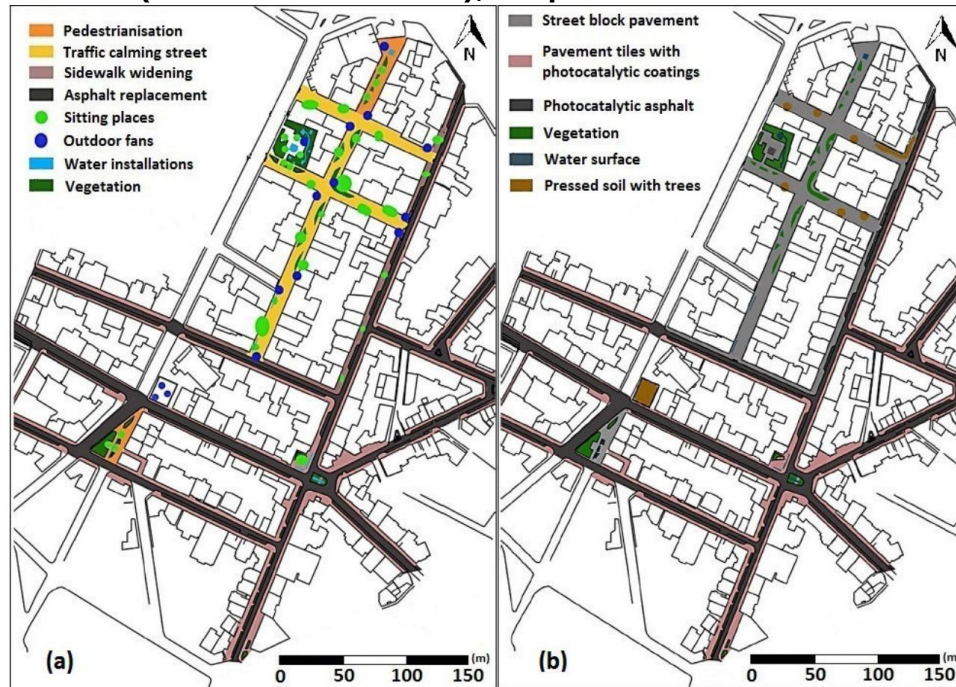


Fig 3.12 Proposed bioclimatic design of the study area – interventions (a) & materials (b)

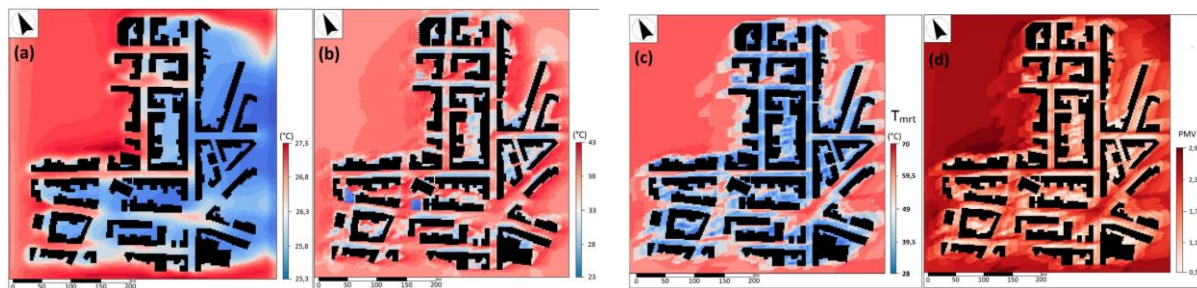


Fig 3.13 Existing situation – simulation – AT, ST, MRT & PMV

Mean values for **PMV index** for the existing urban area range from **0.5 (slightly warm)** to **2.9 (quite hot)**.

German Guideline VDI 3787 (2008) - thermal sensation scale from **-4 (very cold)** to **+4 (very hot)**.

AFTER THE DEVELOPMENT



Fig 4.4 After development

DESIGN ELEMENTS



Fig 4.5 Design elements

PRINCIPLES OF STREET DESIGN

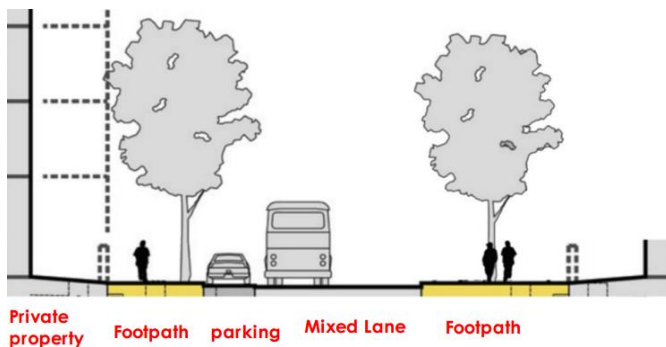
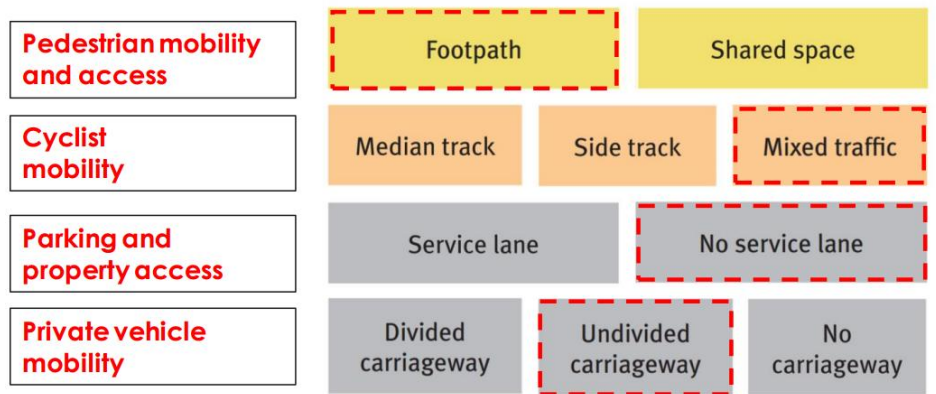
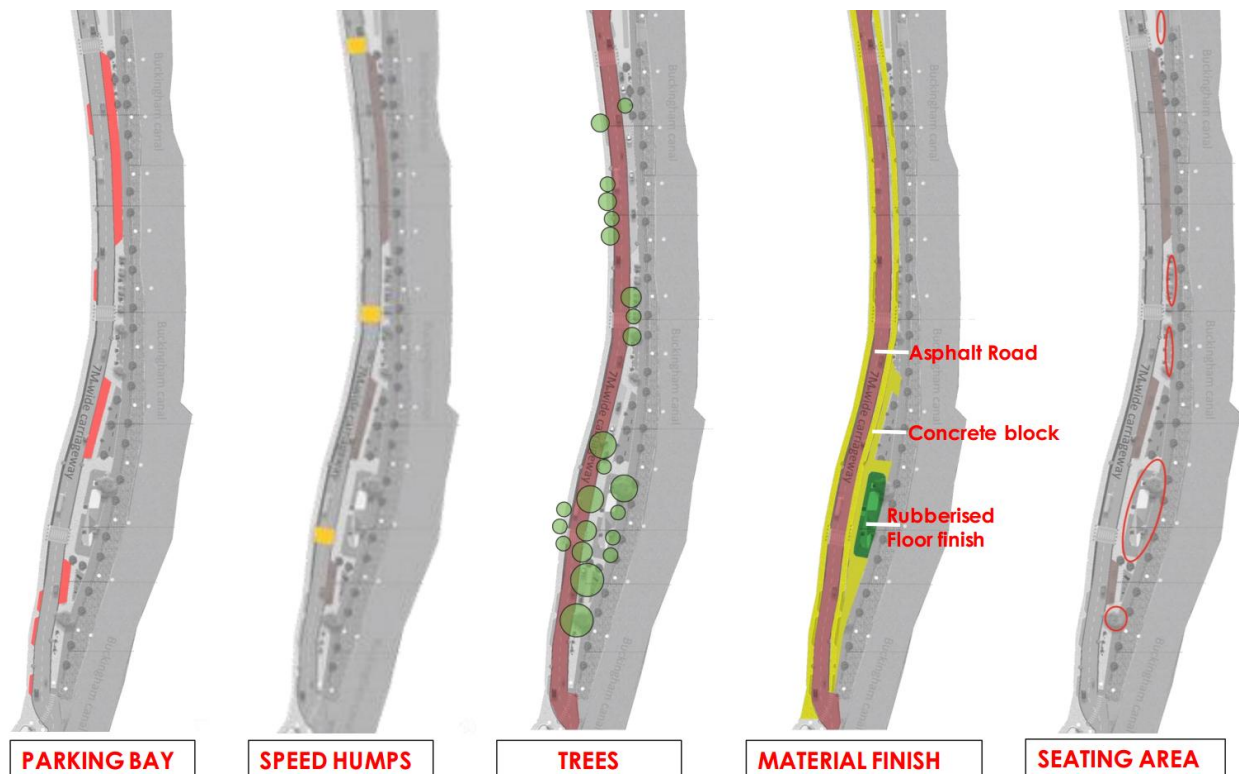
Safety: Creates a safer zone for school kids and pedestrian.

Liveability: More seating area is provided along the existing trees, kids play area.

Pedestrian accessibility: Ends of the street is well connected to the arterial road on both side.

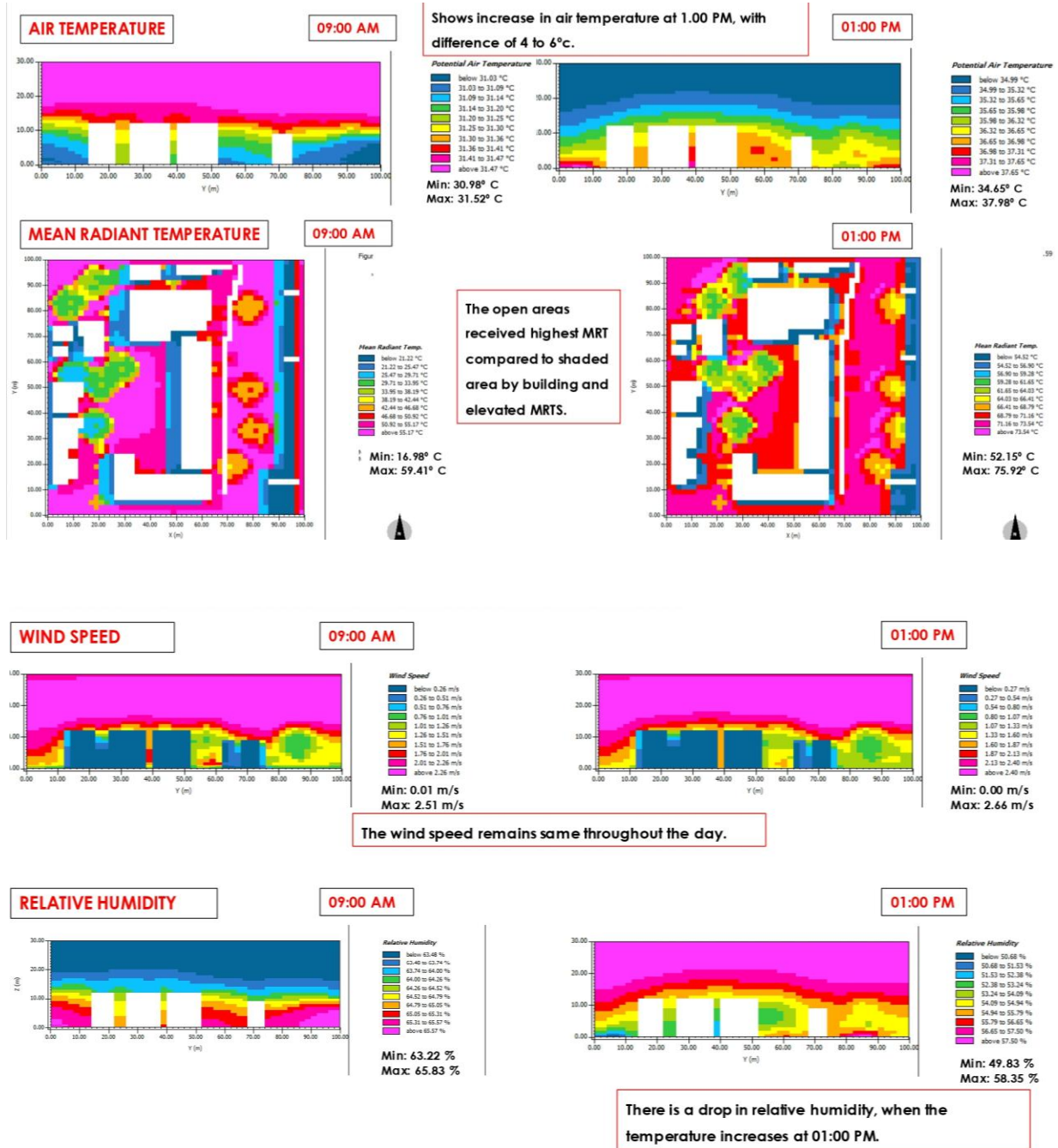
Sensitivity to local context: Connects the space with the canal behind is achieved by decreasing the existing wall size.

Creative use of street space: Developed seating along the existing trees which provides natural shade. Curbs extension for cycle parking.



- Prioritize pedestrians by reducing motor vehicle speeds.
- Since speeds remain low, cyclists can safely travel in mixed traffic.

SIMULATION ANALYSIS



CHAPTER 5 SITE SELECTION

5.1 MYLAPORE, CHENNAI

In order to improve the quality of the city's streets and public spaces in Chennai, 18 sites have been identified for the development of Pedestrian Malls. These places were chosen based on the **nature of activity nodes, pedestrian footfalls, and the opportunity for underutilized areas to be repurposed.**

The pedestrian malls are open spaces that serve as a gathering and activity space for social, recreational and civic purposes.



Fig 5.1 Site Aerial Map

MYLAPORE is a **historic and cultural centre** of Chennai. The streets surrounding the Kapalessshwar Temple area vibrant vending zones and yet over the years, **motorised vehicles have come to dominate the urban landscape** of the area.

5.2 SITE

STREETS AROUND THE NEIGHBOUHOOD

1. North Mada Street
2. South Mada Street
3. East Mada Street
4. Sannadhi Street
5. Ponnambala Vadhyar Street
6. Tank Street



Fig 5.2 Site Map



Fig 5.3 Site Map



Fig 5.4 Temple entrance



Fig 5.5 Street junction



Fig 5.6 Tank street

Vehicular movement on narrow roads makes the street uncomfortable for pedestrian

- People are forced to walk on roads because of encroachments of vendors and unauthorized parking.
- In the case of South mada street, 40% of street is occupied by vendors and parking.

Vendors encroachment on pedestrian



Fig 5.7 Sannadhi Street



Fig 5.8 Encroached Street

5.3 SITE STUDY

FIGURE AND GROUND

- Grid pattern
- Shared wall construction

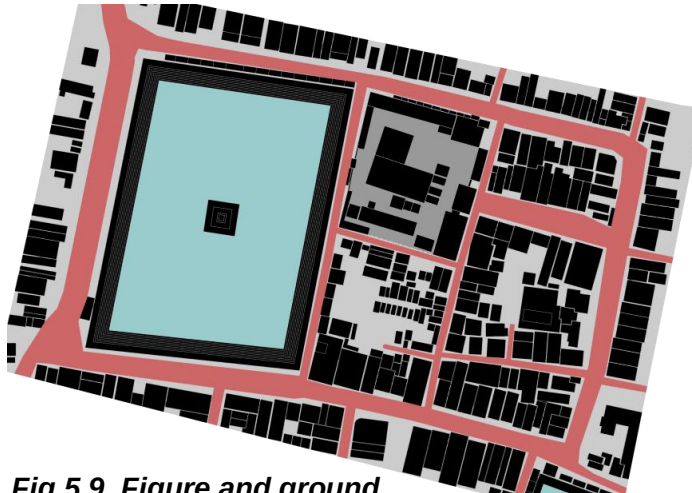
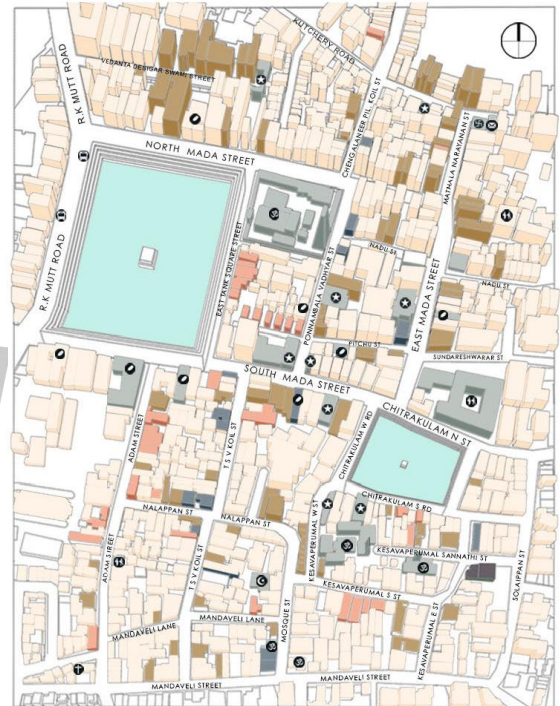


Fig 5.9 Figure and ground



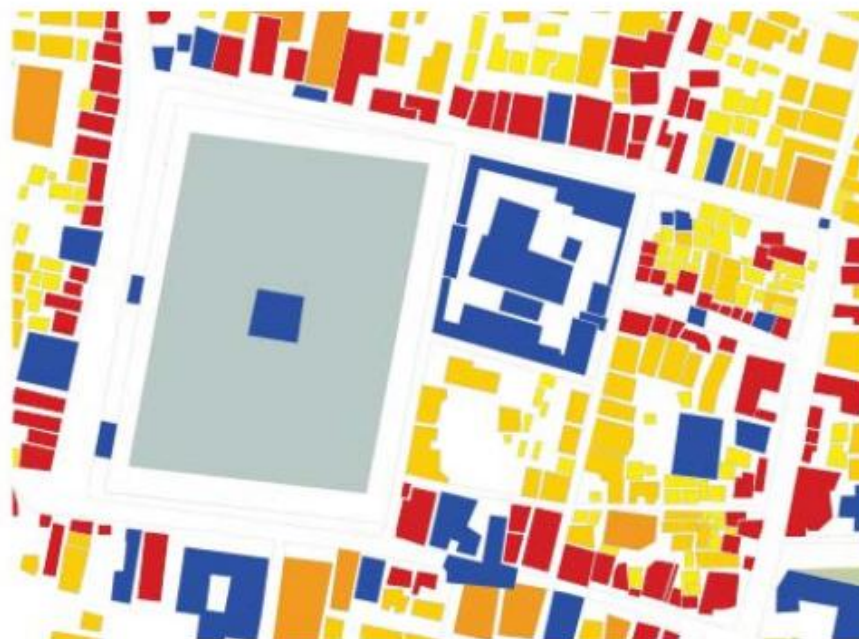
HOUSES of
MYLAPORE

- LANDMARKS
- ART DECO BUILDINGS
- AGRAHARAMS
- VARIED STYLES
- CHURCH
- TEMPLE
- MOSQUE
- SCHOOL
- EATERIES
- BUS STOP
- JAIN TEMPLE
- LANDMARKS

Fig 5.10: Landmark

Map Source: thinkmatter

LAND USE



- Residential turning into Commercial zone.
- Various type of user.

- Religious
- Residential
- Retail
- Mixed Use Housing

Fig 5.11 Land use (7)

STREET VENDORS

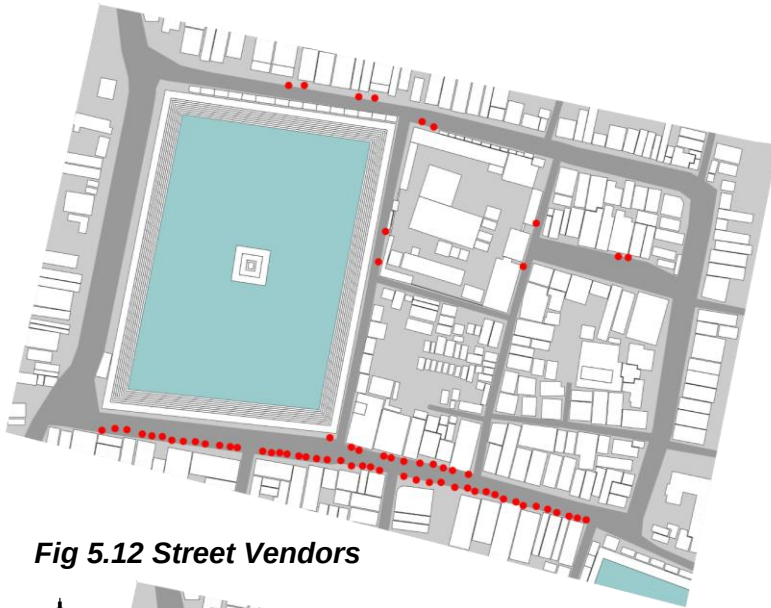


Fig 5.12 Street Vendors

- Existing footpath is encroached by street vendors.
- Retail shops expands their branding in footpath
- Street vendors occupy the space during morning and evening during peak hours.
- More street vendors can be found in south mada street.

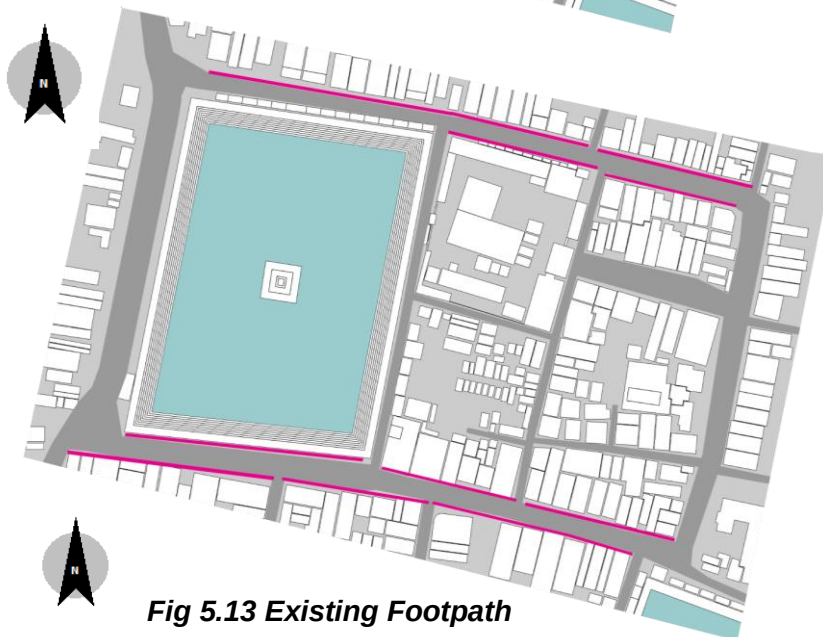


Fig 5.13 Existing Footpath

EXISTING PATHWAY



a



b



c

Fig 5.14 (a,b,c) Street Vendors encroached on

VEGETATION



Fig 5.15 Vegetation

Major species of trees are found near temple tank boundary in north mada street and south mada street. Only parts of the roads are well shaded by tree. Narrow street near the temple is fully shaded by trees. Most seen tree species are *Ficus Religiosa* (Aarasamaram), *Azadirachta Indica* (Neem tree) and *Cassia fistula* (Golden shower tree).

Table 5.1 Vegetation

Tree Name	Botanical Name	Reference	Characteristics	Height	Diameter	Light Requirement
Gulmohar	Delonix regia		fern like leaves	30 and 40 feet	wider than its height	Full sun
Golden Shower	Cassia fistula		alternate, spirally arranged, paripinnately compound leaf	Up to 33feet	1m diameter	requires full sun to bloom the flowers
Mahogany	Swietenia mahagnoni		large, semi-evergreen tree with a canopy that casts dappled shade	50 feet (15.2 m.) or less	3 to 6 feet	partial to full sun
Indian Almond Tree	Terminalia catappa		Broad leaves. Wide layered Umbrella like canopy	30 m (98ft)	35 m	Full sun
Arasamaram/Pee pal Tree	Ficus religiosa		leaves are cordate(heart shaped)	30 metres	3 metres	full sun
Perungali	Plumeria Alba		Narrow and Corrugated leaf.	5m to 8m	8m to 10m	needs atleast 5 hours of direct sunlight a day
Rain Tree	Samanea saman		Oval leaf.	20 m to 30 m	2m Dia	Full sun
Neem Tree	Azadirachta indica		Round and layered canopy	15 –20m	20m	More than 6 hours of preferably morning sunlight in a day
Punnai Tree	Calophyllum inophyllum		low-branching and slow-growing tree with a broad and irregular crown	25 metres	1.5m	full sun
Ashoka	Saraca asoca		erect tree, small and evergreen, with a smooth, grey-brown bark	7–10 m	8 - 12m	Full sun to partial shade

CHAPTER 6 ONSITE MEASUREMENT

Total 12 locations have been selected based on variation of building heights, green cover, proximity to tank, street width, pedestrian and vehicular movement.



Fig 6.1 Site map

6.1 North Mada Street



6.2 East Mada Street

Location 4: B1



ORIENTATION	WEST-EAST
Typology	Mixed residential
Street Width	10m wide
Avg building height	12m - 15m
Vertical surface	Concrete, glass, cladding
Horizontal surface	Asphalt, concrete block
Vegetation	Sparse



Location 5: B2



ORIENTATION	WEST-EAST
Typology	Mixed residential
Street Width	10m wide
Avg building height	12m - 15m
Vertical surface	Concrete, glass, cladding
Horizontal surface	Asphalt, concrete block
Vegetation	Sparse, dense canopy



Location 6: C1



ORIENTATION	WEST-EAST
Typology	Mixed residential
Street Width	10m wide
Avg building height	12m - 15m
Vertical surface	Concrete, glass, cladding
Horizontal surface	Asphalt, concrete block
Vegetation	Dense & Wide canopy



6.3 South Mada Street

Location 7: C3



ORIENTATION	WEST-EAST
Typology	Mixed residential
Street Width	10m wide
Avg building height	12m - 15m
Vertical surface	Concrete
Horizontal surface	Asphalt, concrete block
Vegetation	Sparse, dense canopy



Location 8: C2



ORIENTATION	WEST-EAST
Typology	Mixed residential
Street Width	10m wide
Avg building height	12m - 15m
Vertical surface	Concrete, Brick
Horizontal surface	Asphalt, concrete block
Vegetation	Sparse, dense canopy



Location 9,10: D1,D2



ORIENTATION	WEST-EAST
Typology	Residential
Street Width	5m wide
Avg building height	3m
Vertical surface	brick
Horizontal surface	concrete
Vegetation	Dense & Wide canopy



Location 11,12: E1&F1



ORIENTATION	WEST-EAST
Typology	Mixed residential
Street Width	10m wide
Avg building height	9m - 12m
Vertical surface	Concrete, brick
Horizontal surface	Asphalt, concrete
Vegetation	Sparse



EQUIPMENT USED FOR MEASUREMENT



Heat Stress
WBGT Meter



Anemometer

- Air temperature
- Relative humidity
- Globe temperature
- Wind speed

MEASUREMENT DAY: 05/03/2022

Fig 6.2 Measurement Equipment

The measurement was taken on March 5th 2022, starting of summer period. The location was selected on context with differed in the neighbourhood and also external elements such as vegetation and temple water tank. This location also differs in orientation of streets.

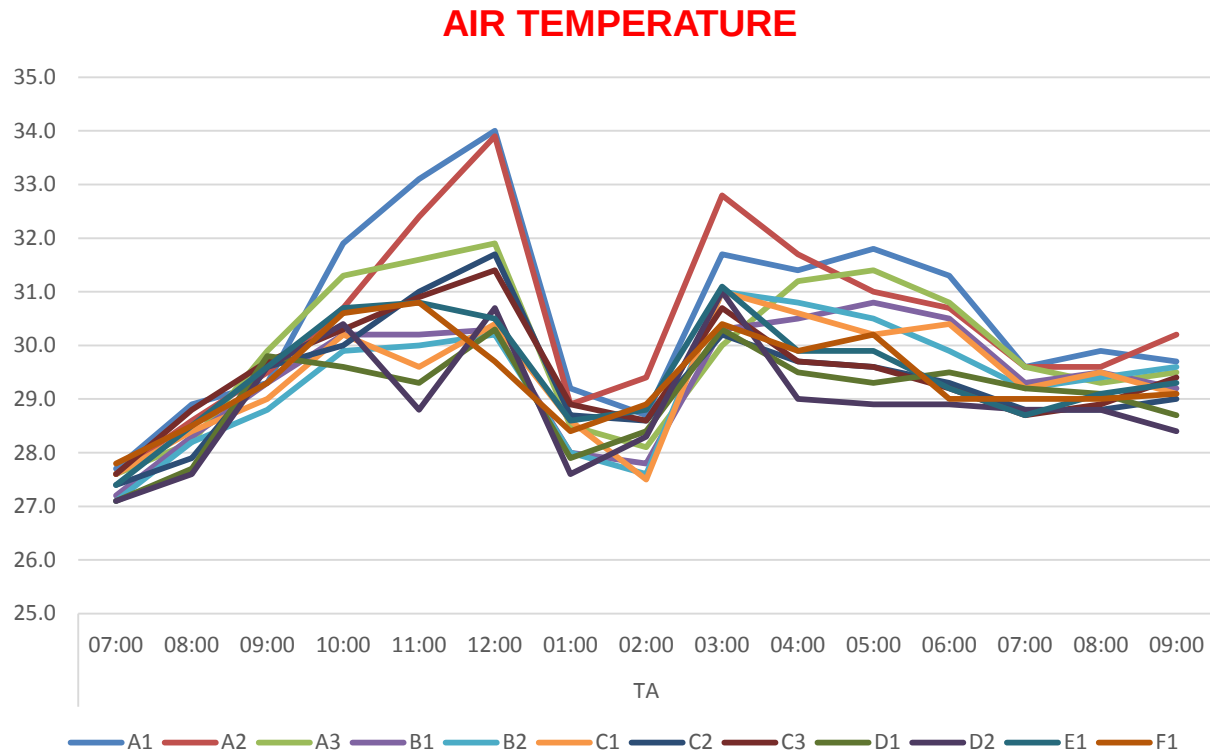


Fig 6.3 Comparison of AT in all 12 location

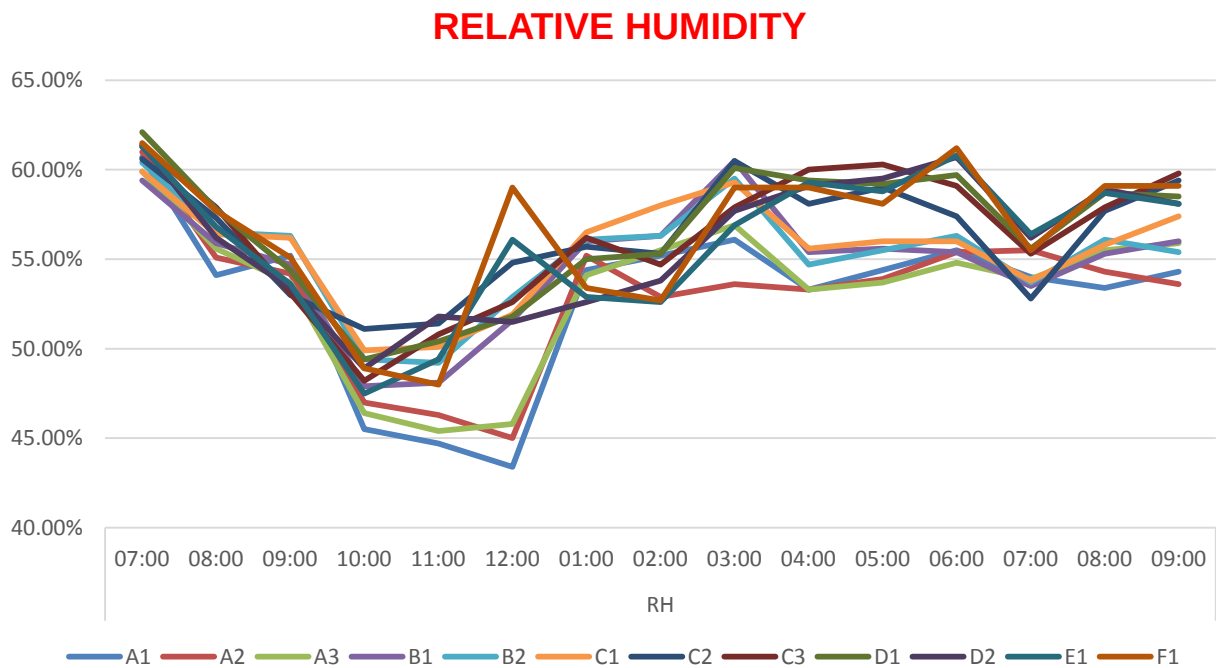


Fig 6.4 Comparison of RH in all 12 location

The maximum day time temperature recorded at A1& A2 is 5°C higher compared to F1. Location which experiences higher air temperature is located in west-east orientation of street and lowest air temperature is located in north-south orientation of street. Lower RH is recorded at A1 (12:00 PM), at same time F1 experiences high RH.

6.4 EAST WEST ORIENTATION OF STREETS

AIR TEMPERATURE

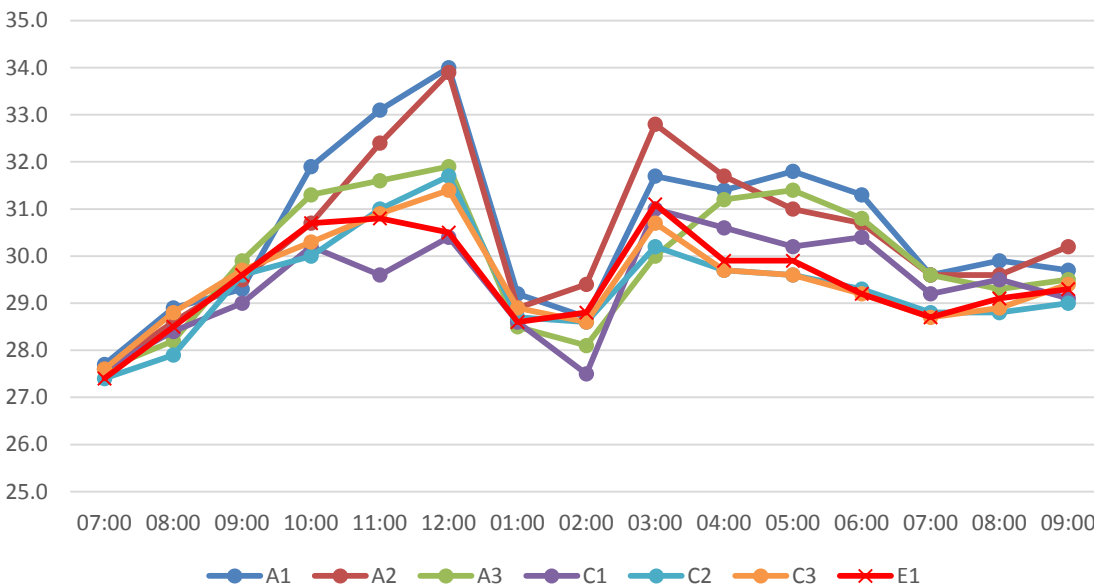


Fig 6.5 Comparison of AT in all 12 location – E-W Orientation

RELATIVE HUMIDITY

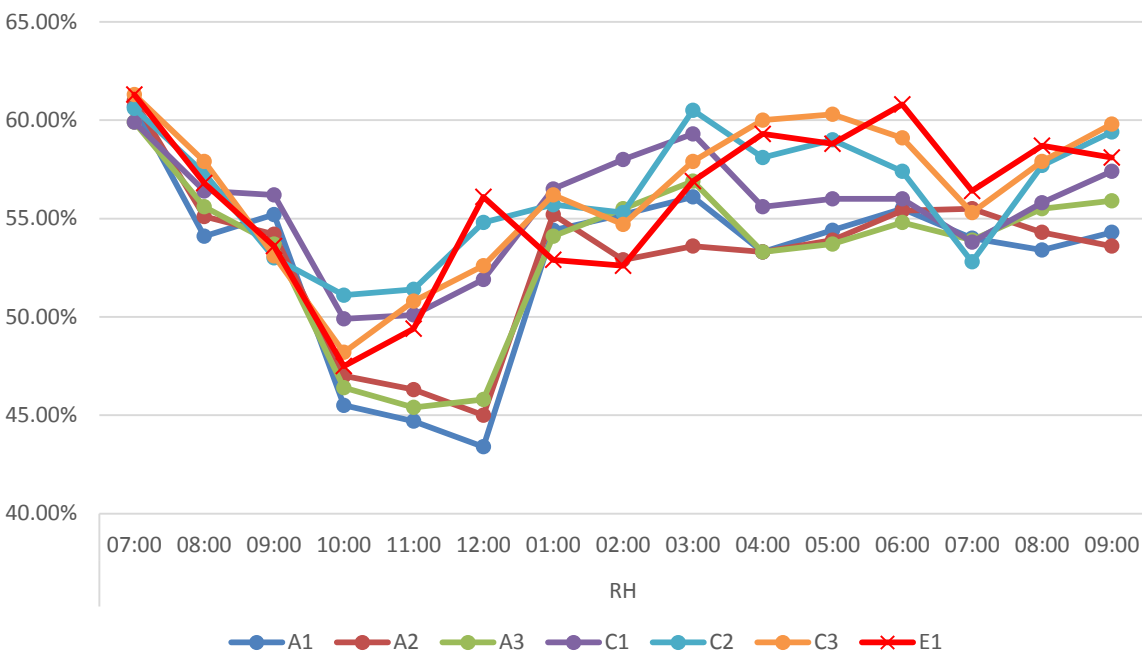


Fig 6.6 Comparison of RH in all 12 location – E-W Orientation

- The maximum day time temperature recorded at A1& A2 is 4°C higher compared to E1.
- C1 recorded lowest in day of 27.5°C, which is most shaded area of all locations.

6.5 NORTH SOUTH ORIENTATION OF STREETS

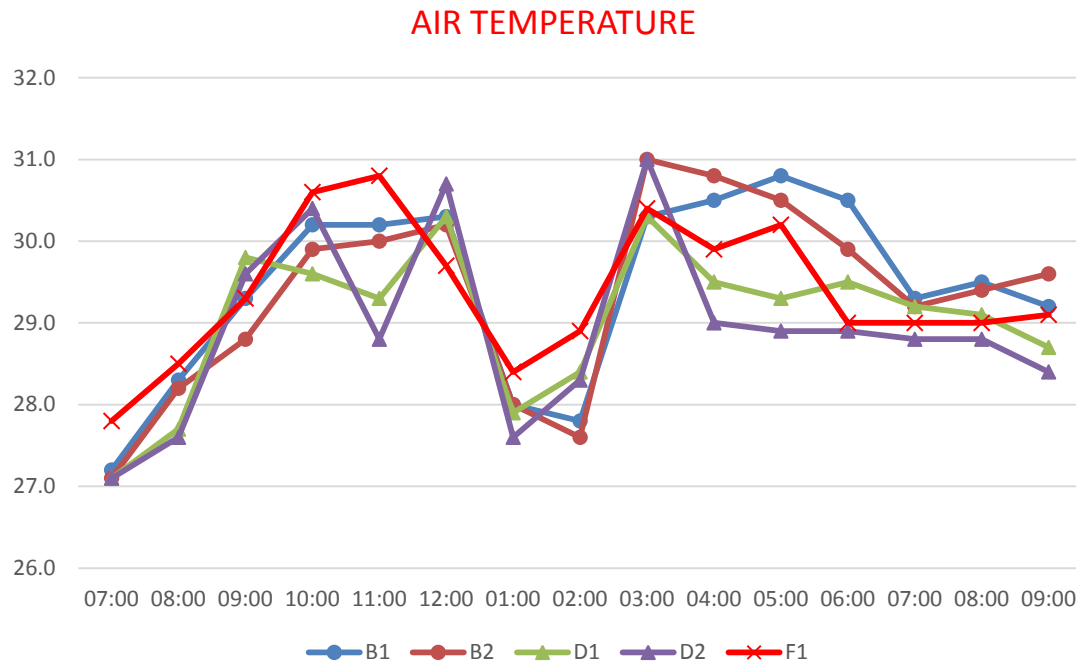


Fig 6.7 Comparison of AT – N-S Orientation

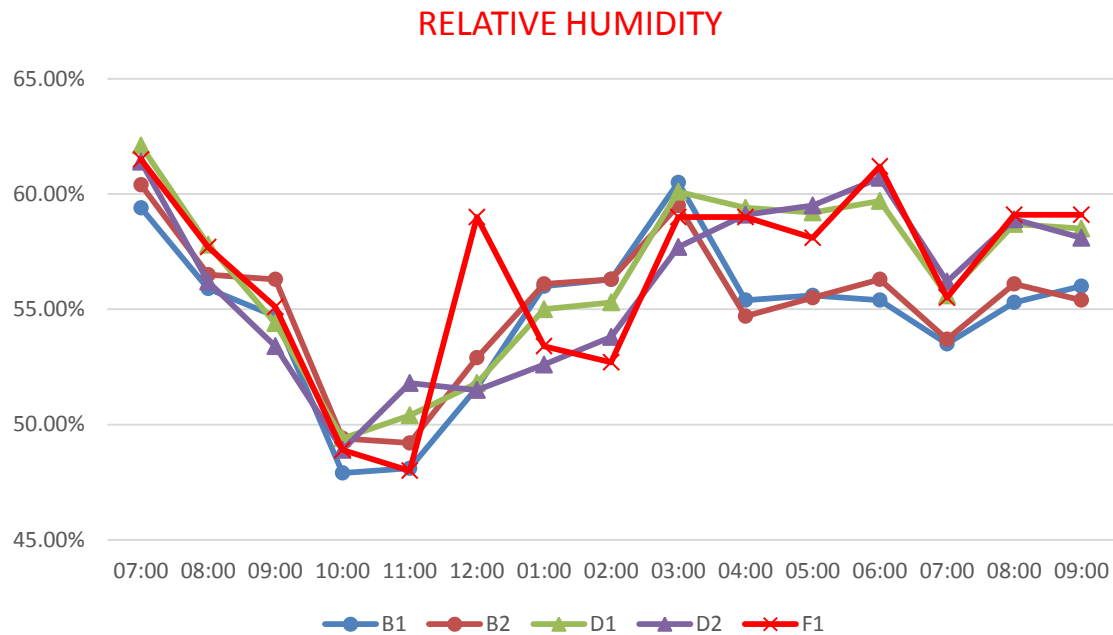


Fig 6.8 Comparison of RH – N-S Orientation

- The maximum day time temperature recorded at B2& D2 with difference of 2°C from lowest.

6.6 EAST WEST ORIENTATION

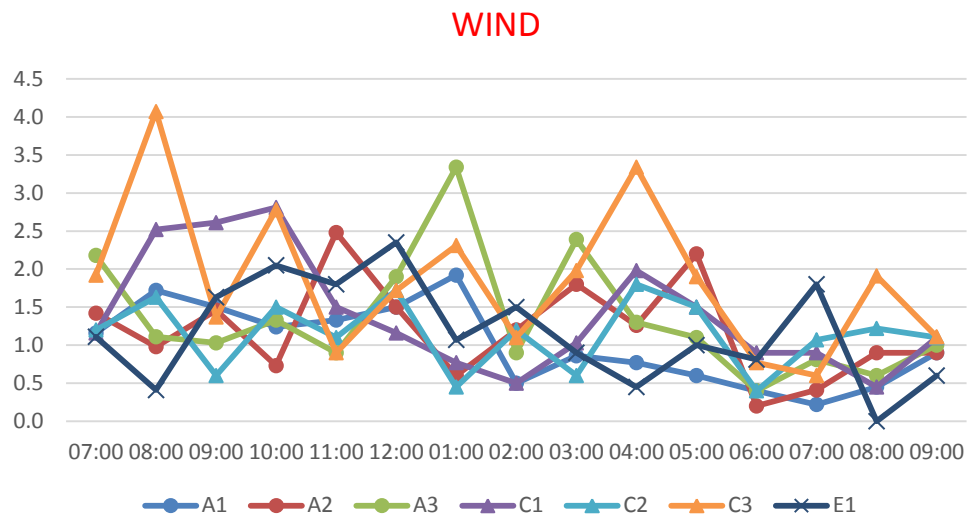


Fig 6.9 Comparison of WIND – E-W Orientation

6.7 NORTH SOUTH ORIENTATION

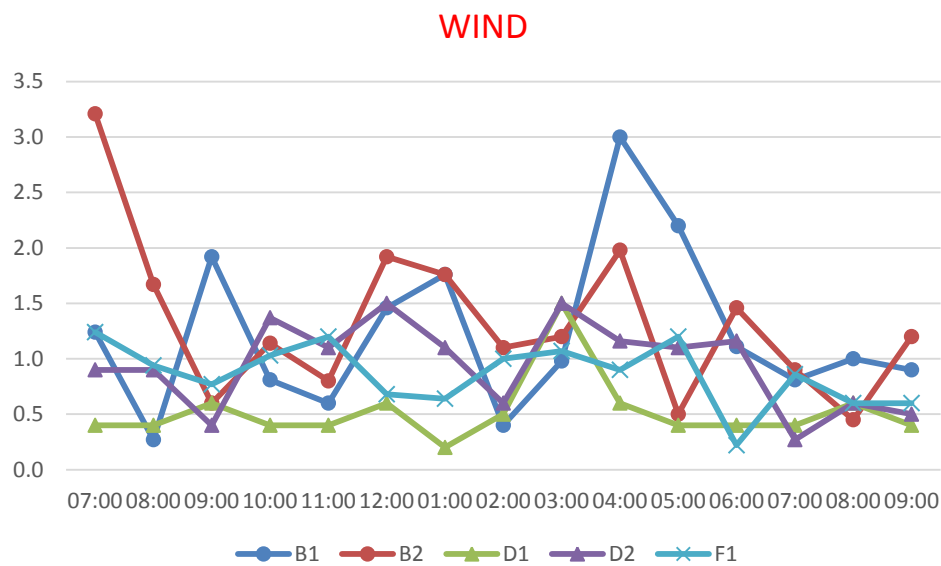
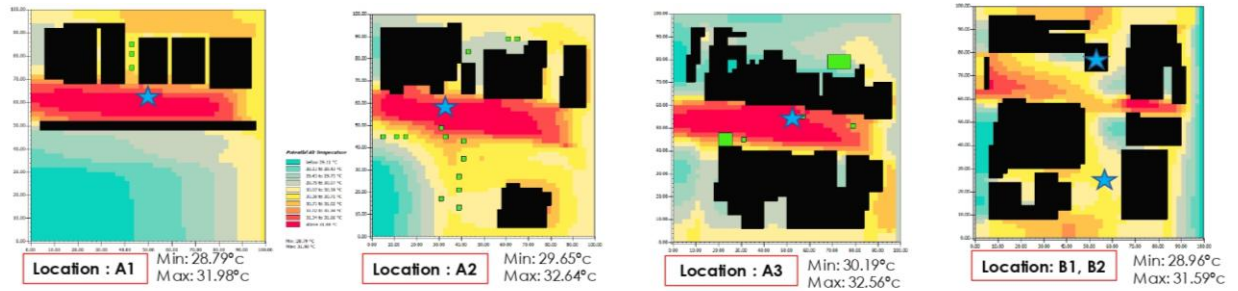


Fig 6.10 Comparison of WIND – N-S Orientation

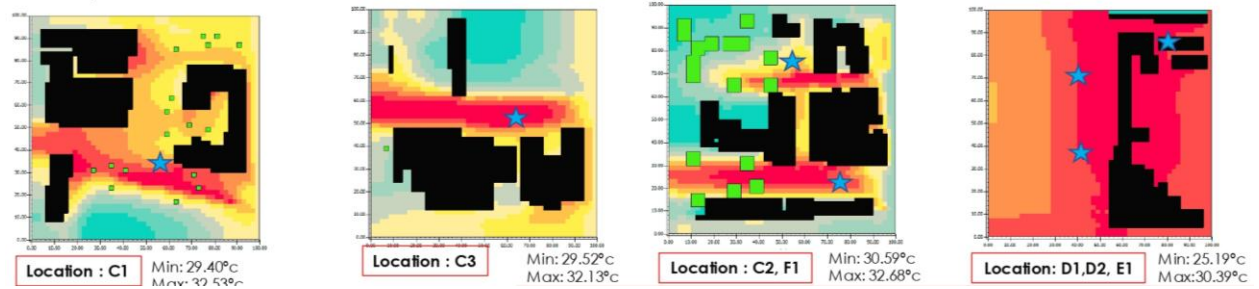
6.8 WIND SPEED

- High wind speed was recorded in east west orientation
- During late evening till night, narrow street experiences very less wind flow.

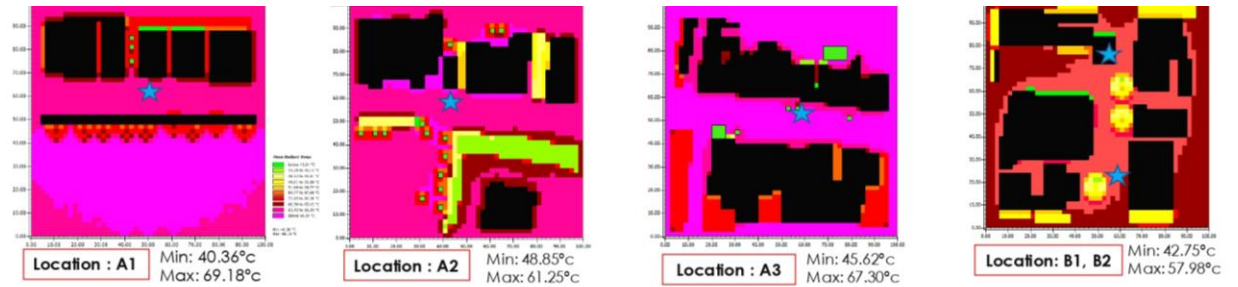
6.9 AIR TEMPERATURE



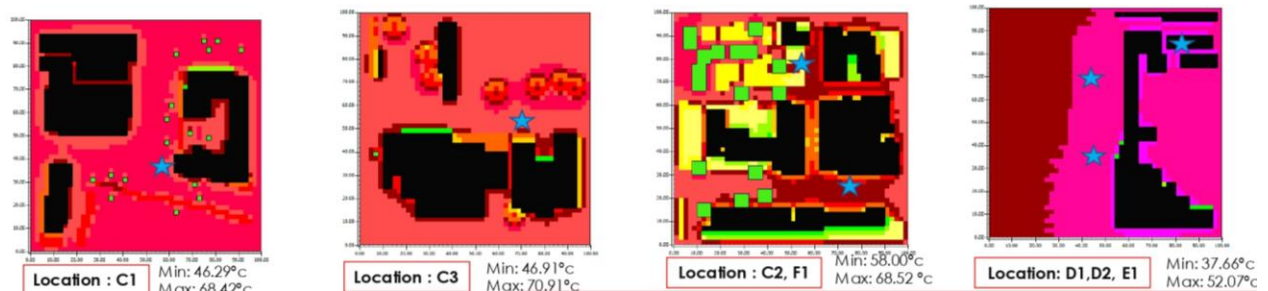
- Main pedestrian areas experiences very high temperature.



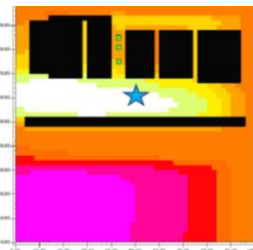
6.10 MEAN RADIANT TEMPERATURE



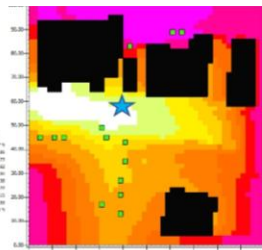
- MRT is lower in shaded area.



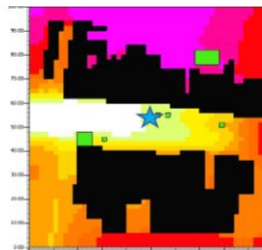
6.11 RELATIVE HUMIDITY



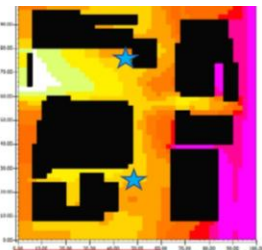
Location : A1 Min: 51.08%
Max: 64.92%



Location : A2 Min: 45.13%
Max: 54.50%



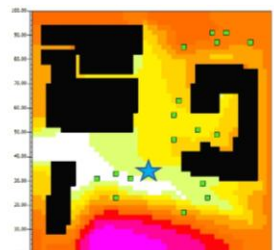
Location : A3 Min: 50.01%
Max: 59.22%



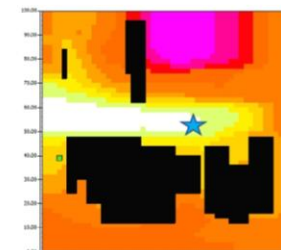
Location: B1, B2 Min: 48.21%
Max: 56.94%

- Wide Road areas experiences less humidity.

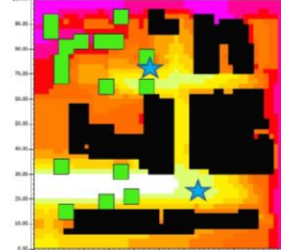
- Areas which are near to temple tanks recorded high RH.



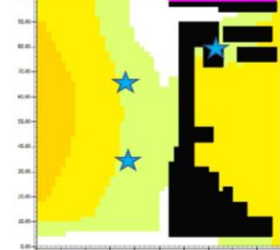
Location : C1 Min: 50.24%
Max: 63.25%



Location : C3 Min: 50.76%
Max: 62.71%

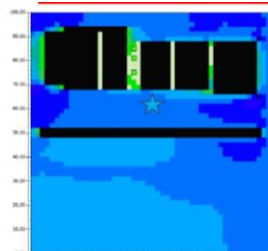


Location : C2, F1 Min: 50.10%
Max: 58.27%

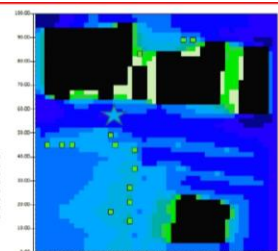


Location: D1, D2, E1 Min: 51.62%
Max: 82.75%

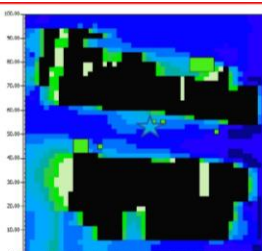
6.12 WIND



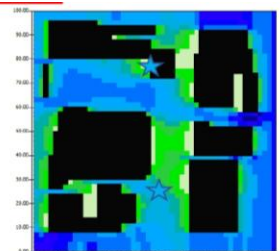
Location : A1 Min: 0.01 m/s
Max: 2.89 m/s



Location : A2 Min: 0.01 m/s
Max: 2.41 m/s

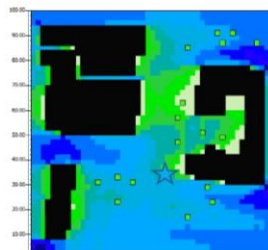


Location : A3 Min: 0.01 m/s
Max: 2.37 m/s

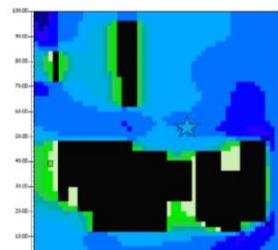


Location: B1, B2 Min: 0.02 m/s
Max: 2.68 m/s

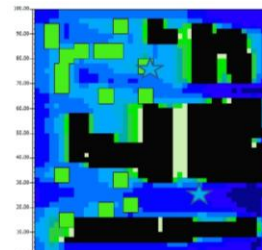
- Wind flow is lesser, where the streets are narrow.



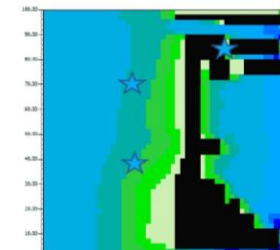
Location : C1 Min: 0.03 m/s
Max: 2.93 m/s



Location : C3 Min: 0.02 m/s
Max: 2.85 m/s



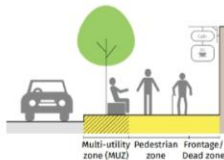
Location : C2, F1 Min: 0.00 m/s
Max: 2.31 m/s



Location: D1, D2, E1 Min: 0.00 m/s
Max: 3.17 m/s

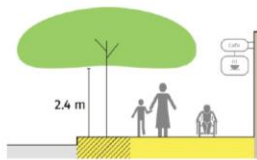
CHAPTER 7 ITERATION DEVELOPMENT

7.1 BASIS FOR ITERATION DEVELOPMENT



CREATING ZONES

- Continuous walking space for pedestrians, clear of any obstructions.
- A buffer between the pedestrian zone and the property edge.

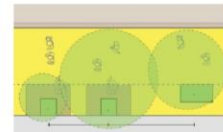
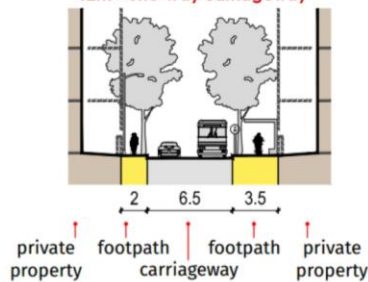


LANDSCAPE AS BUFFER

- Footpath should be well-shaded.
- Trees should be pruned to maintain a vertical clearance of 2.4 m in the walking area.

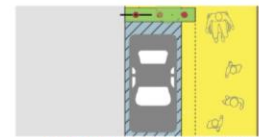
SOURCE 1

12M - one-way carriageway



APPROPRIATELY SPACED - CONTINUOUS SHADE

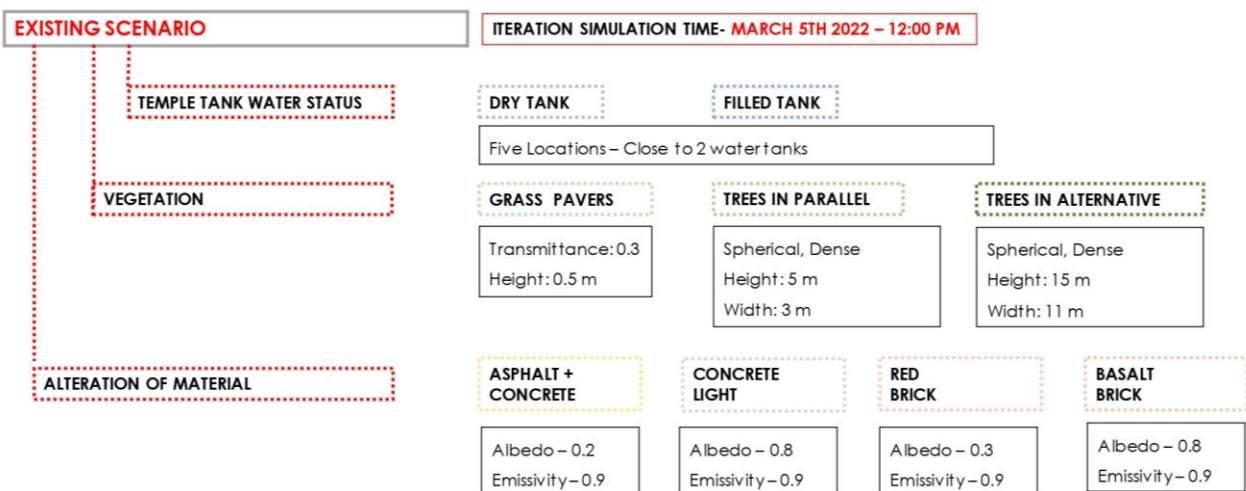
- Wherever seating is provided, climatic comfort should be ensured and the seating should be well shaded.



MATERIAL TO DIFFER ZONE

- To ensure parking bays don't act as additional traffic lanes, a different surface material should be used.

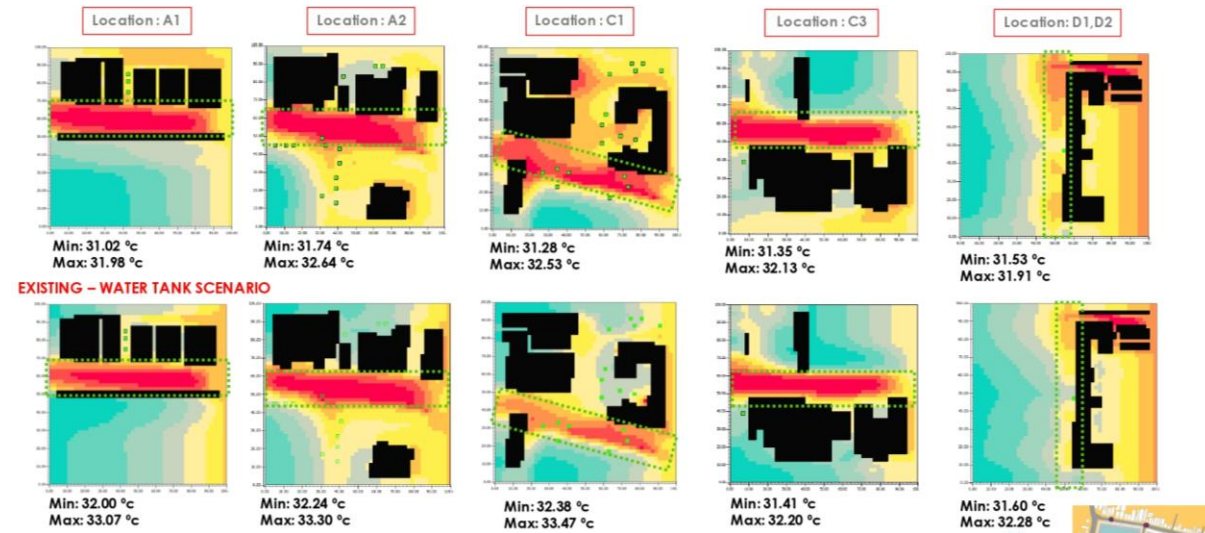
7.2 ITERATION OPTION



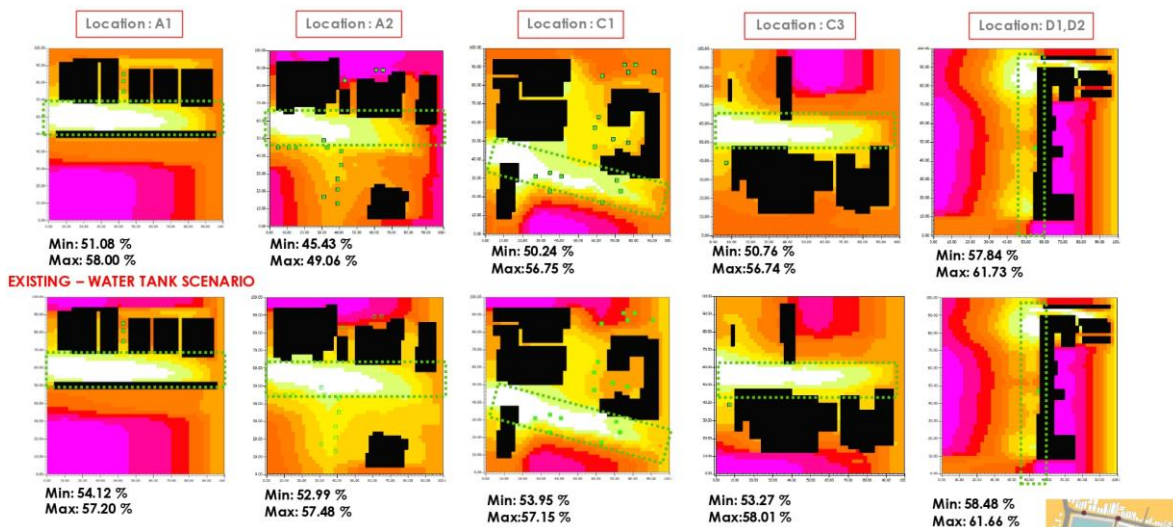
7.3 COMPARISON OF PLACES NEAR WATER TANK



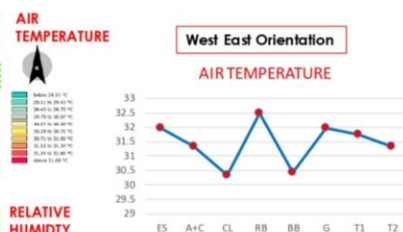
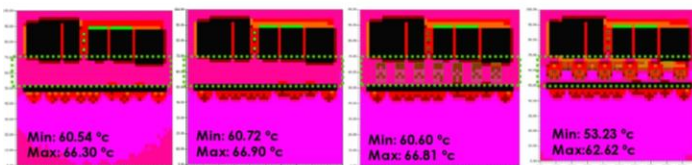
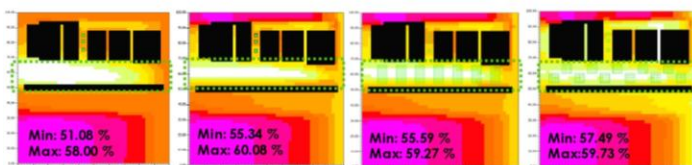
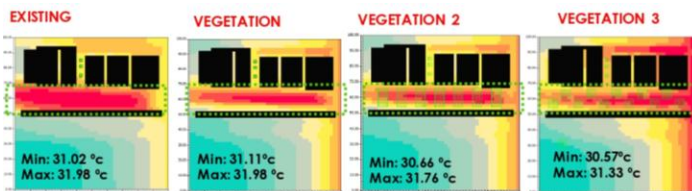
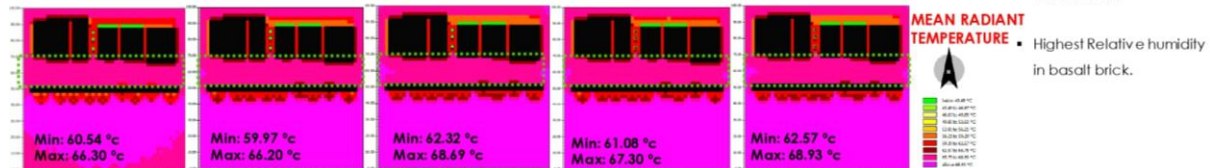
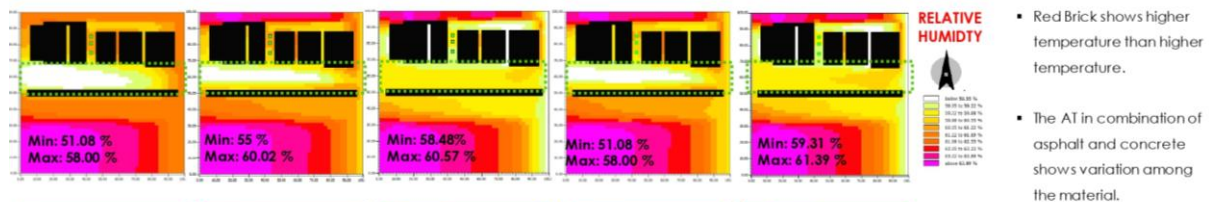
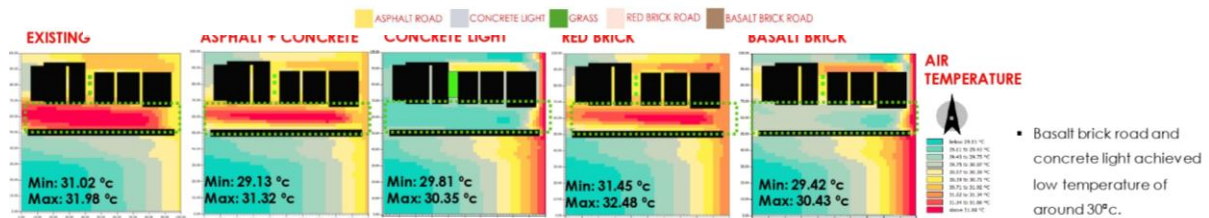
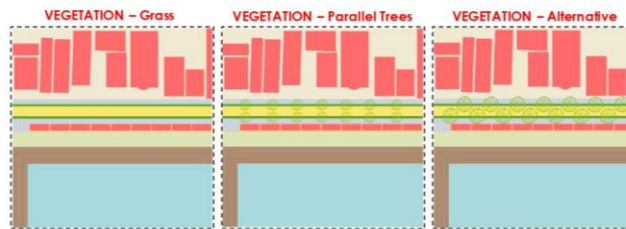
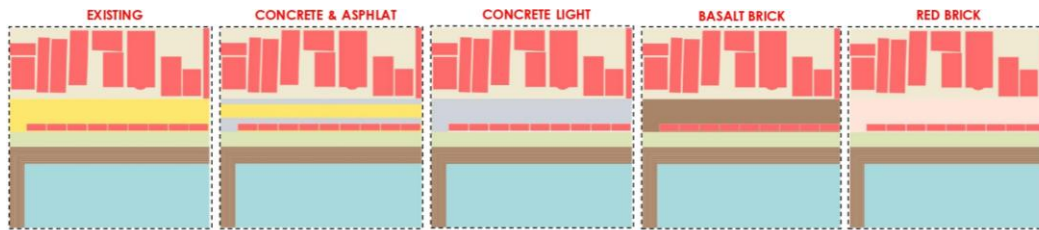
AIR TEMPERATURE



RELATIVE HUMIDITY



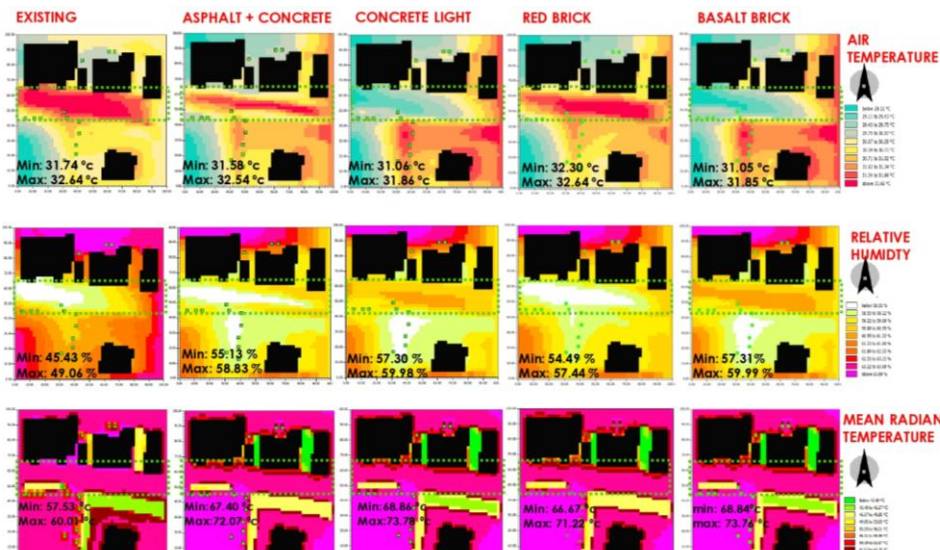
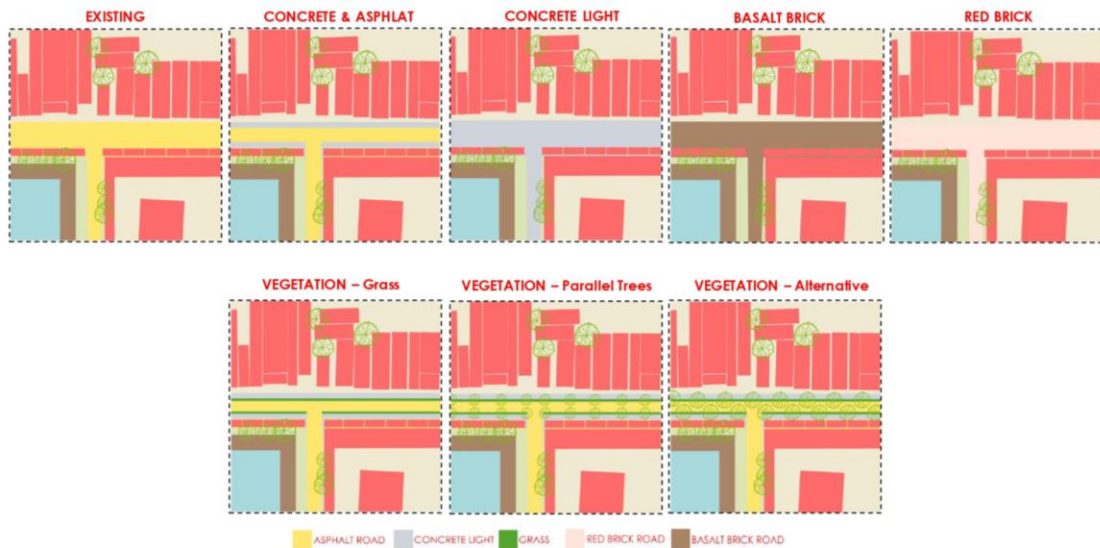
7.4 LOCATION: A1- ITERATION OPTIONS



- Only mild difference in vegetation 1 and vegetation 2.
- Inclusion of grass near pavement shows less AT compared to road surface.
- MRT is less near the tree shaded area.

- Comparing materials and vegetation, material with high albedo shows less AT.
- Whereas in MRT, apart from building height addition of trees reduces MRT.

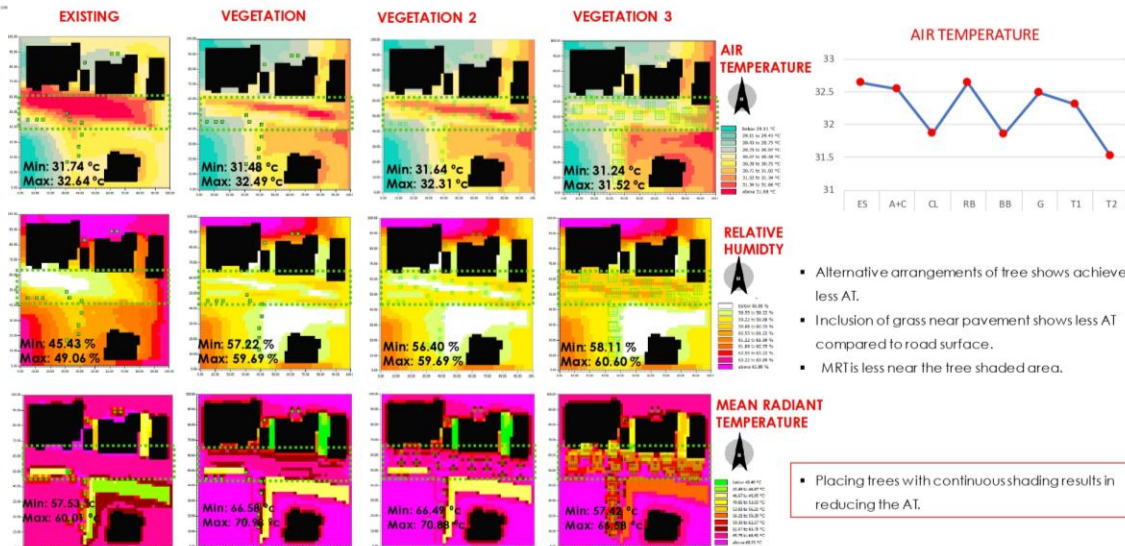
7.5 LOCATION: A2- ITERATION OPTIONS



- Basalt brick road and concrete light achieved low temperature of around 30°C.

- The AT in combination of asphalt and concrete shows variation among the material.

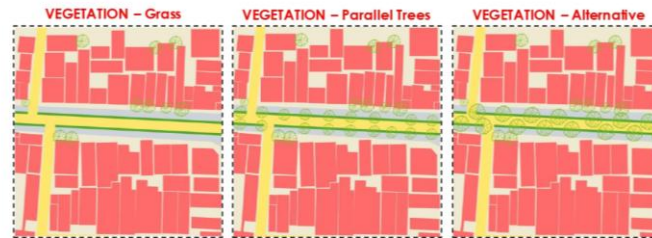
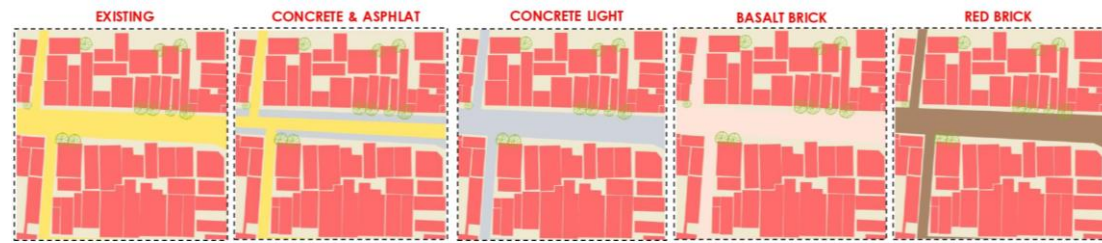
- Highest Relative humidity is more in the concrete and basalt material.



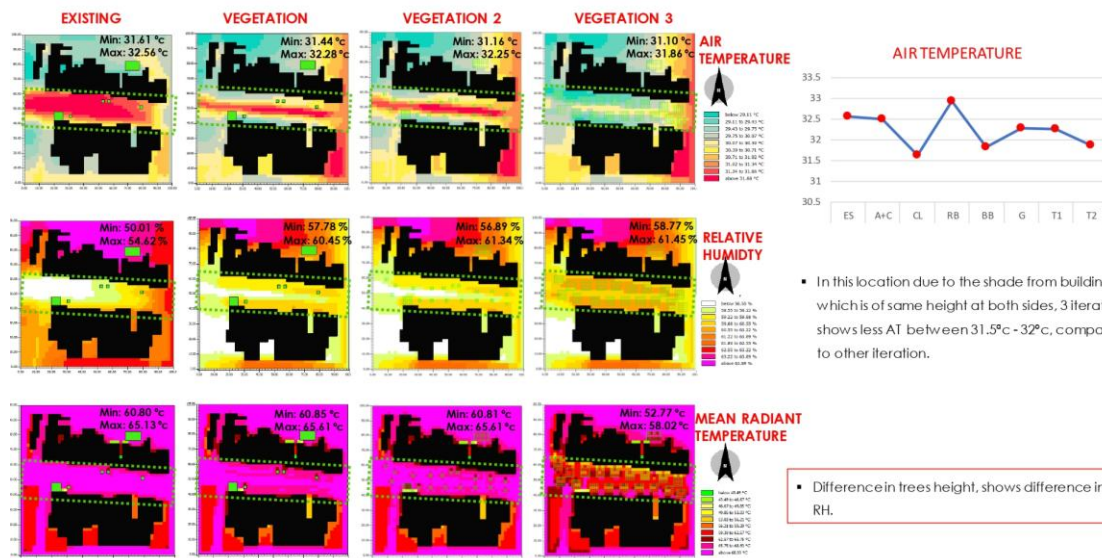
- Alternative arrangements of tree shows achieves less AT.
- Inclusion of grass near pavement shows less AT compared to road surface.
- MRT is less near the tree shaded area.

- Placing trees with continuous shading results in reducing the AT.

7.6 LOCATION: A3- ITERATION OPTIONS



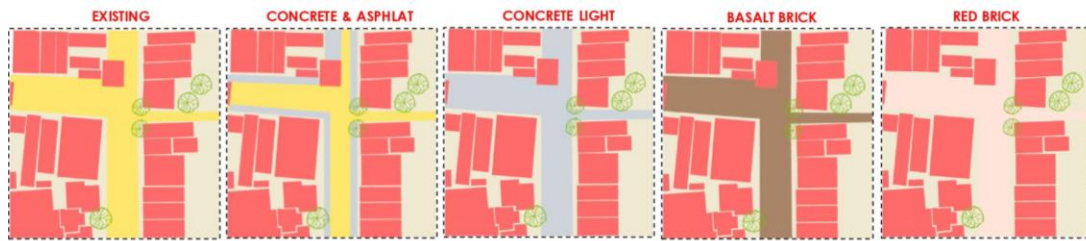
- Due to orientation of street, all three location shows similar changes in iteration.
- This location is not in close proximity to water tank.



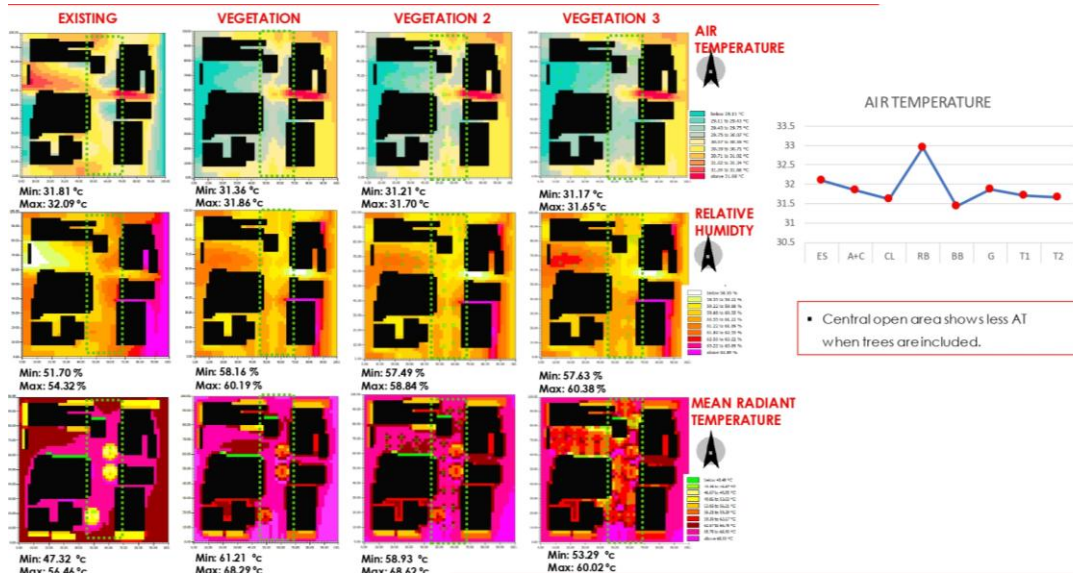
- In this location due to the shade from buildings which is of same height at both sides, 3 iteration shows less AT between 31.5°C - 32°C, compared to other iteration.

- Difference in trees height, shows difference in RH.

7.7 LOCATION: B1, B2- ITERATION OPTIONS



ASPHALT ROAD CONCRETE LIGHT GRASS RED BRICK ROAD BASALT BRICK ROAD



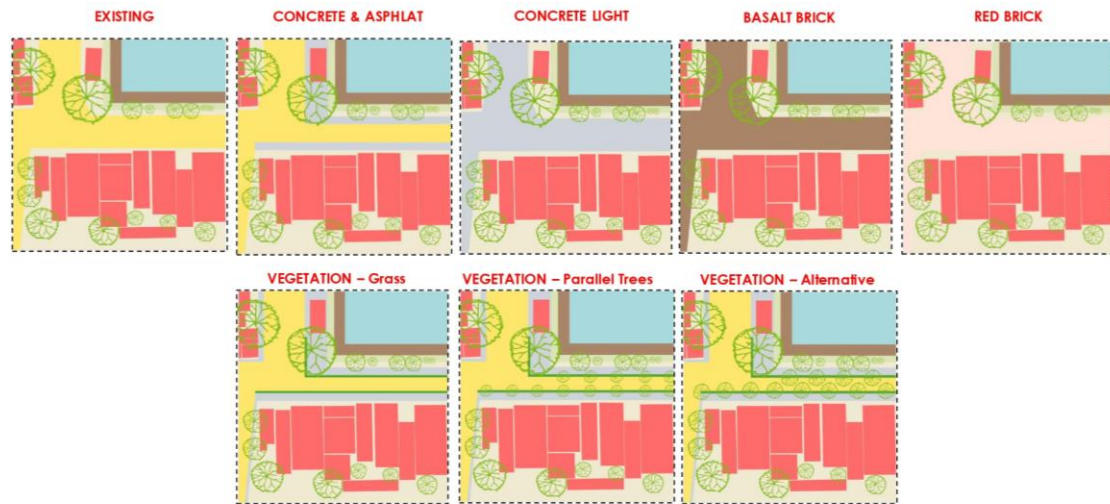
7.8 LOCATION: C1- ITERATION OPTIONS



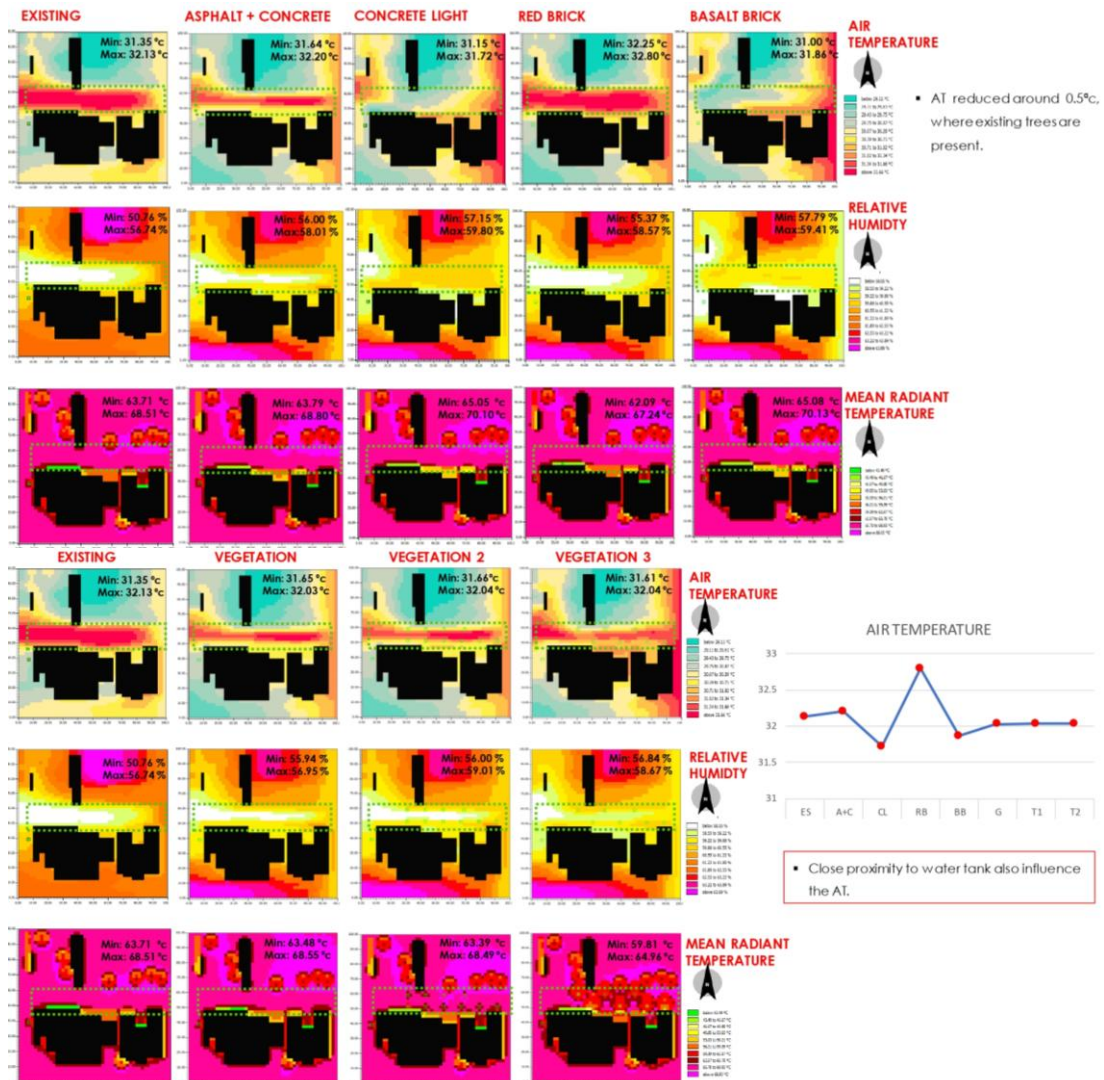
7.9 LOCATION: C2,F1 - ITERATION OPTIONS



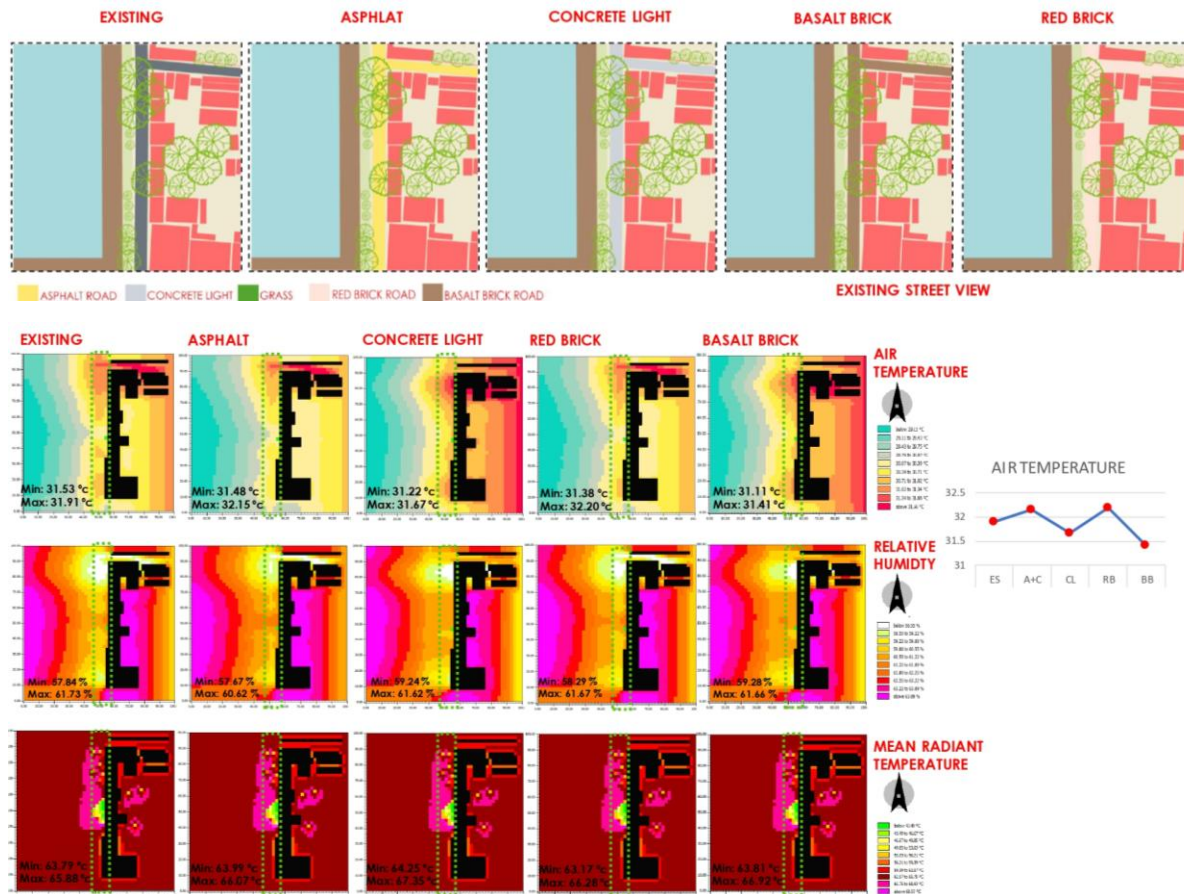
7.10 LOCATION: C3 - ITERATION OPTIONS



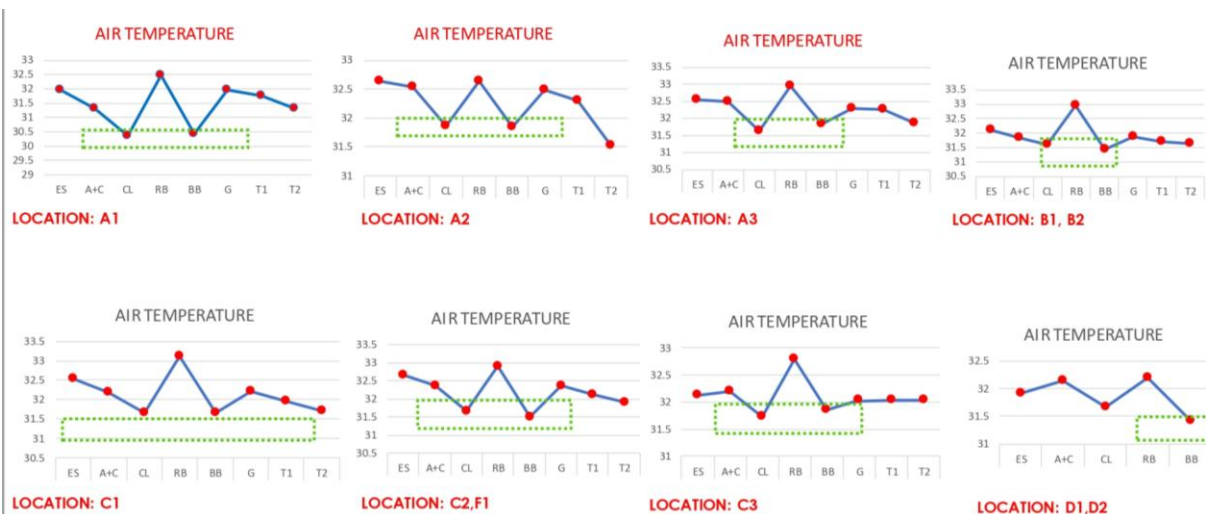
ASPHALT ROAD CONCRETE LIGHT GRASS RED BRICK ROAD BASALT BRICK ROAD



7.11 LOCATION: D1,D2,E1 - ITERATION OPTIONS

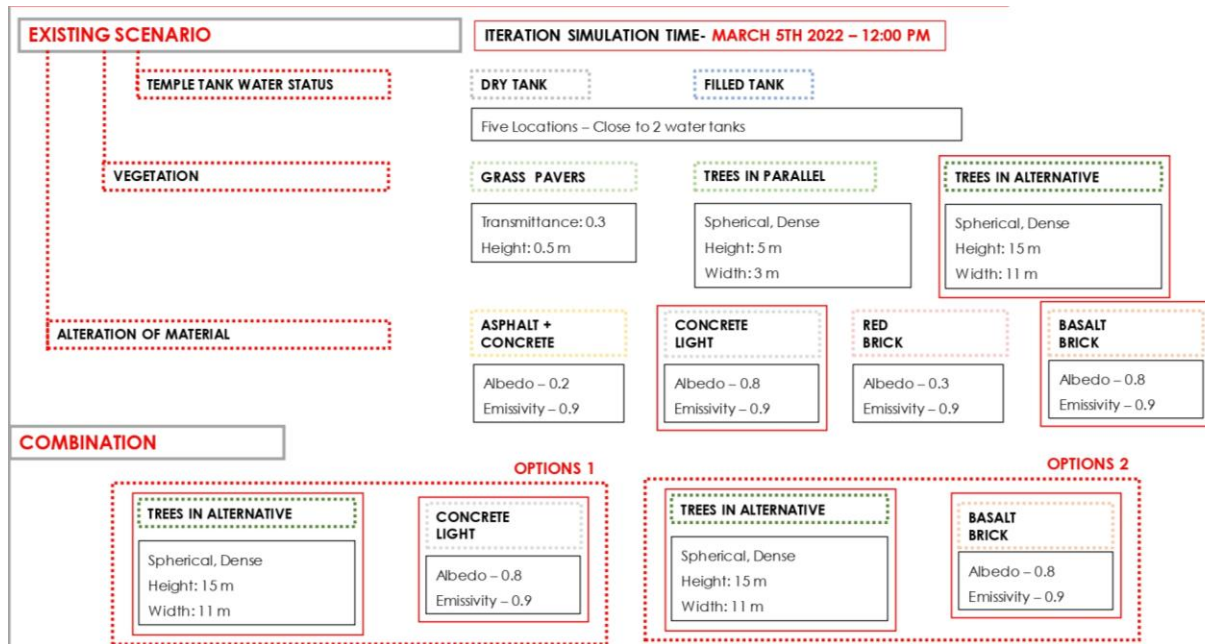


7.12 COMPARISON OF AIR TEMPERATURE

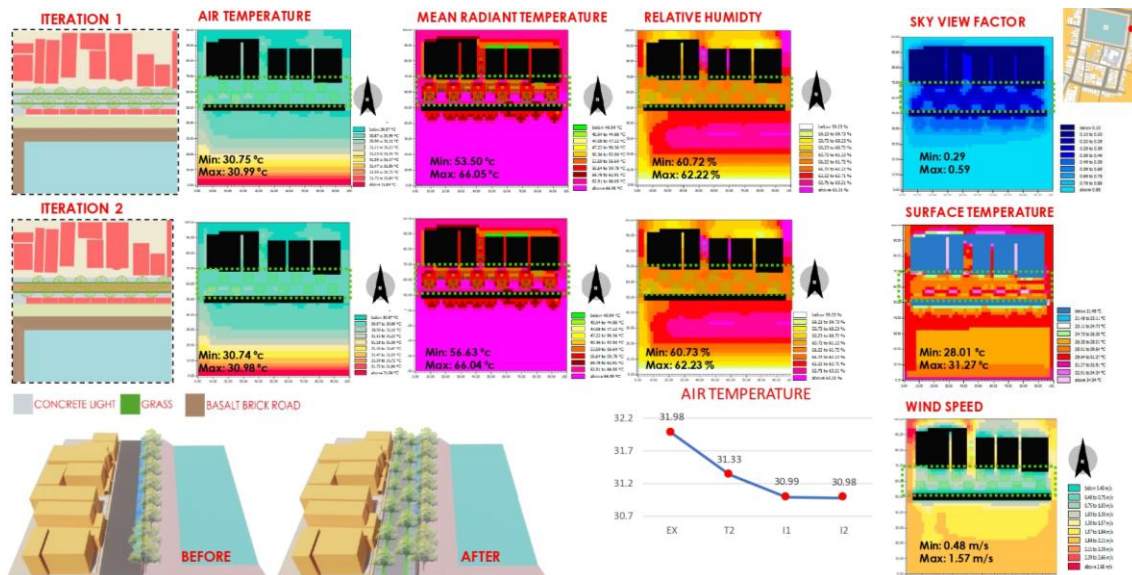


- Overall material with high albedo reduces the temperature.

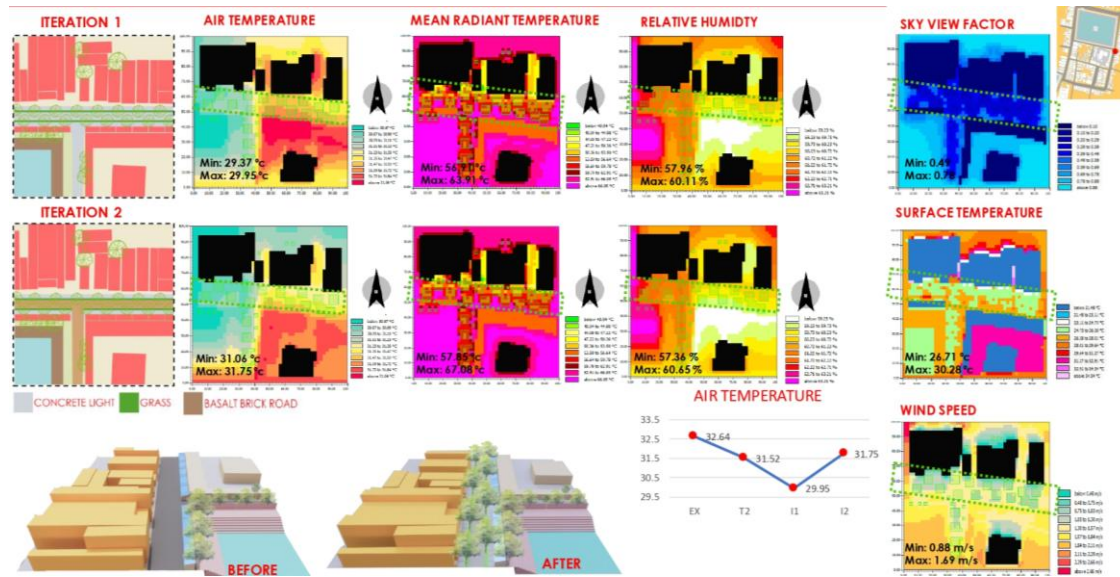
7.13 ITERATION OPTIONS – COMBINATION FROM BASE CASE



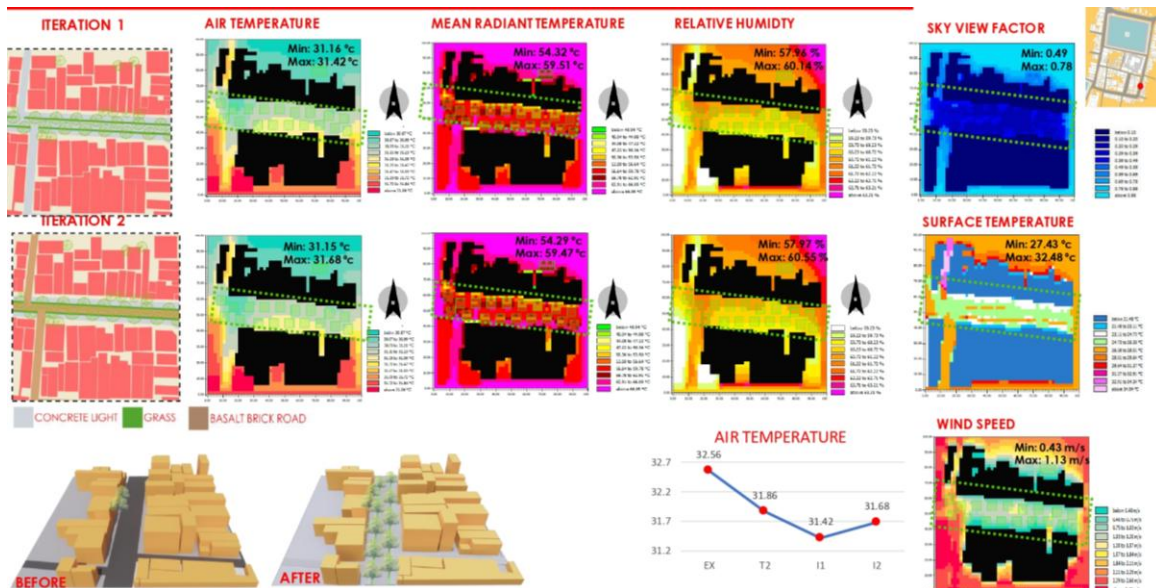
7.14 LOCATION: A1 - ITERATION OPTIONS



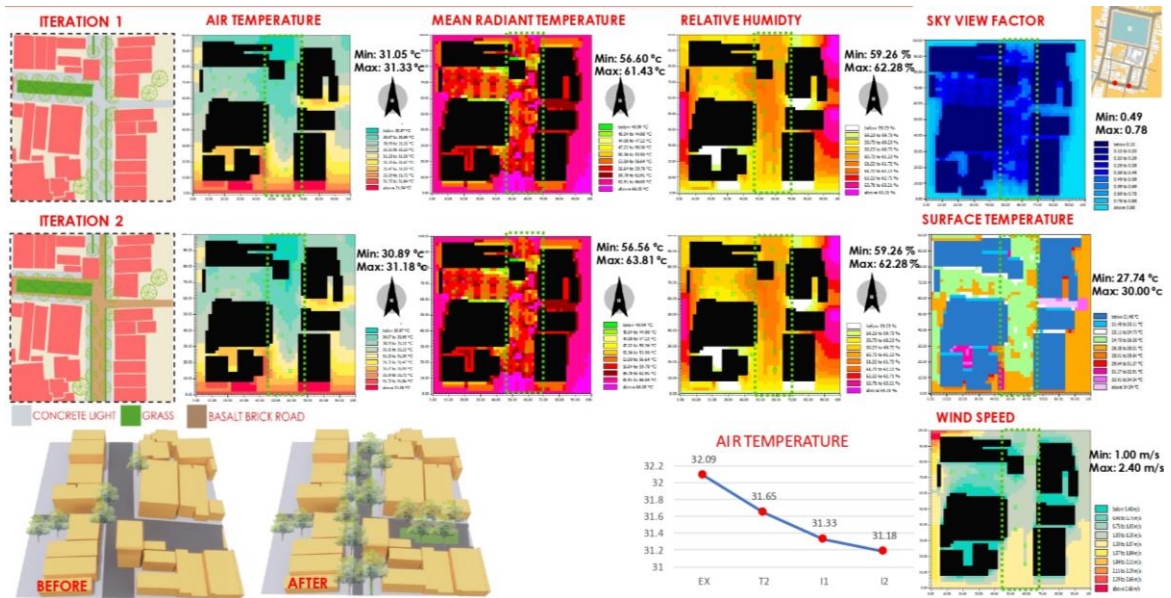
7.15 LOCATION: A2 - ITERATION OPTIONS



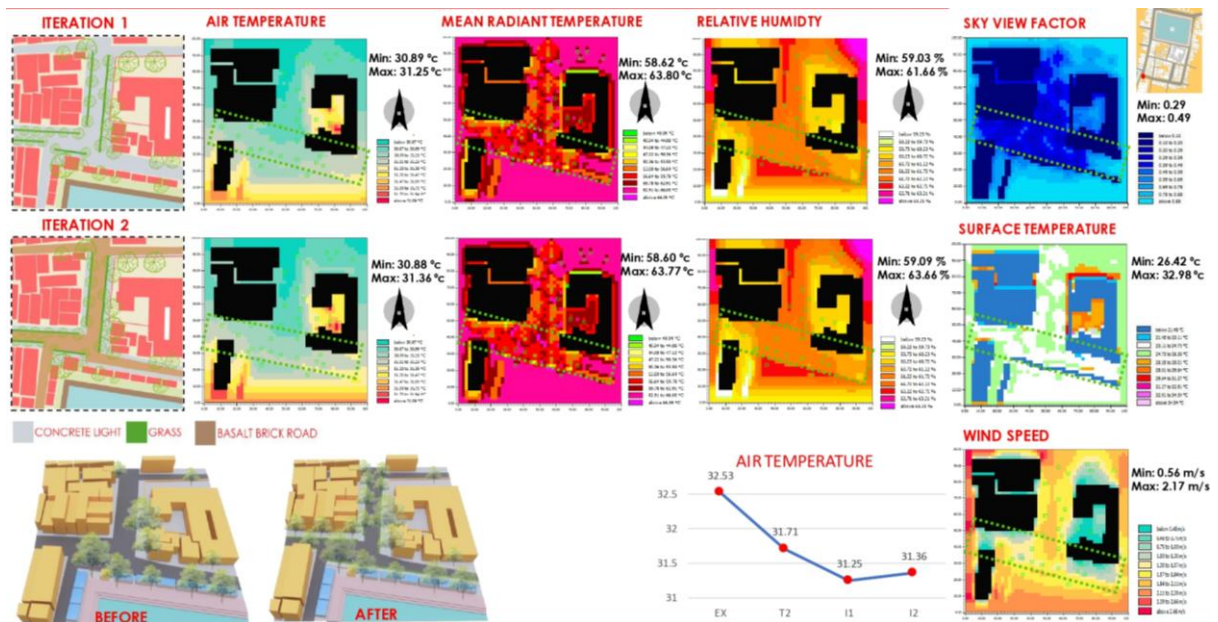
7.16 LOCATION: A3 - ITERATION OPTIONS



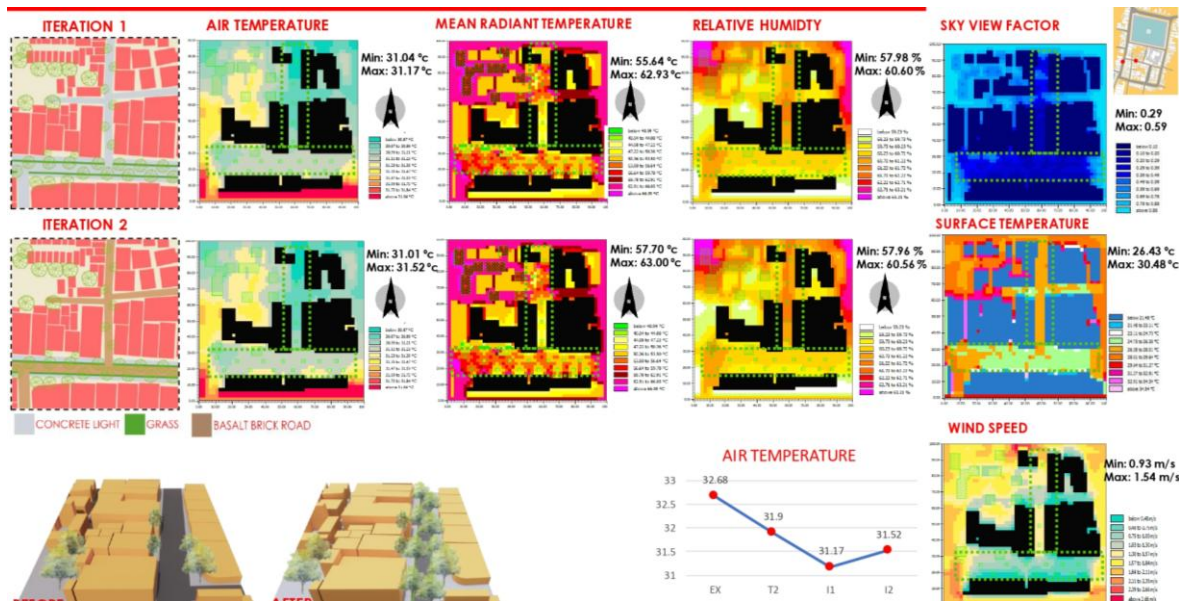
7.17 LOCATION: B1, B2 - ITERATION OPTIONS



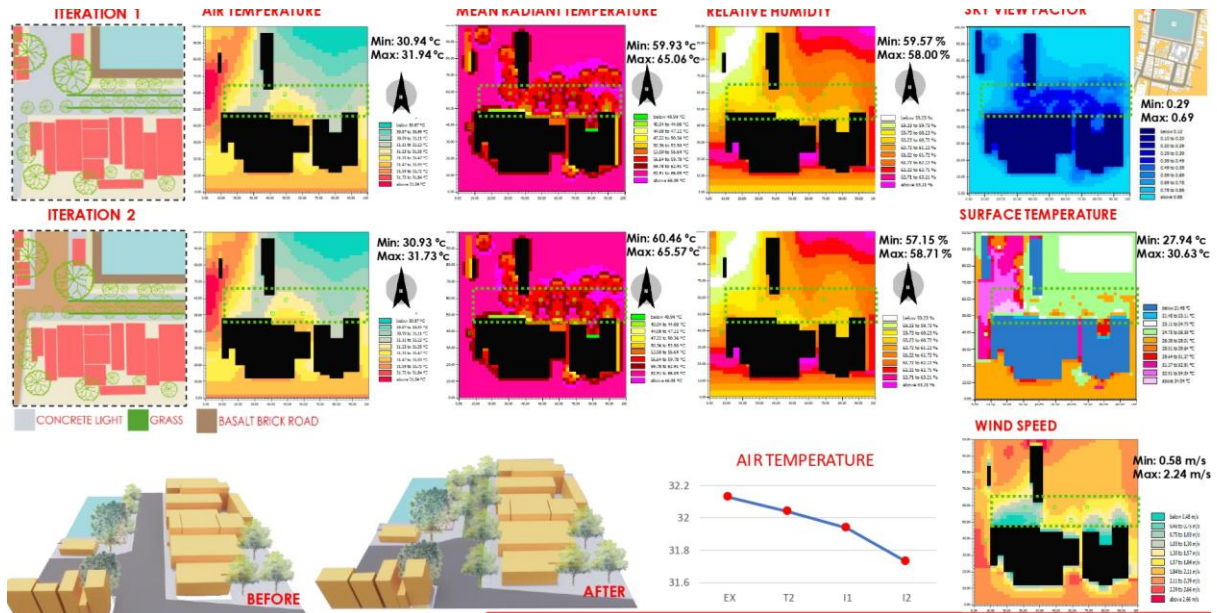
7.18 LOCATION: C1 - ITERATION OPTIONS



7.19 LOCATION: C2,F1 - ITERATION OPTIONS

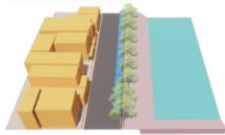


7.20 LOCATION: C3 - ITERATION OPTIONS



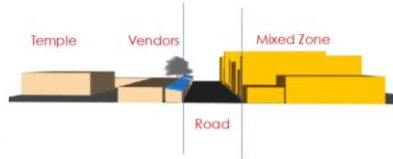
7.21 FUNCTIONAL ASPECT OF STREETS

LOCATION: A1



- Encroached footpath.
- No access to tank.
- Vendors along the tank.
- Roadside parking by commercial users.

LOCATION: A2



- Evening time, few vendor shop pop up on roadside.

LOCATION: A3



- Mixed residential.
- Shops on ground floor and residence on top.

LOCATION: B1, B2



- Encroached footpath.
- Mandapam, Auditorium

LOCATION: C1



- Traffic junction.
- Vendors on roadside

LOCATION: C2



- Traffic junction.
- Vendors on roadside

LOCATION: C3



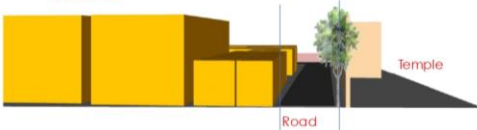
- Heavy traffic junction at peak hours.
- Access to main road.

LOCATION: D1, D2

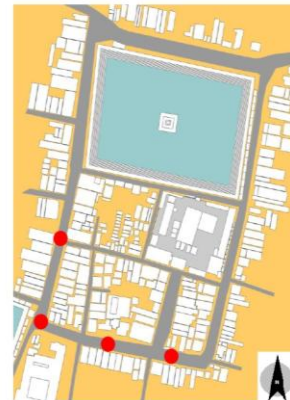
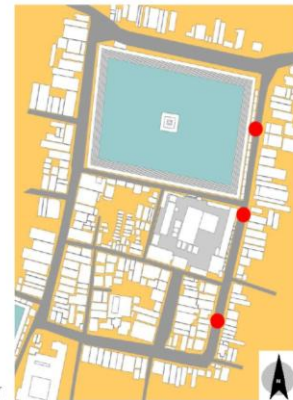


- Ritual spots along tank side.
- Narrow road.
- Less vehicle movement.

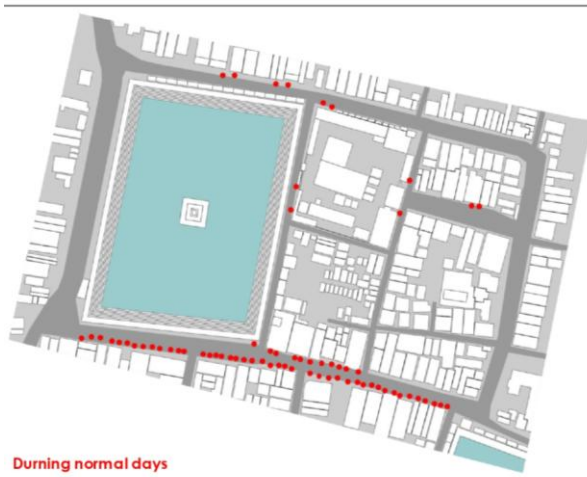
LOCATION: E1



- Narrow road.
- Less vehicle movement.



7.22 STREET VENDORS

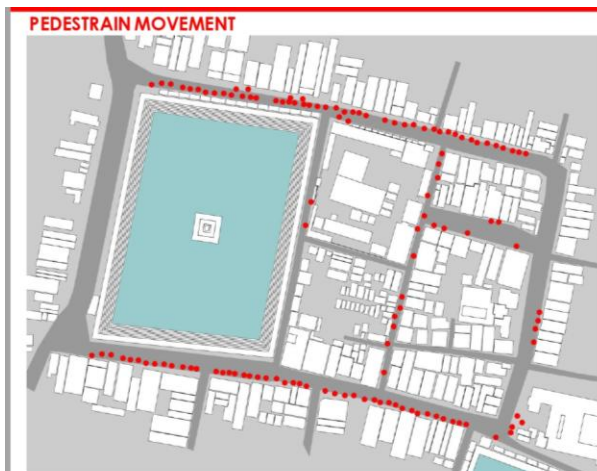


- Street vendors usually found on south mada street encroaching the pedestrian platform.
- Peak Hours: 7 am to 9 am, 6 pm to 9 pm.

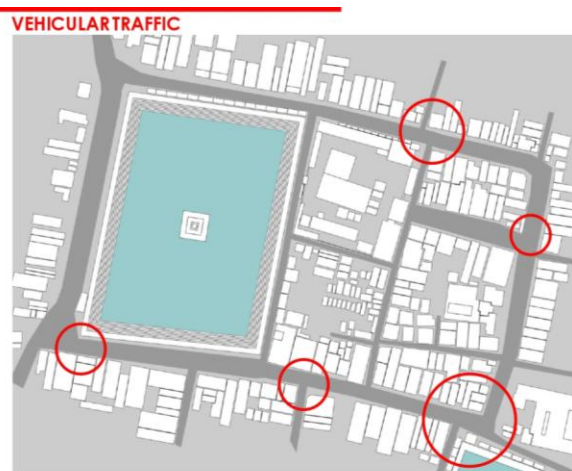


- During festival, new vendors occupy space all around the space around the temple area.
- Peak Month: March, Sept, Oct
- Peak Hours: 6 am to 12 am, 4 pm to 10 pm.

7.23 PEDESTRIAN MOVEMENT & VEHICULAR TRAFFIC



- Major pedestrian movement is seen along the north and south mada street, which is mixed area.



- Vehicular traffic is found near junction.
- Near areas which is occupied by unauthorized parking zone.

7.24 CRITICAL IDENTIFICATION



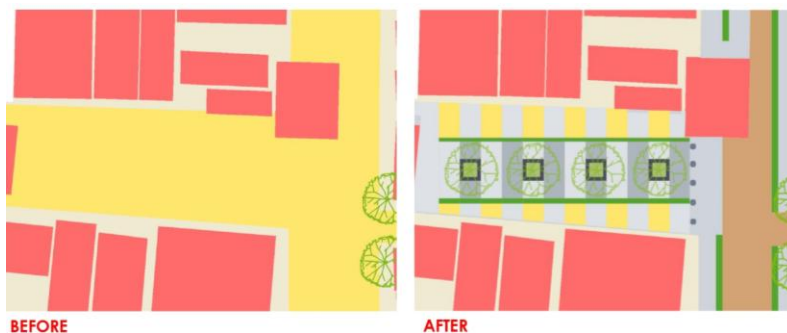
- Surrounding the temple was historically not designed to handle vehicles. Being a popular tourist and pilgrimage spot worsened the situation by increasing pressure for parking.
- The city traffic police close off the mada streets- North, South and East Street which is home to big stores ahead of festival time, to ease congestion.
- Four way junction, roadside vendors, crowded area.
- Few areas are well shaded by tree.
- Regular street vendors cannot be dislocated to new spot, since regular buyers are from the neighbourhood.

7.25 LOCATION: C1



- Four way junction.
- Platform occupied by mechanic shop and street vendors.

7.26 TEMPLE ENTRANCE

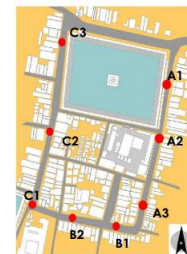
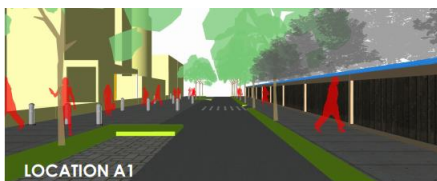
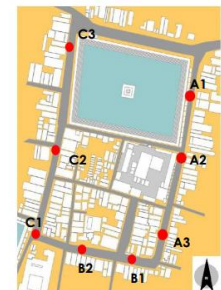
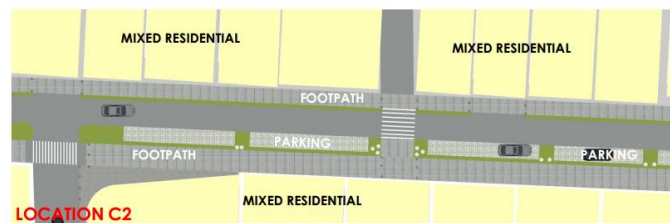
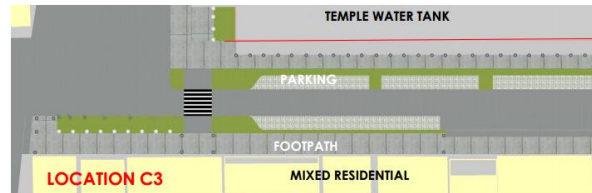
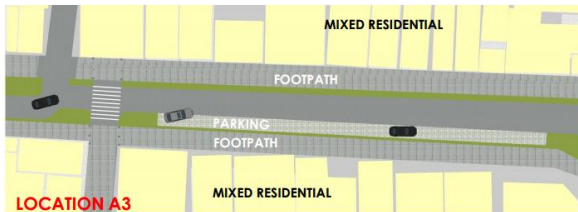
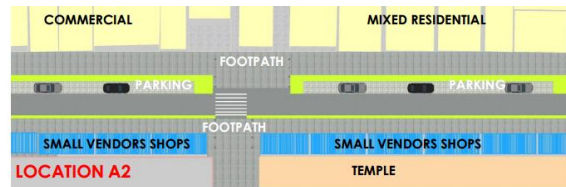
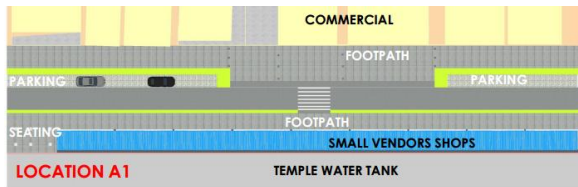


Main ideology is to make the vehicular free zone.

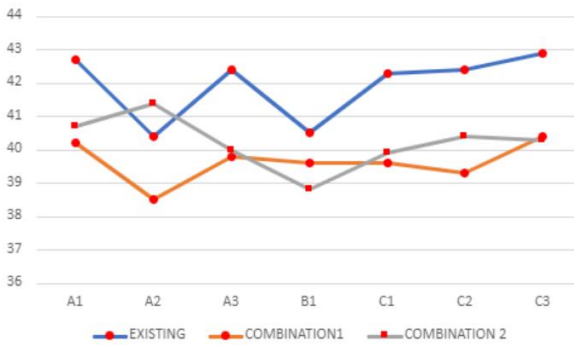
By installing bollards at street entrance can stops vehicles entering the area.

Act as leisure space outside the temple.

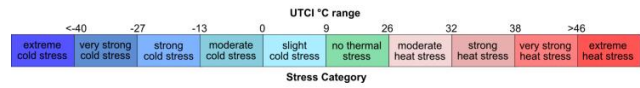
7.27 DESIGN PROPOSAL



7.28 UTCI CALCULATION



LOCATION	EXISTING	COMBINATION1	COMBINATION 2
A1	42.7	40.2	40.7
A2	40.4	38.5	41.4
A3	42.4	39.8	40
B1	40.5	39.6	38.8
C1	42.3	39.6	39.9
C2	42.4	39.3	40.4
C3	42.9	40.4	40.3



- UTCI results shows reduction of (2°C approx.)
- Location A2 achieved least of all other points in combination 1.
- Location oriented along A2, shows increase in value due to higher mean radiant temperature.
- Even after reduction is seen in iteration model, all the points ranges in very strong heat stress. This mainly due to the climatic condition of Chennai.



CHAPTER 8 CONCLUSION

8.1 VEGETATION

- Alternative arrangements of trees provide better shading and reduces in air temperature compared to linear arrangements.
- Difference in canopy size also shows variation in air temperature.
- More trees also causes congestion in narrow street.
- Trees on both side is suitable only if the road width is more than 10m.
- Difference in surface temperature between shaded and unshaded area by tree is around 4°C.
- Provision of trees reduced AT around 0.5°C to 1.5 °C

8.2 SURFACE MATERIAL

- Material with high albedo and light pigment, shows difference in temperature.
- AT difference of 1°C between high albedo and low albedo.
- Materials like, light pigment concrete, basalt brick can reduce the AT around 1.2°C, even without providing vegetation.
- Compared to commonly used road material asphalt, red brick shows more AT.
- It can be further concluded that combination of material and the use of vegetation and grass reduces air temperature by approx. 2°C.

8.3 DESIGN RECOMMENDATION

- Continuous parking along the road side should be avoided, breaks such as buffer area (Landscape) to be provided .
- Providing bollards on pedestrian footpath on entrance can stop vehicle encroaching the footpath.
- Installing different material according to usage.
- For one way road, carriage way should be reduced, avoiding unauthorized usage of road as two ways.
- Services can placed along the buffer zone, so in case of repair it does not affect pedestrian area.

References

Research Paper(Case Study)

3.1 Carlos Bartesaghi-Koc, Shamila Haddad, Gloria Pignatta, Riccardo Paolini, Deo rasad, Mattheos Santamouris, Can urban heat be mitigated in a single urban street? Monitoring, strategies, and performance results from a real scale redevelopment project, Solar Energy, Volume 216, 2021, Pages 564-588, ISSN 0038-092X,

3.2 Karakounos, I. & Dimoudi, A. & Zoras, S.. (2017). The influence of bioclimatic urban redevelopment on outdoor thermal comfort. Energy and Buildings. 158. 10.1016/j.enbuild.2017.11.035.

3.3 Vukmirovic, Milena & Gavrilovic, Suzana & Stojanovic,. (2019). The Improvement of the Comfort of Public Spaces as a Local Initiative in Coping with Climate Change. Sustainability. 11. 6546. 10.3390/su11236546.

BOOKS & ARTICLES

1) Complete Streets - Policy Workbook – ITDP

2) Place making and climate change adaptation

3) NMT Policy

4) Complete Streets Design Manual – ITDP

5) Case study Map – CITYWORKS

6) Mending the seams of an Urban Patchwork Quilt: Achieving an ‘Ordered Chaos’ in Temple Towns of Southern India by Harini S. Rajaraman