The Heat Story

Observing summer temperatures in Ahmedabad

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Observing summer temperatures in Ahmedabad

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LEAF is engaged in research and publication in the area of landscape design and environmental planning. It supports research programs of varying durations every year. Over the years, LEAF has increased its areas of exploration to developing city management matrices, governance and administration studies, urban generation and open space outreach efforts.

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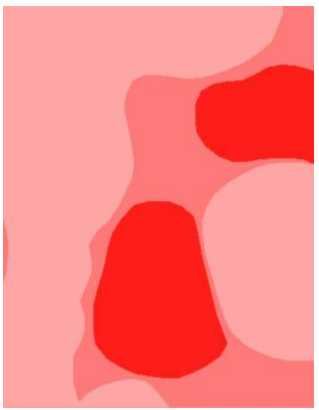


Heat anomalies

Introduction

The prolific Shel Silverstein, about four and a half decades back in his book "The Giving Tree" waxed eloquently about the selfless manner in which a tree could help mankind. In the end of the book, the protagonist rues that as he has slowly taken from the tree all his life, he has also robbed it of the one thing that he needs most in his old age - shade.

In times of global warming and unprecedented spikes in temperatures, the book is almost prophetic. Anahita came to do her short internship in the middle of a blazing summer in Ahmedabad, at a time when any topic finally veered to how the city was burning. Temperatures were in their high forties. In this heat she asked her self a simple enough set of questions; how hot is hot really? And does it really cool?

She found in the local market, wet and dry bulb hygrometers manufactured by a 130 year old British company, named appropriately enough , Zeal.

She showed just that, in large doses and went out in the sun when it blazed the most and set up what at least in her young mind were primitive devices, at five locations in town and took readings throughout the day- in some cases, retreating quickly after setting up the instrument, to a cooler place, so relentless was the heat. The readings in their nuances are rather educative and throw up some very valuable and precise understanding of what really makes things hotter than the sun intended it to be, and what can be done to alleviate such conditions in the city.

We often say that shade is good- her work tells us exactly how much. We often say its very hot- she tells us exactly how much. We often say somethings heat up more than others- she shows us exactly how.

Aniket Bhagwat

Prologue

Space responds to temperature. In current times, this has inversed. Temperature responds to space.

Architecture throughout history has been a reflection of its respective contextual climatic conditions. With both the increase in population and pollution, these notions are subtly changing. One of the most talked about phenomenon that has been observed across continents is the **urban heat island (UHI) effect**. This phenomenon occurs when heat is trapped in small pockets of an urban setup. This happens in densely populated areas due to various reasons :

As the **population** increases, the energy burned by factories, cars, people jogging, to a simple construction worker working with his tools, escapes in the form of heat. A research by the Environmental Protection Agency shows that the annual air temperature of a city with 1 million people can be 1.8–5.4 degrees Fahrenheit (1–3 degrees Celsius) warmer than its surroundings. Cities that are densely populated are also densely constructed and building **materials** are good at insulating or holding in heat making the areas around buildings warmer. In mammoth metropolitan cities, engineers build upward, creating skyscrapers. All this construction means **waste heat**—and heat that escapes insulation has nowhere to go. It lingers in and between buildings in the UHI.

This study aims to investigate this condition in a major urban centre of India, **Ahmedabad**. With an estimated population of over 7 million, Ahmedabad has been listed as one of the fastest growing cities of the decade. Ahmedabad has a hot semi arid climate with the highest temperature recorded by the Indian Meteorological Department to be $50^{o}C$ ($122^{o}F$) in May 2016.

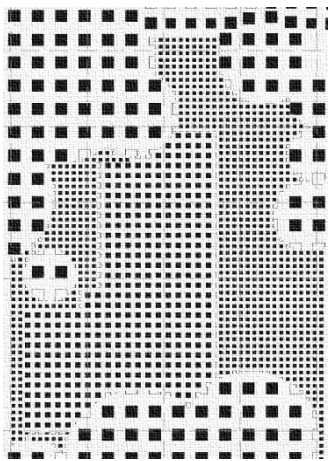
For this research project, I chose to record **microdata** of certain spatial compositions in the city that lead to temperature variations. Factors such as orientation, shadow patterns and materiality are taken into consideration to map a localised urban climatology.

Orientation of a space relative to the direction of the sun causes distinctive shadow patterns. The areas which are shaded constantly through the day tend to show a lesser reading of temperature than areas that receive minimum shadow.

Materiality of a space is one of the factors that also results in temperature changes. Every material has an inherent property known as thermal conductivity. Thermal conductivity is the rate at which heat passes through a specified material, expressed as the amount of heat that flows per unit time through a unit area with a temperature gradient of one degree per unit distance (W/mK). This means that if a material has high thermal conductivity, the rate at which heat energy passes through the material is high and hence it retains less heat, making it cooler than materials with less thermal conductivity.

Five urban locations in the city are chosen to understand the distinct nature of heat that is observed in each of these locations. These observations are recorded through drawings and maps.

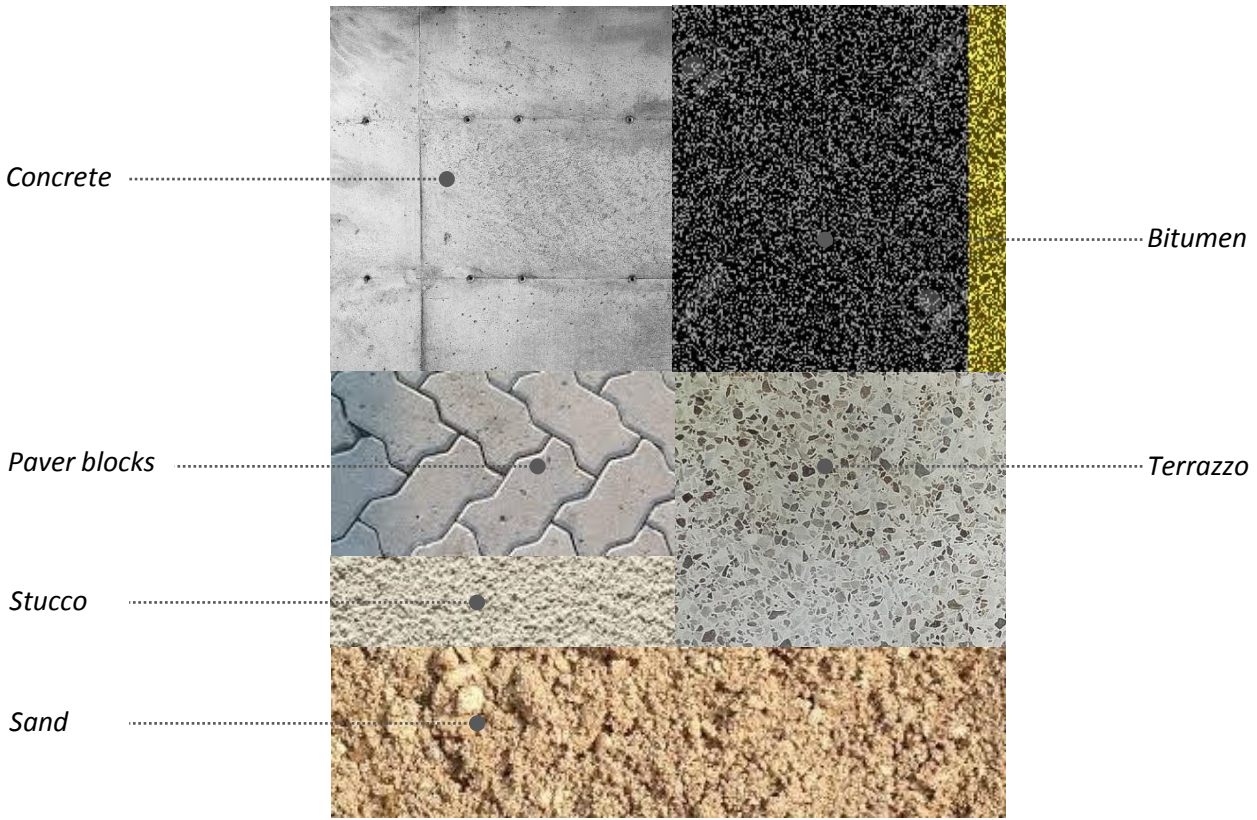
Observations have been made in the month of June 2018 where the average high temperature recorded in Ahmedabad was 42^{o}C and the average low temperature recorded was 28^{o}C. Recordings were taken at 11:00 am, 2:00 pm and 5:00 pm. During afternoon, the sun starts moving towards the west and reaches its highest position in the sky during high noon. Ten thermometers were placed on specific locations on site and temperatures were recorded across the site simultaneously at these times. Heat patterns are made based on the temperatures obtained. Each site shows a different heat pattern depending on its materiality and orientation.

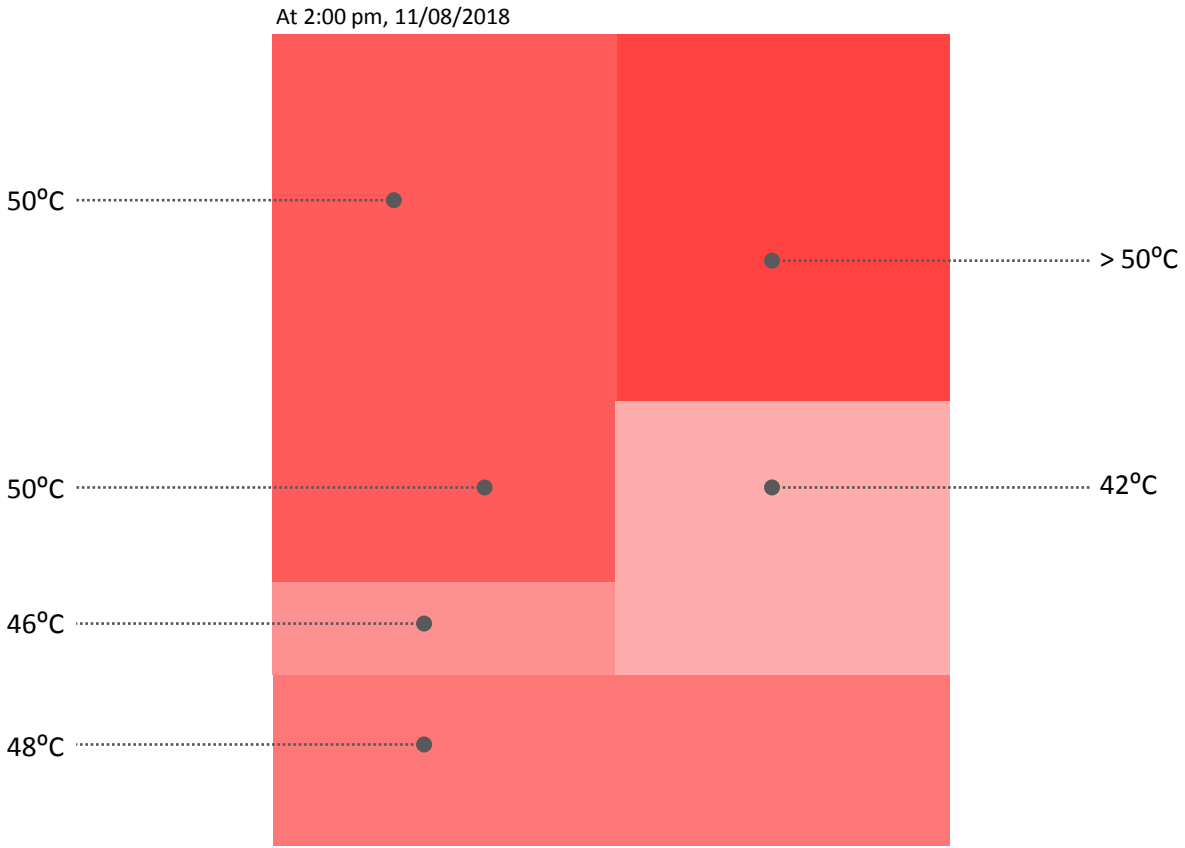


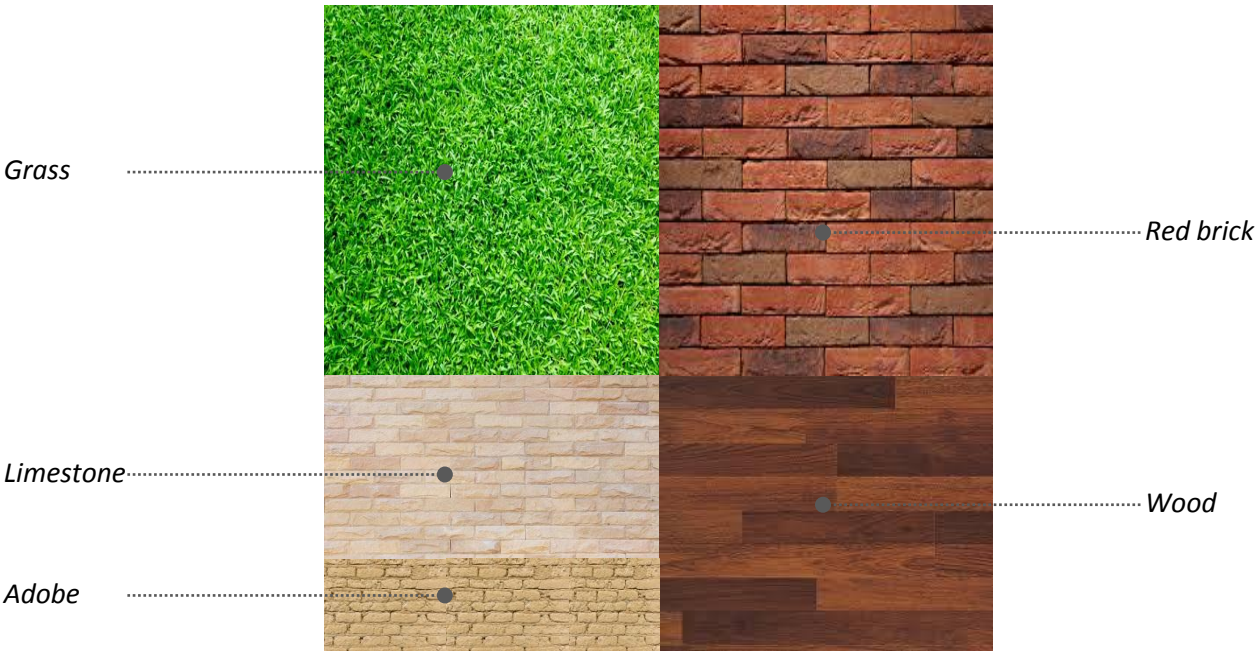
Material disparities

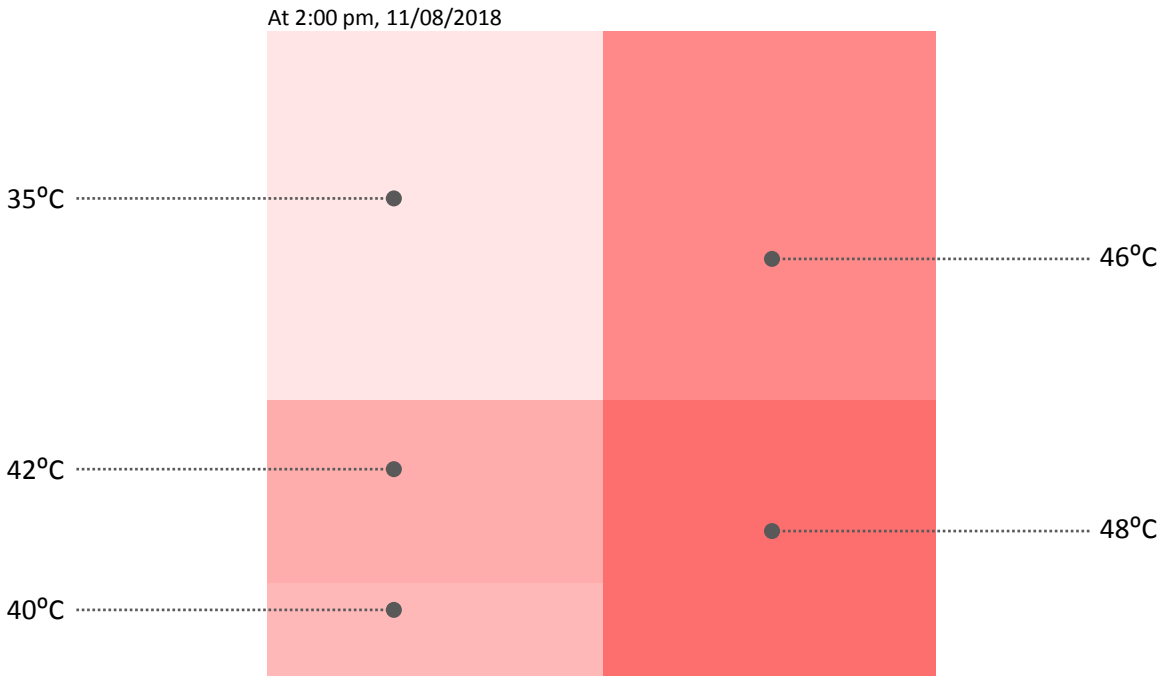
2a. Materials, temperatures, spaces

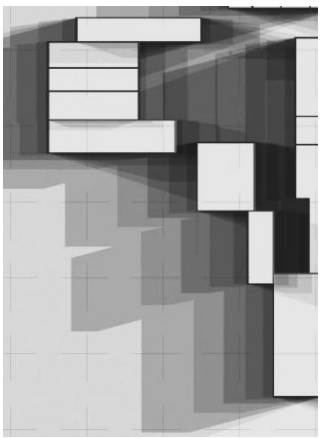
Different building materials have varying thermal properties. Hence certain materials can retain more heat than others causing the surrounding to heat up more.


Concrete
Bitumen
Paver blocks
Terrazzo
Stucco
Sand


At 2:00 pm, 11/08/2018
50°C
> 50°C
50°C
42°C
46°C
48°C


Grass
Red brick
Limestone
Wood
Adobe


At 2:00 pm, 11/08/2018
35°C
46°C
42°C
48°C
40°C

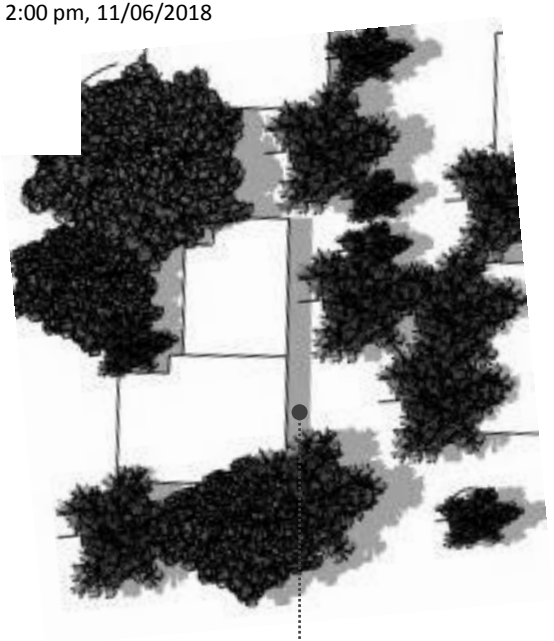


Layers of shadows

2b. Shade, temperature, spaces

From dawn to dusk, as the sun travels from east to west, the heat rays coming from the sun are blocked by buildings or trees. The areas in shade show a drop in temperature than the ones under direct sunlight.

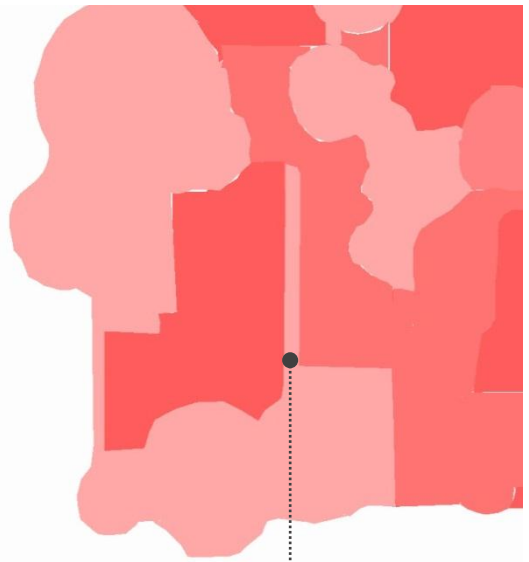
At 2:00 pm, 11/06/2018



Bungalow in Ambavadi

A slight shadow is observed by the building at 2:00 pm. The surrounding trees also shade certain areas.

At 2:00 pm, 11/06/2018

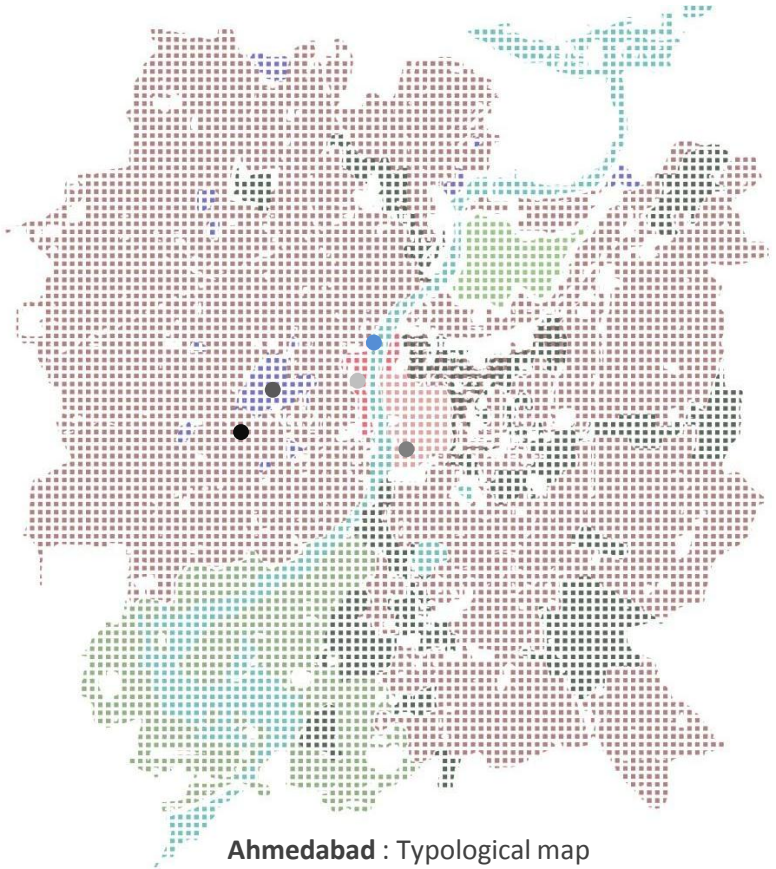


Bungalow in Ambavadi

A temperature drop of 8^{o}C is observed in the shaded areas and is represented by a lighter shade of red.

3. Ahmedabad City

Certain public and private conditions in the city can help in understanding the urban climatic fabric of the city. As summer temperatures soar, these conditions show striking changes in heat within a seemingly limited area. Five locations are chosen for this study which are representative of Ahmedabad's varied urban typology.



Ahmedabad : Typological map

Locations of study

- Ambawadi
- C.G.Road
- ATIRA
- Dada Hariyani *pol*
- Sabarmati riverfront

Index

- Residential Area
- Commercial Area
- Institutional Area
- Core Walled City
- Agriculture
- Central Jail
- Industrial Area
- Waterbody and river

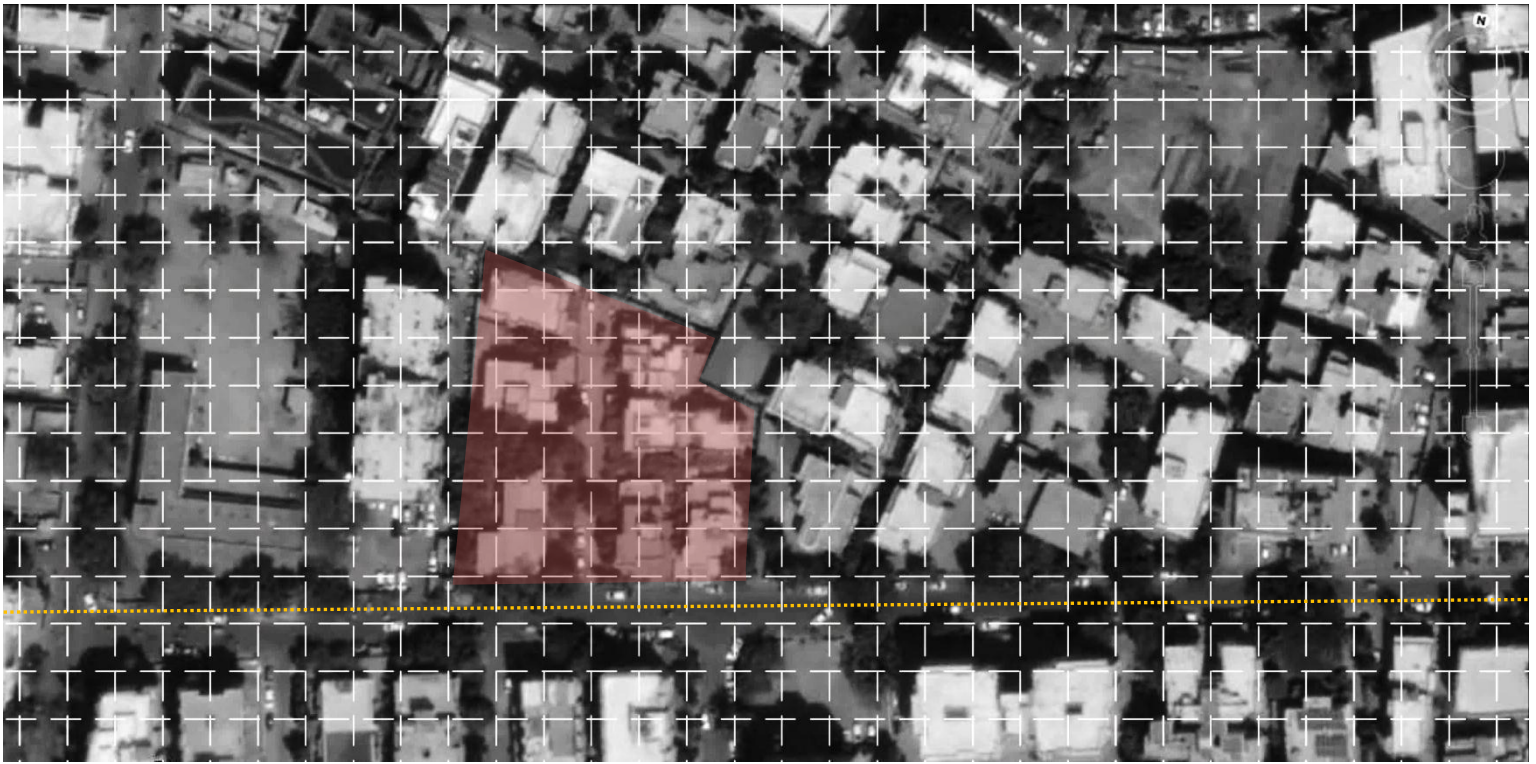
Spaces and heat

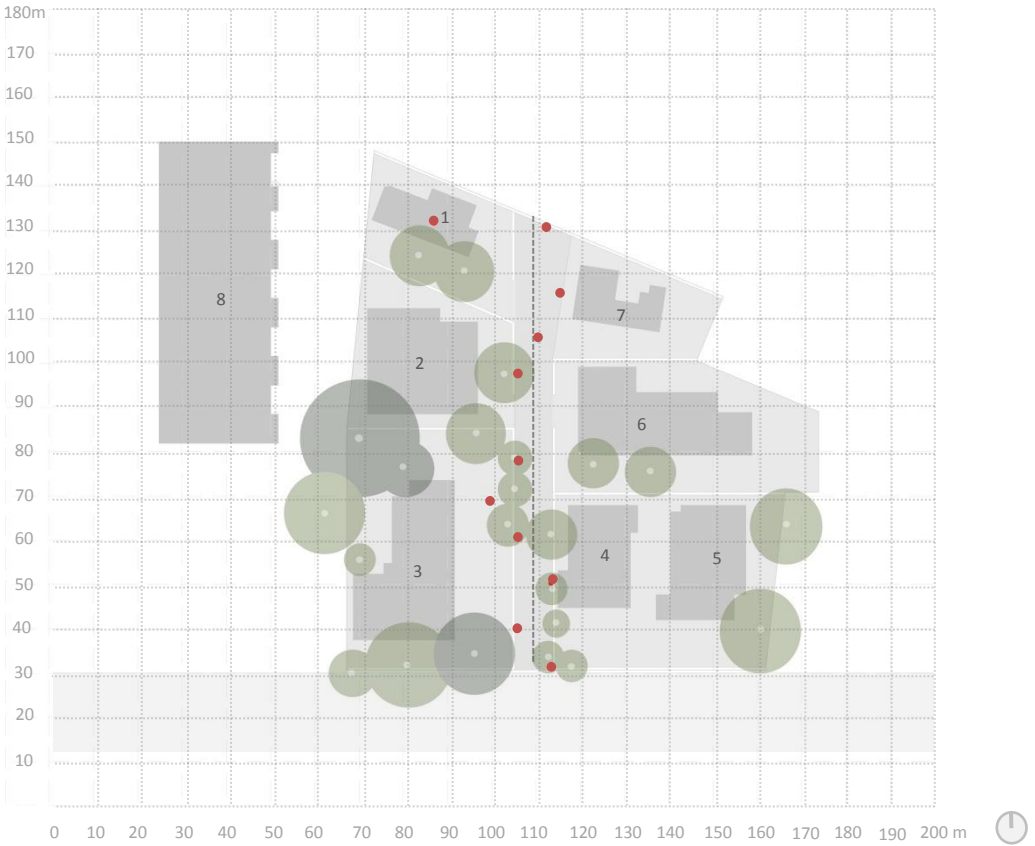
In June 2018, Ahmedabad recorded an average high temperature of 42^{o}C. But within the city limits, spaces showed a range of temperatures at different times of a day. The following are a series of studies investigating this phenomenon.

a. Residential Area

Ambavadi is a small area in Ahmedabad city that is categorically recognised by its quaint bungalows and tall rows of *asopalav* trees. This location is near Ambavadi circle and comprises of six residences and the street in between is lined with *asopalavs*.

Site





Index

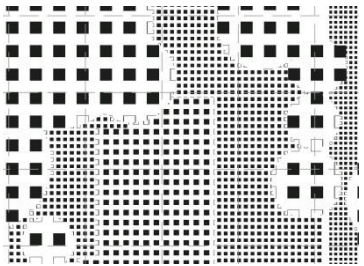
- Site
- Main road

Heights of buildings

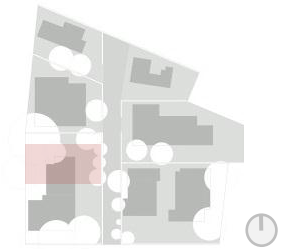
1	- 9 m	5	- 6 m
2	- 6 m	6	- 7 m
3	- 6 m	7	- 9 m
4	- 6 m	8	- 30 m

Types of trees

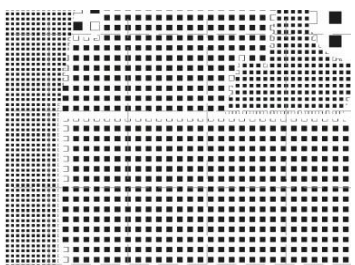
- *Neem*
- *Asopalav*
- Points of measurement



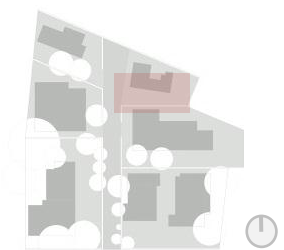
Trees present in this zone have high conductivity



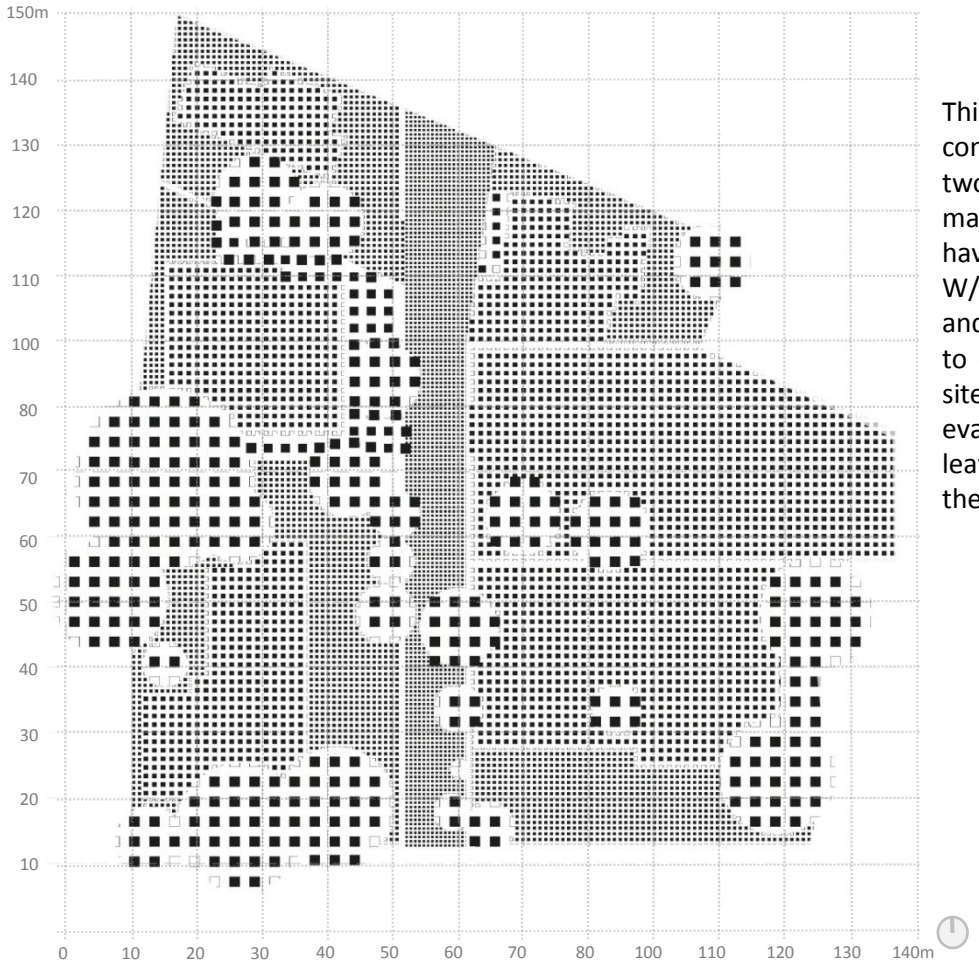
Heat storage is very less.



Lack of trees indicates less conductivity



Heat storage is more.

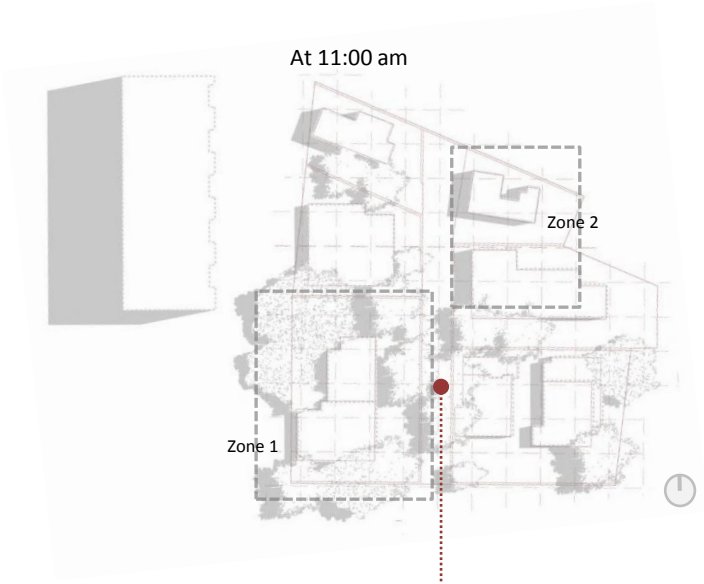


This map shows the difference in thermal conductivity of materials found on the site. The two/three storeyed bungalows are primarily made of brick and concrete – materials which have very less thermal conductivity (0.2-0.1 W/mK). These materials heat up the surroundings and do not allow the heat stored in the afternoon to escape. But due to the tree cover present on site, this effect is balanced. By the process of evapotranspiration, the water present on the leaves of trees is converted to water vapour thereby cooling the surroundings.

Index

- - > 3 W/mK
- - 2.0-1.0 W/mK
- - 0.4-0.3 W/mK
- - 0.2-0.1 W/mK

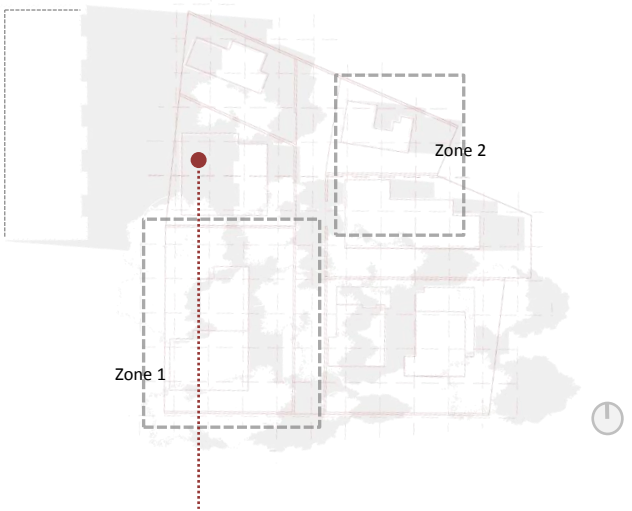
At 11:00 am



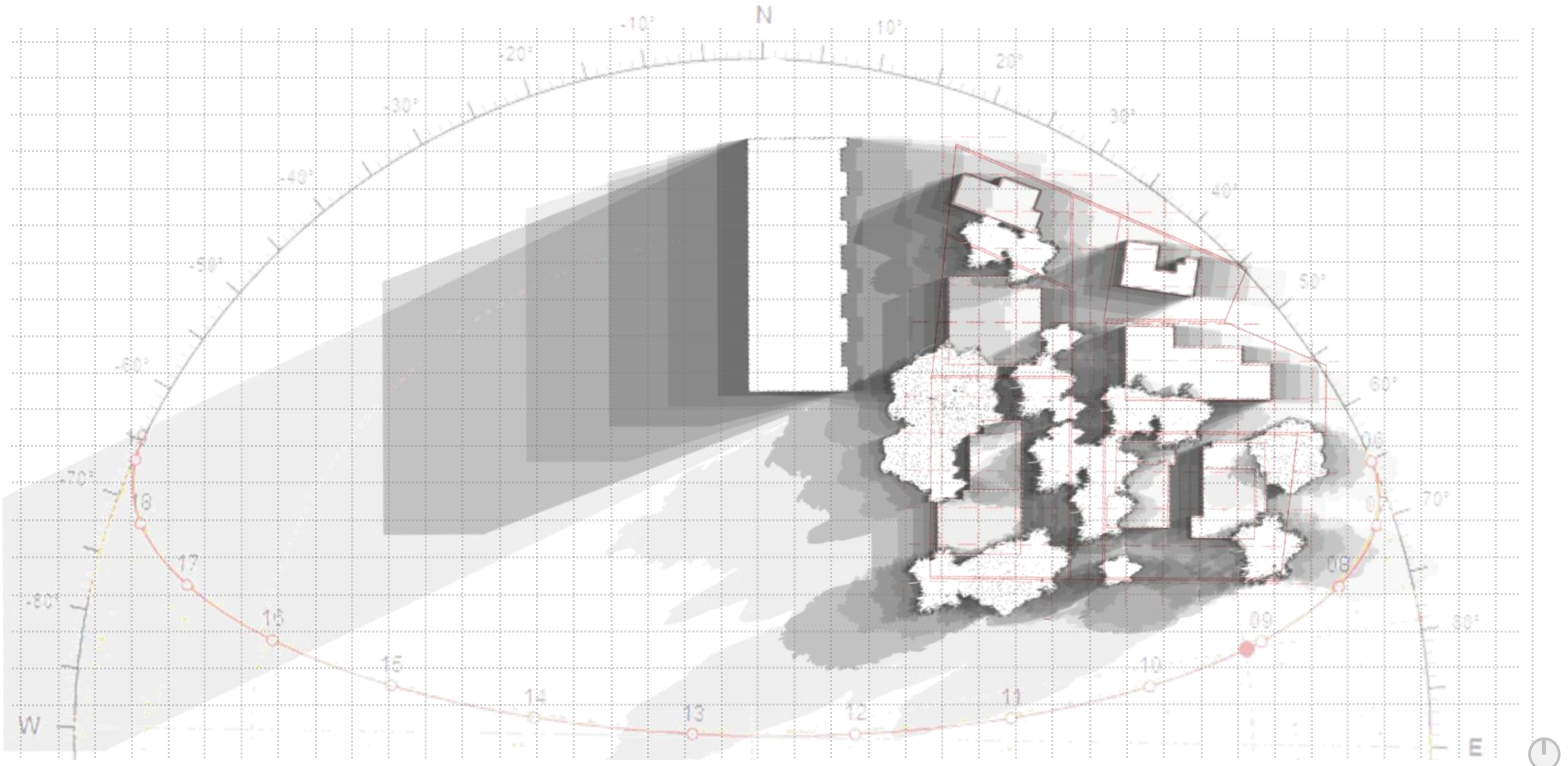
Half of the street is lined with tall *asopalav* trees that cast a soft shadow in the morning.

Zone 1 is constantly shaded because of the presence of trees, in contrast to Zone 2 which receives very less shadow because of lack of green cover. This indicates that the two zones will have variations in temperature that is recorded .

At 5:00 pm

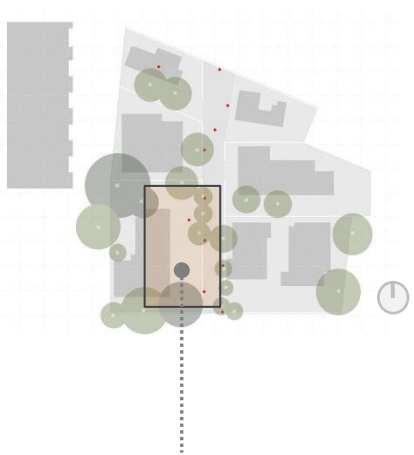


In the evening, the 33m tall building on the west end of the site starts casting a sharp shadow on the site.



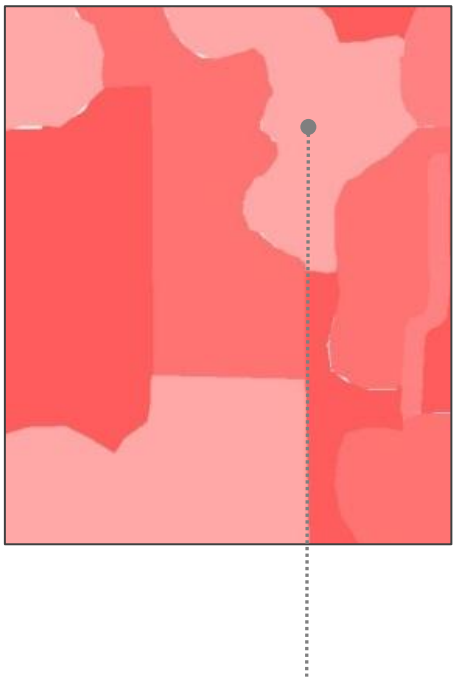
10m x 10m grid

Observing temperatures of a particular zone



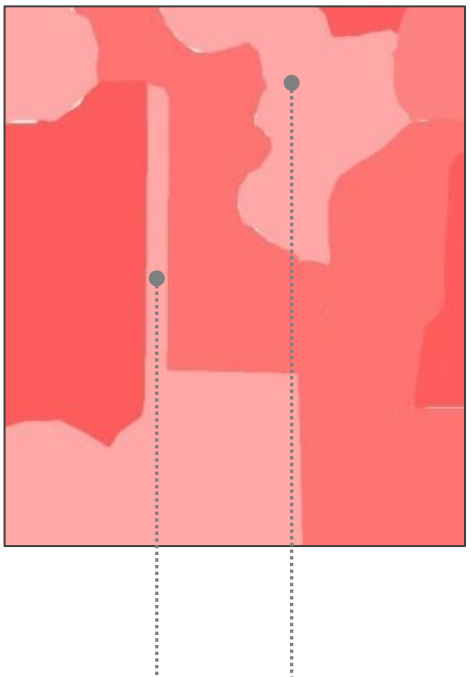
Area- 2000 sq. mts
Sparse tree cover
Vacated bungalow.

At 11:00 am, 11/06/2018



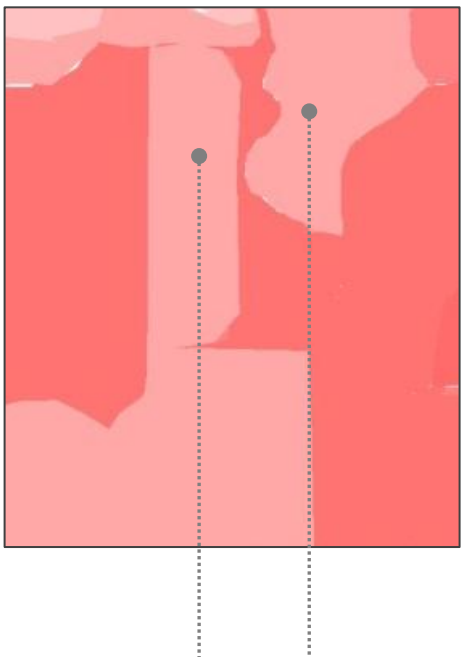
Temperature difference of upto $10^{o}C$ is observed in areas shaded under trees.

At 2:00 pm, 11/06/2018



Decrease in temperature is directly proportional to the shadow cast by the building and trees.

At 5:00 pm, 11/06/2018



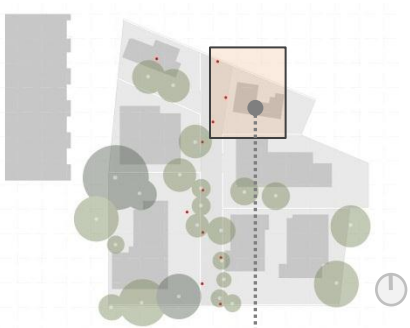
As the evening approaches, the overall temperature decreases by 7°C and the areas under shadows increase.

In a very small area on site, simultaneously a temperature of 48°C and 36°C is observed – the darkest red being the highest temperature and the lightest pink showing the lowest temperature. The areas which are shaded by trees or by buildings show a temperature drop.

From sunrise to sunset minor changes are observed in this heat pattern. As the length of the shadow increases in the evening, the area shown in light pink increases, this indicates that a relatively larger area shows a temperature reading of 36°C at 5:00 pm.

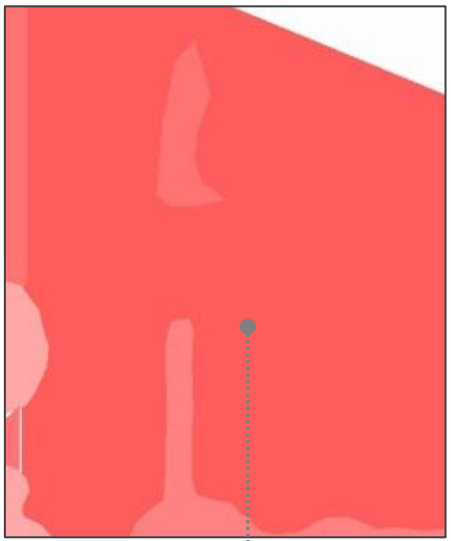
Index

> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C



Area- 2000 sq. mts
Sparse tree cover
No shade.

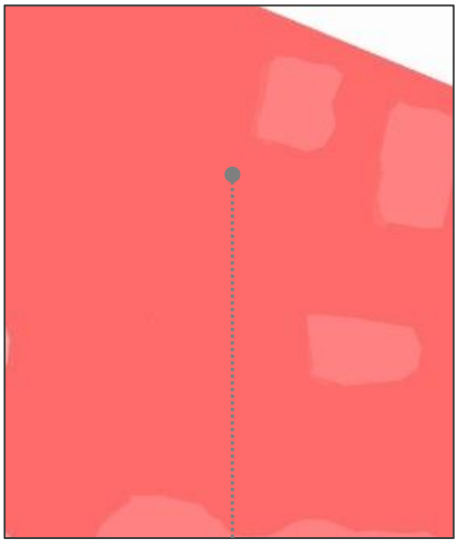
At 11:00 am, 11/06/2018



A temperature of 48°C is observed in this zone due to lack of material variations.

At 2:00 pm, 11/06/2018

At 5:00 pm, 11/06/2018



Due to lack of trees in this zone, temperatures drop less than 4°C in the evening.

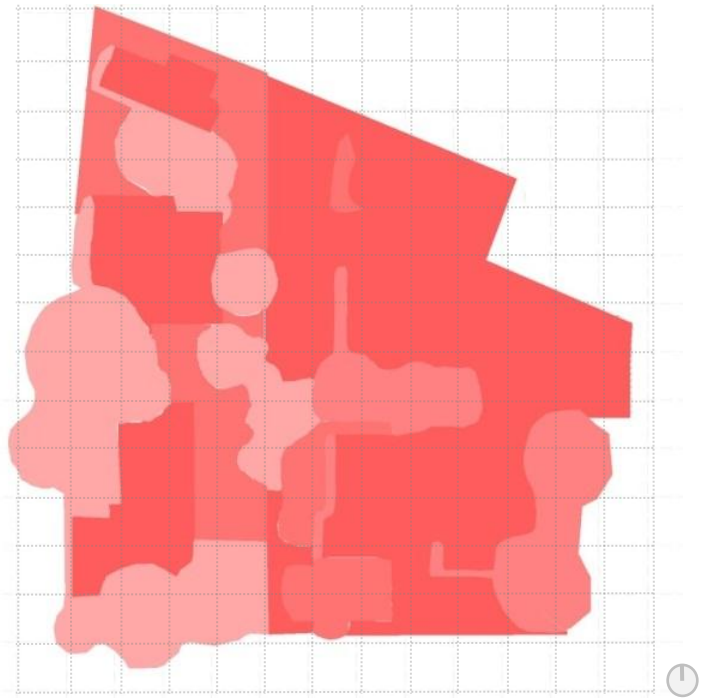
This zone is drastically different as compared to the previous one, since it has absolutely no tree cover. Due to this, a temperature of 48°C is observed at 11:00 pm. The concrete building present in this zone heats up the surroundings and does not let the heat to escape even in the evening. Thereby at 5:00 pm, the temperature drops by a mere 4°C.

Index

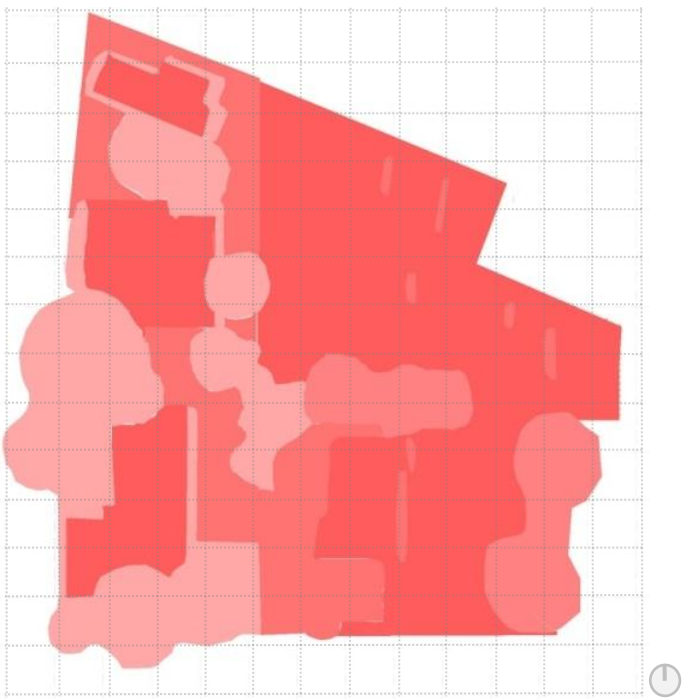
- > 50°C
- 48°C - 50°C
- 46°C - 48°C
- 44°C - 46°C
- 42°C - 44°C
- 40°C - 42°C
- 38°C - 40°C
- 36°C - 38°C
- 34°C - 36°C
- 32°C - 36°C

Observing temperatures of the entire site

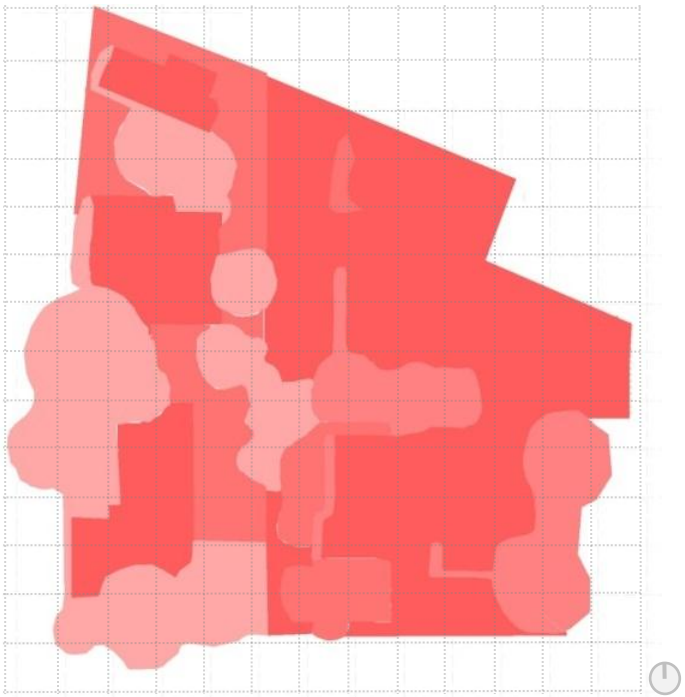
At 11:00 am, 11/06/2018



At 2:00 pm, 11/06/2018



At 5:00 pm, 11/06/2018



Inferences

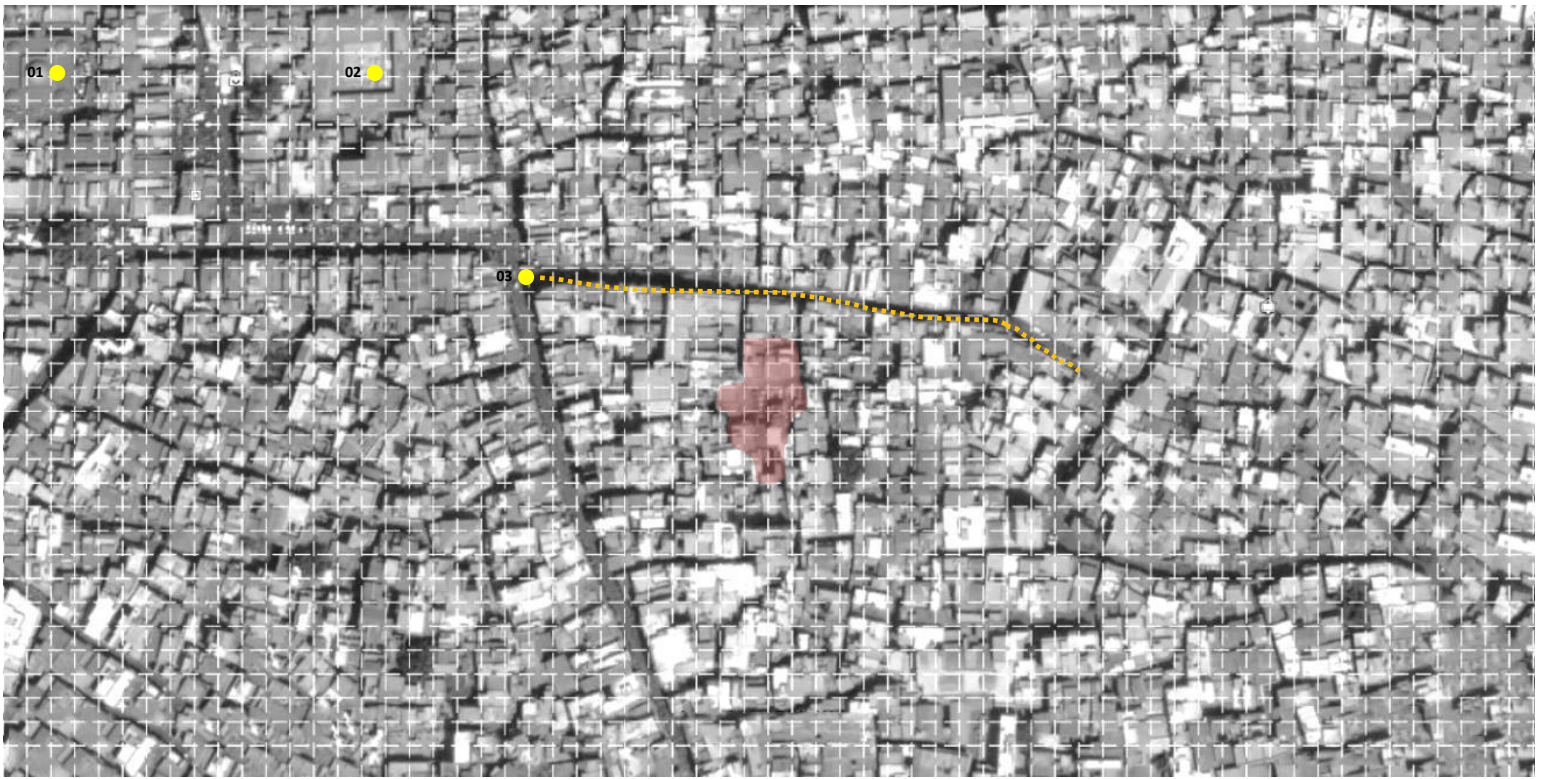
Material variation, shadow patterns, and tree cover on site impact the **erratic spatial distribution of temperature**. This shows that temperature is responsive to the **composition of space** in urban residential areas of the city.

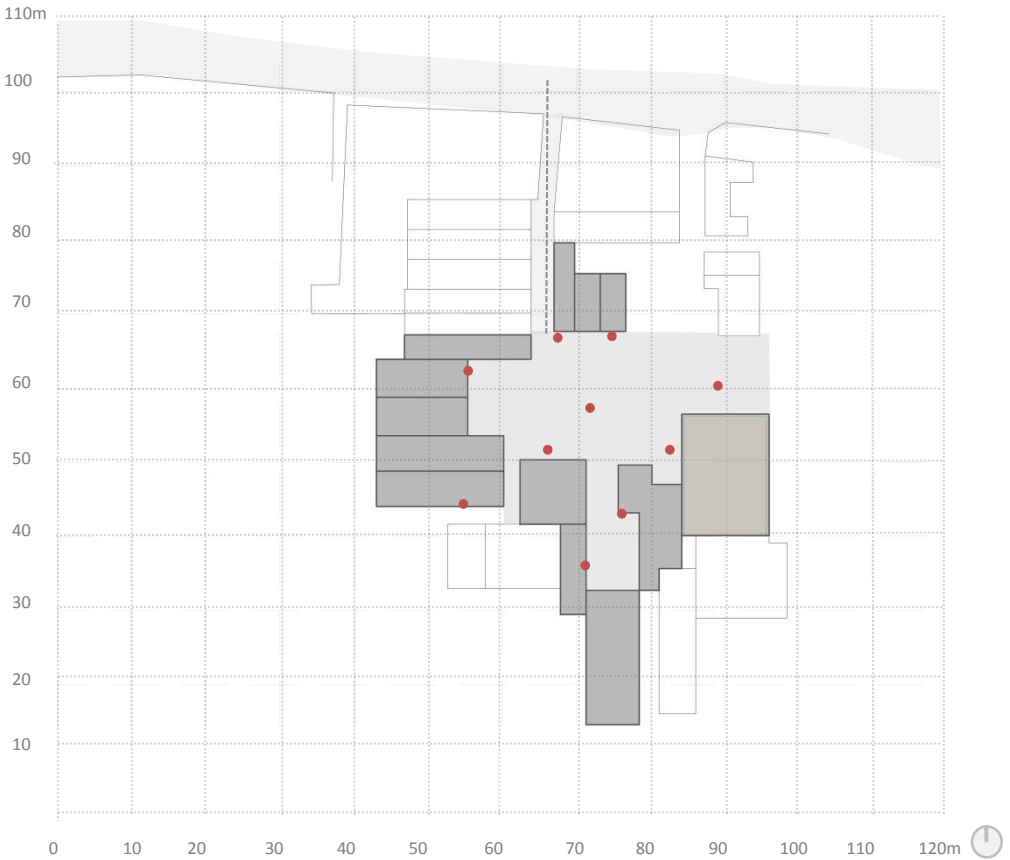
Index

> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C

b. Old City

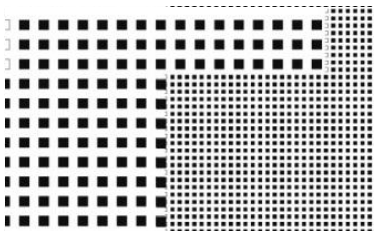
Pols are clusters of two/three storeyed homes densely packed in the Old City of Ahmedabad. Primarily made of wood, *kota* stone and brick, these homes can sometimes share a common wall. Within *pols* there are courtyards that are surrounded by such homes. Such is the nature of this site located in the Dada Hariya ni *Pol*.


01
02
03

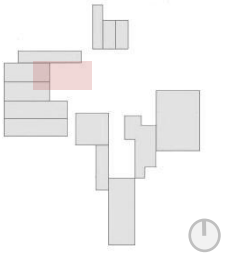


Index

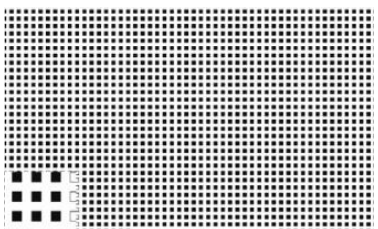
- Site
- Dada hariya ni *pol*
- 1 -Manek chowk
- 2 -Mosque
- 3 -Entrance to the *pol*
- Courtyard
- Two storeyed *pol* houses
- Collapsed house
- Points of measurement



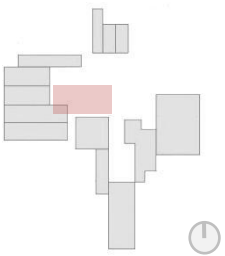
Materials with both high and low thermal conductivity .



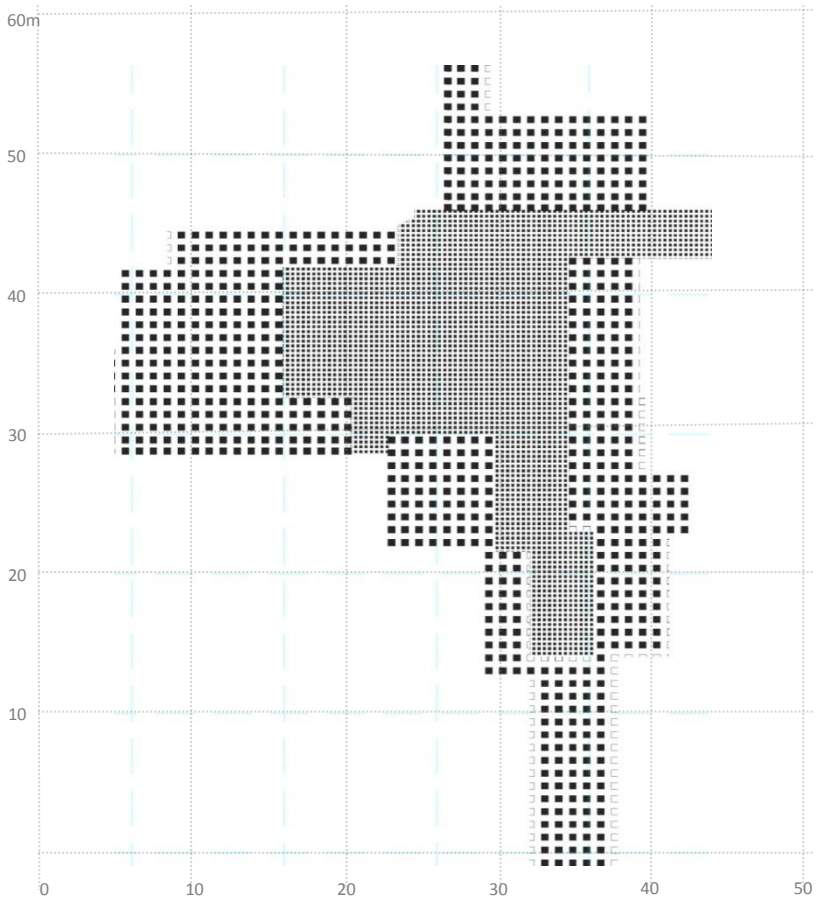
Heat storage is balanced.



Materials with very high thermal conductivity.



Heat storage is more.



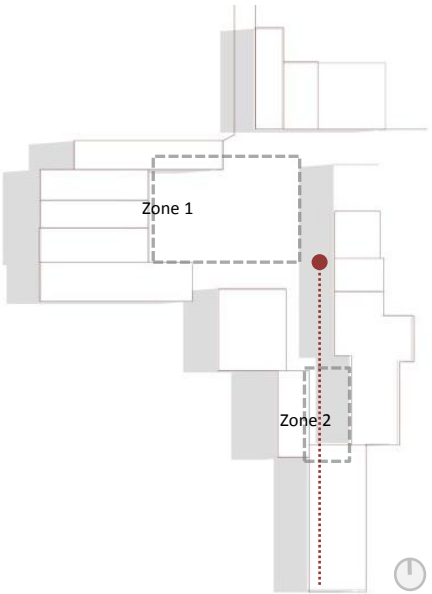
This map shows the difference in thermal conductivity of materials found on the site. The *pol* houses on site are constructed using materials such as wood, brick and *kota* stone. These materials compared to materials such as concrete have a higher thermal conductivity and can allow the heat to escape faster. The central courtyard made of paver blocks has a tendency to store immense amount of heat and create an urban heat island.

Index

- 2.0-1.0 W/mK

- 0.2-0.1 W/mK

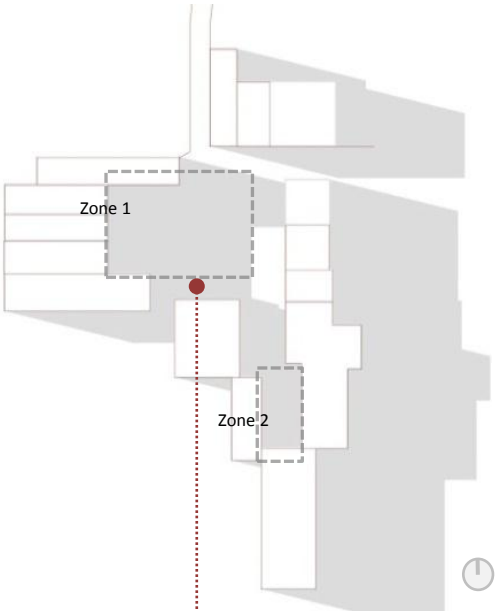
At 11:00 am



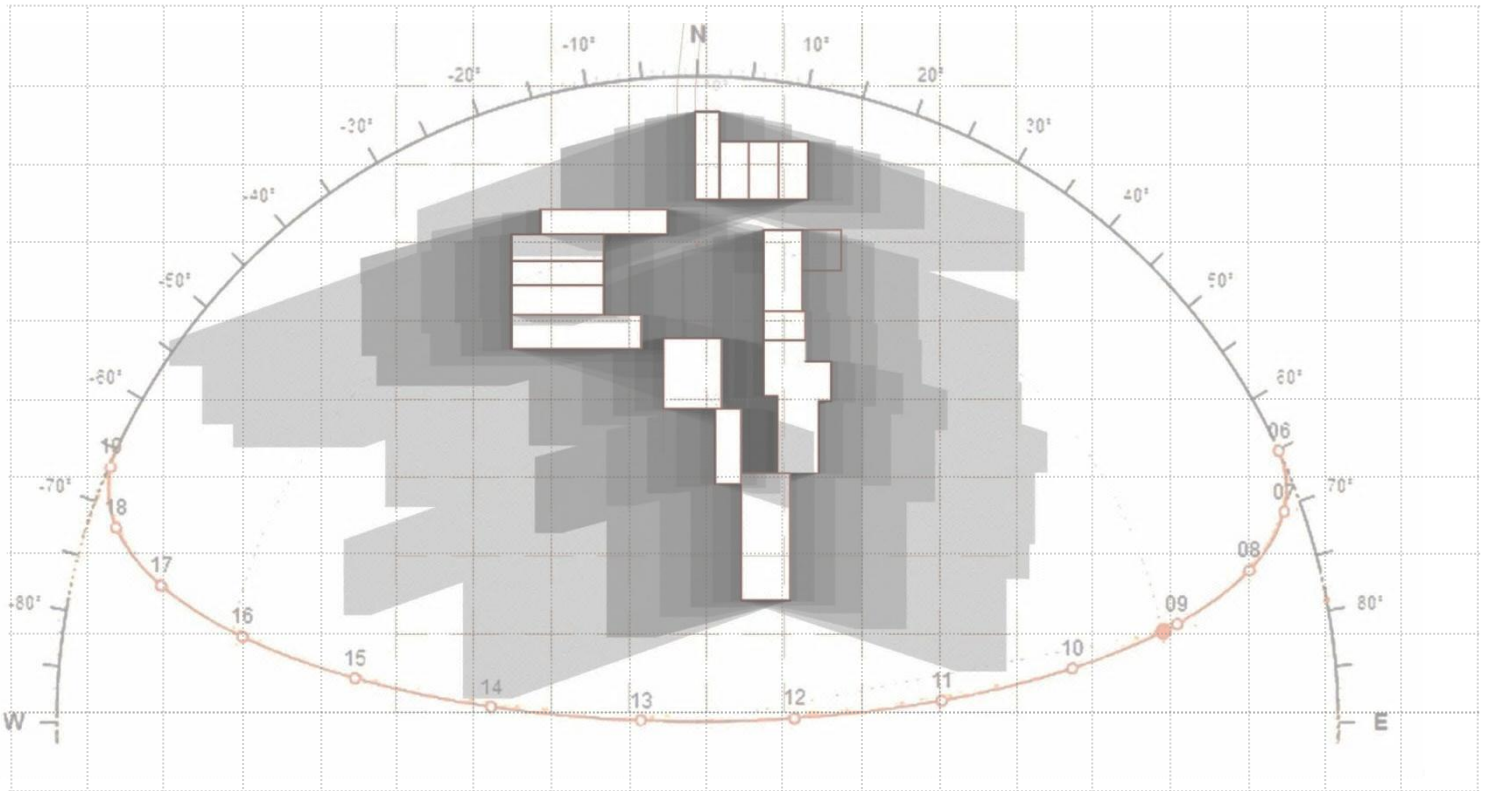
Two storeyed *pol* houses cast minimal shadows in the central courtyard.

Zone 1 receives very less to no shadow in the afternoon. Zone 2 receives constant shadow because of the presence of three *pol* houses in close proximity to each other.

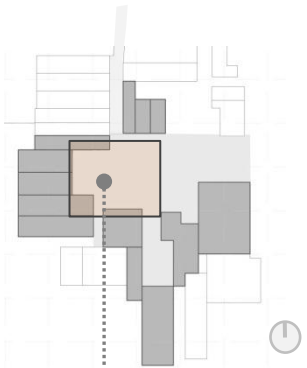
At 5:00 pm



In the evening, as the sun begins to set, the courtyard receives maximum shadow from the surrounding buildings.

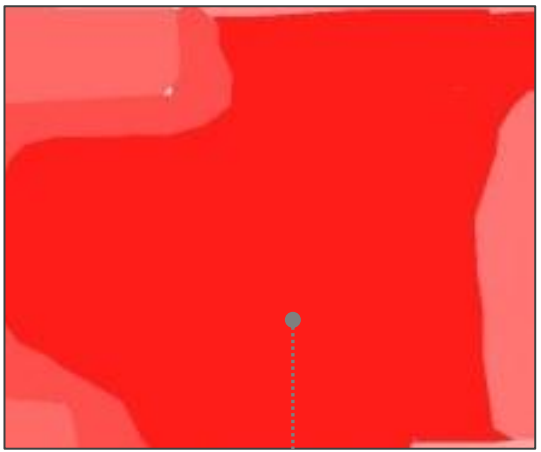


10m x 10m grid



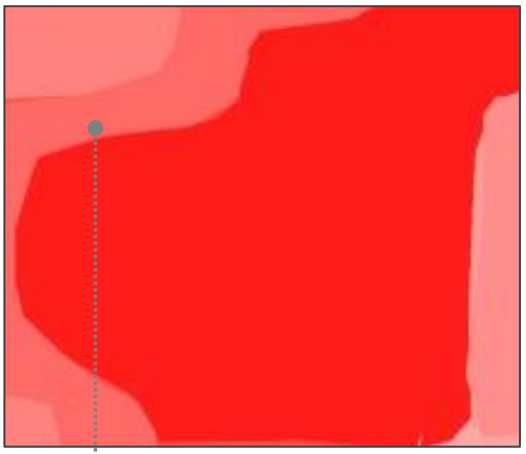
Area- 100 sq. mts
No tree cover
Open courtyard.

At 11:00 am, 09/06/2018



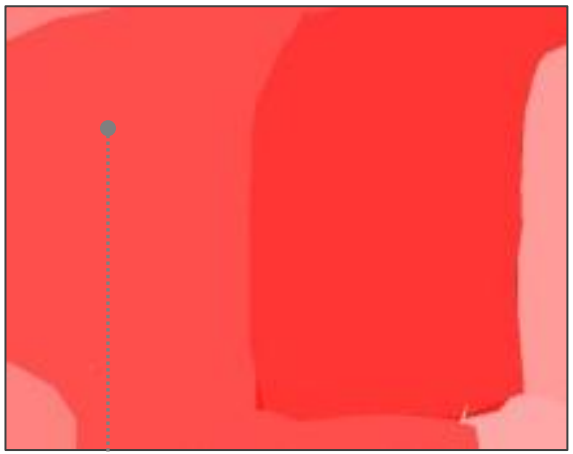
A constant temperature of 50°C is observed in this zone as the courtyard stores a lot of heat in the morning.

At 2:00 pm, 09/06/2018



The *pol* houses cast a slight shadow and in these areas a temperature of about 46°C is observed.

At 5:00 pm, 09/06/2018



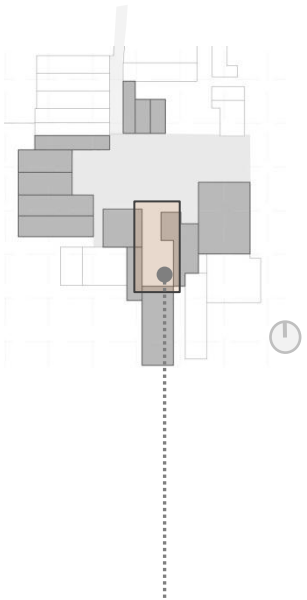
As the sun sets, the length of the shadow cast by the houses increases and the shaded area of the courtyard shows a lower temperature.

The courtyard is an urban heat island. Due to the lack of trees, this area stores large amount of heat in the morning and only minor variations are observed in temperature in the shaded areas. Even at dusk, the temperature does not drop.

This courtyard is used as a parking area by the residents of the *pol* houses and the cars parked in this area also get heated up at noon and make this area unbearable to walk.

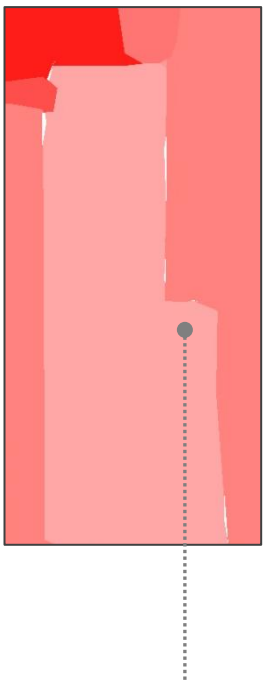
Index

> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C



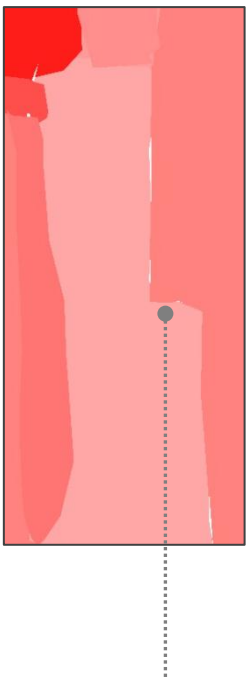
Area- 90 sq. mts
No tree cover
Constantly shaded space.

At 11:00 am, 09/06/2018



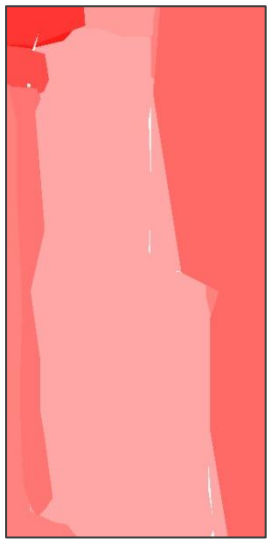
A constant temperature of 42°C in this zone on the south end of the site.

At 2:00 pm, 09/06/2018



The temperature remains the same as this area is constantly shaded by the surrounding houses.

At 5:00 pm, 09/06/2018



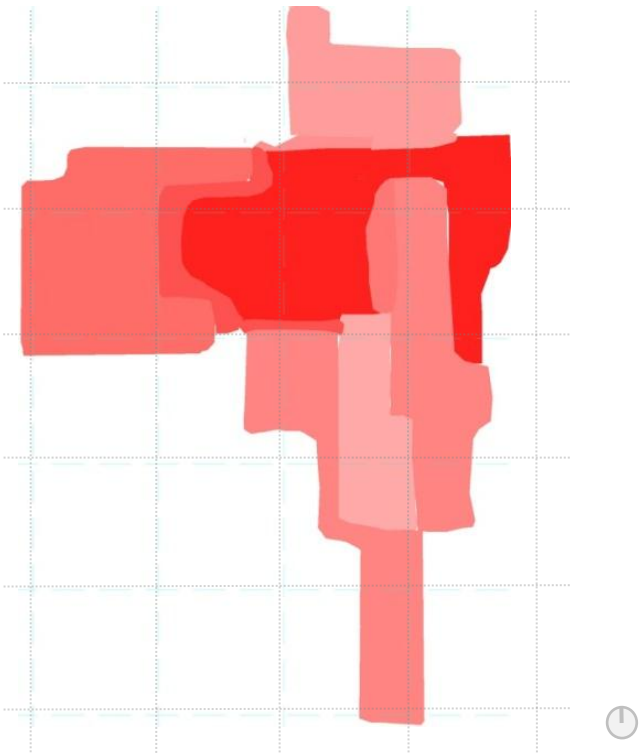
In contrast to the courtyard, this zone shows a relatively lower temperature of 42°C. Three *pol* houses surround this area and hence it is constantly shaded throughout the day. And since the *pol* houses are in close proximity to each other (distance between two *pol* houses is 7m), this area is not affected by direct sunlight as most of the sunlight is blocked by the houses.

Index

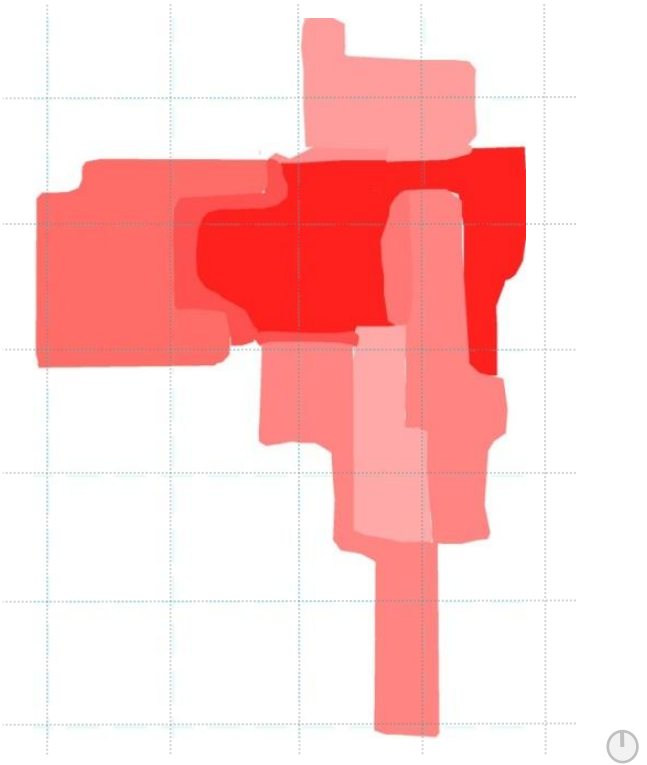
> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C

Observing temperatures on the entire site

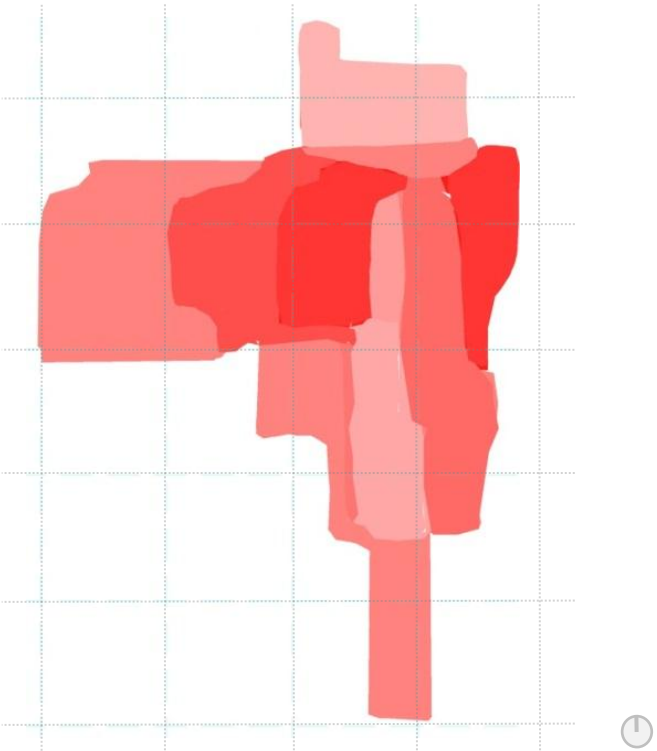
At 11:00 am, 09/06/2018



At 2:00 pm, 09/06/2018



At 5:00 pm, 09/06/2018



Inferences

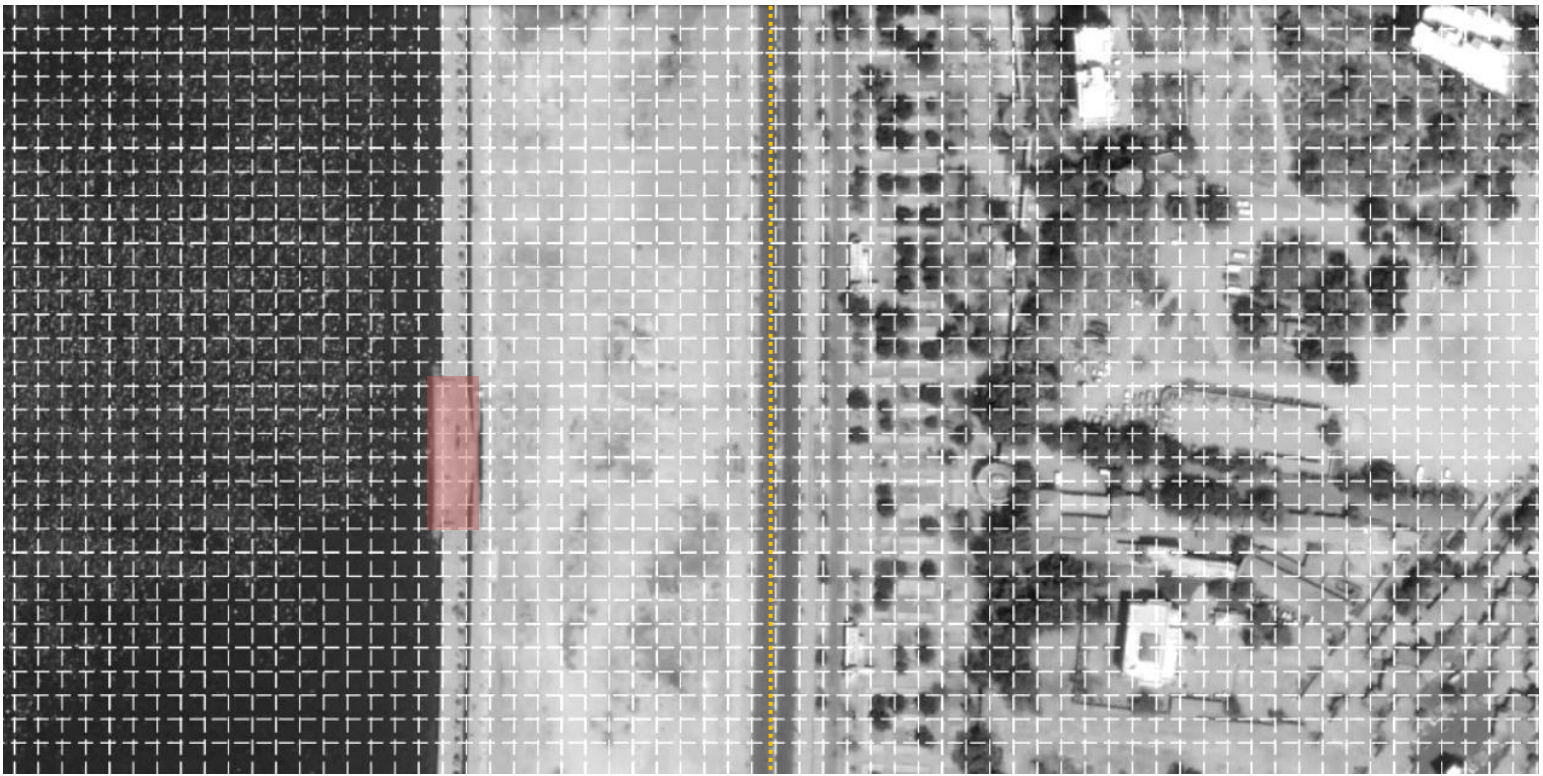
The heat patterns of the site show that within the network of *pol* houses an urban heat island (UHI) has evolved in the courtyard surrounded by a relatively cooler temperature regime. Temperature responds to **proximity of elements in space**.

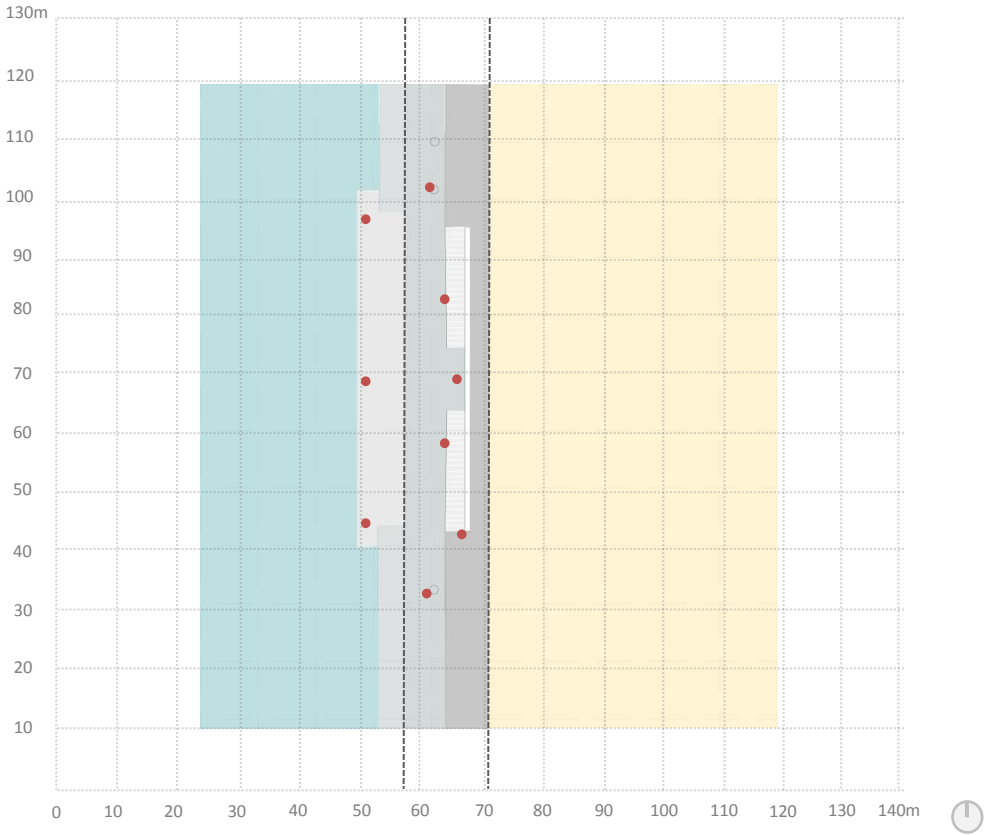
Index

> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C

c. Sabarmati Riverfront

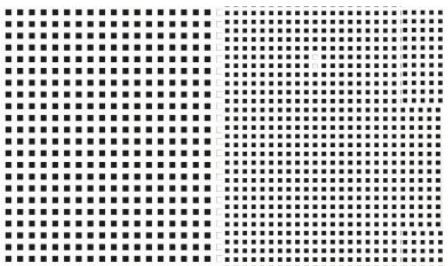
Ahmedabad city is divided into two urban conditions by the Sabarmati river – the walled city and the new city. The dividing infrastructure is the riverfront that defines the lines of the river. The location is a section of the promenade which is adjacent to a road that leads to the airport.



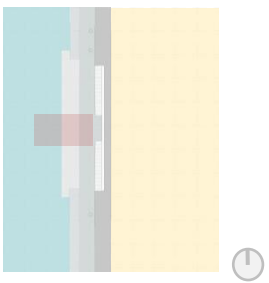


Index

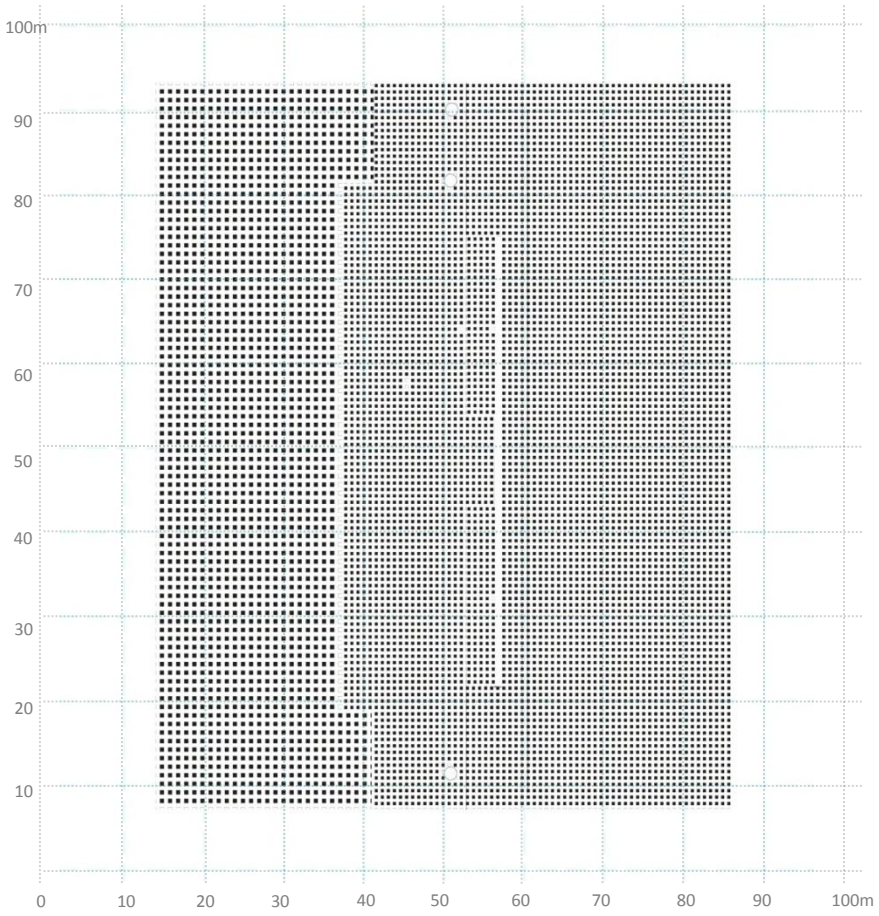
- Site
- Road to the airport
- Deck Lvl +0.0 m
- Elevated walkway Lvl + 6.15 m
- Sabarmati river
- Open plot Lvl +6m
- Points of measurement



Concrete has a very low thermal conductivity (0.4 W/mk).



Heat storage is more.



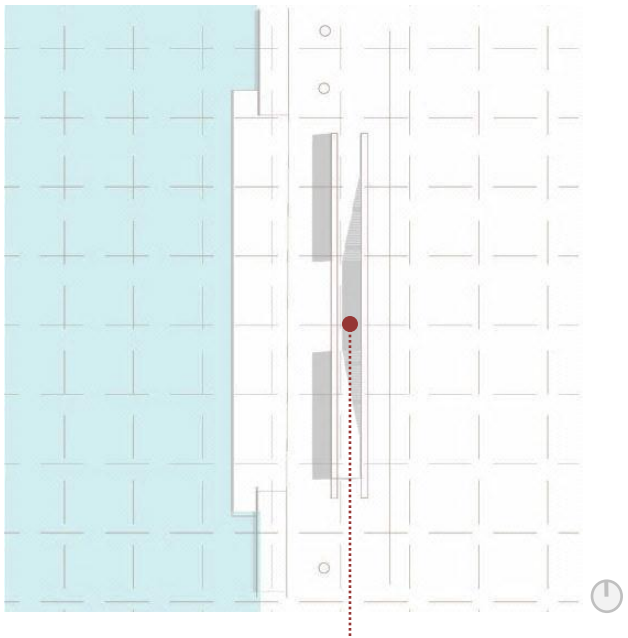
The Sabarmati Riverfront is a concrete embankment and includes about 20 km of pedestrian promenades on each bank. Concrete has a low thermal conductivity and does not allow the heat to transfer. The banks of the river have a high humidity and hence the intensity of the heat felt is slightly less.

Index

- 0.5 W/mK

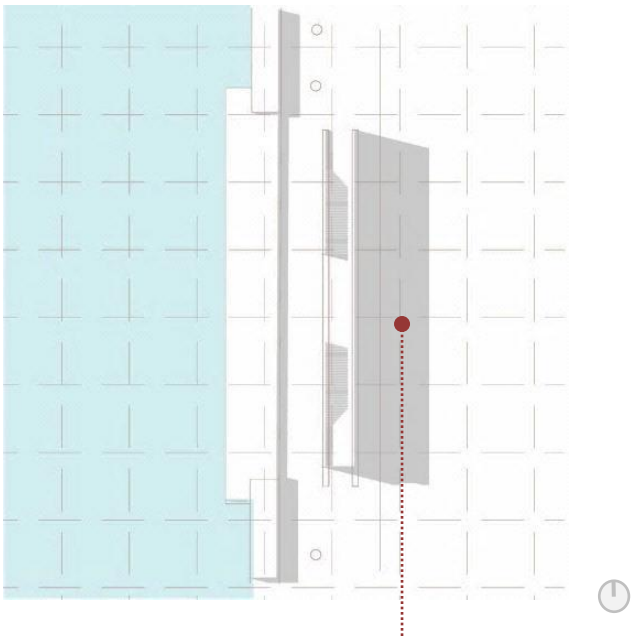
- 0.4 W/mK

At 11:00 am

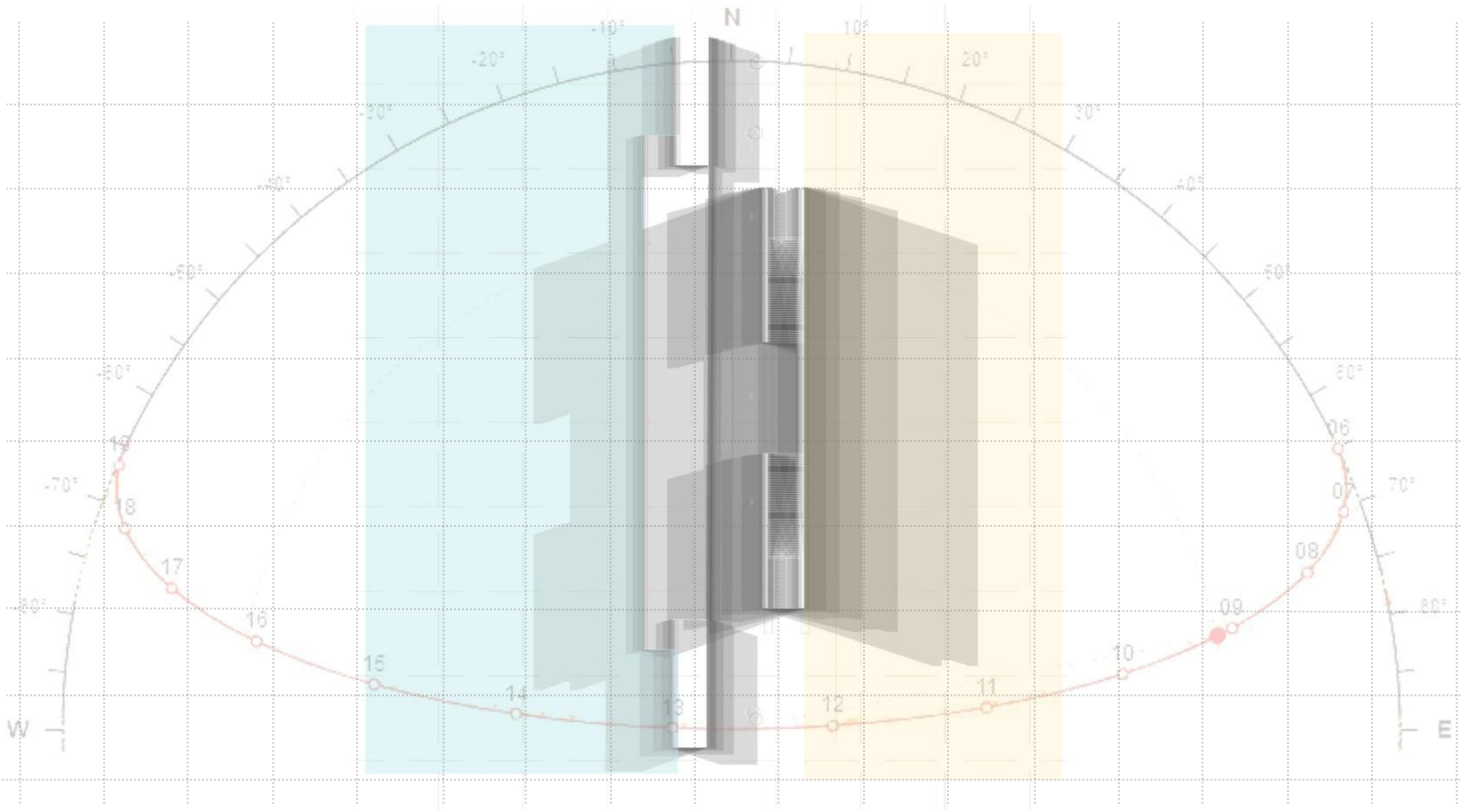


The staircase receives shadow from adjacent walls.

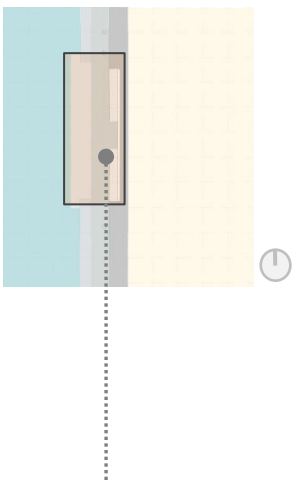
At 5:00 pm



The riverfront stretch barely gets shadow except early morning and evening .

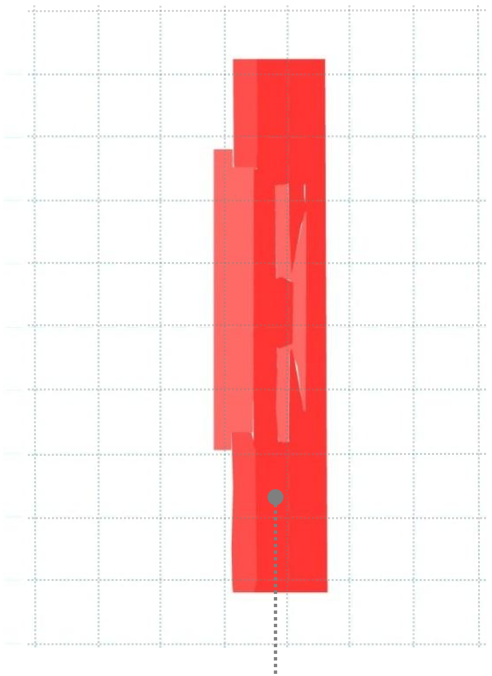


10m x 10m grid



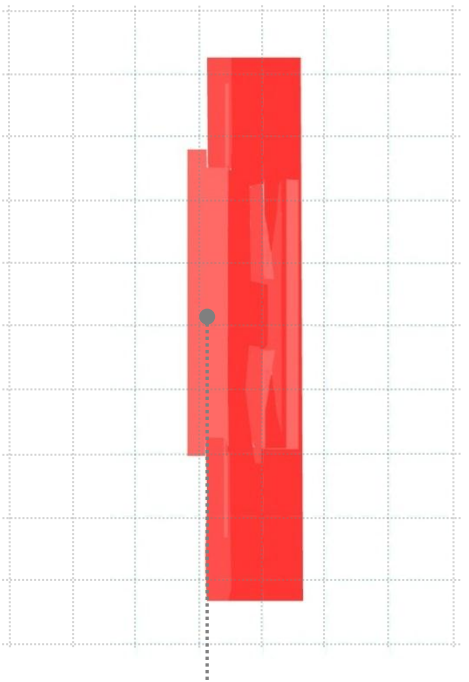
Area- 2200 sq. mts
No tree cover
Under constant sunlight.

At 11:00 am, 12/06/2018



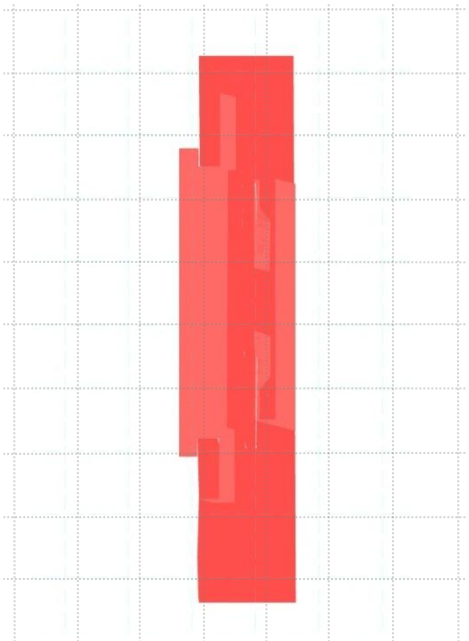
A constant temperature of 50^{o}C is observed in this zone because there is no obstruction for the sun rays.

At 2:00 pm, 12/06/2018



The concrete deck near the river shows a 2^{o}C drop in temperature.

At 5:00 pm, 12/06/2018



Inferences

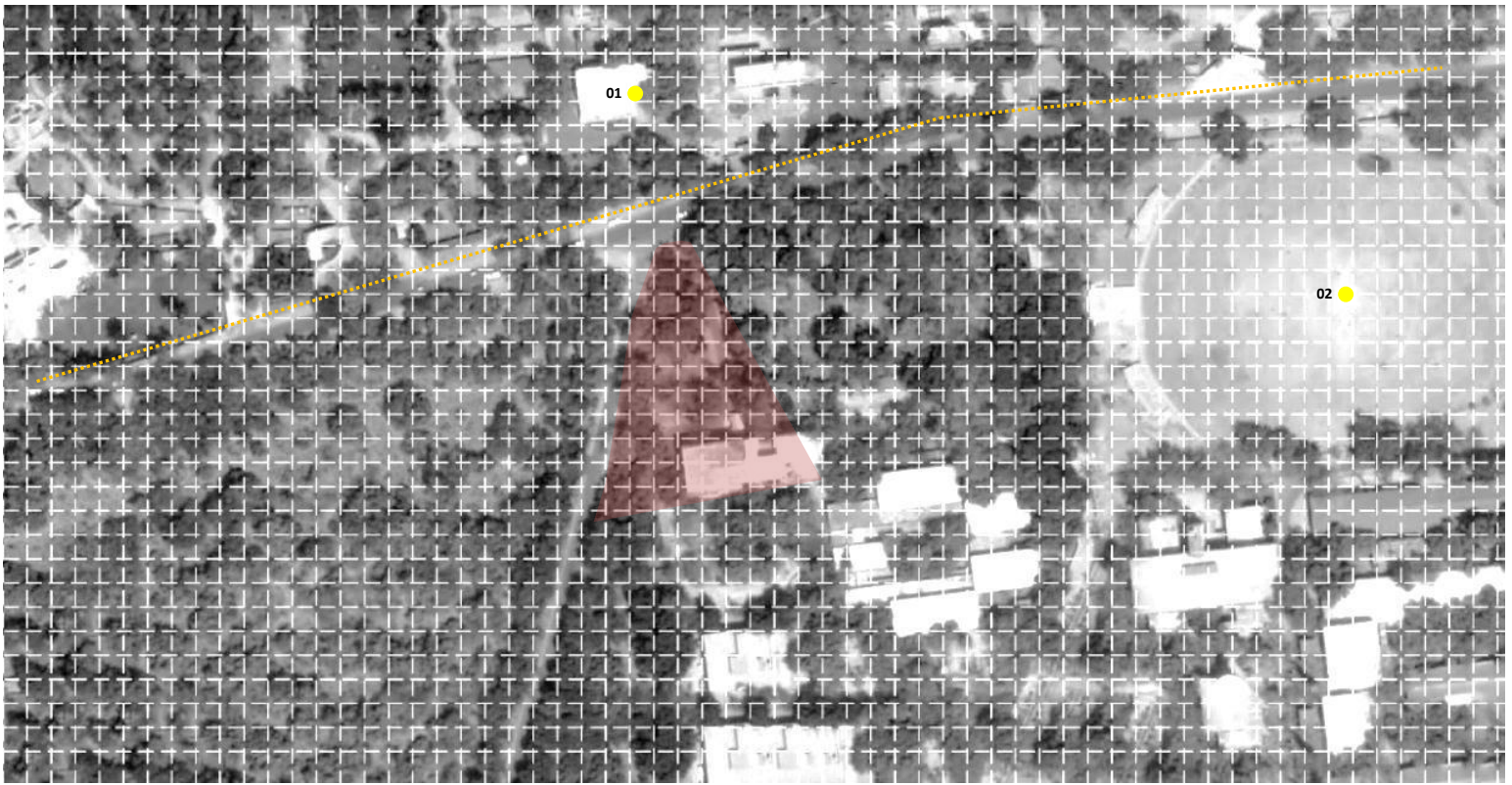
As observed in the heat patterns of the site, the riverfront shows a tendency to get heated up extensively throughout the day. As concrete has a very low thermal conductivity, it stores up a lot of heat making the riverfront one of the hottest public spaces in the city. Temperature responds to **materiality of space**.

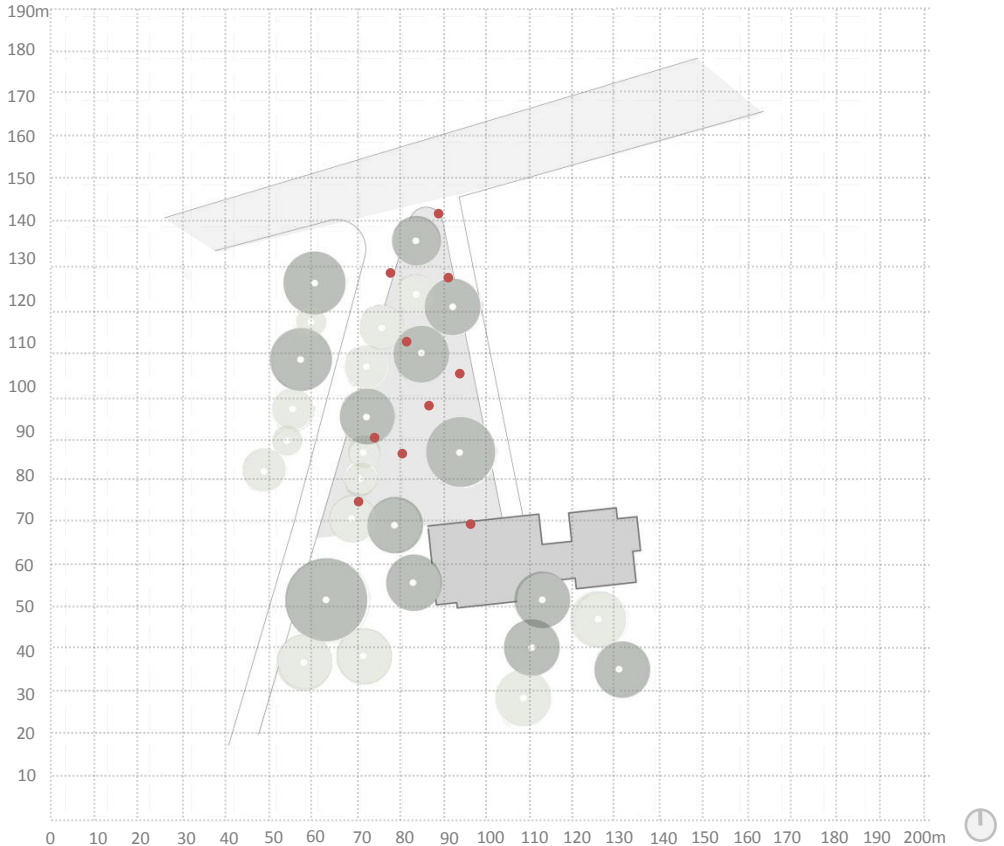
Index

> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C

d. Institutional Area

Ahmedabad Textile Industries Research Association, ATIRA is a 2,72,000 Sq. mts, campus located in the university area of Ahmedabad. It is recognised to have a plant coverage of over 1,000 trees. This has made it a popular spot for joggers and morning walkers in the city.


01
02

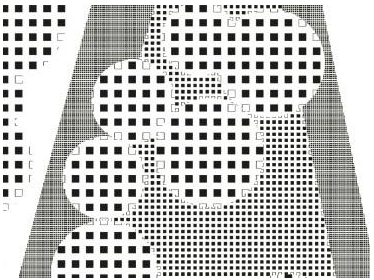


Index

- Site
- Main road
1 - Physical Research Laboratory
2 - GU ground
- Lvl +0.0 m
- 2 storeyed office building

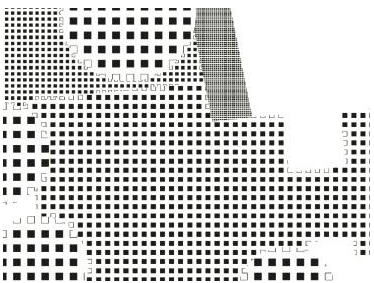
Types of trees

- *Neem*
- *Babul*
- Points of measurement

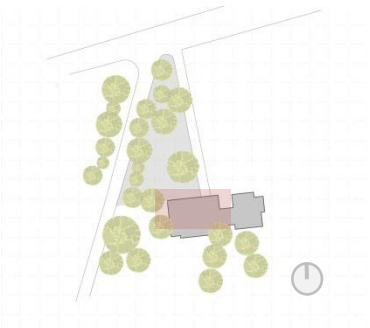


Trees present in this zone have very high conductivity.

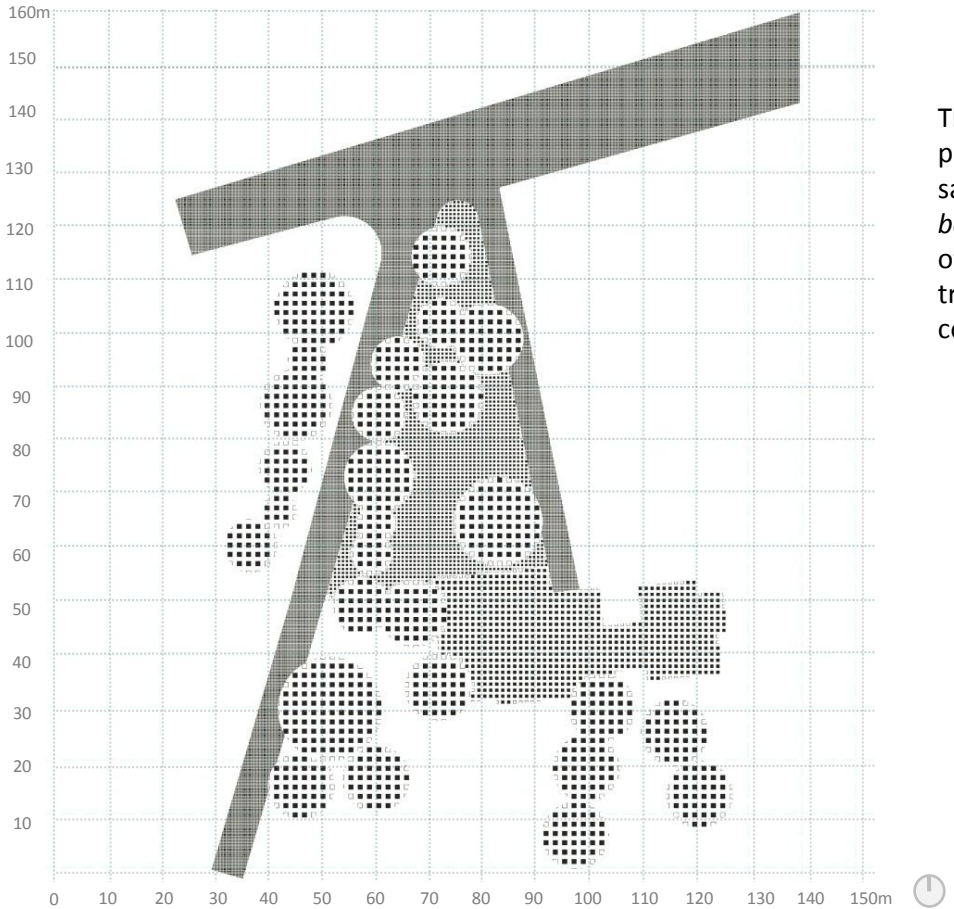
Heat storage is very less.



Lack of trees indicates less conductivity.



Heat storage is more.

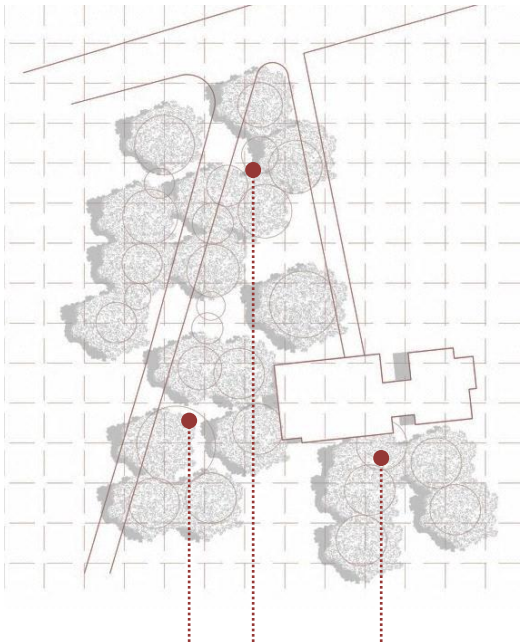


The following map shows difference in thermal properties on site. The bitumen road encloses a sand pit which comprises of clusters of *neem* and *babul* trees. The building on the south-east end of the site is primarily made of concrete. The trees present on site balance the low thermal conductivity of concrete, sand and bitumen.

Index

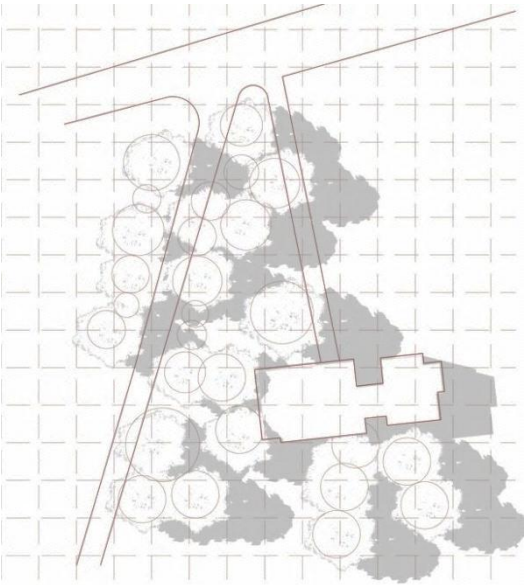
- - > 3 W/mK
- - 0.4-0.3 W/mK
- - 0.2-0.1 W/mK

At 11:00 am

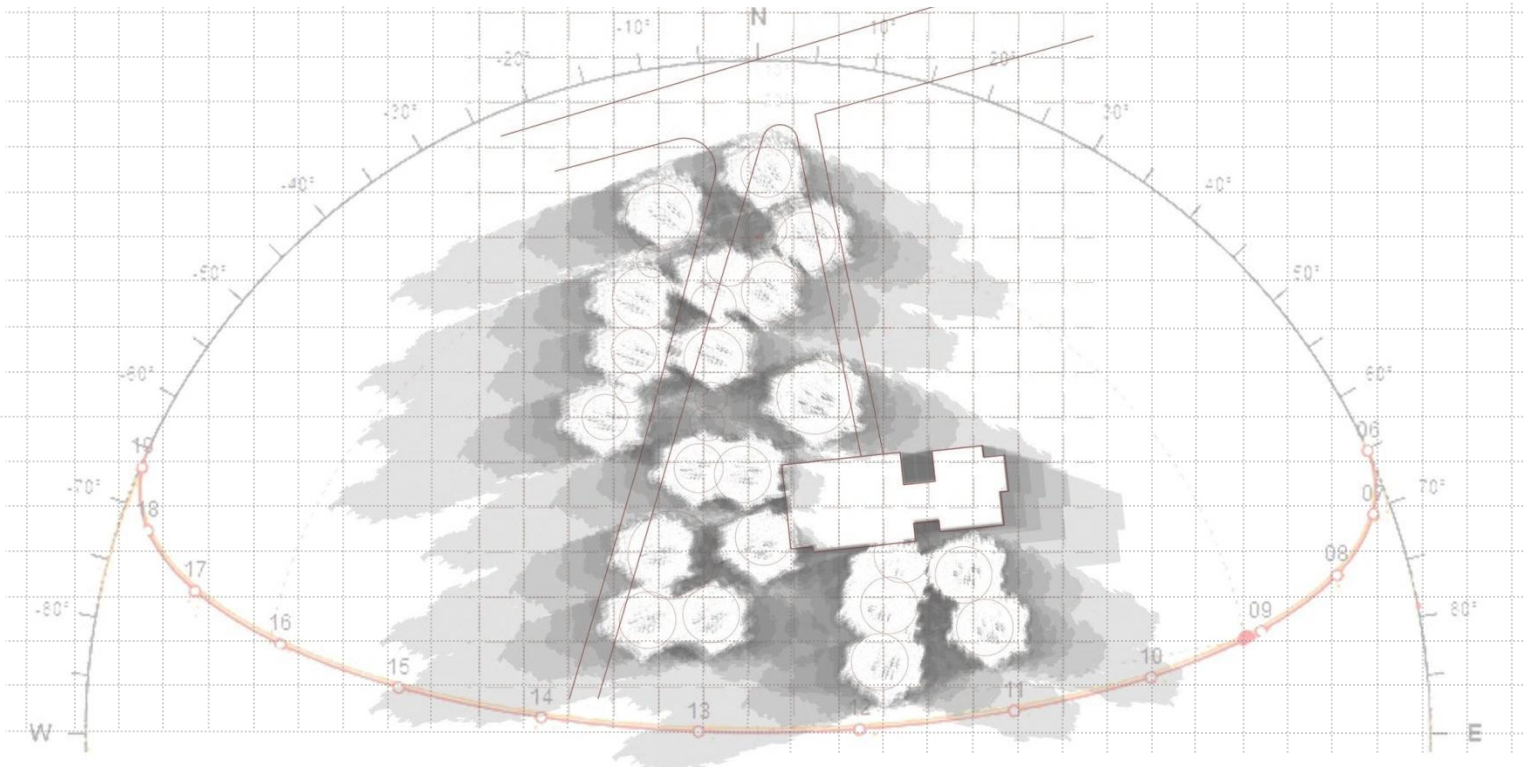


Cluster of trees provides constant shade.

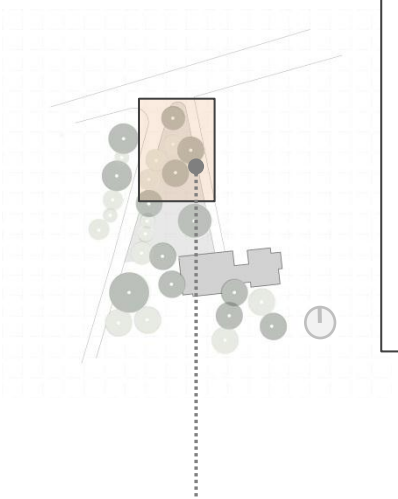
At 5:00 pm



By evening, the entire site becomes completely shaded.

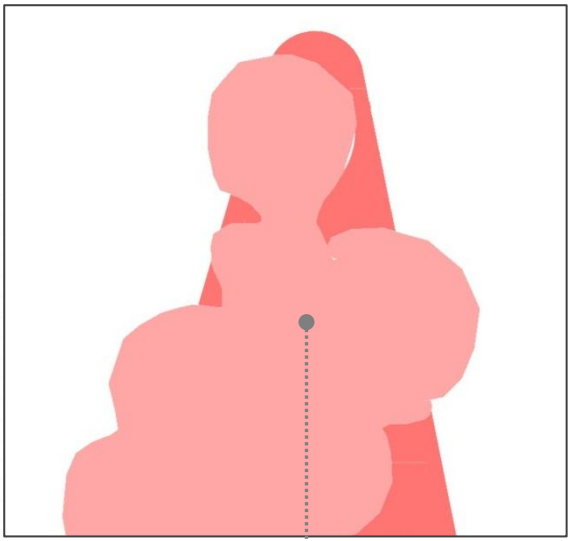


10m x 10m grid



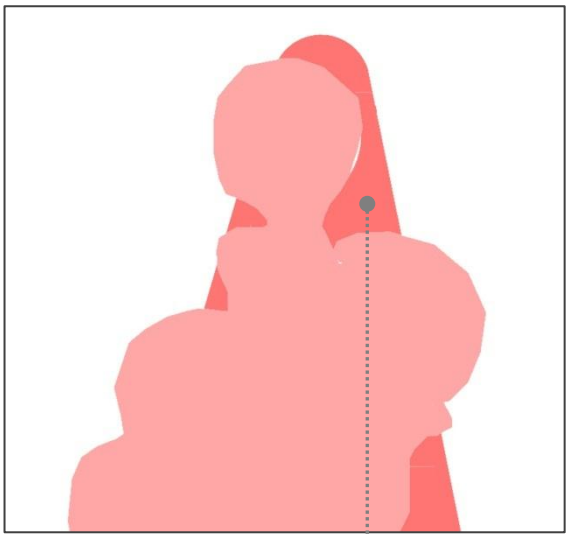
Area- 1200 sq. mts
Dense tree cover
Constantly shaded area.

At 11:00 am, 13/06/2018



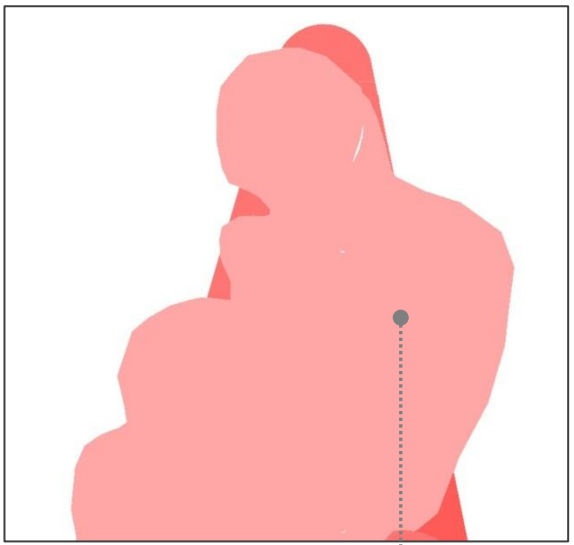
A constant temperature of 34°C is observed in this zone as it experiences shade throughout the day from the trees.

At 2:00 pm, 13/06/2018



In smaller areas, where there is no shade a temperature difference of 10°C is observed.

At 5:00 pm, 13/06/2018



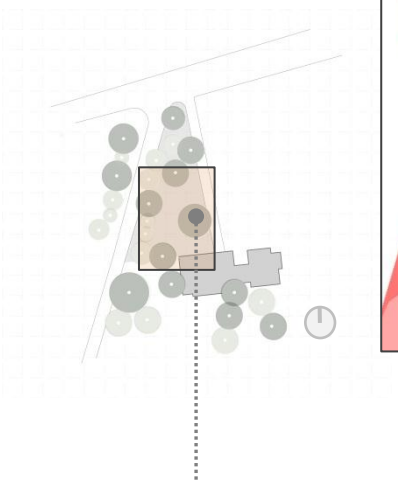
By evening, as the length of the shadow increases, the area showing a lower temperature also increases.

At ATIRA, large clusters of trees form the primary composition of space. The dense tree cover on the site provides ample shade throughout the day and keeps the surrounding cool by evapotranspiration.

Throughout the city, such microclimates can result in decreasing the mean temperature and also balance the urban heat island effect.

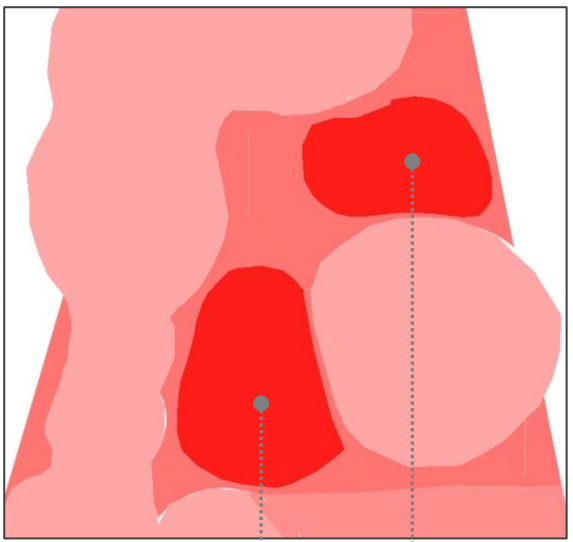
Index

> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C



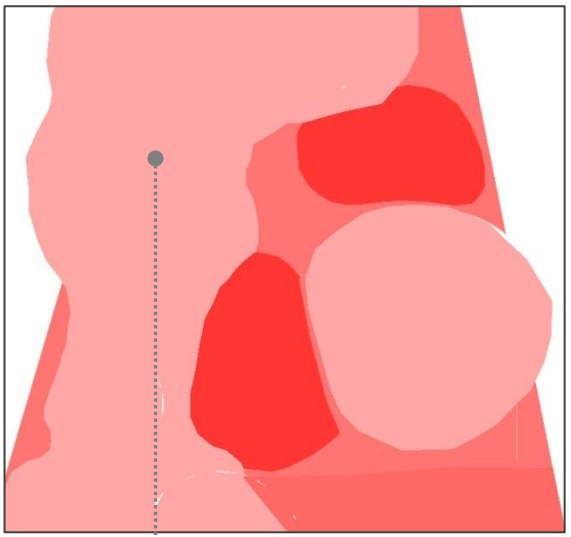
Area- 1400 sq. mts
Sparse tree cover
Slightly shaded.

At 11:00 am, 13/06/2018



The following areas receive no shade from the trees and the entire site is covered with sand, thereby heating these areas the most

At 2:00 pm, 13/06/2018



In areas under constant shade of the trees, a temperature of 34°C is observed.

At 5:00 pm, 13/06/2018

By evening, a gradual decrease in temperature is observed.

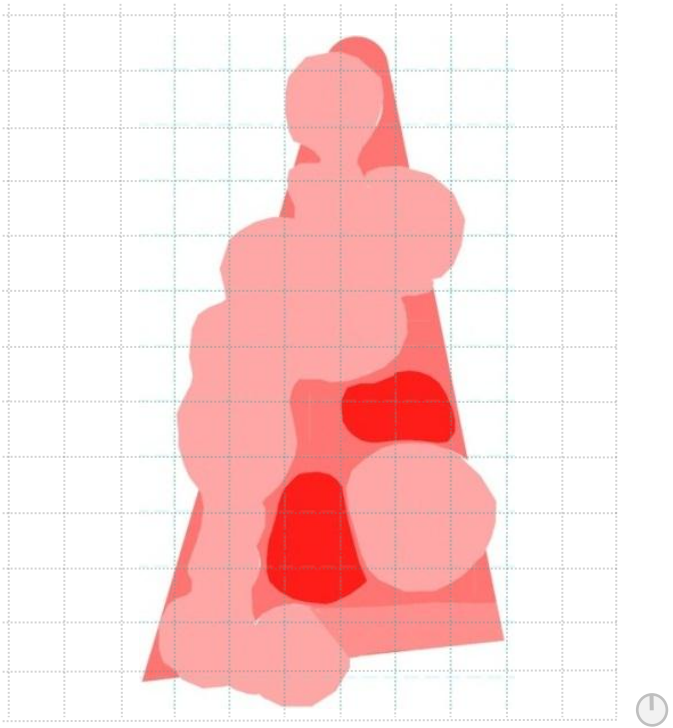
The following heat patterns show interesting formal compositions of temperature. Three major islands are observed with two of them being extremely hot and one being relatively cool because of the presence of a large *neem* tree.

Index

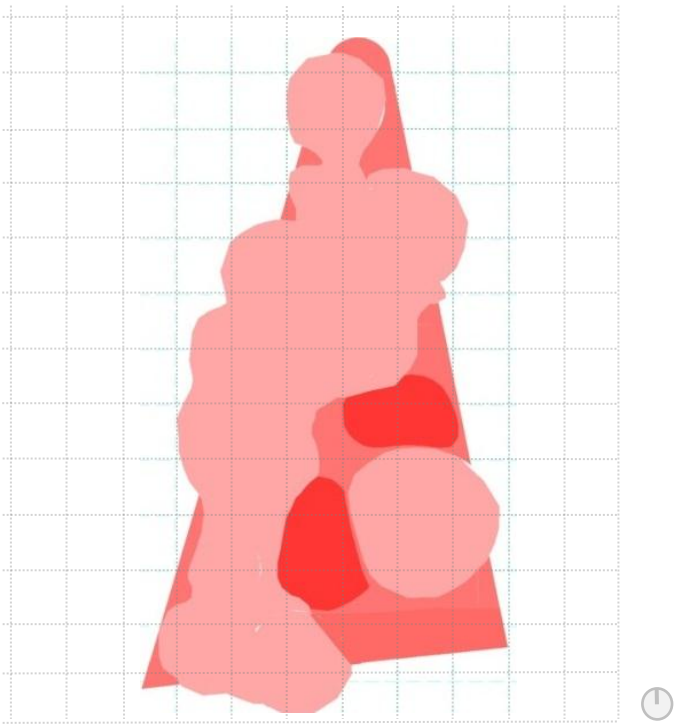
> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C

Observing temperatures on the entire site

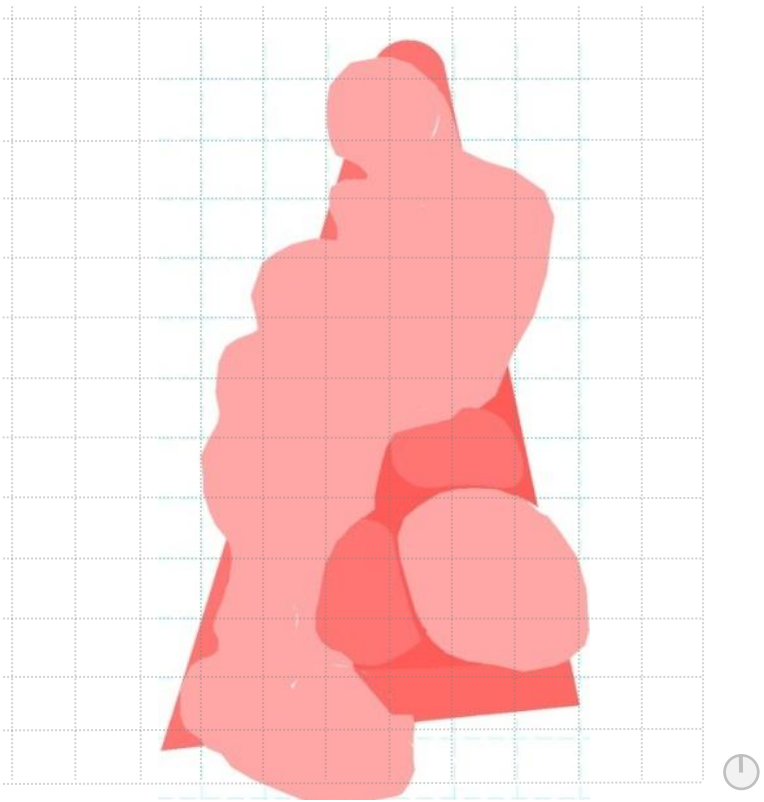
At 11:00 am, 13/06/2018



At 2:00 pm, 13/06/2018



At 5:00 pm, 13/06/2018



Inferences

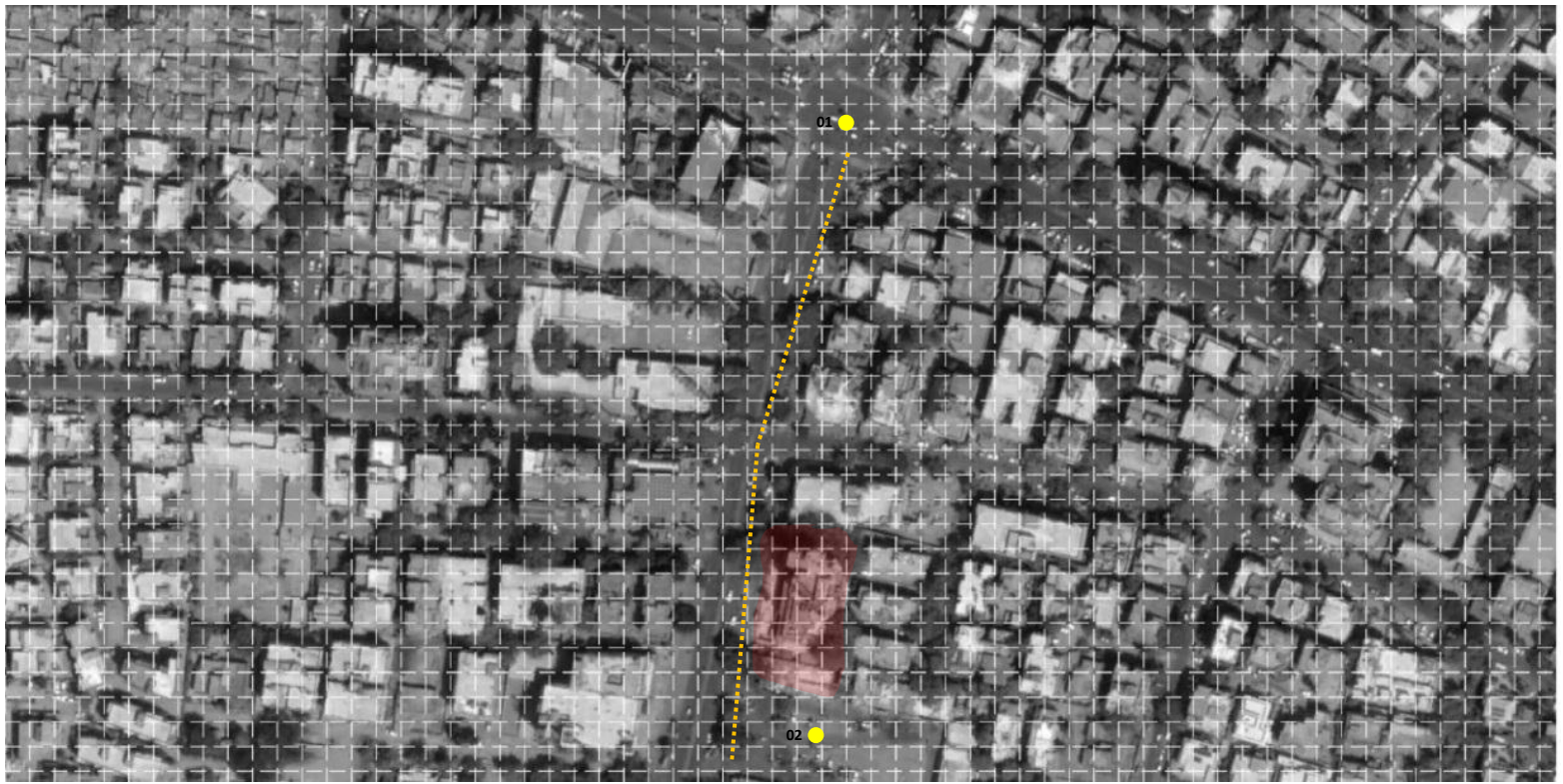
The heat patterns of the site show the environmental dynamic of temperature. Due to dense tree cover (except two small heat islands), this site proves to be the coolest space observed in this study. Temperature responds to **ecological land use**.

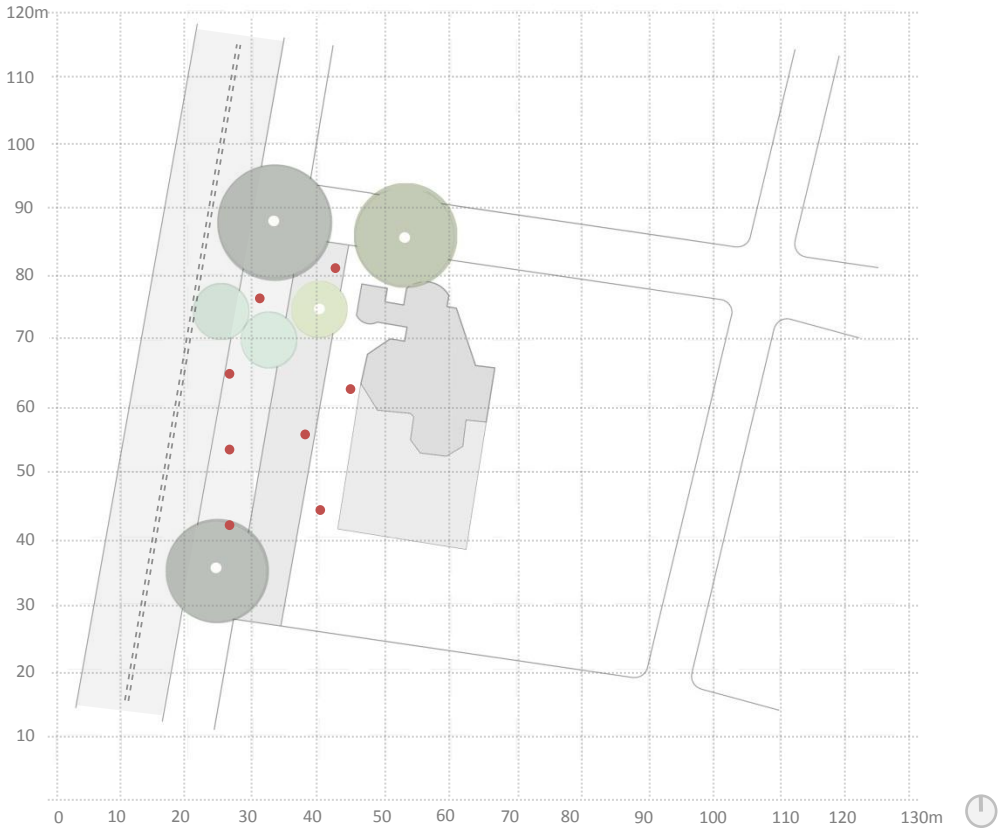
Index

> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C

e. Commercial Area

Chimanlal Girdharlal Road (C.G. Road) is one of the major roads of Ahmedabad and is considered to be one of the most significant retail locations in the city. Flanked by retail shops, restaurants and commercial buildings, C.G. Road is highly populated and experiences heavy traffic everyday.


01
02

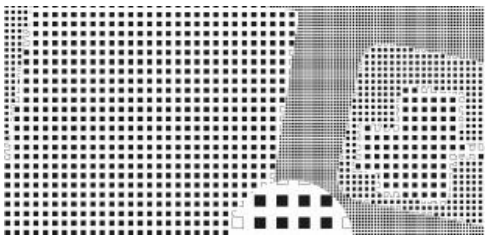


Index

- Site
- C.G. Road
- 1 - Swastik char rasta
- 2 - Municipal market
- Lvl +0.0 m
- 8 storeyed building

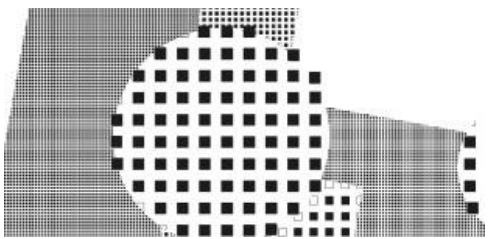
Types of trees

- *Neem*
- *Gulmohar*
- *Pipal*
- Points of measurement



Lack of trees indicates less conductivity.

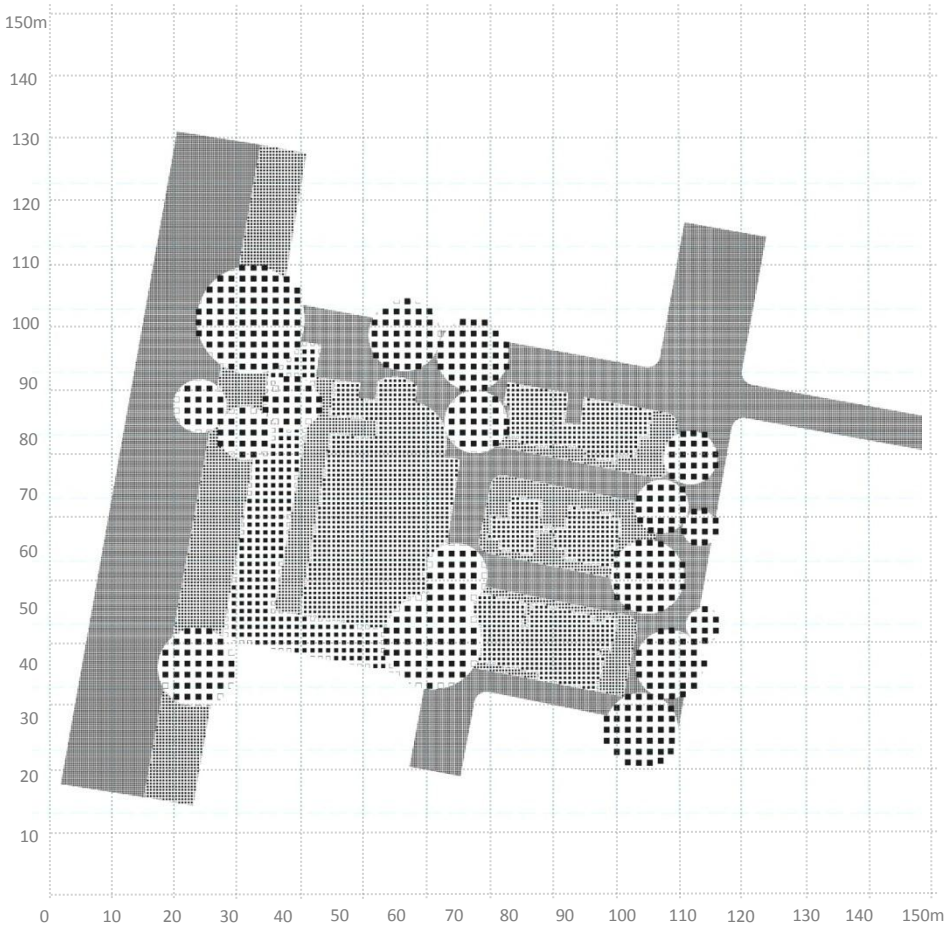
Heat storage is more.



Trees present in this zone have very high conductivity.

Heat storage is very less.

Observing material properties

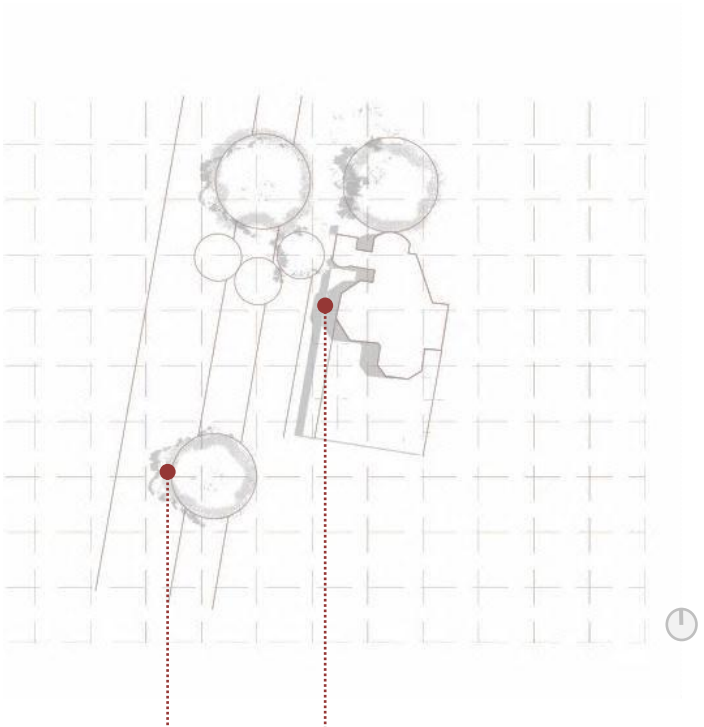


This map shows the difference in thermal conductivity of materials found on the site. The eight storeyed building on the north west end of the site is made of concrete and has stone paving. A few trees are also present on site. Due to the variation in materials found on site, the heat effect caused by the bitumen road and the concrete building is negated.

Index

- - > 3 W/mK
- - 2.0-1.0 W/mK
- - 0.4-0.3 W/mK
- - 0.2-0.1 W/mK

At 11:00 am

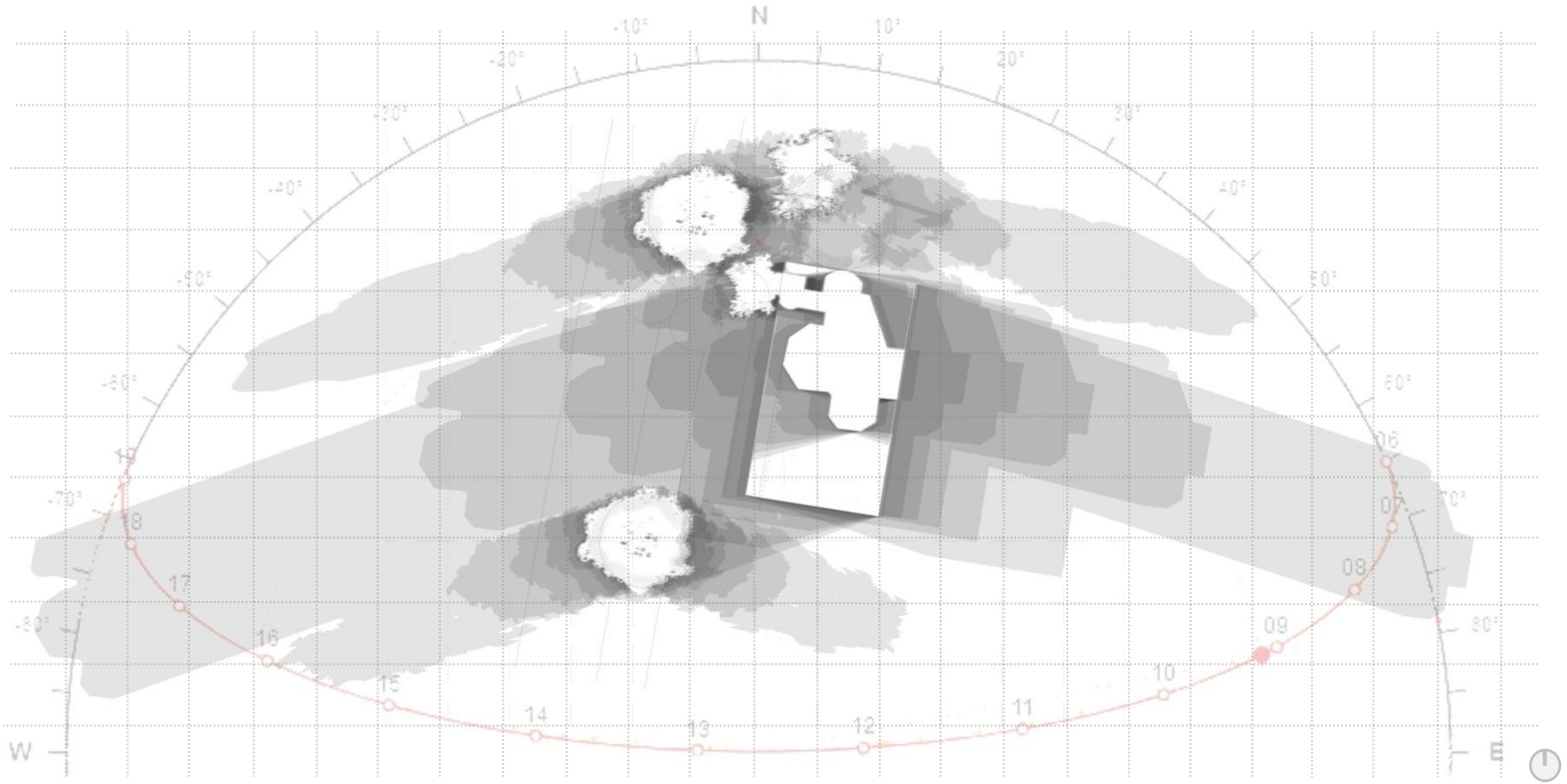


Slight shadow cast by the trees and the building is observed.

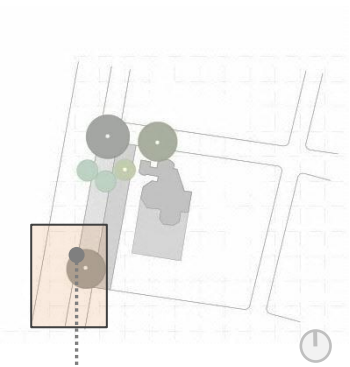
At 5:00 pm

Maximum shadow is observed in these areas.

Observing shadow patterns

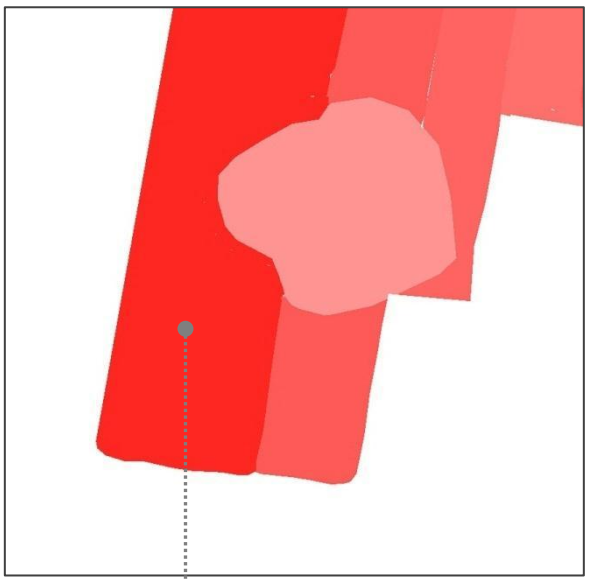


10m x 10m grid



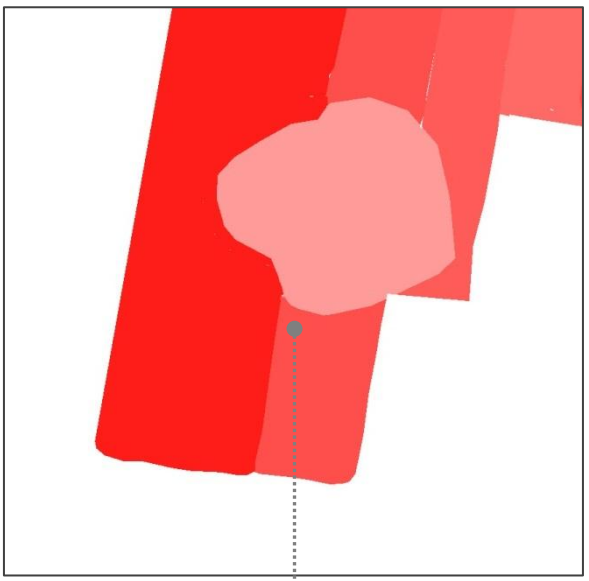
Area- 70 sq. mts
One tree
Main road and pedestrian road.

At 11:00 am, 12/06/2018



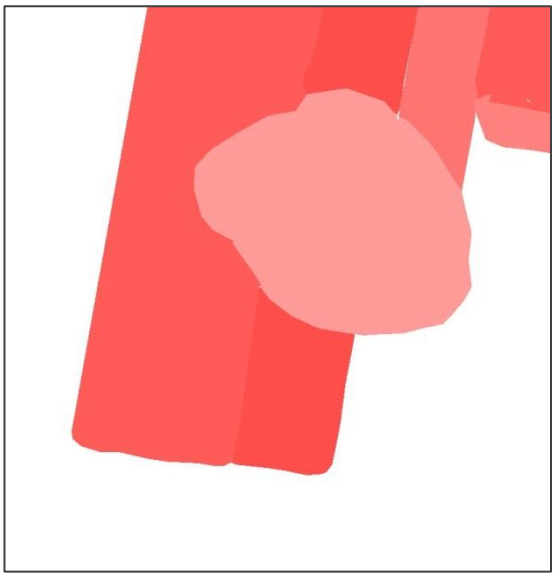
The bitumen road heats up the highest and a temperature of 50°C is observed.

At 2:00 pm, 12/06/2018



A slightly lower temperature is observed on the pedestrian road that is made of paver blocks.

At 5:00 pm, 12/06/2018

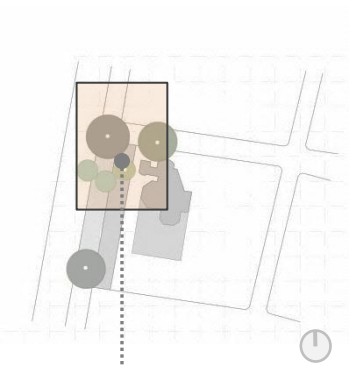


Bitumen roads in the city get heated up and a line of trees on either side of the road can help in decreasing the overall temperature. Comparatively, paved roads show a lower temperature.

Index

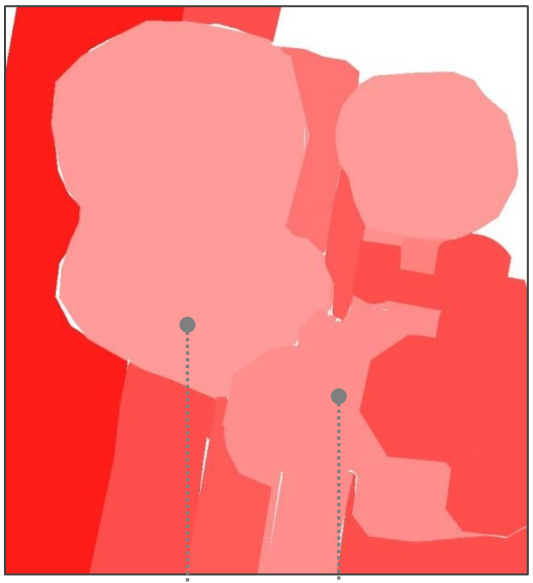
> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C

Observing temperatures on a particular zone



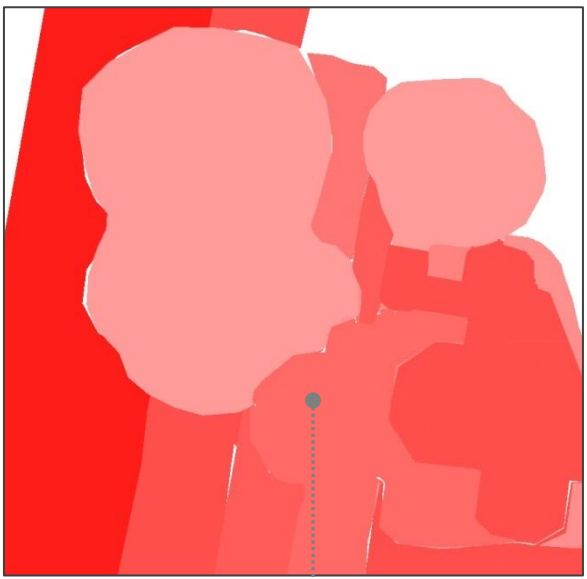
Area- 70 sq. mts
Dense tree cover
Partially shaded.

At 11:00 am, 12/06/2018



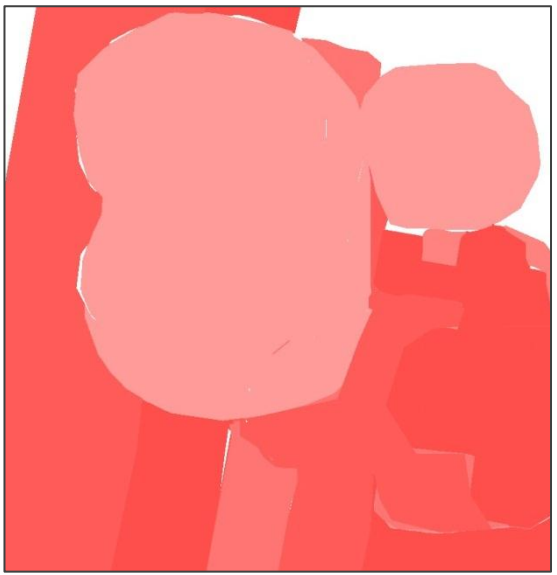
Areas shaded by the trees and the building, record lower temperatures than the main road.

At 2:00 pm, 12/06/2018



The area previously under the shadow of the building shows a slight increase in temperature.

At 5:00 pm, 12/06/2018



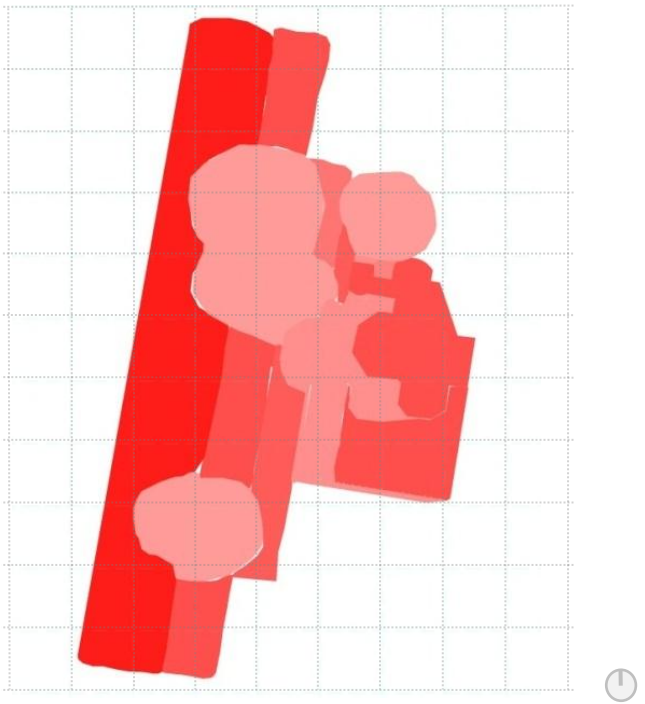
In a highly populated commercial area of Ahmedabad, temperatures vary according to the building orientation and tree cover. Areas under the shade of a building constantly are relatively cooler than the main road. Presence of trees on the road keep the pedestrian walks cooler during the day.

Index

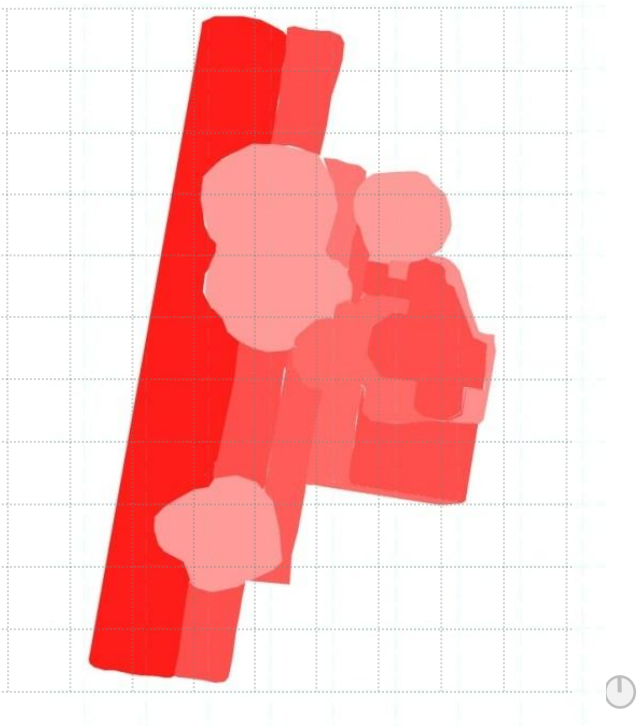
> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C

Observing temperatures on the entire site

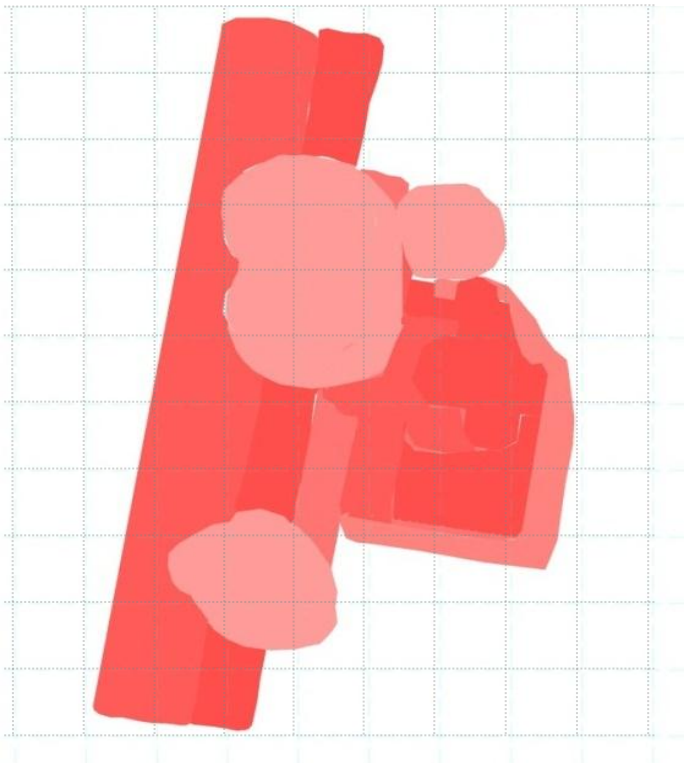
At 11:00 am, 12/06/2018



At 2:00 pm, 12/06/2018



At 5:00 pm, 12/06/2018



Inferences

The heat patterns of the site show that in a commercial setup, taller buildings and tree cover can cool the pedestrian walks but the main road remains heated throughout the day. The patterns show that temperature responds to **heights of built forms** .

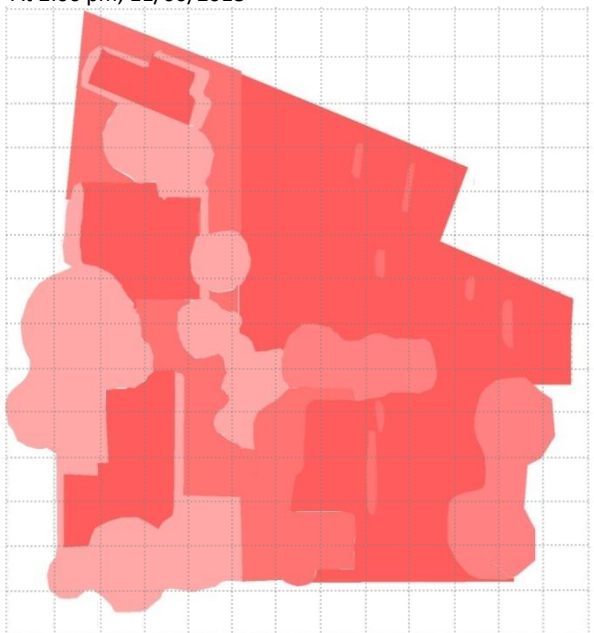
Index

> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C

6. Observations

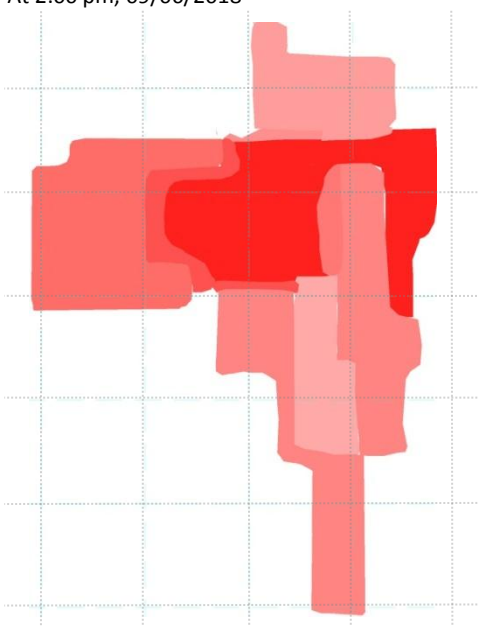
The five locations observed have completely different temperature changes and comparisons have been made regarding the nature of heat that is produced in small pockets of the city.

At 2:00 pm, 11/06/2018



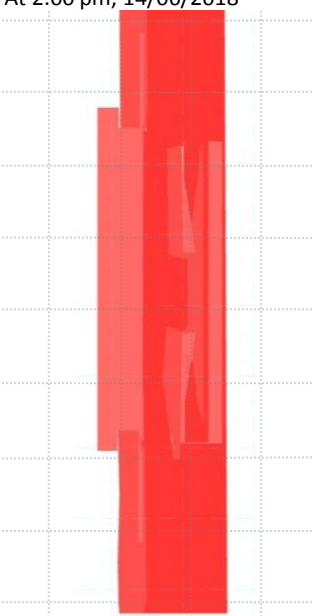
Residential Area, *Ambavadi.*

At 2:00 pm, 09/06/2018



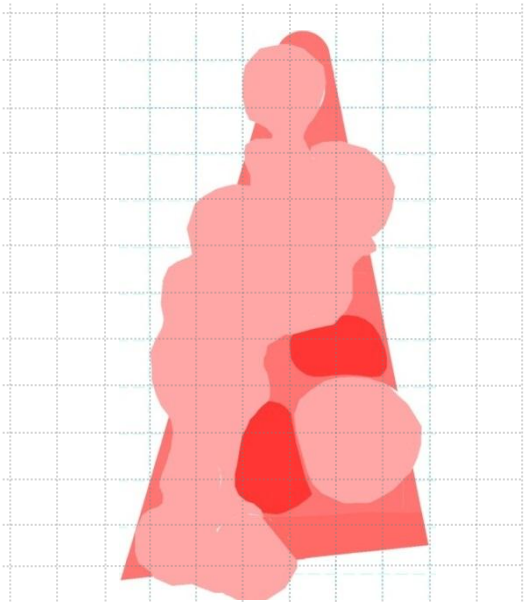
Old city, *Dada Hariya ni Pol.*

At 2:00 pm, 14/06/2018



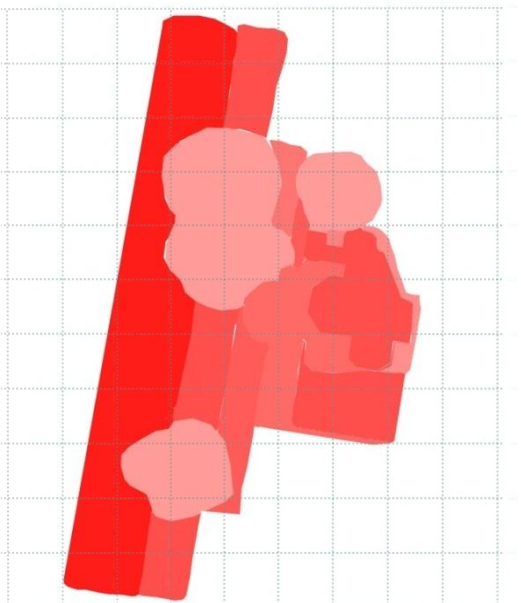
Riverfront, *Sabarmati Riverfront.*

At 2:00 pm, 13/06/2018



Institutional Area, *Ambavadi*

At 2:00 pm, 12/06/2018



Commercial Area, *C.G. Road*

Index

> 50°C	40°C - 42°C
48°C - 50°C	38°C - 40°C
46°C - 48°C	36°C - 38°C
44°C - 46°C	34°C - 36°C
42°C - 44°C	32°C - 36°C

Due to high urbanization, cities are growing at an incomprehensible speed and this rate and scale has resulted in the increase in average temperature of the earth by manifolds. The city of Ahmedabad is also growing at an alarming rate with a disparate urban strategy. This study shows that in smaller areas of the city, heat responds to various spatial factors. This study also attempts to demonstrate quantitatively as to how materiality and shadows can affect temperature. It hopes to assist in designing spaces more sensitively to their climatic conditions. The following are inferences from the study :

Residential Area, Ambavadi
Temperature responds to **composition of space**

Old City, Dada Hariya ni *Pol*
Temperature responds to **proximity of elements in space**.

Institutional Area, ATIRA
Temperature responds to **ecological land use**.

Commercial Area, C.G. Road
Temperature responds to **heights of built forms.**

Riverfront, Sabarmati Riverfront
Temperature responds to **materiality of space**.

List of trees

Neem (*Azardirachta indica)*

Babul (*Acacia arabica)*

Asoka (*Polyalthia longifolia)*

Pipal (*Ficus religiosa)*

Gulmohar (*Delonix regia)*

Champa (*Plumeria alba*)

Karanj (*Pongamia pinnata*)

List of Materials and their thermal conductivity

Concrete - 0.4 W /Mk

Sand - 0.3 W /mK

Stucco - 0.2 W /mK

Cement Plaster - 0.2 W /mK

Red Ceramic – 1.0 W /mK

Terrazzo – 2.1 W /mK

Stonecrete -1.7 W /mK

Bitumen - 0.17 W /mK

Brick - 0.8 W /mK

Water - 0.5 W /mK

- Ram Joshi, Hardik Raval, Maharshi Pathak, Sumit Prajapati, Ajay Patel, Vijay Singh, Manik Kalubarme - Urban Heat Island Characterization and Isotherm Mapping Using Geo-Informatics Technology in Ahmedabad City, Gujarat State, India (2015) International Journal of Geosciences.

- Jerry Brotton – A history of the world in twelve maps.

- https://neutrium.net/heat_transfer/thermal-conductivity-of-common-materials/

Anahita Brahmbhatt is a student of the undergraduate program in Architecture at Architectural Association, London. This study is part of her summer internship of 12 weeks. She has completed two years of the undergraduate program in Architecture at SCIArc, Los Angeles and two years of the undergraduate program in Design at CEPT, Ahmedabad.
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August 2018