

# **ARTISANS VILLAGE IN KERALA**

A Thesis

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

by

**V.S. THARUNA (40890020)**



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

## **SATHYABAMA**

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

**Accredited with Grade "A" by NAAC**

**JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

**MAY 2022**



# SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY  
(DEEMED TO BE UNIVERSITY)

Accredited with Grade “A” by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

[www.sathyabama.ac.in](http://www.sathyabama.ac.in)



## DEPARTMENT OF ARCHITECTURE

### BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **V.S. THARUNA (40890020)** who carried out the Thesis entitled “**ARTISANS VILLAGE IN KERALA**” under our supervision from January 2022 to May 2022.

**Internal guide**

(Dr ARULMALAR R)

**Internal Panel Member**

(Ar. SHEETAL  
AMRAOTKAR)

**External guide**

(Ar R BALAMURUGAN)

**DR. DEVYANI GANGOPADHYAY**

Dean, School of Building and Environment  
Head of Department

**Submitted for Viva voce Examination held on** 06- May-2022

**Internal Examiner**

**External Examiner**

## DECLARATION

I **V.S THARUNA** hereby declare that the Thesis Report entitled “**ARTISANS VILAGE IN KERALA**” is done by me under the guidance of **AR. R. ARULMALAR** (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: 04.05.2022**

**PLACE: Chennai**



**SIGNATURE OF THE CANDIDATE**

## ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this Pre-Thesis project and for completing it successfully. I am grateful to them.

I convey my thanks to **Dr. Devyani Gangopadhyay, Dean and Head of the department, Dept. of Architecture, School of Building and Environment**, for providing me necessary support and details at the right time during the progressive reviews.

My special thanks to **Dr. Suresh Kuppusamy**, our Design chair and **Ar. R. Balamurugan** , (External guide) and **Ar. Sheetal Amraotkar** (Thesis Coordinator) for their valuable comments and guidance during the project work.

I would like to express my sincere and deep sense of gratitude to my Project Guide **Ar. R. Arulmalar** for her valuable guidance, suggestions and constant encouragement which paved way for the successful completion of my project work.

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

## **ABSTRACT**

Traditional buildings focused only on architectural features and elements for attaining desired thermal comfort. But now days, while construction of residences, people are focusing on modernization rather than giving importance to microclimate. Traditional architecture are the good examples of how architecture evolved according to human needs, sustaining ecological balance. Kerala vernacular architecture which is famous for its use of natural and passive methods for a comfortable indoor environment. The orientation of building, internal zoning, the presence of internal courtyard, passive strategy, massing, landscape, use of locally available materials and special methods of construction, etc. have together created the indoor environment. The modern buildings, with the use of present technology, results in higher rate of energy consumption. This paper makes an effort to understand and analyses the features of traditional architecture of Kerala.

## TABLE OF CONTENTS

| CHAPTER No. | TITLE                                           | PAGE No.  |
|-------------|-------------------------------------------------|-----------|
|             | ABSTRACT                                        | v         |
|             | LIST OF TABLES                                  | xii       |
|             | LIST OF FIGURES                                 | xiii      |
| <b>1</b>    | <b>INTRODUCTION</b>                             | <b>1</b>  |
| 1.1         | INTRODUCTION                                    | 3         |
| 1.2         | AIM                                             | 4         |
| 1.3         | RESEARCH QUESTIONS                              | 4         |
| 1.4         | OBJECTIVE                                       | 4         |
| 1.5         | NEED FOR THE STUDY                              | 16        |
| 1.6         | SCOPE AND LIMITATIONS FOR THE STUDY             | 18        |
| <b>2</b>    | <b>LITERATURE REVIEW</b>                        | <b>19</b> |
| 2.1         | KERALA VERNACULAR ARCHITECTURE                  | 4         |
| 2.2         | SIGNIFICANT FEATURES OF KERALA VERNACULAR HOUSE | 5         |
| 2.3         | GREEN SYSTEM                                    | 7         |
|             | 2.3.1 GRIHA                                     | 10        |
| 2.4         | CLIMATE STUDY                                   | 13        |
| 2.5         | CLIMATE RESPONSIVE ARCHITECTURE OF KERALA       | 18        |
| <b>3</b>    | <b>LITERATURE STUDY</b>                         | <b>18</b> |

|          |                                           |           |
|----------|-------------------------------------------|-----------|
| 3.1      | RESEARCH PAPER                            | 18        |
| 3.2      | PREVALENT PLANNING STYLE OF KERALA        | 24        |
| 3.3      | PALIAM NALUKETTU                          | 26        |
| 3.4      | KANIPPAYYUR MANNA ETTUKETTU               | 32        |
| 3.5      | MARANAT MANA PATHINARUKETTU               | 35        |
| 3.6      | SANSKRITI KENDRA ANANDGRAM, DELHI         | 42        |
| 3.7      | UTTARAYAN ART VILLAGE, VADODARA, GUJARATH | 48        |
| 3.8      | CHOLAMANDAL ARTIST VILLAGE, CHENNAI       | 51        |
| 3.9      | GOVARDHAN ECOVILLAGE                      | 54        |
| <br>     |                                           |           |
| <b>4</b> | <b>ANALYSIS AND RESULTS</b>               | <b>66</b> |
| 4.1      | COMPARATIVE CASESTUDY ANALYSIS            | 68        |
| 4.2      | POINTS ACHIEVED THROUGH GRIHA             | 68        |
| 4.3      | USER GROUP ANALYSIS                       | 69        |
| 4.4      | MAHONEY TABLE                             | 73        |
| 4.5      | AREA STATEMENT                            | 75        |
| 4.6      | POTENTIAL AIR TEMPERATURE                 | 76        |
| 4.7      | ZONING                                    | 83        |

|          |                               |            |
|----------|-------------------------------|------------|
| <b>5</b> | <b>MATERIAL STUDY</b>         | <b>93</b>  |
| 5.1      | SHADOW ANALYSIS               | 93         |
| 5.2      | DAYLIGHT ANALYSIS             | 96         |
| 5.3      | WIND ANALYSIS                 | 97         |
| 5.4      | INFLUENCE OF CLIMATE          | 100        |
| 5.5      | STRUCTURE                     | 100        |
| <br>     |                               |            |
| <b>6</b> | <b>SUMMARY AND CONCLUSION</b> | <b>118</b> |
| <br>     |                               |            |
|          | <b>REFERENCES</b>             | <b>120</b> |
|          | <b>APPENDICES</b>             | <b>121</b> |

## LIST OF TABLES

| TABLE No. | TITLE                            | PAGE No. |
|-----------|----------------------------------|----------|
| 1.1       | System origin                    | 11       |
| 3.1       | Inference                        | 16       |
| 3.9.1     | Vernacular method                | 57       |
| 4.1       | Comparative analysis             | 69       |
| 4.2       | Points achieved through GRIHA    | 70       |
| 4.5       | Area statement                   | 77       |
| 5.5.1     | Rainwater harvesting calculation | 105      |
| 5.5.9     | Energy analysis                  | 111      |
| 5.5.14    | Iteration 1                      | 119      |

## LIST OF FIGURES

| FIGURE No. | TITLE                                    | PAGE No. |
|------------|------------------------------------------|----------|
| 1.1.       | Traditional and modern vernacular houses | 1        |
| 2.1        | Vastu shastra                            | 4        |
| 2.2        | Guruvayur temple                         | 5        |
| 2.3        | Madhur temple                            | 5        |
| 2.4        | The standard layout of kerala temple     | 6        |

|      |                                      |    |
|------|--------------------------------------|----|
| 2.5  | The standard layout of kerala temple | 7  |
| 2.6  | Traditional building of kerala       | 8  |
| 2.7  | Global energy use                    | 9  |
| 2.14 | Climate analysis                     | 11 |
| 2.15 | Design strategies                    | 14 |
| 3.1  | Different roof found across kerala   | 17 |
| 3.2  | Traditional residence in Kerala      | 18 |
| 3.3  | Architectural valuation system       | 19 |
| 3.4  | Temperature vs Time                  | 20 |
| 3.5  | Relative humidity vs time            | 20 |
| 3.8  | Types of planning styles of kerala   | 23 |
| 3.9  | Tharavad complex                     | 24 |
| 3.10 | Front view and varandah              | 25 |
| 3.11 | Interior view                        | 26 |
| 3.12 | Plan                                 | 27 |
| 3.13 | Design strategies                    | 28 |
| 3.14 | Deep overhangs                       | 29 |
| 3.15 | Machu                                | 29 |
| 3.16 | Gateway                              | 30 |
| 3.17 | Interior view                        | 31 |
| 3.18 | Site plan                            | 31 |
| 3.19 | Ground floor plan                    | 32 |

|       |                                  |    |
|-------|----------------------------------|----|
| 3.20  | Attic vent                       | 35 |
| 3.21  | View                             | 35 |
| 3.22  | Site plan                        | 36 |
| 3.23  | Form evaluation                  | 36 |
| 3.24  | Climate analysis                 | 37 |
| 3.25  | Foreign influence on window      | 37 |
| 3.26  | Eaves over hang                  | 38 |
| 3.27  | Ground floor plan                | 38 |
| 3.28  | Pathayapura house                | 40 |
| 3.6.1 | Sanskriti kendra anadgram Delhi  | 40 |
| 3.7.1 | Uttarayan art village - Vadodara | 45 |
| 3.8.1 | Cholamandal artist village       | 49 |
| 3.9.1 | Indian artist                    | 63 |
| 4.31  | User space groups                | 71 |
| 4.32  | User space groups                | 71 |
| 4.33  | User space groups                | 72 |
| 4.34  | User space groups                | 72 |
| 4.35  | Proximity chart                  | 73 |
| 4.4   | Mahoney table                    | 75 |
| 4.61  | Potential Air temperature        | 78 |
| 4.62  | Radiant temperature              | 79 |
| 4.63  | Relative Humidity                | 80 |

|        |                                        |     |
|--------|----------------------------------------|-----|
| 4.64   | Inference                              | 81  |
| 4.65   | Co2                                    | 82  |
| 4.66   | Wind speed                             | 83  |
| 4.67   | Wind Direction                         | 84  |
| 4.71   | Vastu shastra                          | 85  |
| 4.72   | Considering the existing site features | 85  |
| 4.74   | Heat gain                              | 87  |
| 4.78   | Wind flow                              | 88  |
| 5.1    | Site zoning                            | 95  |
| 5.3    | Radiation analysis                     | 96  |
| 5.4    | Day light analysis                     | 98  |
| 5.6    | Wind analysis                          | 99  |
| 5.5.1  | Contour study                          | 103 |
| 5.5.12 | Wind analysis                          | 115 |
| 5.5.15 | Day light analysis                     | 116 |
| 5.5.16 | Rammed earth                           | 117 |
| 5.5.17 | Roof analysis                          | 118 |

## LIST OF SYMBOLS AND ABBREVIATIONS

|      |   |                                 |
|------|---|---------------------------------|
| LPD  | - | Liters per day                  |
| KWh  | - | Kilowatt hours                  |
| DA   | - | Daylight autonomy               |
| MJ   | - | Mega joules                     |
| Amp  | - | Ampere                          |
| ODP  | - | Ozone depletion potential       |
| GWP  | - | Global warming potential        |
| CPCB | - | Central pollution control board |

# CHAPTER 1

## INTRODUCTION

### 1.1 INTRODUCTION

Vernacular architecture was developed hundreds of years ago and was developed gradually over the years and has taken different factors into consideration like climate, region, culture, availability of materials, skills, and tradition of local workers etc. Hence earlier buildings were more efficient in nature in terms of making use of locally available material for construction of buildings, using passive strategy. The buildings that are constructed using locally available materials show a greater aspect to the existing environment and consider the constraints imposed by the climate. Climate too plays a very important role.



***Fig 1.1 Traditional and Modern vernacular houses***

The modern practice in architecture lacks conscious effort in using passive methods of controlling the indoor environment and excessive use of modern materials irrespective of their efficiency in regulating the indoor environment has often resulted in high energy consumption. Vernacular architecture sets an example of harmony between dwellings, dwellers, and the physical environment. But it is often ignored in modern times.

## **1.2 AIM**

To create an artist village to revitalize the artist's life to assist and promote the art development of Kerala.

## **1.3 OBJECTIVE**

- 1 To design an Artisan village based on Kerala Vernacular architecture.
- 2 To analyse on identified design strategies and approach how it as been responded to the climate.
- 3 To incorporate on various type of strategies which needs to be incorporated in the identified design typology.
- 4 To incorporate cost effective materials and construction techniques.

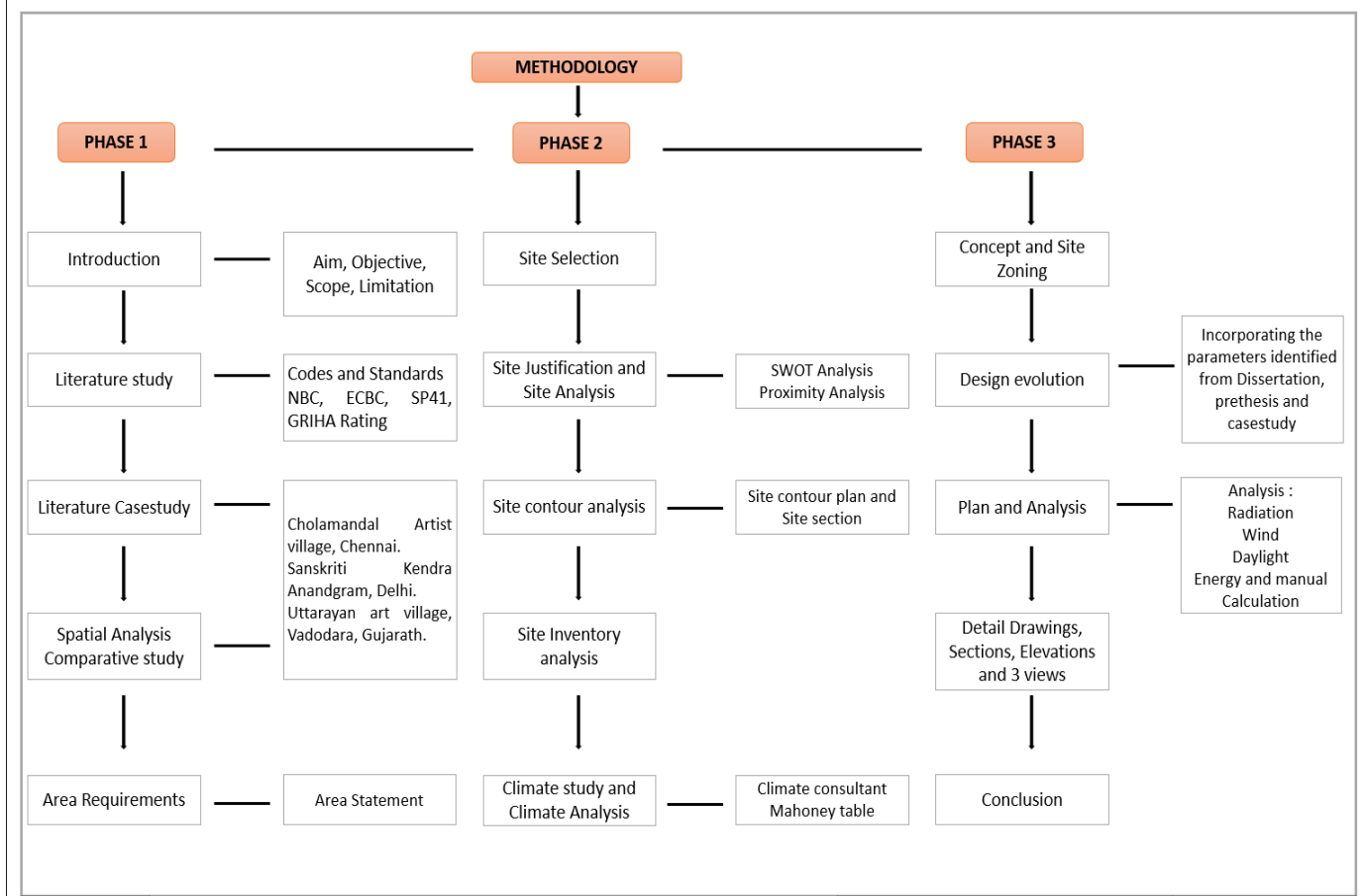
## **1.4 NEED FOR THE STUDY**

The growth and development of our society has a large impact on our natural environment. In Modern design of building usually have less thermal comfort than vernacular architecture building. This is because modern design building usually uses brick and concrete to build up the wall, floor slab and ceiling, which absorbs more heat than timber. Concrete absorbs heat when temperature is high and release heat when the temperature is low. The study of local vernacular architecture and lessons about climate responsive planning techniques can be helpful to approach towards green building design. Vernacular architecture influenced by the Climate, locally available building material, Indigenous Construction Techniques, Local customs, and Social Traditions. The structures capitalize on the native knowledge of how buildings can be effectively designed as well as how to take advantage of local materials and resources.

## **1.5 LIMITATION**

1. The project will not focus on landscape design, research will be based on Sustainable Architectural requirement.
2. Art gallery, exhibition and Artist residence block will be detail out.

## 1.6 METHODOLOGY



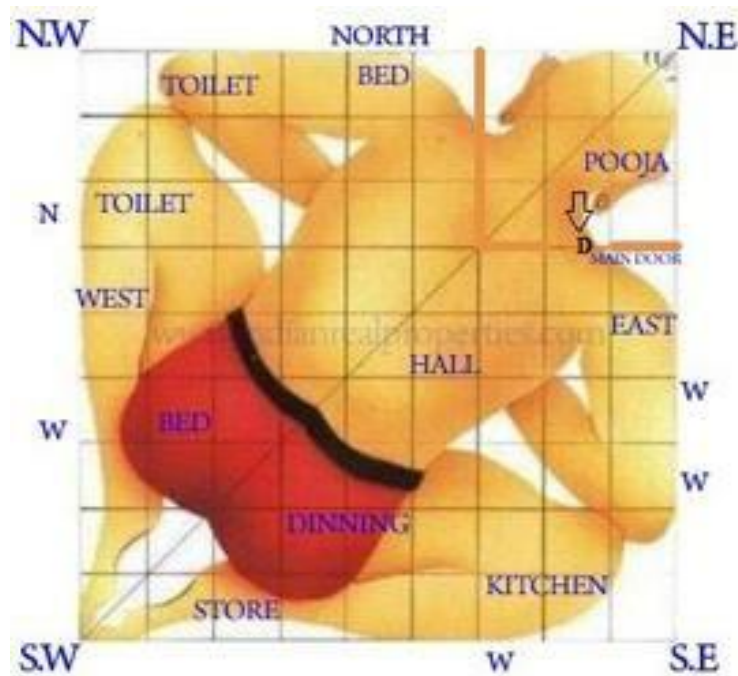
## CHAPTER 2 LITERATURE REVIEW

### 2.1 ARCHITECTURE OF KERALA

Kerala Architecture is one of the most exciting examples of preservation of traditional and vernacular styles, multiple foreign influences, and Aryan invasion, and Dravidian culture of different rulers. The architecture, environment and culture of Kerala show a contrast side to the rest of India. Kerala is blessed with abundant water, verdant forests, and rich lands.

Traditional Kerala architecture is primarily based on the principles of:

- **Thatchu Shashtra (Science of carpentry)**
- **Vaasthu Shashtra (Science of architecture and construction)**



**Fig 2.1 Vaasthu shashtra**

Houses were constructed facing the east, preferably and the design of the buildings as well as the materials used for construction is locally available and conducive to geographical as well as climatic conditions of the state. The understanding and appreciation

of environment and climate is reflected in traditional architecture. Kerala architecture are broadly divided into two distinctive areas based on different set of principles:

- **Religious Architecture** - Temples of Kerala as well as several old churches, mosques etc.
- **Domestic Architecture** - Primarily seen in most of the residential houses.



*Fig 2.2 Guruvayur temple*



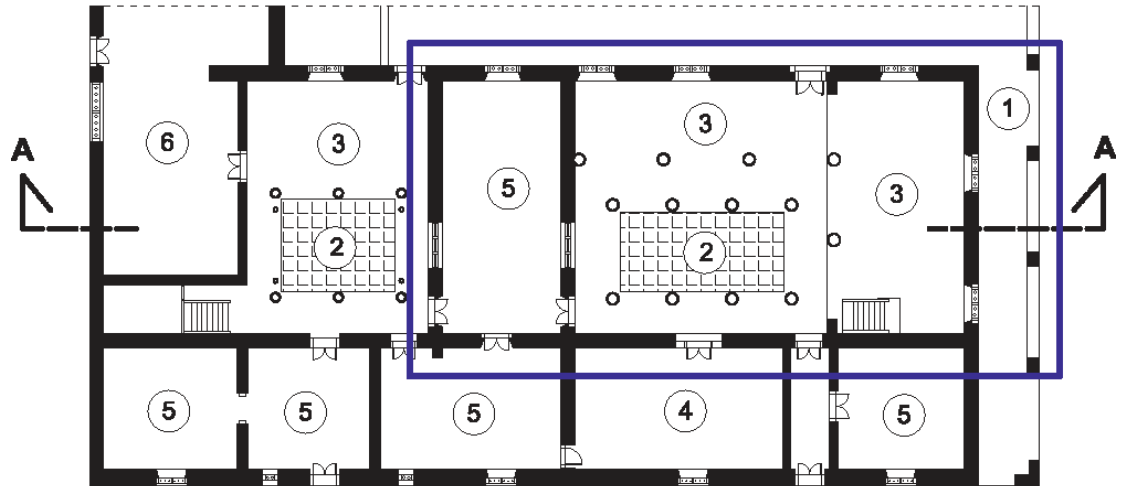
*Fig 2.3 Madhur temple*



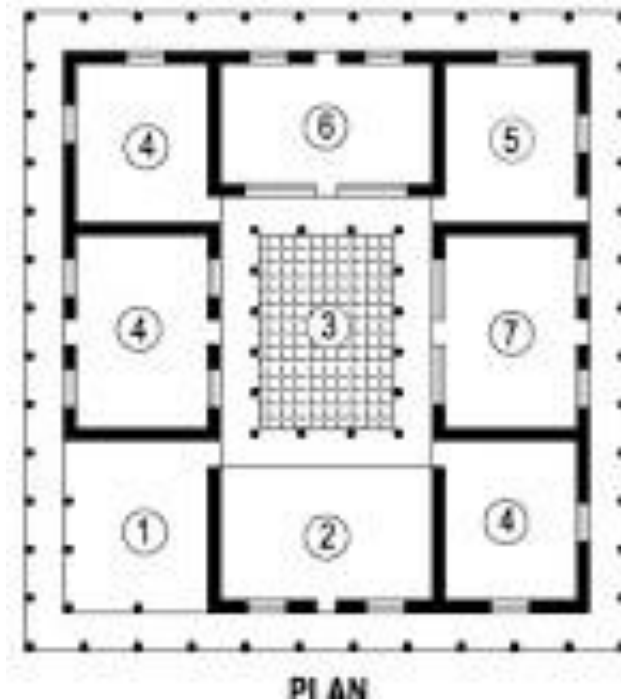
*Fig 2.4 The standard layout of a Kerala time*

## 2.2 SIGNIFICANT FEATURES OF KERALA VERNACULAR HOUSES

- **PLAN** - The primitive models of circular, square, or rectangular plain shapes with a ribbed roof evolved from functional consideration.
- Traditional architecture is influenced based on the climate of Kerala.
- The natural building materials available for construction in Kerala are stones, timber, clay, and palm leaves
- **ROOF** - long, steep sloping roof built to protect the house's walls and to withstand the heavy monsoon are normally laid with tiles or thatched labyrinth of palm leaves which are supported on a roof frame made of hardwood and timber.
- **GABLE WINDOWS** - were evolved at the two ends to provide attic ventilation.
- **WALLS** - The southern wall and western wall are 24 centimeters thicker than the rest of walls to protect from intense rays of sun.



**GROUND FLOOR PLAN**



**Fig 2.5 The standard layout of Kerala**

**PASSIVE STRATEGY** – Cross ventilation, pond, internal courtyard, dual courtyard

#### **MATERIALS-**

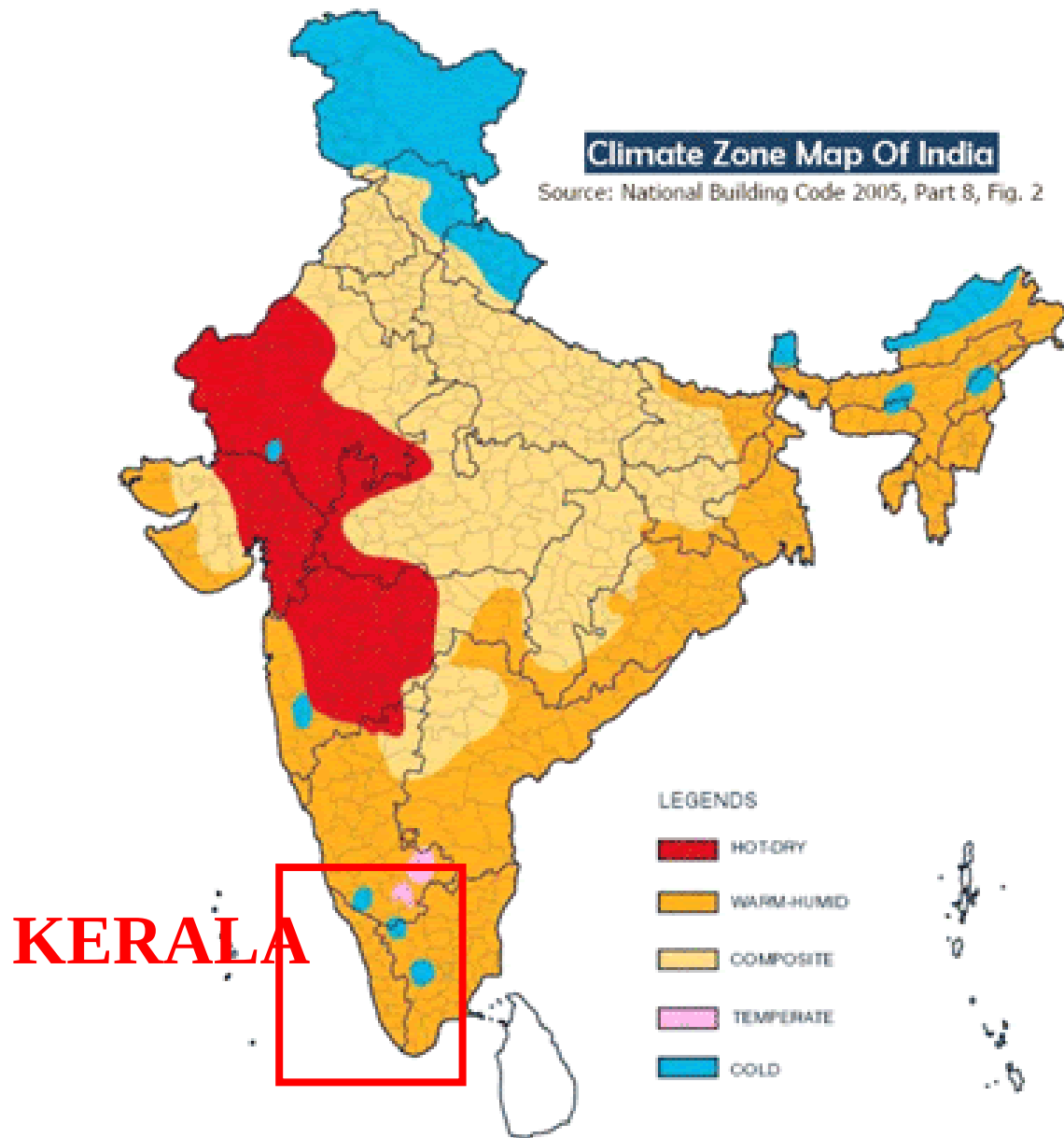
- Abundantly found materials in Kerala – Granite, Laterite soft laterite, Lime mortar, Timber
- Timber remains the prime structural material, bamboo

- Clay for walls, filling for timber floors
- Palm leaves are still used effectively for thatching the roofs and partition of walls along with mud.
- **RAINFALL** – Heavy rainfall from south-west and north east monsoons to protect from sun and rain the roofs of the building come down very low.
- **VERANDAH** all around the building for protection
- The width of verandah varies from 2ft to 12ft.
- **BEDROOMS** - Window openings were brought in at ground level or which as small windows or jalis to give diffused light without glare.



*Fig 2.6 Traditional building of Kerala*

## 2.3CLIMATE STUDY



*Fig 2.13 India map*

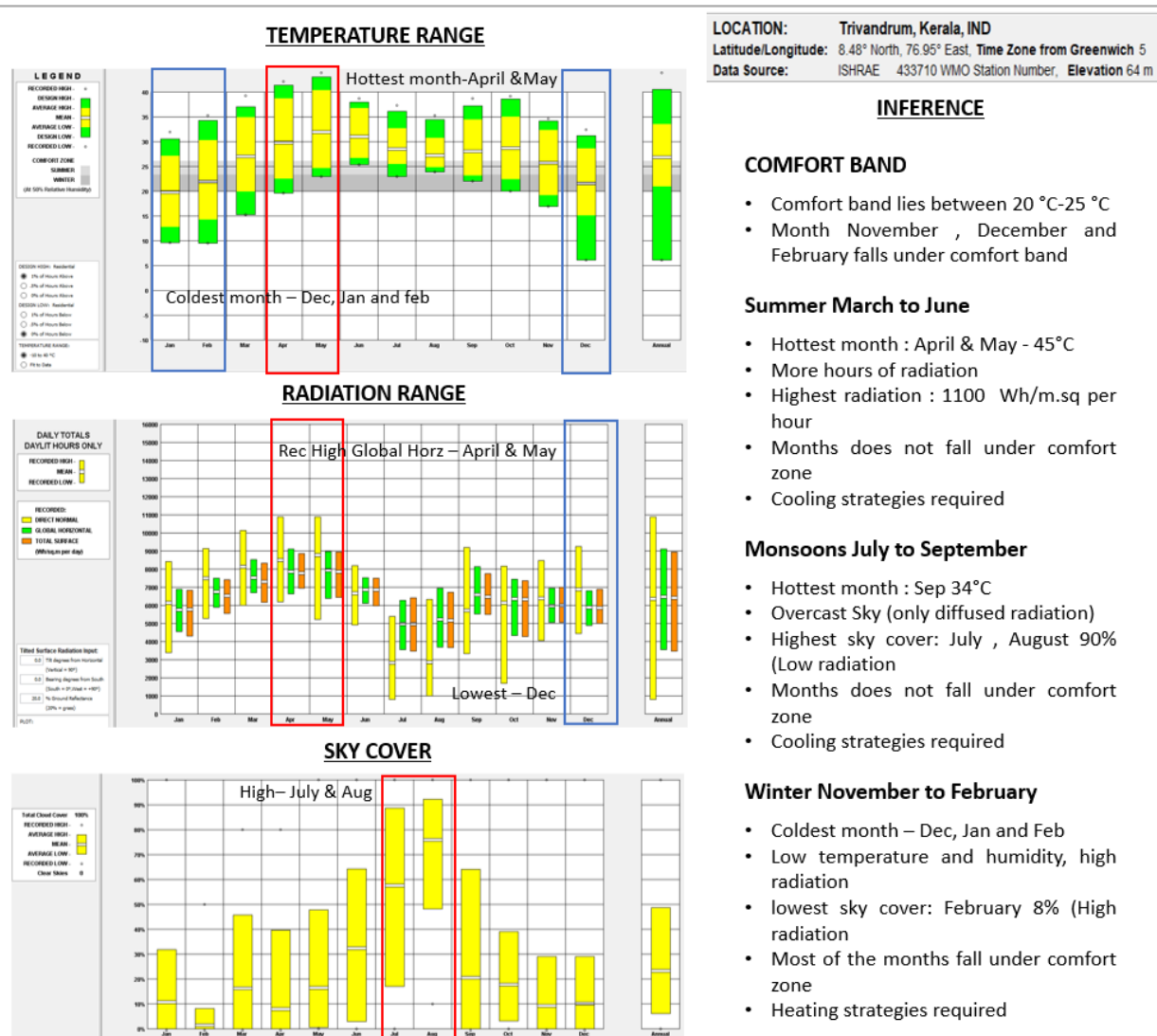
### GEOGRAPHICALLY:

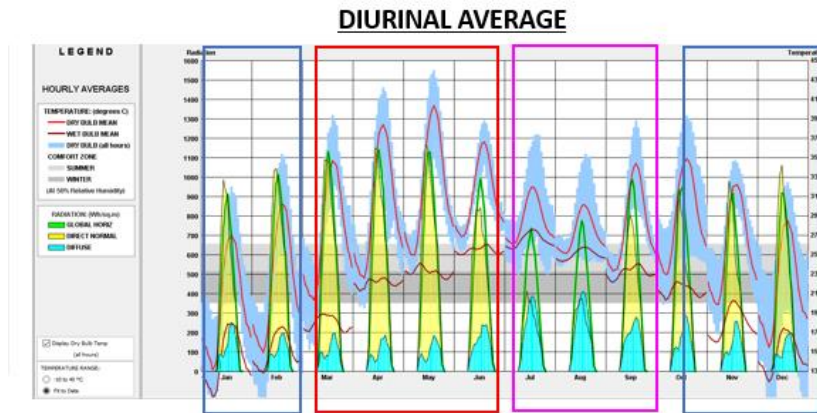
- Warm and humid covers
- Coastal India
- 300-400km inland of the coast, which covers most of southern India

- Large part of North-east India

## CHARACTERISTICS OF WARM AND HUMID CLIMATE:

- Temperature is moderately high during day and night
- Very high humidity and rainfall
- Diffused solar radiation if could cover is high and intense if sky is clear.
- Calm to very high winds from prevailing wind direction
- There are long monsoon periods with heavy rain. But the breeze especially in coastal areas can increase discomfort considerably





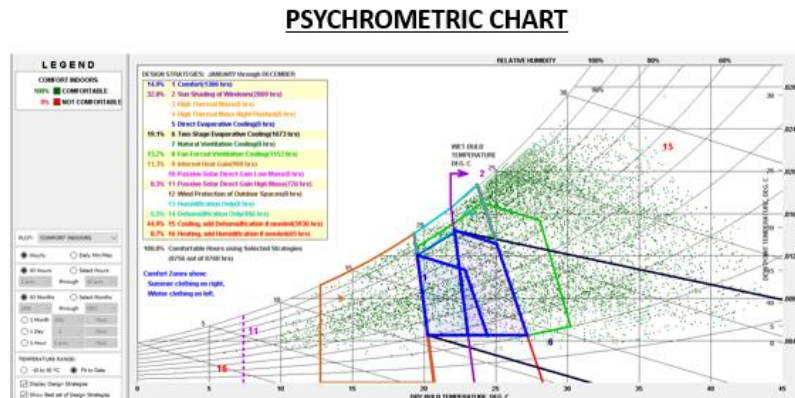
## INFERENCE

### Summer month

- March, April, May & June peak of summer with very low humidity
- High direct radiation in summer and winter

### Winter month

- Cold and dry with low humidity and low night temperature



### Monsoon

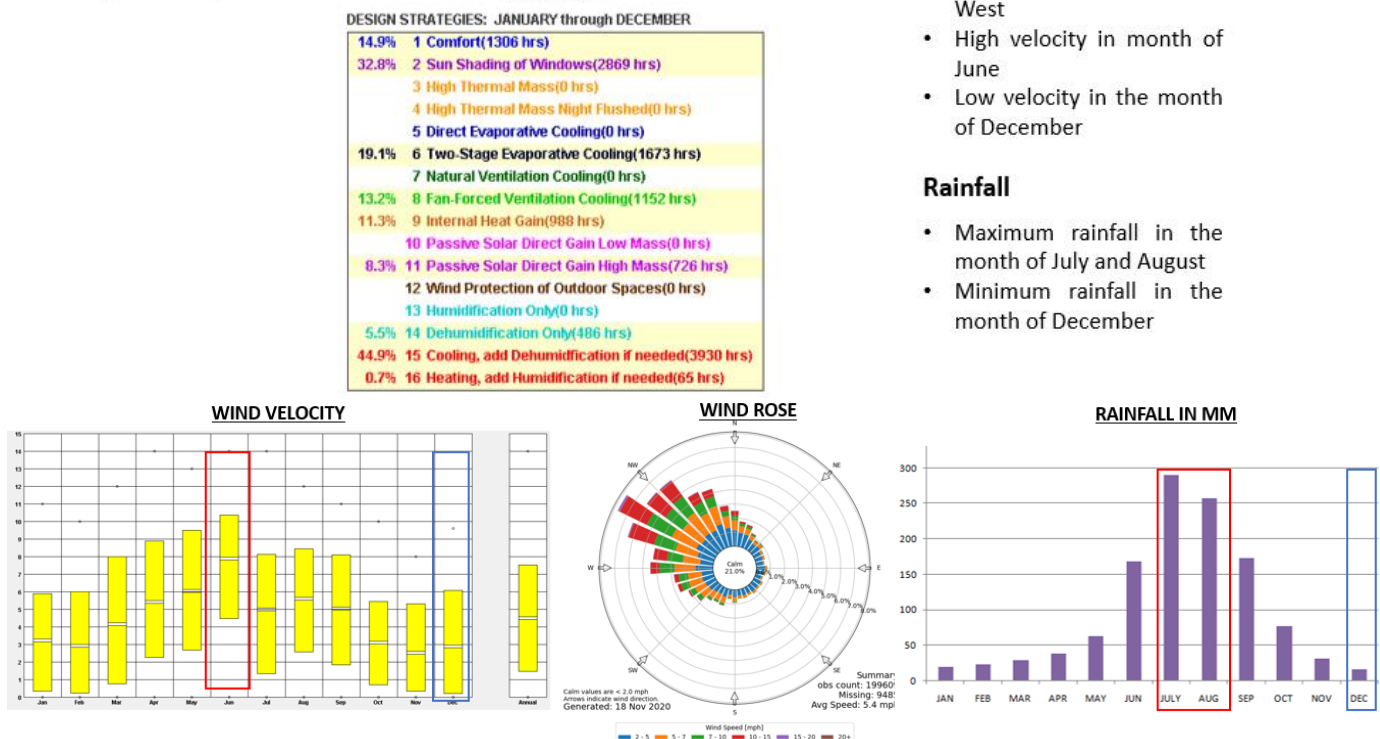
- Almost no direct radiation in the month of September, October & November
- Relatively higher humidity in August September, October & November

### Wind direction

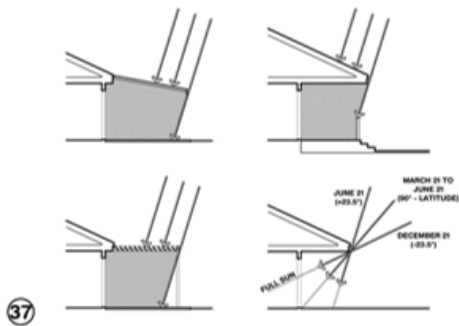
- High from North west and West
- High velocity in month of June
- Low velocity in the month of December

### Rainfall

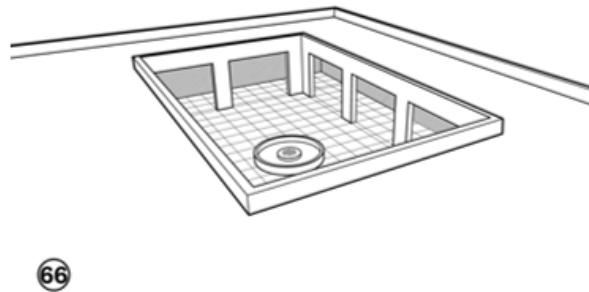
- Maximum rainfall in the month of July and August
- Minimum rainfall in the month of December



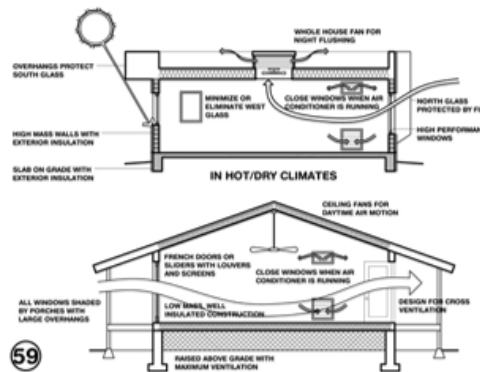
**Fig 2.14 Climate Analysis**



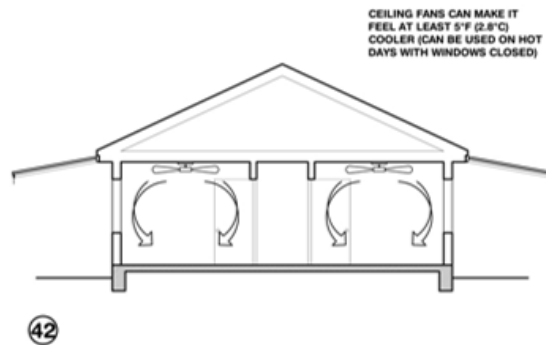
37 Window overhangs (designed for this latitude) or operable sunshades (awnings that extend in summer) can reduce or eliminate air conditioning



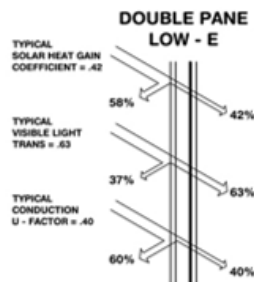
66 Traditional passive homes in hot windy dry climates used enclosed well shaded courtyards, with a small fountain to provide wind-protected microclimates



59 IN HOT/HUMID CLIMATES In this climate air conditioning will always be needed, but can be greatly reduced by building design minimizes overheating



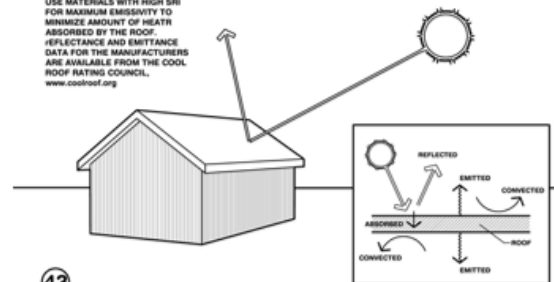
42 On hot days ceiling fans or indoor air motion can make it seem cooler by 5 degrees F (2.8C) or more, thus less air conditioning is needed



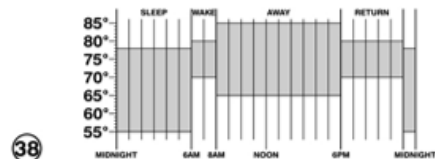
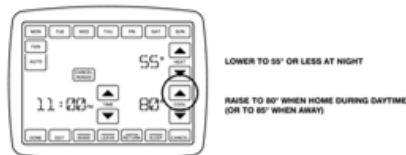
30 High performance glazing on all orientations should prove cost effective (Low-E insulated frames) in hot clear summers or dark overcast winters

#### SOLAR REFLECTANCE INDEX (SRI)

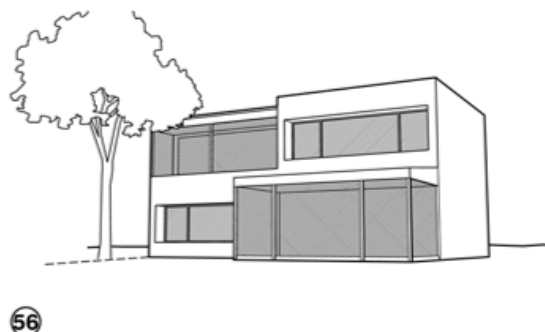
USE MATERIALS WITH HIGH SRI FOR MAXIMUM EMISSIVITY TO MINIMIZE AMOUNT OF HEAT ABSORBED BY THE ROOF. REFLECTANCE AND EMISSANCE DATA FOR THE MANUFACTURERS ARE AVAILABLE FROM THE COOL ROOF RATING COUNCIL, [www.coolroof.org](http://www.coolroof.org)



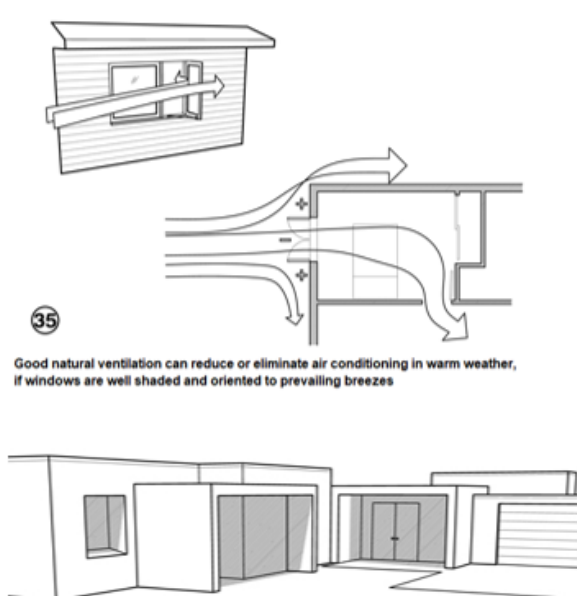
43 Use light colored building materials and cool roofs (with high emissivity) to minimize conducted heat gain



38 Raise the indoor comfort thermostat setpoint to reduce air conditioning energy consumption (especially if occupants wear seasonally appropriate clothing)

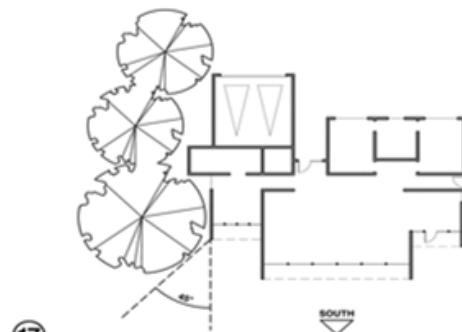


56 Screened porches and patios can provide passive comfort cooling by ventilation in warm weather and can prevent insect problems



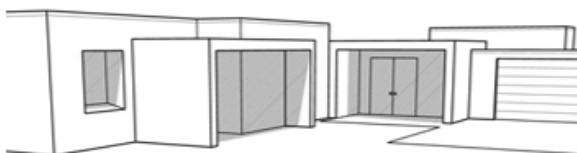
35

Good natural ventilation can reduce or eliminate air conditioning in warm weather, if windows are well shaded and oriented to prevailing breezes



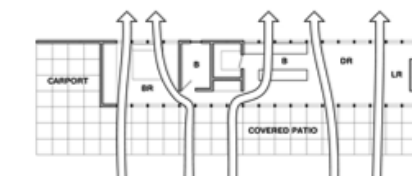
17

Use plant materials (bushes, trees, ivy-covered walls) especially on the south side to minimize heat gain (if summer rains support native plant growth)



45

Flat roofs work well in hot dry climates (especially if light colored)



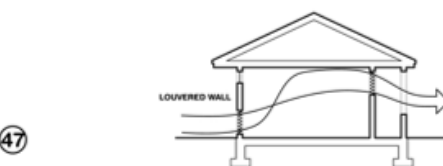
47

Use open plan interiors to promote natural cross ventilation, or use louvered doors, or instead use jump ducts if privacy is required



61

Traditional passive homes in hot dry climates used high mass construction with small recessed shaded openings, operable for night ventilation to cool the mass



36

To facilitate cross ventilation, locate door and window openings on opposite sides of building with larger openings facing up-wind if possible



ATTACHED TO UNDERSIDE OF ROOF DECK

RADIANT BARRIERS ARE SHINY FOILS WITH EMITTANCE OF .05 OR LESS WITH AT LEAST 1" CLEARANCE, ATTIC MUST BE VENTED



ATTACHED TO BOTTOM OF RAFTERS



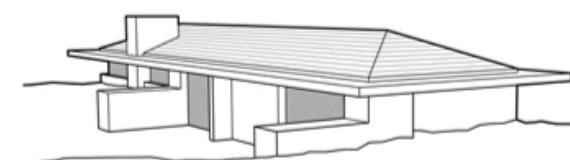
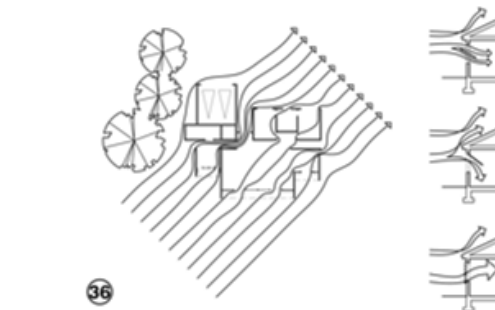
STAPLED BETWEEN TRUSSES (OFTEN MULTIPLE SHEETS)



DRAPED OVER TOP OF TRUSSES OR RAFTERS

26

A radiant barrier (shiny foil) will help reduce radiated heat gain through the roof in hot climates



60

Earth sheltering, occupied basements, or earth tubes reduce heat loads in very hot dry climates because the earth stays near average annual temperature

**Fig 2.15 Design strategies**

## 2.4 CLIMATE RESPONSIVE ARCHITECTURE OF KERALA

The planning and architecture of the vernacular housing patterns have evolved over time taking into consideration various parameters like the local climatic conditions, availability of local building materials and the skill employed in the construction. The courtyard houses of Kerala show a direct response to the climatic conditions of the place. In the hot humid climatic conditions of this region, the courtyard ensures easy ventilation. Traditionally, the sloping roof of the houses lets in a little sunlight to the interiors of the traditional Kerala houses; this is compensated by the presence of the large courtyard.

The courtyard has some religious association too, as traditionally, the open courtyard in a Kerala house is considered as the '*devasthanam*' -the most sacred place assigned to the gods and hence construction is not allowed there. The presence of highly insulative building envelop for thermal protection, provision of verandahs for protection of external walls from solar radiation and the pitched roof for protection from heavy rain together are highly effective for a passive environment control system in Kerala vernacular residential architecture.

## CHAPTER 3 LITERATURE STUDY

### 3.1 RESEARCH PAPER

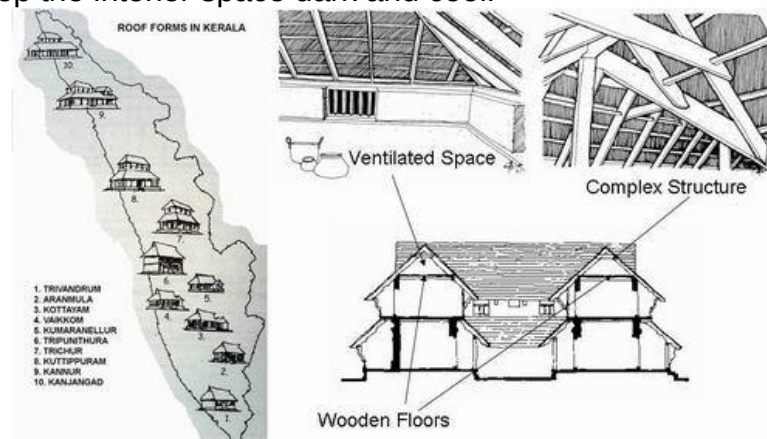
| TOPIC                                                                                                                           | AUTHORS                                                | AIM                                                                                                                                      | INFERENCE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Architecture shaped by socio-cultural influence and climate:<br>Lessons learnt from study of vernacular architecture of Kerala. | Dr. Janmejoy Gupta,<br>Naushaba Jameel & PushpitaPadhy | This paper studies the evolution of vernacular architecture of Kerala in response to climatic conditions and varied cultural influences. | The traditional features are replicated in some modern buildings, but the functional utility of the buildings is lost while replicating them.<br>Planning devices like courtyards, suitable orientation, envelope design, responsive roof design and appropriate fenestration design should be employed. Stress on locally available materials without major modifications in their organic states along with encouraging the use of local crafts and skills should be done.<br>There is also needed to create awareness among people and adapt their aesthetics sense in a more culturally contextual and nature appropriate way. |

**Table 3.1 Inference**

#### **Various strategies for indoor thermal comfort in domestic structures of Kerala:**

- **ROOFS:** The roof is not exposed to direct sun for the whole day, whereas in terraced buildings, the flat roof is exposed to sun throughout. The permeable tiled roof cools down faster owing to its low thermal mass
- Fish clay tiles performance well to maintain the indoor temperature
- Roof slopes are inclined at an angle of 45 degrees and gables are provided at the ends of roof to enhance ventilation to allow warm air to escape.
- **WALLS:** are painted in light colors so that it reflects radiation. Walls have rough texture causing self-shading for walls.

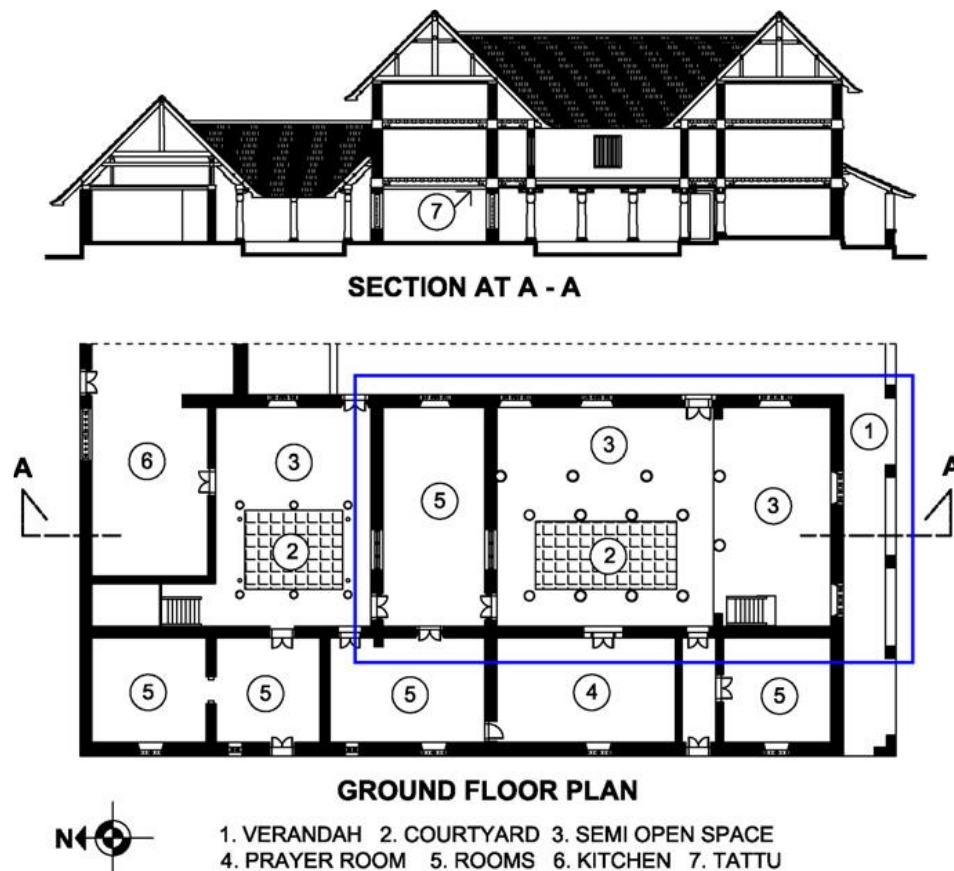
- The walls made of porous laterite helps to cool the building. The thickness prevents radiation from penetrating.
- The clay plastering provides further insulation.
- West and south walls are thicker than the north and east.
- COURTYARD: Openings are fewer towards the exterior and more towards the courtyard taking in less radiation and facilitating air circulation.
- Which also consists of shallow pool of water for passive cooling
- Open lay-out living spaces daily activities occur around the courtyard
- VERANDAH: External verandah and internal courtyard protects the building from rain and sun
- WINDOW: The Traditional houses have smaller windows with wooden shutters which admit just the required amount of sunlight based on the function of the space under consideration.
- FLOORING: The flooring is made out of Indian patent stone, which is usually colored black to keep the interior space dark and cool.



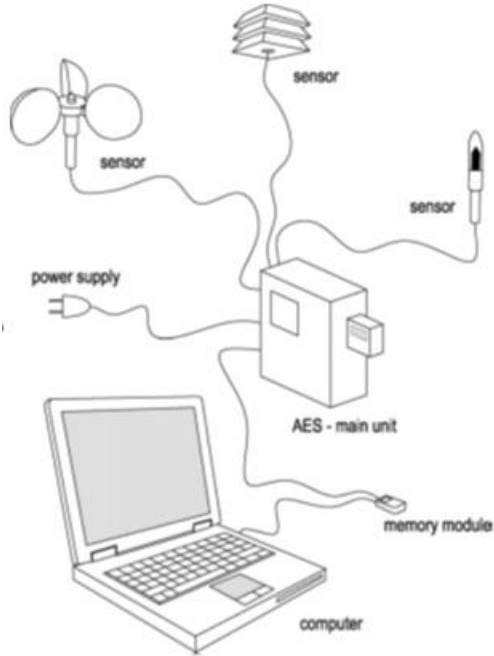
**Fig 3.1 Different roof found across Kerala**

| TOPIC                                                                                                                                                          | AUTHORS                                           | AIM                                                                                                                                                                             | INFERENCE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Passive environment control system of Kerala vernacular residential architecture for a comfortable indoor environment: A qualitative and quantitative analyses | A.S. Dili ,<br>M.A. Naseer , T. Zacharia Varghese | This paper says that the passive environment control system employed in Kerala vernacular architecture is highly effective in providing thermal comfort indoors in all seasons. | The presence of internal courtyard within the living spaces and optimum window openings provided for a continuous air movement, highly insulative building envelop for thermal protection, provision of verandahs for protection of external walls from solar radiation and the pitched roof for protection from heavy rain together contribute to a passive environment control system in Kerala vernacular residential architecture.<br>The passive environment control system of Kerala vernacular architecture is very effective in providing thermal comfort to the occupants. |

**Table 3.2 Inference**



**Fig 3.2 Traditional residence in Kerala**



AES installation around the courtyard



RH and temperature sensors in bedroom



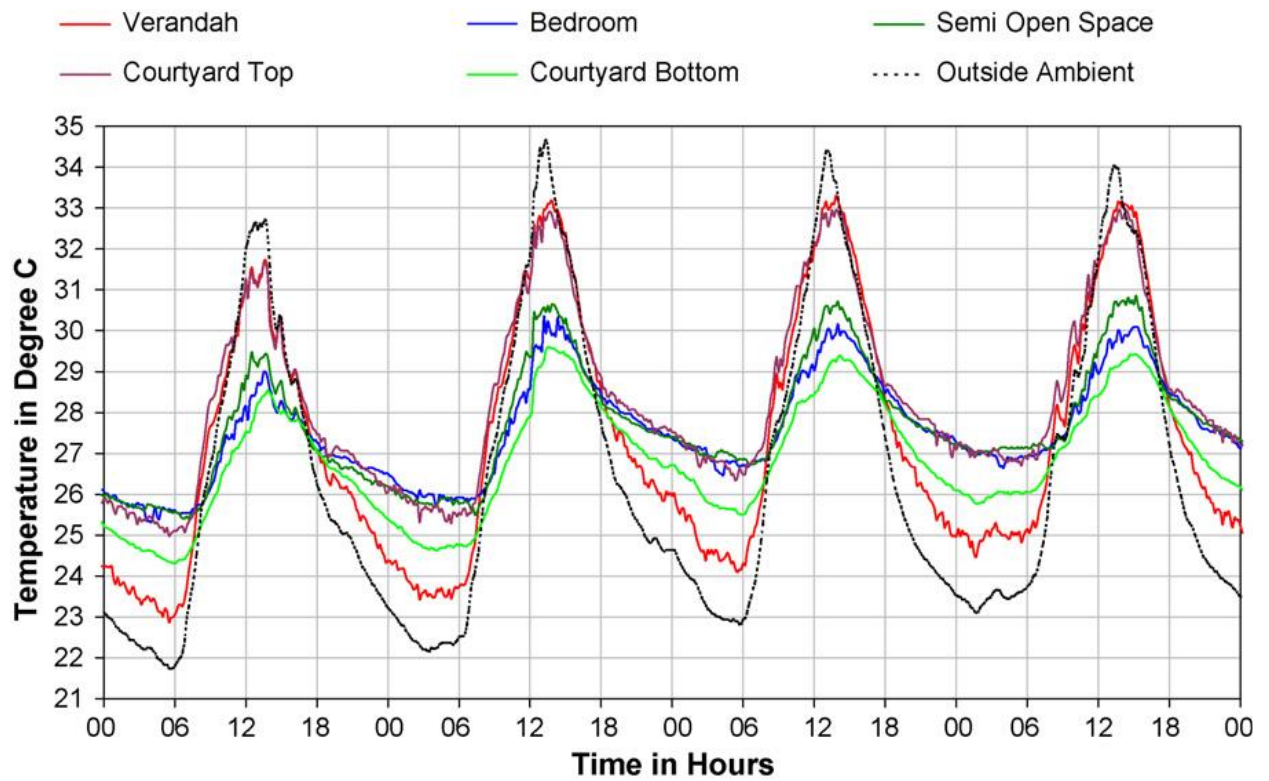
Outdoor wind velocity sensor



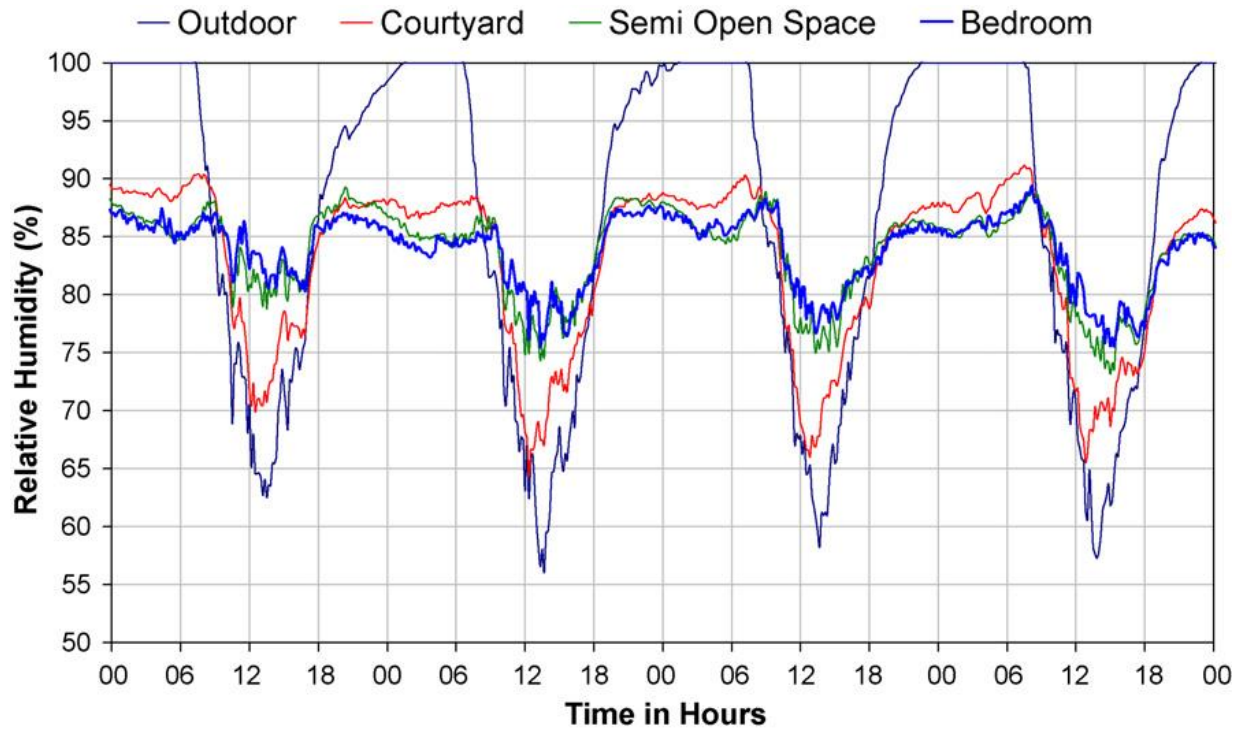
Outdoor temperature and RH sensors

Fig. 9. Installation of AES in the selected locations of Nilambur Kovilakam.

**Fig 3.3 AES – Architectural valuation system**



**Fig 3.4 Temperature vs Time**



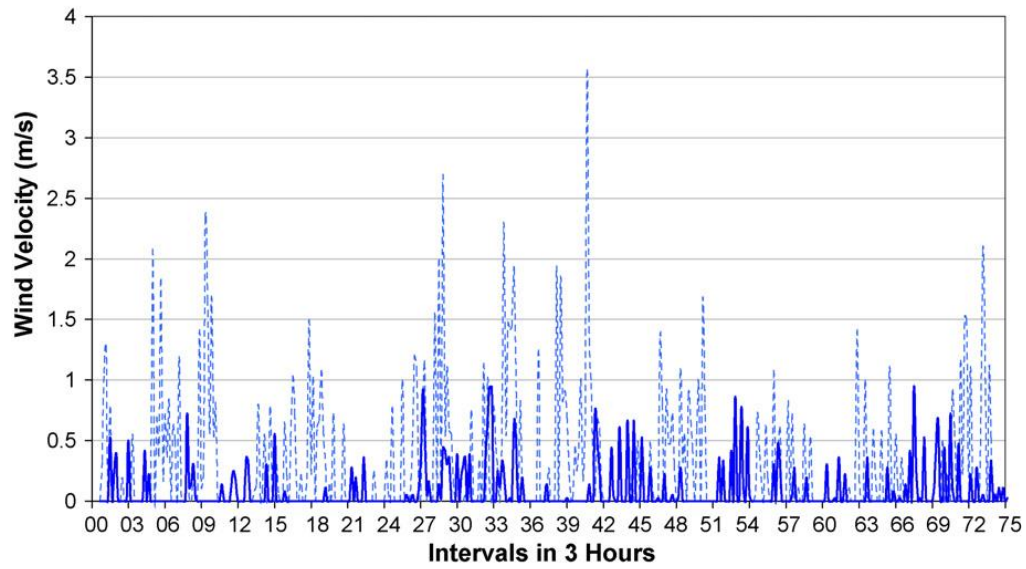
**Fig 3.5 Relative Humidity vs Time**

#### **TEMEPERATURE VS TIME RESULT:**

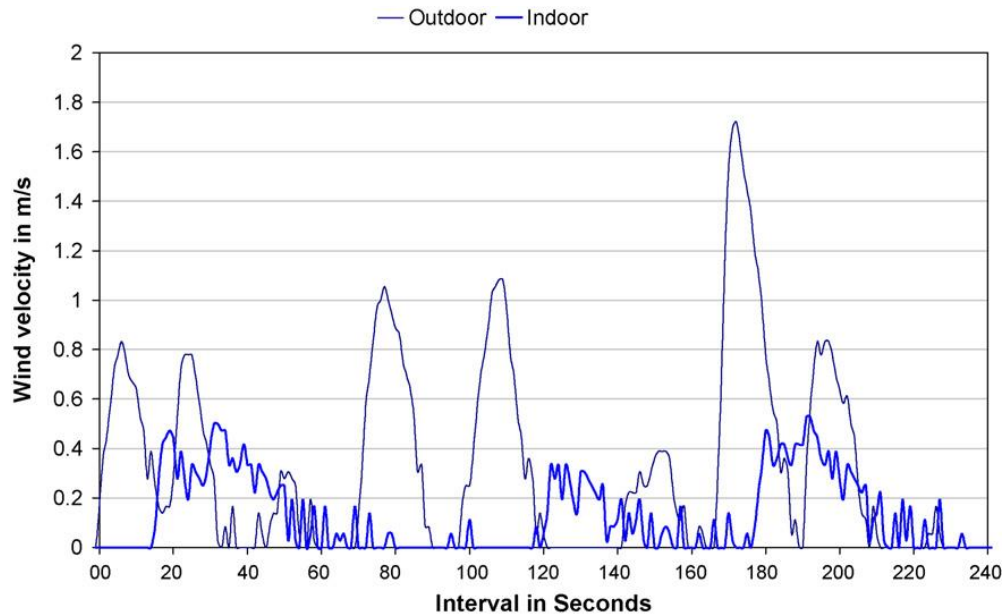
- The outdoor temperature has a diurnal variation of 12 ° C - from 22 ° C to 34 ° C
- Indoor temperature was varying from 26 ° C to 30 ° C showing a diurnal variation of just about 4 ° C
- The lower part of the courtyard is found to be cooler by about 5 ° C
- The temperature recorded inside the room is found to be lower by about 4 ° C than that of semi open space around the courtyard during daytime.

#### **RELATIVE HUMIDITY VS TIME RESULT:**

- The variation of RH at different locations
- The RH of the bedroom is varying almost than the semi-open space throughout.
- RH of the courtyard is the most fluctuating one among the interiors, but during night, it has only a variation of around 3% with that of bedroom and semi-open space.
- During the daytime, RH of the courtyard reaches its minimum



**Fig 3.6 Wind velocity vs Time**



**Fig 3.7 Wind velocity vs Time**

#### RESULT :

- The outdoor wind velocity is highly fluctuating and reaches its maximum around 3.5 m/s, the indoor air movement is maintained around 0.5 m/s.
- The cooler air settles at the Bottom the building system is maintaining a continuous and controlled air flow indoors.
- This actually helps to accelerate the evaporative cooling by continuous exchange of air

### 3.2 PREVALENT ARCHITECTURE STYLES OF KERALA

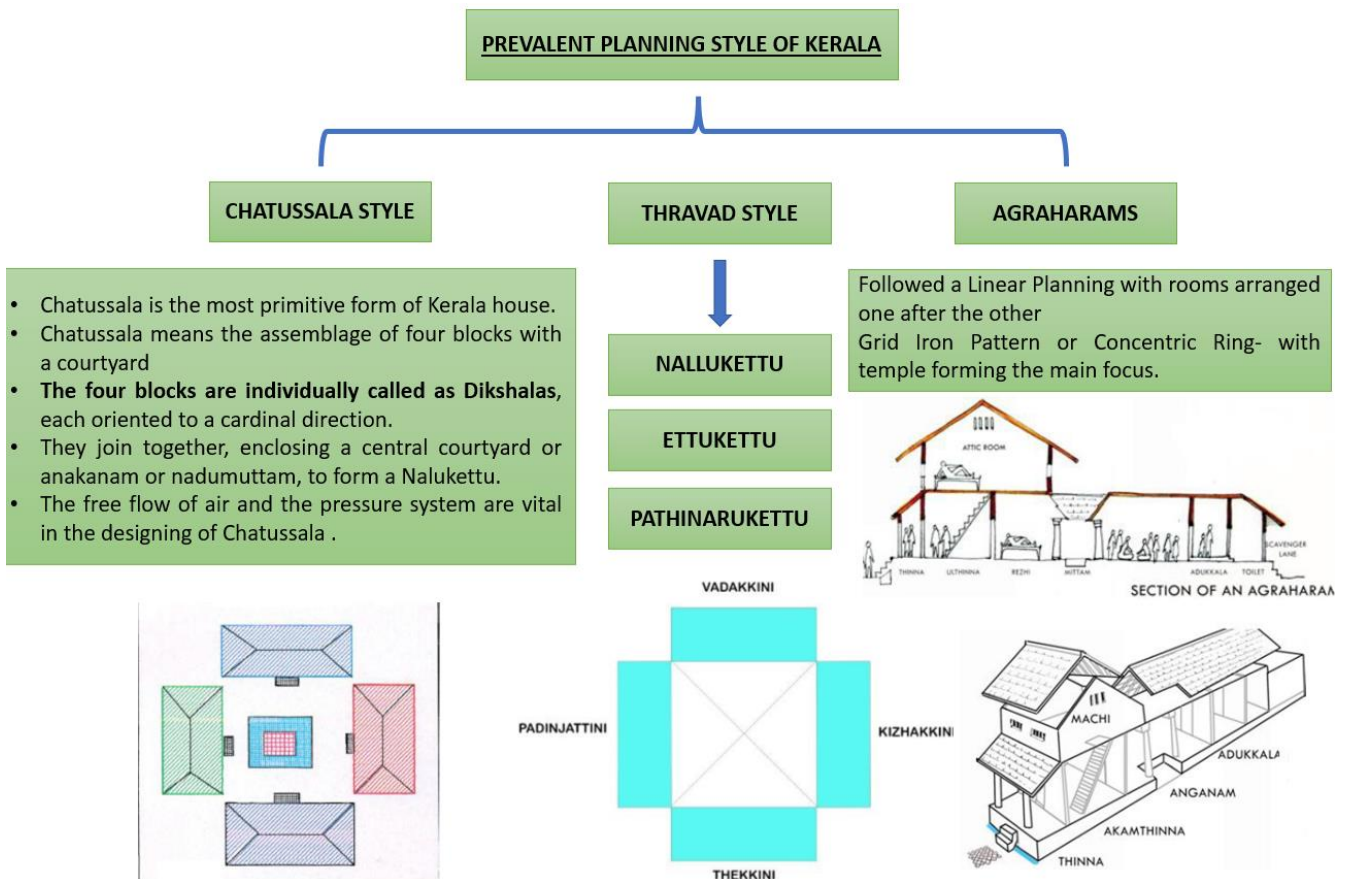
Kerala had developed its own housing concepts from time immemorial, which is unique in the sense that it is highly scientific, technical and adaptive to the environment. The major styles of Kerala's architecture are classified into two major styles as mentioned below:

*Chatussala* and *Thravad* style.

*Agraharams*.

The types of Traditional Houses can also be broadly classified into four types depending on The number of blocks contained in the dwelling:

- *Ekashala* (a single unit block)
- *Dwishala* (an assemblage of two blocks)
- *Trishala* (three blocks)
- *Chatussala* (four blocks with courtyard)
- 



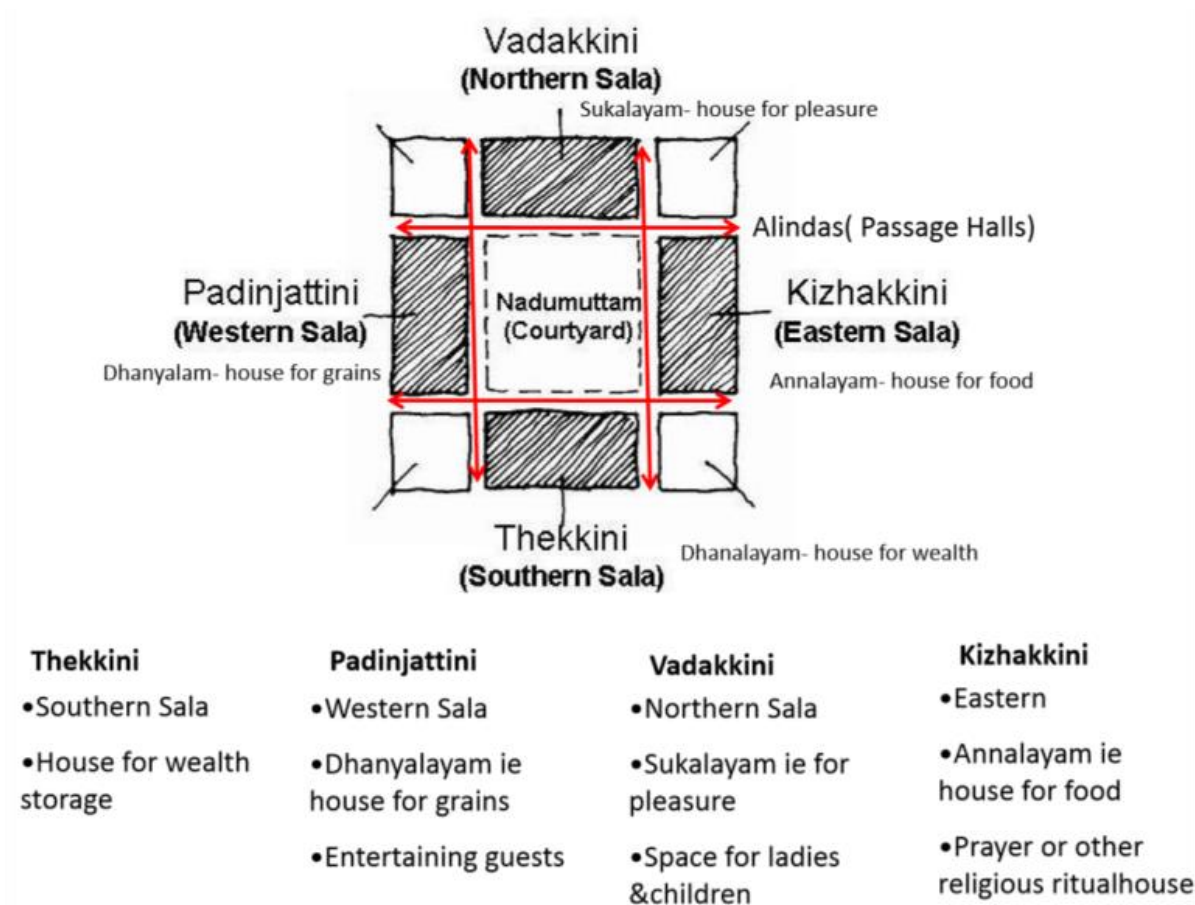
**Fig 3.8 Types of planning styles of Kerala**

#### THRAVAD STYLE

- The traditional homestead in Kerala is the 'tharavadu', a complex built unit comprising of many sections with specific usages.
- It has evolved from the basic Chatussala form. The basic units of these houses were square or rectangular structures where four blocks are joined together with a central courtyard open to the sky.

The four halls on the sides are named:

- vadakkini(northern block),
- padinjattini(western block),
- kizhakkini(eastern block) and
- thekkini(southern block).



**Fig 3.9 Thravad complex**

Different names of the blocks in Thravad Style:

Based on the number of courtyards, the Thravad Style House has been broadly divided into following three types as mentioned below:

1. Nalukettu-one courtyard with four blocks in cardinal directions.

2. Ettukettu-two courtyards with eight blocks in cardinal directions.
3. Pathinarukettu-four courtyards with sixteen blocked structure.

### 3.3 PALIAM NALUKETTU

| SPECIFICATIONS |                                                    |
|----------------|----------------------------------------------------|
| Location       | Chendamangalam near Paravur in Ernakulam district. |
| Climate        | Warm and humid                                     |



***Fig 3.10 Front view and Verandah***

**ORIENTATION:** Naalu kettu faces south- Direct sunlight from late morning to early afternoon. Provided with free circulation of wind and air without any obstruction.

**PLINTH:** Plinth height = 75cm, verandah area height = 60cm. Since paravur was a flood prone area where plinth area protected form the floods to an extend.

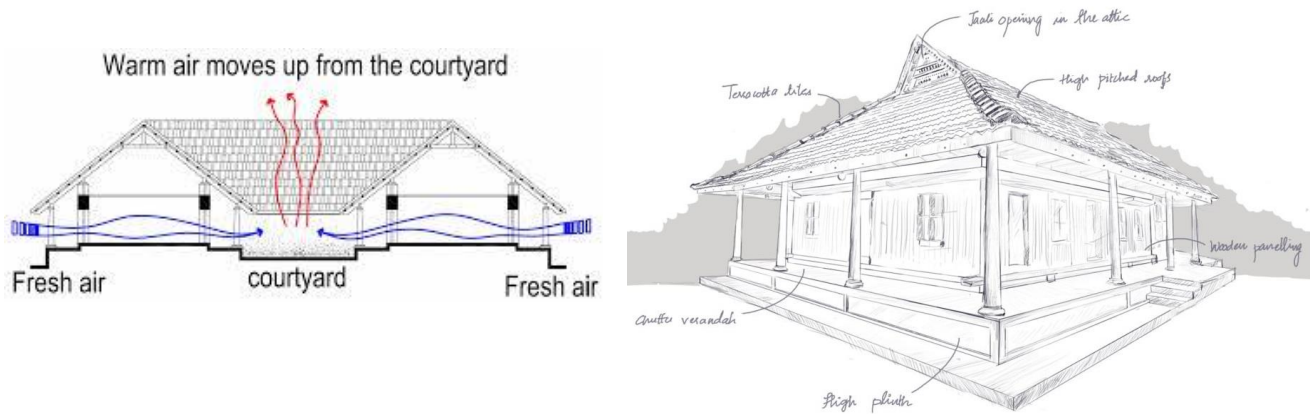
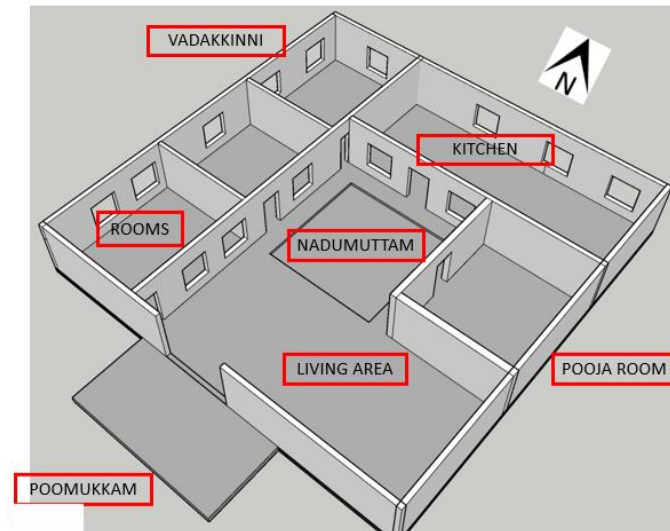
**TWO STOREYED STRUCTURE:** Ground floor consists of: Kitchen, Kizhakkini, Thekkini, Delivery rooms, Ara. First floor consists of: Four private bedrooms.



**Fig 3.11 Interior view**

Nalukettu is the traditional homestead of Tharavadu where many generations of a matrilineal family lived. The architecture was especially catered to large families of the traditional tharavadu, to live under one roof and enjoy the commonly owned facilities. Among those architectural strategies a few are, as follows:

- That at the middle of the padnijatini(western block), there will be the pooja muri(place of worship) and 'nellara' (room for keeping paddy).
- On both the sides there will be two bed rooms Thekkini and kizhakkini are meant for receiving the guests.
- Vadakkini is for cooking and dinning. (Kitchen and dining room).
- In the middle of the structure there will be the central yard which will be in a rectangular shape. 'Nadumuttam' (central yard) will be useful for getting light and air into the house.
- More over there will be an underground cave for storing the rain water that falls in the 'Nadumuttam'.



**Fig 3.12 Plan**

## COURTYARD

- Plays a very important role in controlling the temperature within the house
- Micro climate modifier
- Overhangs of 1 meter width are provided in order to protect rain from getting to the interiors
- Continuous circulation of air within the interior
- Enables passive cooling

## VERANDAH

- External verandah and internal courtyard protects the building from rain and sun
- Verandah all around the building for protection
- The width of verandah varies from 2ft to 12ft.
- Ladies were not allowed to go outside therefore verandah is the only place of interaction



**GABLE WINDOWS:** were evolved at the two ends to provide attic ventilation.



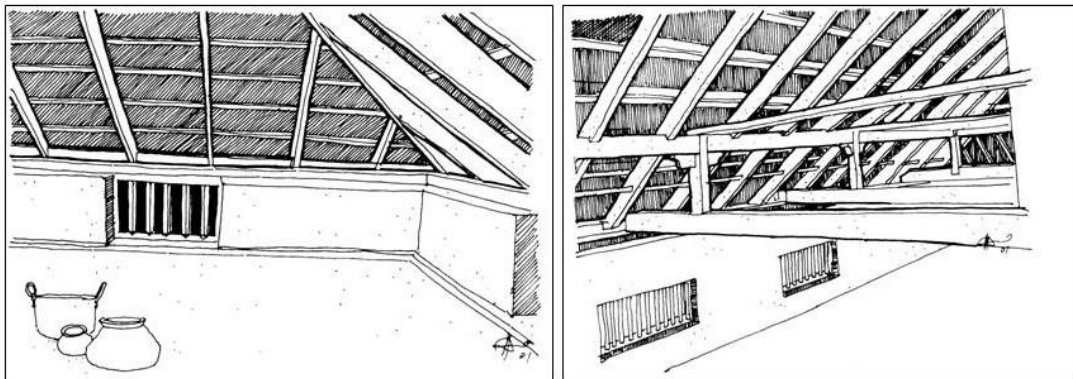
**Fig 3.14 Deep overhangs**

### ROOF

- Traditional pitched roof with a slope of 45 degree supported over timber frames
- Covered with traditional roofing clay tiles
- The pitches slope enables the easy drain of rainwater
- Extended over the verandah at a length of 2m which protects the walls from direct heat and rains

### MACHU

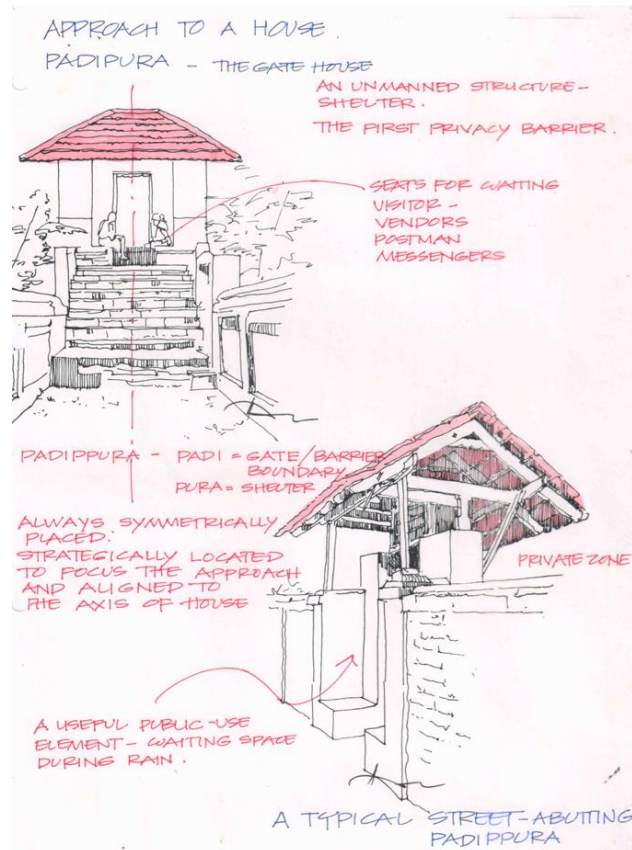
- Similar to false ceiling provided beneath the roof made of timber
- Air between the ceiling and the roof which act as an insulator that prevents the conduction of exterior heat through roof
- Ventilations are provided between machu and the room
- This space is generally used as the store for utensils tools, dry fuel etc.
- This volume of space that holds the roofing system also plays the important role of keeping lower floor cool by working as a buffer.



**Fig 3.15 Machu**

## PADIPPURA

- The gateway or gate house at the entrance to the plot it is the first built forms seen while approaching a house.
- The sizes of padippura vary depending on the status and affluence of the owner.
- Located usually on the western or eastern side of the house and it vary in size and detailing from a covered doorway to sometimes a double storied structure
- Padippuras have seating facilities in the form of thinna or platform.



**Fig 3.16 Gateway**

### **WALLS:**

- **MATERIAL** -Laterite with sand filling and lime plastering
- **THICKNESS** - 30cm thick which provided insulation and kept the interiors cool
- **PAINT** - light colors so that it reflects radiation. Walls have rough texture causing self-shading for walls.
- The walls made of porous laterite helps to cool the building. The thickness prevents radiation from penetrating.
- The clay plastering provides further insulation.
- West and south walls are thicker than the north and east

**COLUMNS:** Entirely made out of timber

**ROOF:** Timber and clay tile

### **FLOORING:**

Surkhi flooring - Cool interiors

EGG PLASTERING – Making the floor smooth and shiny

The delivery room had tiles laid which was imported during that time from other countries

Floors were made in three different level – the ara and thekkini were raised to a height of 45cm and the basement below the ara

**PALIAM NALUKETTU**



**COURTYARD**



**PASSAGE WAY**

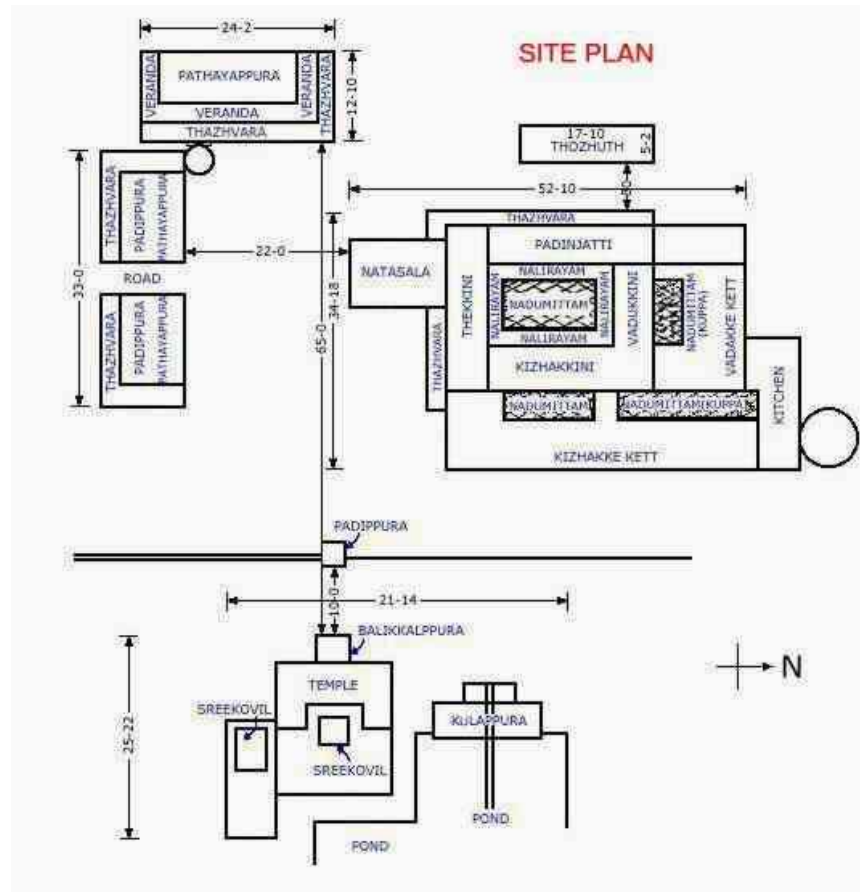


***Fig 3.17 Interior view***

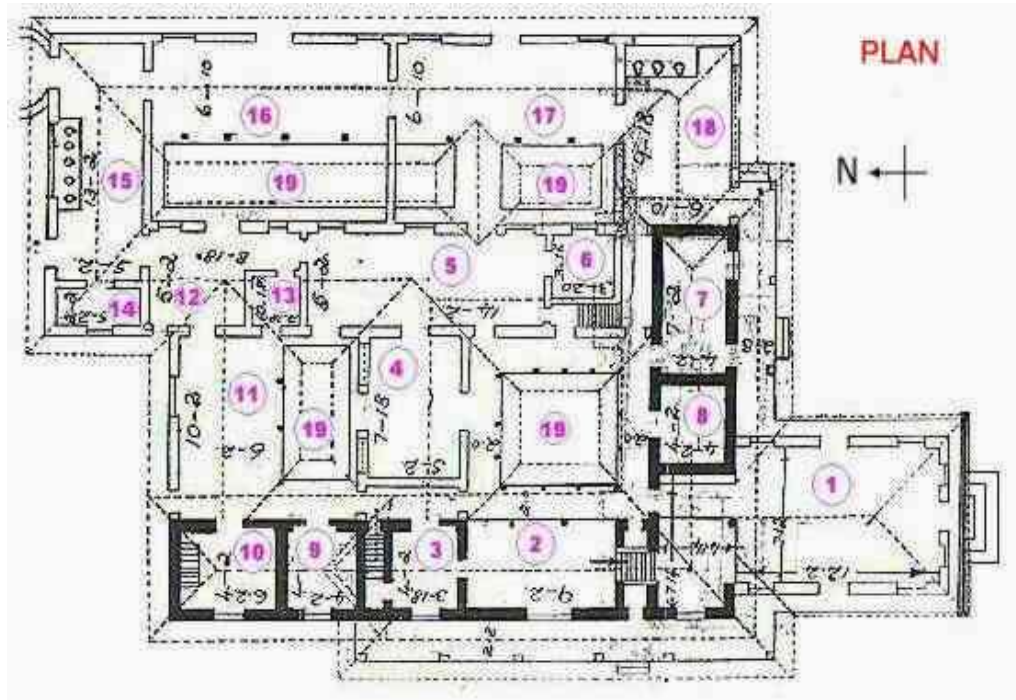
### **3.4 ETTUKETTU KANIPPAYYUR MANNA**

| SPECIFICATIONS |                                |
|----------------|--------------------------------|
| Location       | Kunnamkulam, Trissur district. |
| Climate        | Warm and humid                 |

- An 'Ettukettu' is that which is joined by two 'nalukettu's.
- An 'Ettukettu' will have two nadumuttams. (central yard)
- For larger homes and wealthier families, there are more elaborate forms of the Nalukettu, called the Ettukettu (eight halls with two central courtyards).



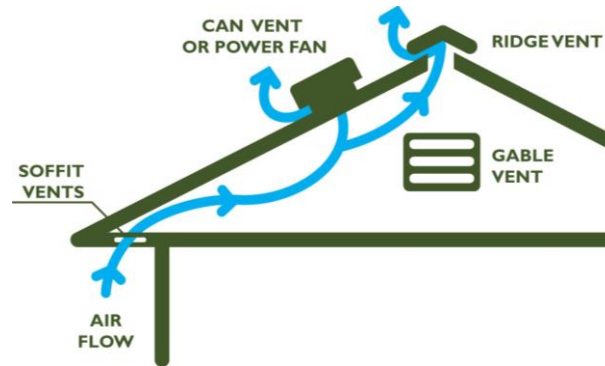
**Fig 3.18 Site plan**



**Fig 3.19 Ground floor plan**

1. 'Natasaala' & 'Poomukham' (Drawing Room) - Place to receive persons of all castes who have no 'Theendal'
2. 'Padinjattithara - serve them meals.
3. 'Deenamuri' (Sick Room) - Room for sick male members.
4. 'Vadukkini' (The northern part) - Place to do rituals like 'Oupaasanam', 'Sraadham', etc.
5. 'Meladukkala' - Day-to-day dinner hall for Namboothiris.
6. Room used by ladies at the time of menses.
7. 'Kalavara' (Store room)
8. 'Paathrakkalavara' (Vessel store room)
9. 'Puthanara' (New chamber) - Room to store pickles and keep luggage of Antharjanams.
10. 'Vadakke Akam' - Labour Room
11. 'Vadakke Kett' - Lunch hall for Namboothiris for noon meals.
12. 'Cheriya Meladukkala' or 'Thundanadukkala' - Dinner hall for Antharjanams.
13. 'Sreelaakam' - Worship Room
14. 'Morakam' - Kitchen store room to keep buttermilk, etc.
15. 'Adukkala' - Kitchen
16. 'Kizhakke Kett' ('Vadakketh') - Dinner hall for Antharjanams.
17. 'Kizhakke Kett' ('Thekketh') - Dinner hall for Namboothiris on special occasions.
18. 'Oottupura' - Place to prepare feast on special occasions.
19. 'Nadumittam' - Inner courtyard or quadrangle.

- Side lighting and top lighting are used to bring in daylight
- The fenestration are generally placed in northern side to get glare free sunlight
- Shading devices for windows as well as walls are used to cut down solar heat gain
- Eaves act as shading device



**Fig 3.20 Attic vent**

**ROOFING SYSTEM:** The roof frame was supported on the pillars on the wall erected on a plinth raised from ground for protecting against dampness and insect's steep pyramidal roof with 45degree pitch, deep overhangs, shaded verandahs.



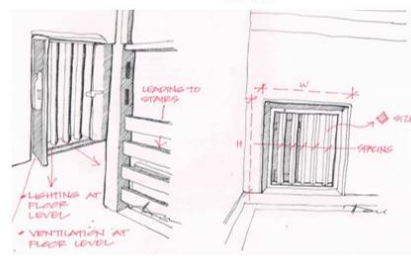
**ETTUKETTU  
KANIPPAYYUR MANNA**

Attic ventilation

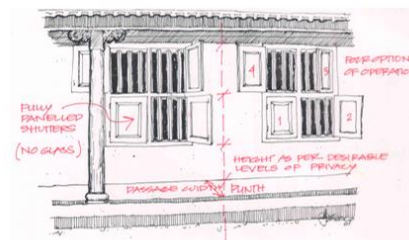
The projecting caves cover a verandah all round

wooden Jalli below the windows all around and opened to the courtyard

**VIEW**



**FLOOR LEVEL WINDOWS**



**DAY LIGHT**



**EAST SIDE ELEVATION**



**FRONT SIDE ELEVATION**

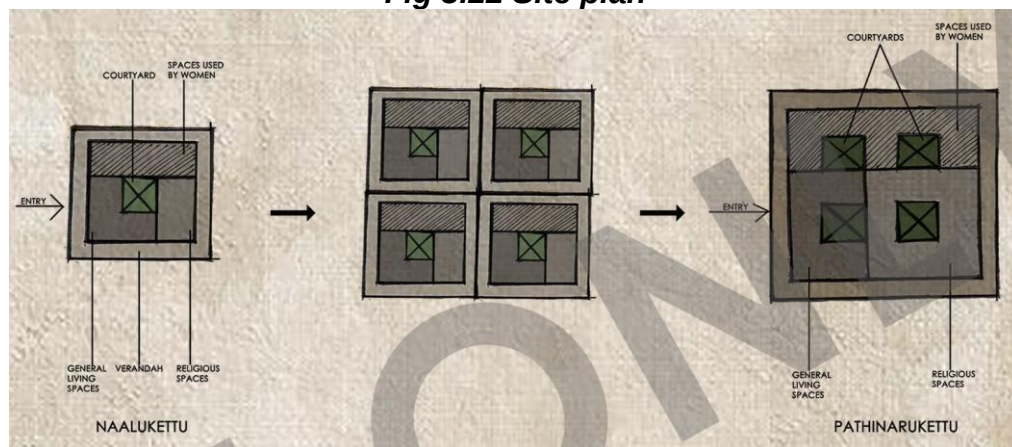
**Fig 3.21 View**

### 3.5 PATHINARUKETTU MARANAT MANA

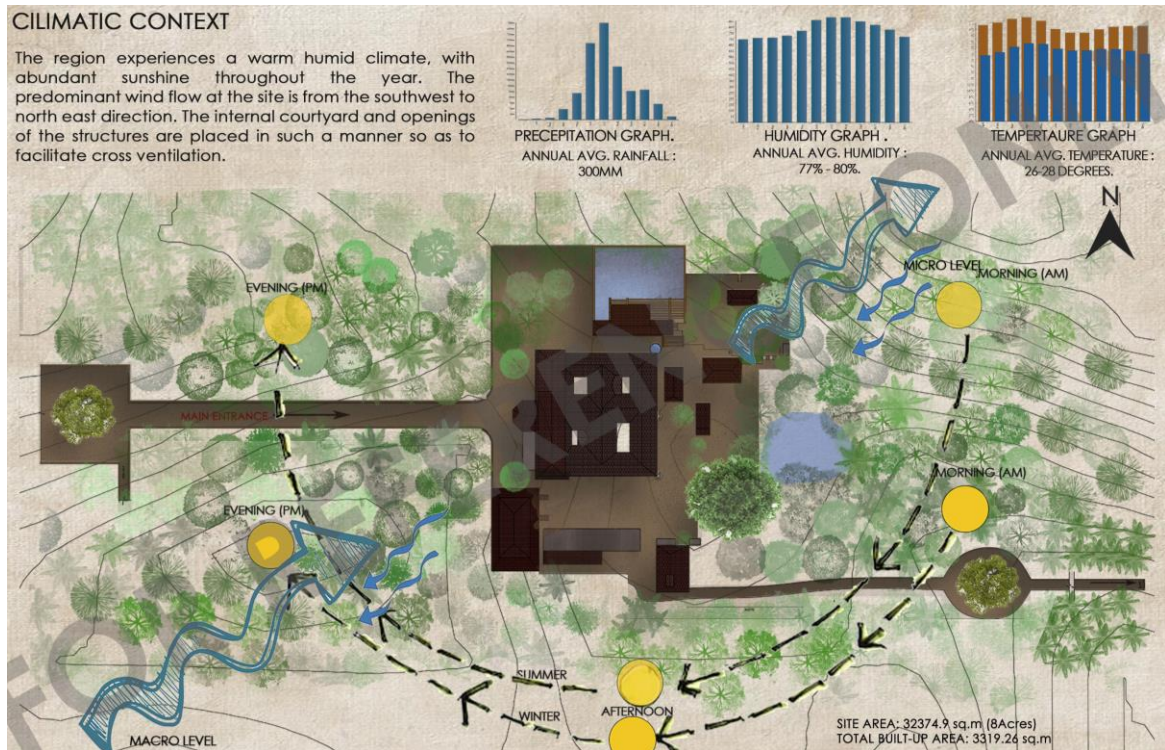
| SPECIFICATIONS |                                                       |
|----------------|-------------------------------------------------------|
| Location       | P.O.Chembrasseri,<br>Pandikkad,Malappuram Dist,Kerala |
| Climate        | Warm and humid                                        |



**Fig 3.22 Site plan**

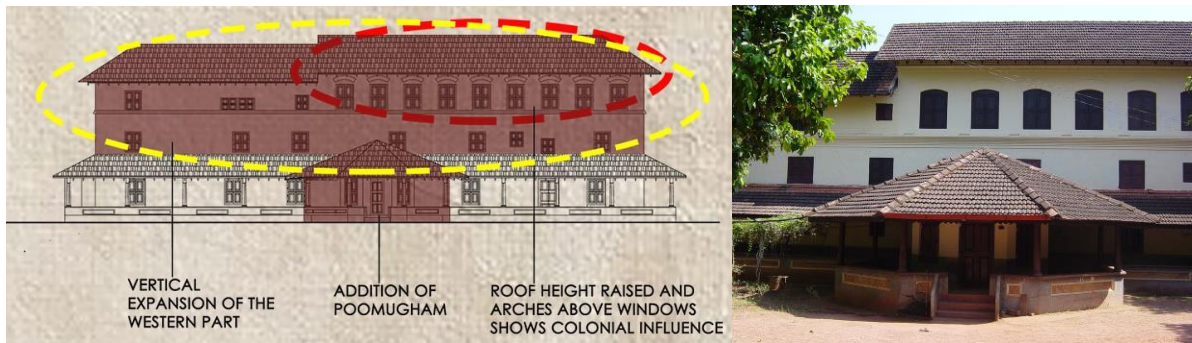


**Fig 3.23 Form evaluation**



**Fig 3.24 Climate analysis**

On the western side of the building, the front portion is where the later additions were made in the 1940's. These changes portrayed strong foreign influences seen in height changes, arches windows etc. Expansion and arrangement of spaces in a pattinaarukeetu when compared to a nalukettu. North – used women, South and west – pooja related function.

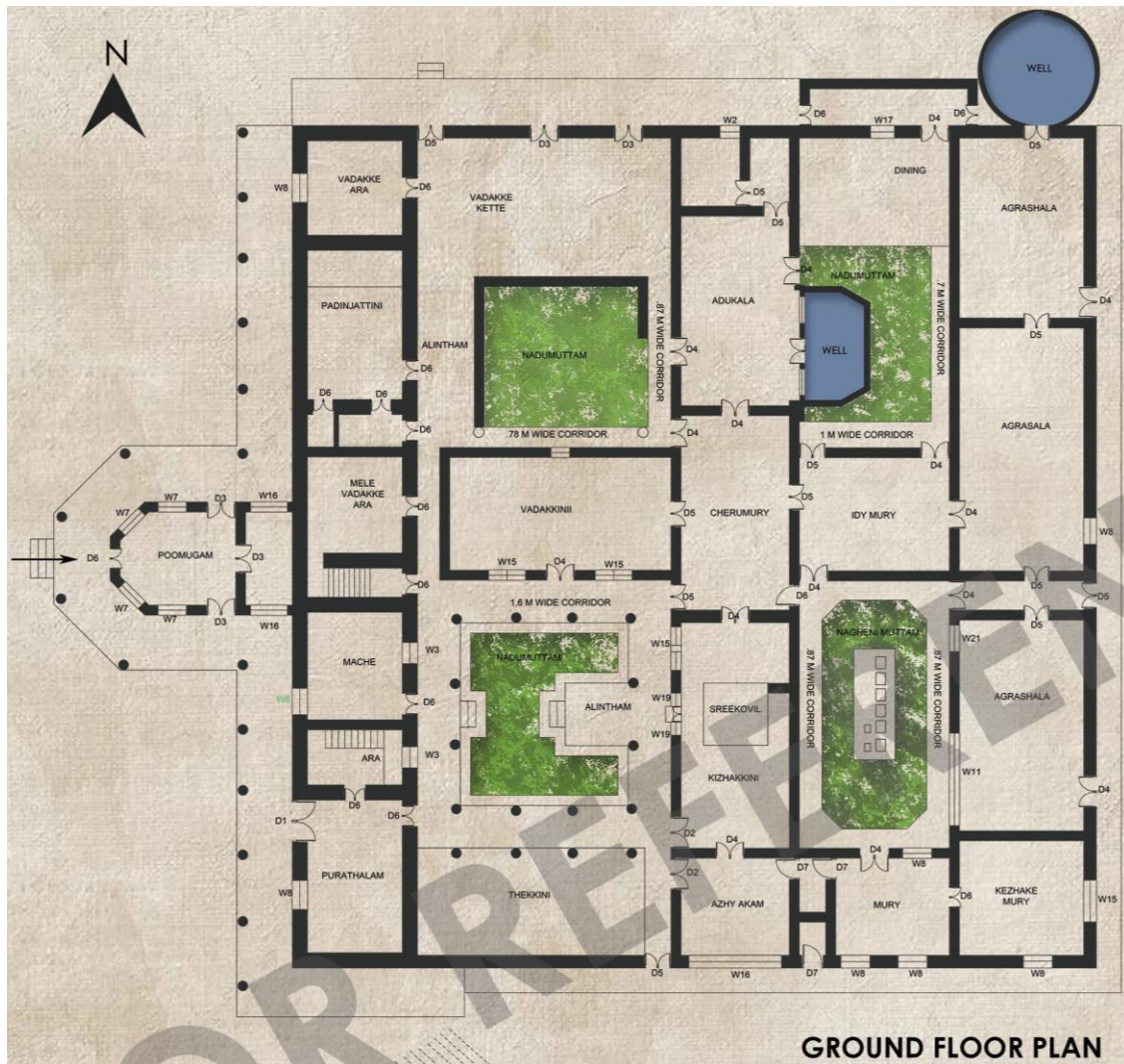


**Fig 3.25 Foreign influence on window**

- Eaves overhang - 1.5mts
- The sloping roof protects the wall and interior spaces from the driving rain.
- The raised western side provides shading for the interior spaces from the south western sun, keeping the spaces cool.



**Fig 3.26 Eaves overhang**



**Fig 3.27 Ground floor plan**



*Fig 3.28 Pathayapura house*

### 3.6 SANSKRITI KENDRA ANANDGRAM, DELHI

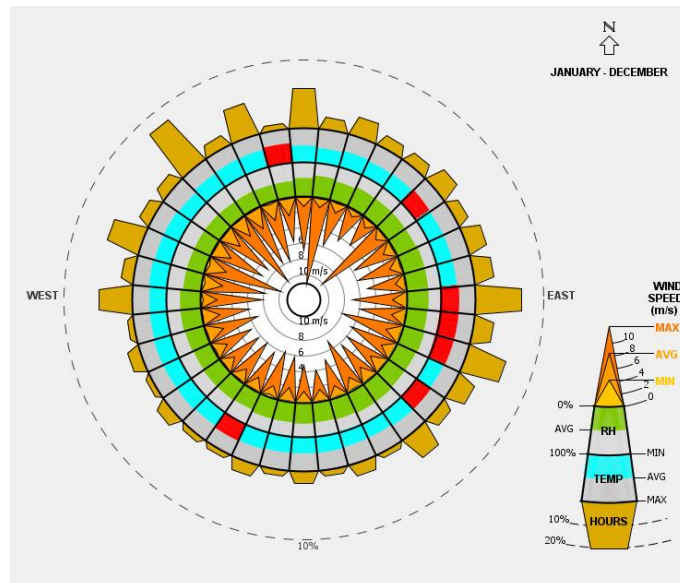


*Fig 3.6.1 Master plan*

|                                  |                                      |
|----------------------------------|--------------------------------------|
| Location                         | Aya nagar, 10Kms south of New Delhi. |
| Architect<br>Landscape Architect | Upal Ghosh<br>Mohammed shaheer       |
| Site Area                        | 8 Acres                              |

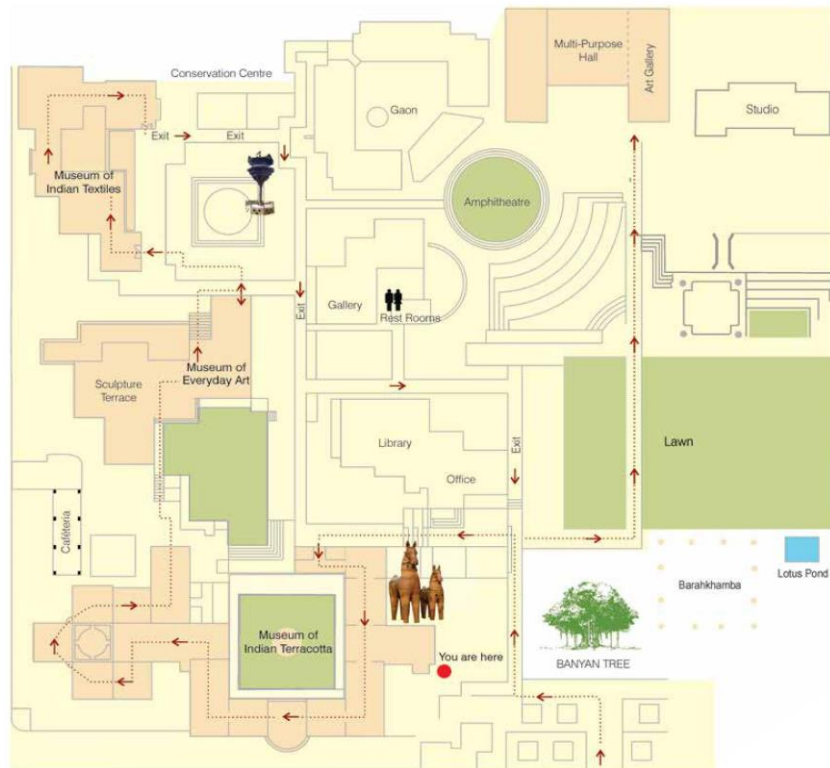
**Table 3.6.1 Specification**

- Public spaces like museums and office the governing body comes first with entry.
- Siting spaces comes next having a privacy planting trees.
- Workspace: Studios and dormitories private zone
- Services are places at far end of the site away from public movement and along the service road.



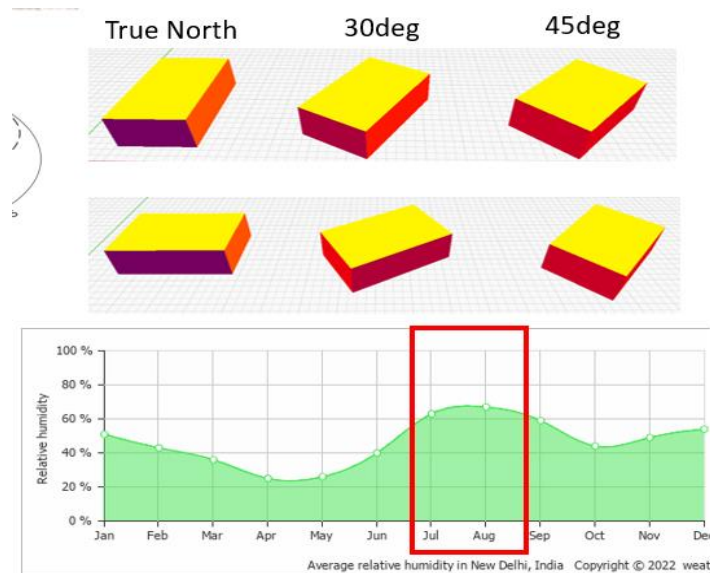
**Fig 3.6.2 Windrose diagram**

- Orienting building in such a way that longer façade on NORTH SOUTH and shorter on EAST WEST.
- To increase the humidity levels in dry summer trees and water ponds for evaporative cooling.
- Used Trees as Wind barriers and also created buffer zone

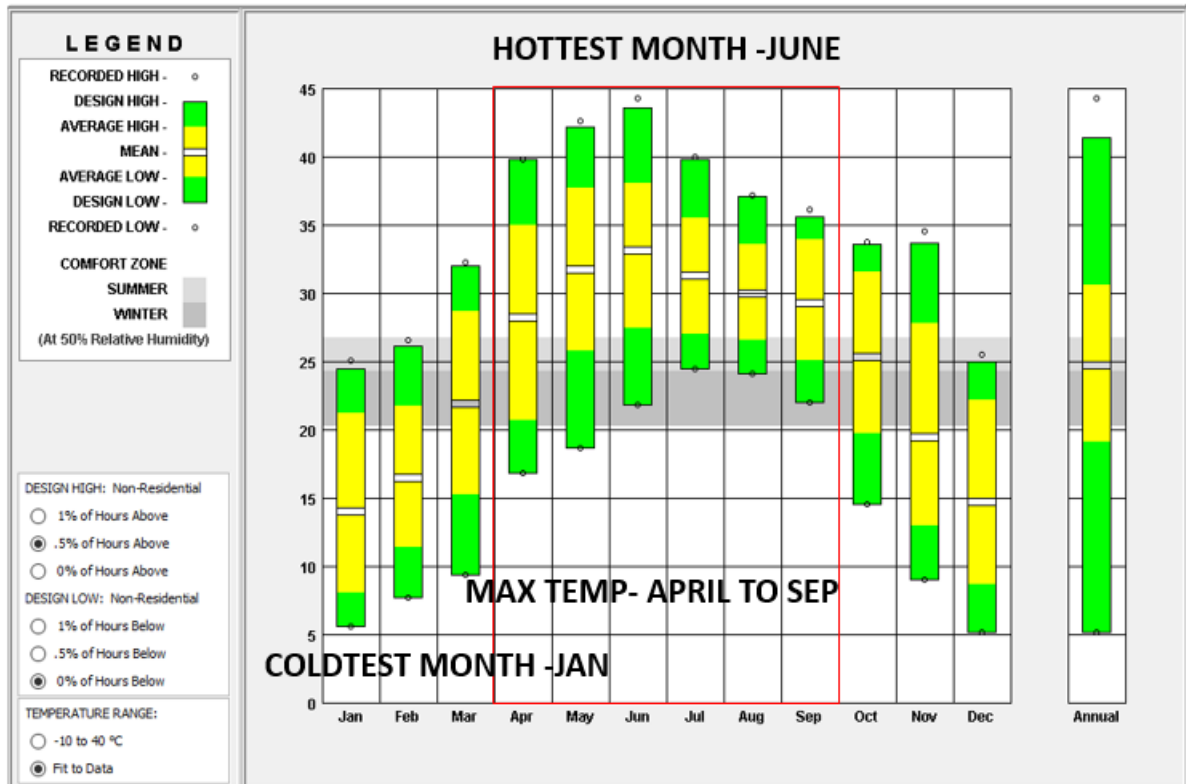


**Fig 3.6.3 Master plan**

- The prevailing wind direction of Delhi is SOUTHEAST & NORTHWEST monsoon creates steady strong winds from December to April, and calm winds from June to October.
- Buildings are clustered together to minimize exposure to cold winds. The buildings must be compact.



**Fig 3.6.3 Master plan**



**Fig 3.6.3 Temperature**

Played with levels – A two storey structure which is internally connected, both visually and physically by a double height covered court.

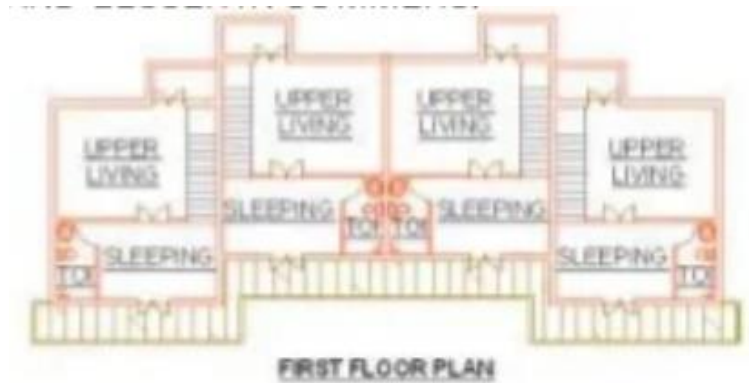
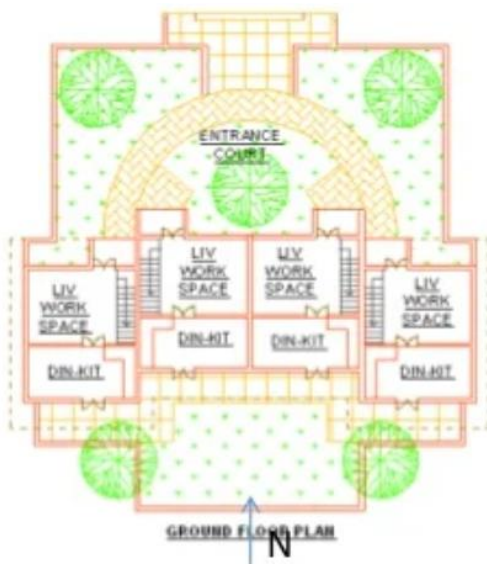
All the areas are placed along the south side as to have advantage of sun



**Fig 3.6.4 Baithak**

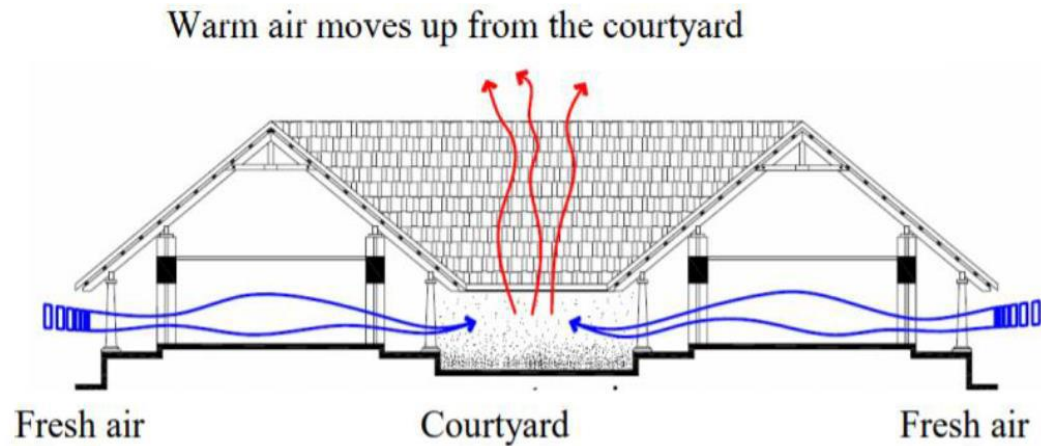


**Fig 3.6.5**



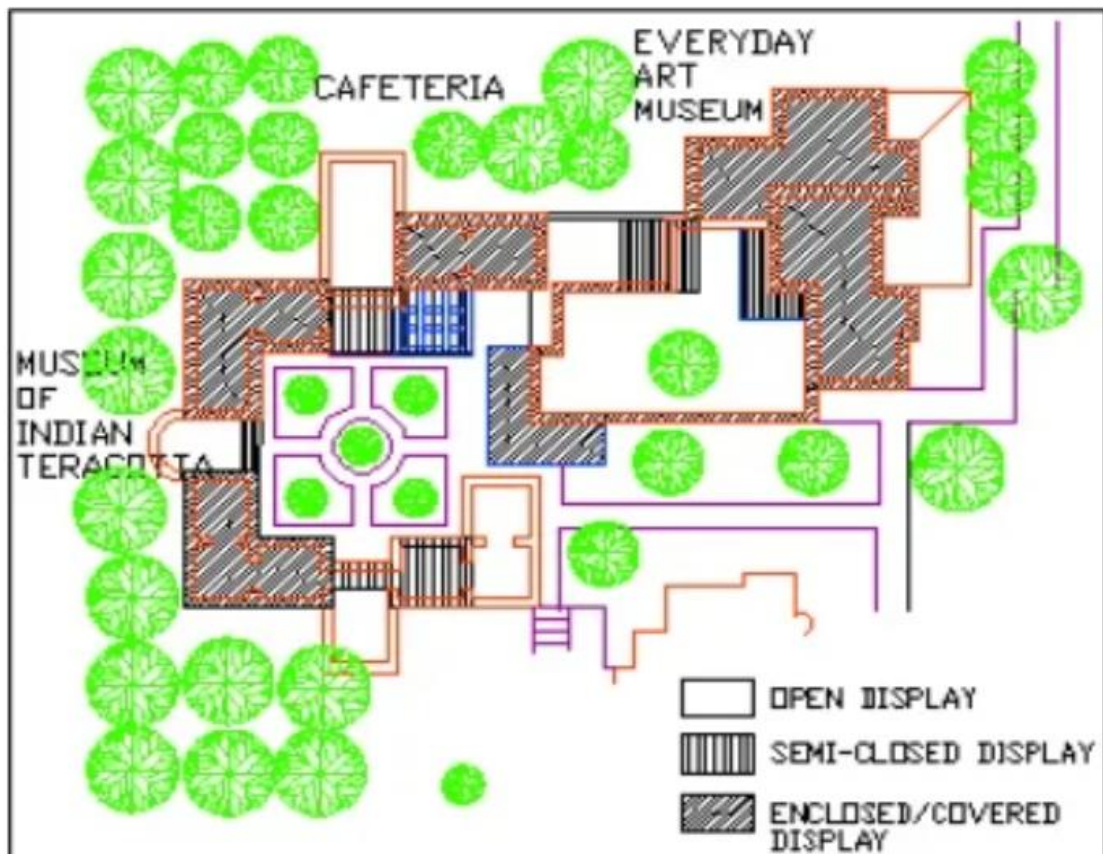
**Fig 3.6.6 Studios**

Most of the building are planned around courtyard. It has been used to increase the air exchange rate. There are eight studios in two blocks. The units are small and simple but provide a variety of spaces, both indoor and outdoor.



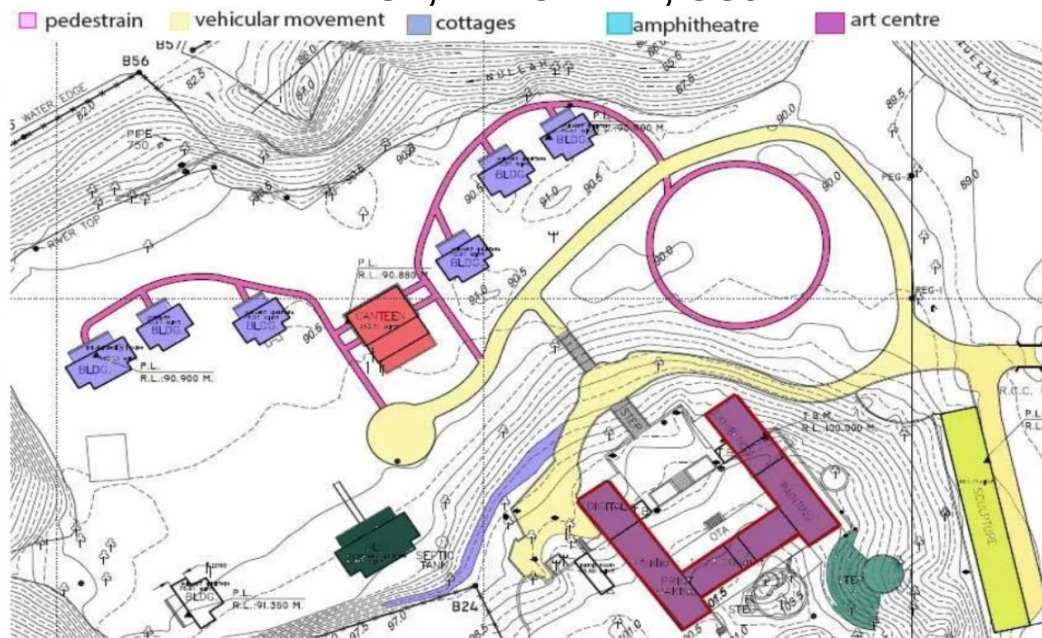
**Fig 3.6.7**

West wall is covered with trees which protect from sun and cold winter winds. The layout of spaces is such that a visitor moves from one exhibit to the next without repeating any. Modular units have been arranged around landscape courtyards. The roof is always pyramid as it suits the square plan and blend with scale and rural setting.



**Fig 3.6.8**

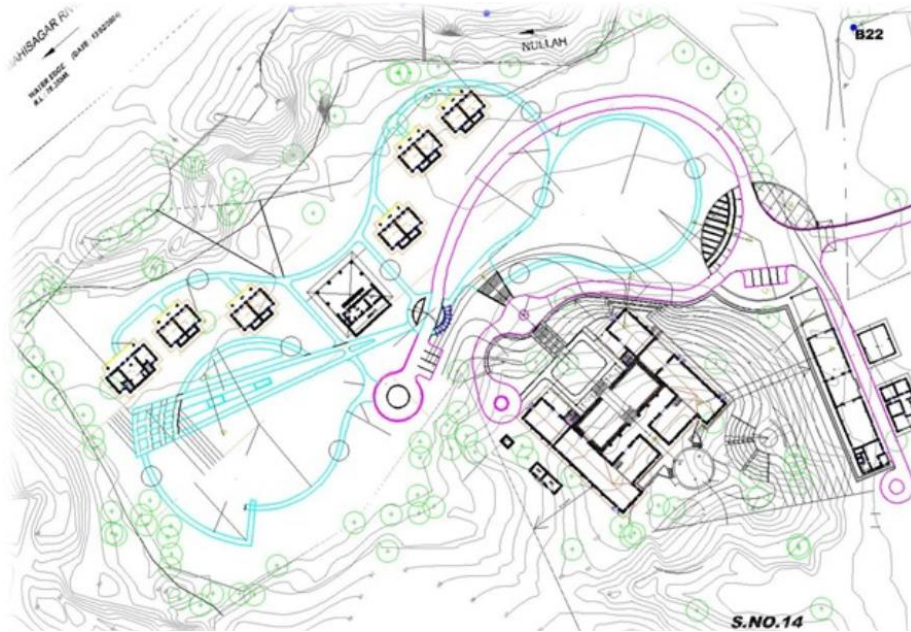
### 3.7 UTTARAYAN ART VILLAGE, VADODARA, GUJARATH



**Fig 3.7.1**

|                      |                                    |
|----------------------|------------------------------------|
| <b>Location</b>      | <b>Vadodara, Gujarat</b>           |
| <b>Architect</b>     | <b>Karan grover and associates</b> |
| <b>Site Area</b>     | <b>80 Acre</b>                     |
| <b>Built up area</b> | <b>4120m</b>                       |

Plan form: Simple c shape plan with central courtyard. Courtyard act as a social space and break out space. Working space for artist were carefully oriented in such way studios are angled towards the best source of light. Double heightened studios with skylights for natural lighting and wind extractors for proper ventilation.



**Fig 3.7.2**

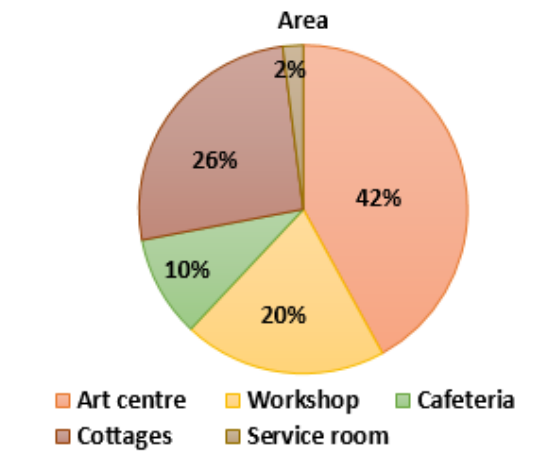
Use of contours:

**Upper:** Art centre

**Middle:** Cafeteria and cottages

**Lower:** deck over viewing river

Vehicular access and pedestrian are connected by a wide stairway over viewing the whole campus and it act as linking bridge



**Fig 3.7.3**

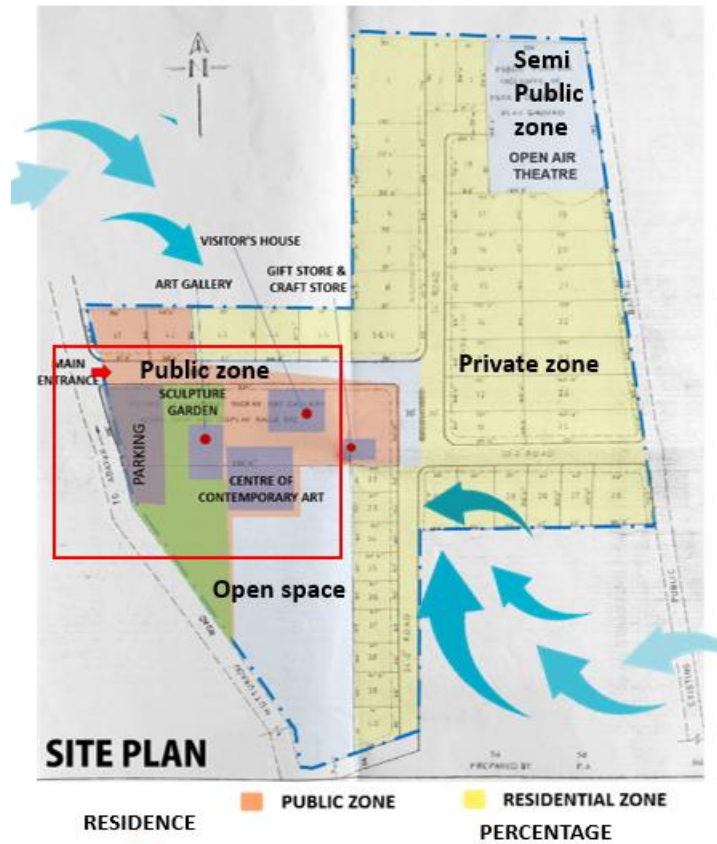
**Unbuilt area, Lawn area, Outdoor exhibition area, Amphitheatre, Road network and pathways, Evening plaza ,Deck area**



**Fig 3.7.4 Residential and Dormitory**

- Residential area is all segregated from rest of campus
- No of cottages – 4
- No of servant quarters – 2
- To receive proper sunlight cut out in roof
- Jalli work – To make façade interesting different jali pattern were used.

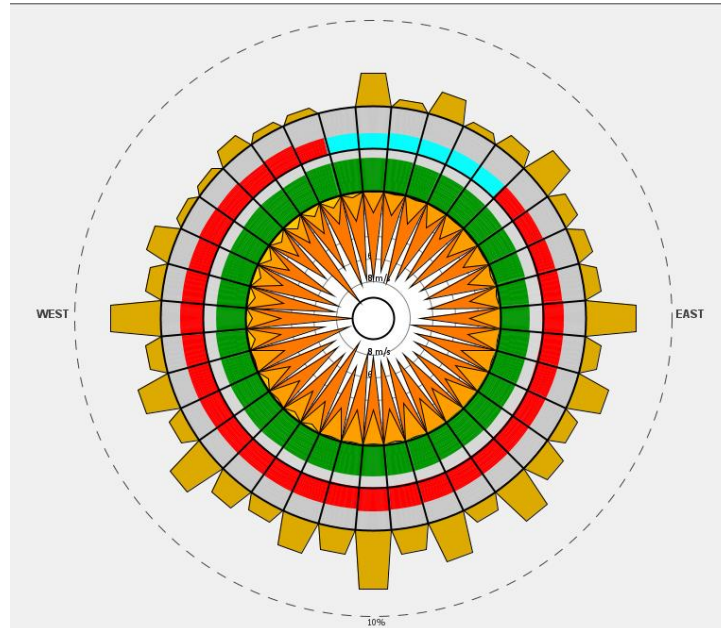
### 3.8 CHOLAMANDAL ARTIST VILLAGE, CHENNAI



*Fig 3.8.1 Site plan*

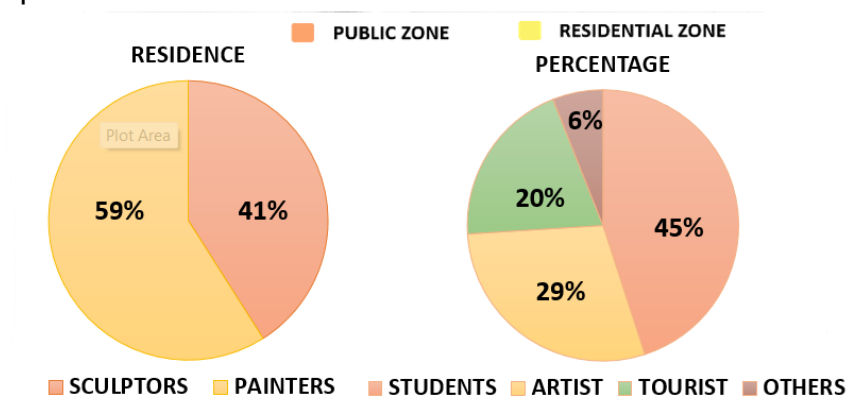
|                            |                                                    |
|----------------------------|----------------------------------------------------|
| <b>Location</b>            | <b>Injambakkam,<br/>Palavakkam, Tamil<br/>Nadu</b> |
| <b>Architect</b>           | <b>Shilpa architects<br/>and M. V. Devan</b>       |
| <b>Site Area</b>           | <b>10 Acres</b>                                    |
| <b>% of built up area</b>  | <b>64%</b>                                         |
| <b>No of plots</b>         | <b>45</b>                                          |
| <b>Total area of plots</b> | <b>18357 sq.m</b>                                  |

The center for art lovers and patrons of the artist. It has galleries for paintings, sculptures and an open-air international sculpture park around the complex. The village houses art galleries, museums, and an open-air theatre for dance and theatre performances. The artist village it has over twenty resident painters and sculptors, who live as a community.



**Fig 3.8.2** Predominant wind direction is from South East to North West

- The display areas were maximized in rectilinear shaped galleries with natural daylight and high ceilings. The galleries opened to the gigantic trees and the sculptures blended into the landscape.
- The staggered placement of the two display areas helped retain the existing landscape



**Fig 3.8.3**

**RESIDENTIAL AREA:**

Each house has its own parking space or garage. All the houses are designed by the plot owners themselves. Therefore, there are diversity between the different houses. The houses range from G to G+2. The houses are constructed from brick and concrete. There are houses that remain the same since the day the community was founded, while most of them are renovated to accommodate parking and to expand vertically. The plans are designed to maximize the use of natural lighting and ventilation. Sculptors have a front yard who exhibit their works. Each plot have different areas. There is an Amphitheatre present in the residential areas, these provide entertainment and are also used for events.

## MATERIAL

- The building was treated with exposed brickwork and concrete. No additional plaster or painting was envisaged.
- Wire cut brick cladding is done on the exterior.
- Glazed vitrified tiles for flooring and terracotta tiling for terrace.
- The sunshades are designed as eaves and are Mangalore tiles.



**Fig 3.8.4**

- The staggered placement of the two display areas helped retain the existing landscape. The larger wing housed the permanent exhibit area and the museum area of the building.
- The focus of the design was to get as much natural light as possible while cutting out the glare and heat.
- This was achieved by orientating to get in the glare free lighting from the north.
- The openings in the museum overlooking the lower level spaces navigates natural light into all corners of the building.

### 3.9 GOVARDHAN ECOVILLAGE

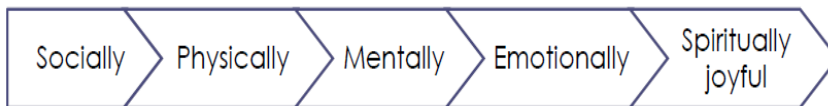
I

| SPECIFICATIONS                 |                                                                                                                    |
|--------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Location                       | Galtare, Wada, Thane, Maharashtra                                                                                  |
| Site area                      | 70 acres                                                                                                           |
| Built-up area                  | 2,400.65 m <sup>2</sup>                                                                                            |
| Air-conditioned area           | 0 m <sup>2</sup>                                                                                                   |
| Non Air-conditioned area       | 2,400.65 m <sup>2</sup>                                                                                            |
| Energy consumption reduction   | 57% reduction in energy consumption compared to GRIHA benchmark (for 839 m <sup>2</sup> non air conditioned space) |
| Energy Performance index (EPI) | 37.5 KWh/ m <sup>2</sup> /year                                                                                     |
| Renewable Energy               | Rated capacity of solar PV installed on site is 39KW                                                               |

|                          |                                          |
|--------------------------|------------------------------------------|
| GRIHA provisional rating | 5 Stars                                  |
| Year of completion       | 2012                                     |
| Architect team           | Biome environmental solution , Bangalore |
| Climate                  | Warm and humid                           |

### 3.9.1 Fig showing the star grade

THE EXPERIENCE OF LIFE IN GEV WILL BE



**Table 3.4** Additional reduction from GRIHA benchmark for EPI

| Reduction from GRIHA Benchmark for EPI (x) | Points |
|--------------------------------------------|--------|
| $0\% \leq x < 10\%$                        | -      |
| $10\% \leq x < 20\%$                       | 1      |
| $20\% \leq x < 30\%$                       | 2      |
| $30\% \leq x < 40\%$                       | 4      |
| $40\% \leq x < 50\%$                       | 6      |
| $x \geq 50\%$                              | 8      |

**Additional reduction from the GRIHA  
benchmark for EPI**

The equipment installed within the project are BEE-  
star labelled



RAMMED EARTH HOMES`



COURTYARD EFFECT



BIO GAS



EASILY AVAILABLE MATERIALS

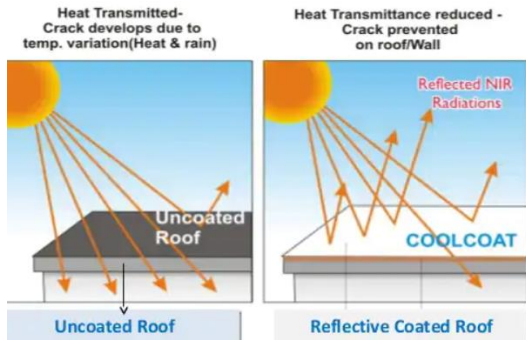
### **3.9.2Fig showing area**

| S<br>I.<br>N<br>o | Criteria                                                                                                            | vernacular method involved in achieving the points                                                                                                                                                                                                           |
|-------------------|---------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.                | Site selection                                                                                                      | <ul style="list-style-type: none"> <li>• foot hills, The site is undulating with prominent ridges and valleys.</li> <li>• To reduce the overall carbon foot print, 90% of the materials were sourced from within 100 Kms radius of their facility</li> </ul> |
| 2.                | Preserve and protect landscape during construction/compensatory depository forestation                              | Buildings planned in such a way that minimal trees are cut and agriculture is not impacted                                                                                                                                                                   |
| 3.                | Soil conservation (post construction)                                                                               | <ul style="list-style-type: none"> <li>• Preservation of topsoil been used has a raised bed for agriculture</li> <li>• Buildings on hard ground to save on foundation cost</li> </ul>                                                                        |
| 4.                | Design to include existing site features                                                                            | Layout based on Hydrogeological survey's inputs so that development does not impact negatively the recharge and discharge zones of water.                                                                                                                    |
| 5.                | Reduce hard paving on-site                                                                                          | <ul style="list-style-type: none"> <li>• Open-joint clinkers</li> <li>• Gravel, stone chippings and shells</li> <li>• Woodchips and pine bark</li> </ul>                                                                                                     |
| 6.                | Enhance outdoor lighting system efficiency and use renewable energy system for meeting outdoor lighting requirement | Solar PV panels                                                                                                                                                                                                                                              |
| 7.                | Reduce landscape water requirement                                                                                  | <ul style="list-style-type: none"> <li>• Recycling of grey water , rainwater harvesting</li> <li>• Recovering up to 95% of sewage water using a green sewage management technology called Soil Biotechnology, which is used for landscaping</li> </ul>       |
| 8.                | Reduce building water use                                                                                           |                                                                                                                                                                                                                                                              |
| 9.                | Optimize building design to reduce conventional energy demand                                                       | Solar PV panels of 39KW capacity                                                                                                                                                                                                                             |
| 10.               | Optimize energy performance of building within specified comfort                                                    | <ul style="list-style-type: none"> <li>• Buildings have elongated plans, with a single row of rooms and courtyards to allow cross ventilation</li> <li>• Vents provided at the top where the hot air rise up</li> </ul>                                      |

### 3.9.9.1 Table showing vernacular method

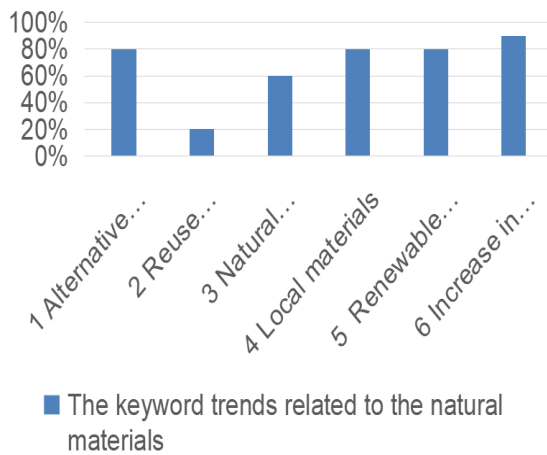
| Sl. No | Criteria                                                                        | vernacular method involved in achieving the points                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10.    | Optimize energy performance of building within specified comfort                | <ul style="list-style-type: none"> <li>Buildings have elongated plans, with a single row of rooms and courtyards to allow cross ventilation</li> <li>Vents provided at the top where the hot air rise up</li> <li>The buildings are built on High ground where they receive better breeze and are designed to be only one bay deep to allow for cross ventilation. Large semi-covered spaces provide for comfortable daytime use.</li> <li><b>For achieving visual comfort:</b> <ol style="list-style-type: none"> <li>Optimum window openings</li> <li>Light floor for light diffusion</li> <li>Soft landscape outside giving no reflected glare</li> </ol> </li> <li><b>For achieving thermal comfort:</b> <ol style="list-style-type: none"> <li>Double tile roofing for final roofs</li> <li>Shaded walls and openings</li> </ol> </li> </ul> |
| 11.    | Reduce volume, weight and time of construction by adopting efficient technology | Foundation – Stone<br>Wall :Stabilized mud block wall<br>Doors and windows : reused wood from old buildings<br>Roof : Thatch roof made of sugarcane thatch , precast arch panels<br>Floor : Cow dung floor with rammed earth sub floor , marble stone flooring<br>Local sourced material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 12.    | Use low-energy material                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 13.    | Renewable energy based hot water system                                         | Solar water heaters of capacity to meet 100% hot water needs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 14.    | Waste management                                                                | <ul style="list-style-type: none"> <li>Biogas plant</li> <li>Wood dust forms an ingredient along with cow dung, in making of dhoop sticks</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 15.    | Innovation                                                                      | <ul style="list-style-type: none"> <li>The ponds and water bodies were made in the areas where soil was suitable for earth construction.</li> <li>the re-use of the construction waste material in creating the permanent raised beds in cultivation of the rice crop and vegetables.</li> <li>precast construction, U-Block lintels, and standardization of building elements like arches and windows speeded the construction process thereby reducing the of construction</li> </ul>                                                                                                                                                                                                                                                                                                                                                           |

### 3.9.9.2 Table showing vernacular method

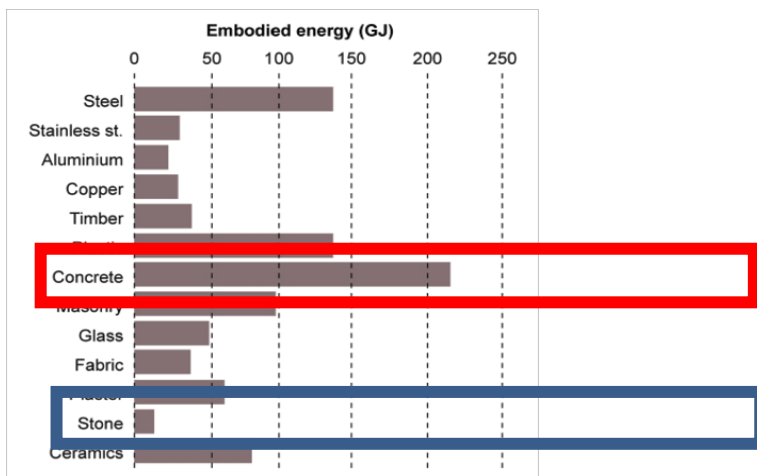


| MATERIALS            | EMBODIED ENERGY (MJ/kg) |
|----------------------|-------------------------|
| STONE                | 1                       |
| TIMBER               | 8.5                     |
| STABILIZED MUD BLOCK | 646MJ/m3                |
| CLAY TILE ROOF       | 2-7                     |
| COB                  | < 0.2                   |

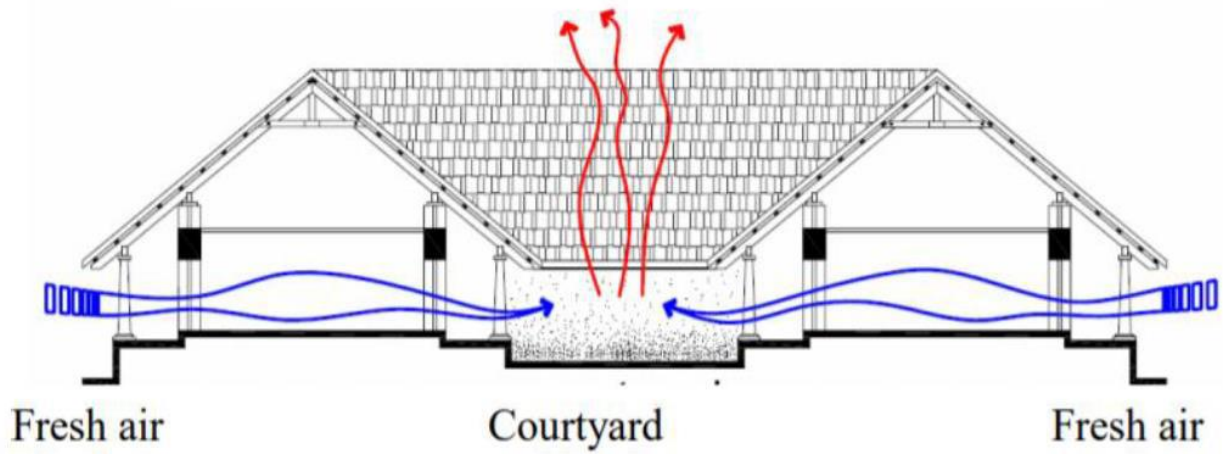
80% of the total materials used in the building low-energy



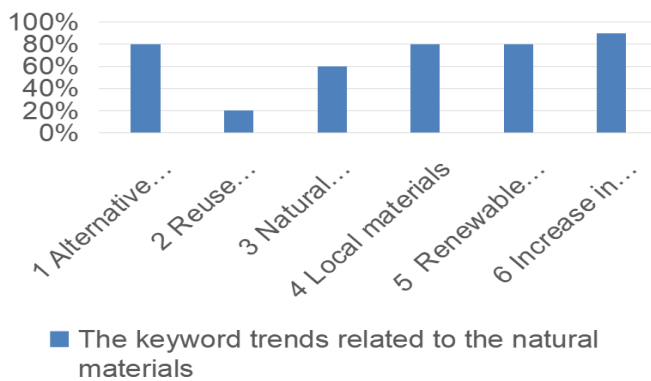
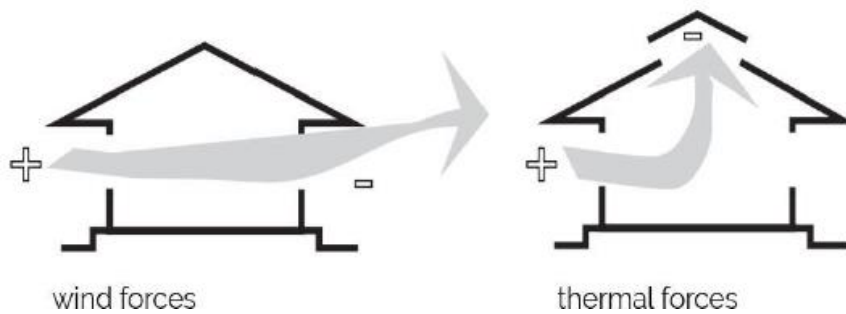
| MATERIALS     | ALBEDO(%) | EMITTANCE(%) | SRI |
|---------------|-----------|--------------|-----|
| RED CLAY TILE | 33        | 90           | 36  |
| SOLAR PANEL   | 30        | 80           |     |



Warm air moves up from the courtyard



3.9.2 Fig showing stack eff

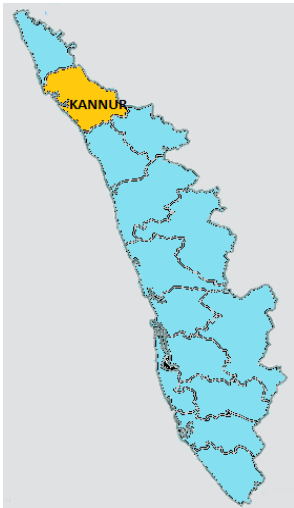


## INDIAN ARTIST - K.G SUBRAMANYAN

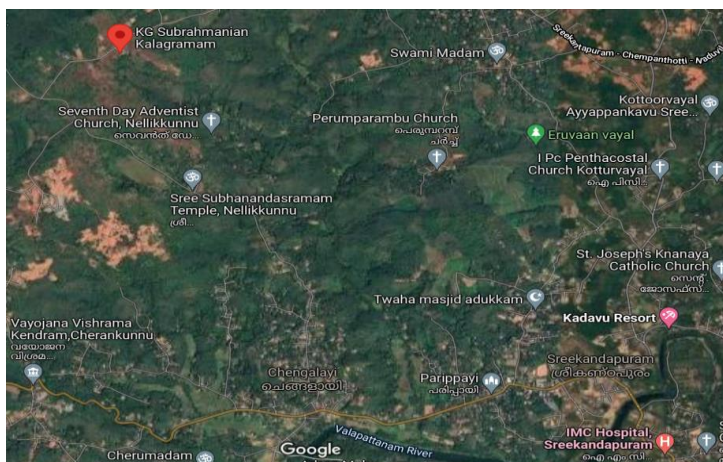


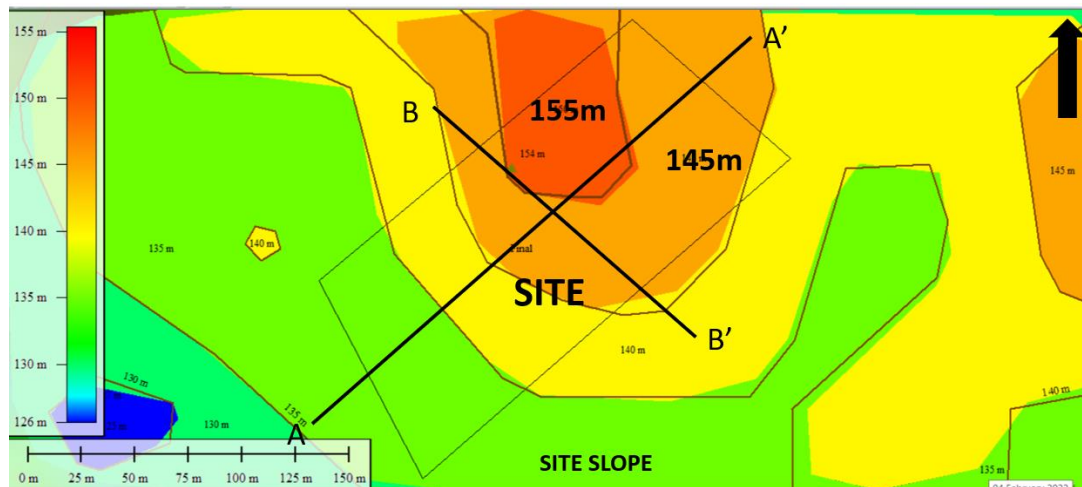
**Kalpathi Ganpathi "K.G." Subramanyan** was an Indian artist. He was awarded the Padma Vibhushan in 2012. K.G. Subramanyan was greatly influenced by folk art from Kerala, Kalighat painting and Pattachitra from Bengal and Odisha, as well as Indian court paintings.

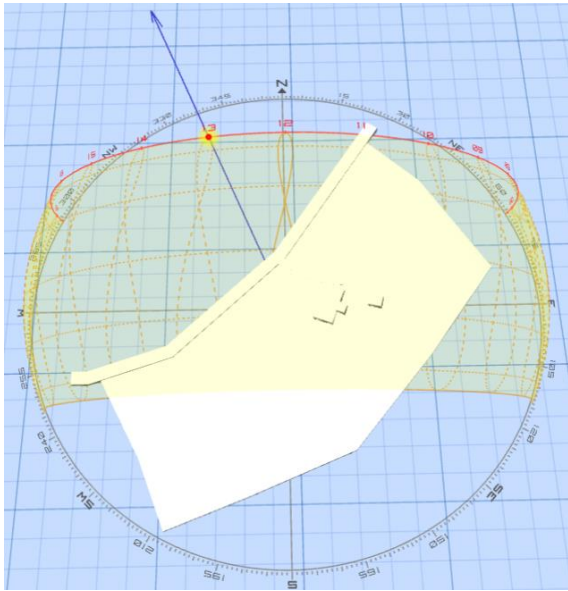
|            |                                                                   |
|------------|-------------------------------------------------------------------|
| Born       | 1924<br>Kuthuparamba, Kannur, Kerala,<br>India                    |
| Died       | 29 June 2016 (aged 92)<br>Vadodra, Gujarat, India                 |
| Education  | Visva-Bharati University                                          |
| Occupation | Painter,<br>sculptor, muralist, printmaker,<br>writer, academic   |
| Movement   | Contextual Modernism, Baroda<br>Group                             |
| Awards     | Padma Shree, Kalidas<br>Samman, Padma Bhushan, Padma<br>Vibhushan |



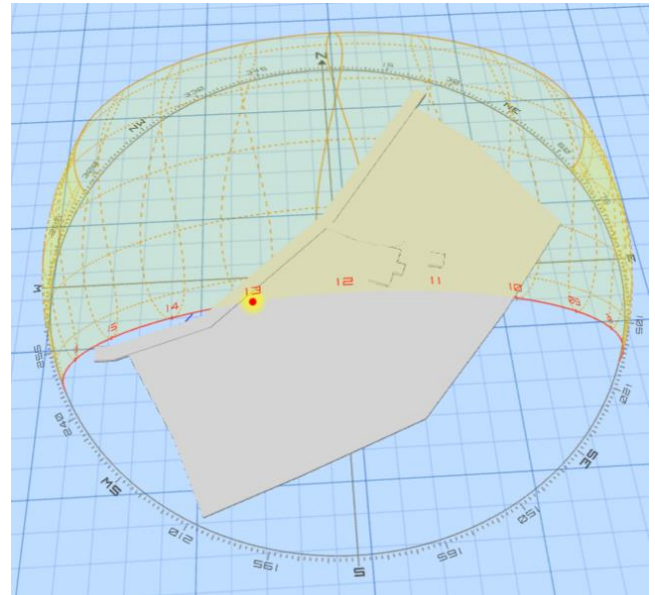
|                        |              |
|------------------------|--------------|
| <b>AIRPORT</b>         | 53 MINS      |
| <b>RAILWAY STATION</b> | 1 HR 20 MINS |
| <b>BUS STOP</b>        | 5 MINS       |
| <b>TOWN</b>            | 8 MINS       |
| <b>IMC HOSPITAL</b>    | 14 MINS      |





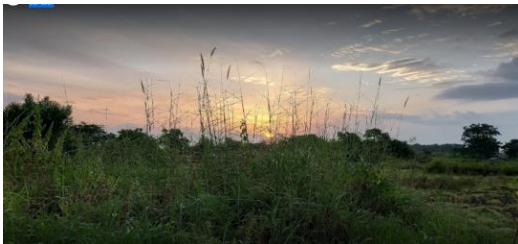


summer solstice

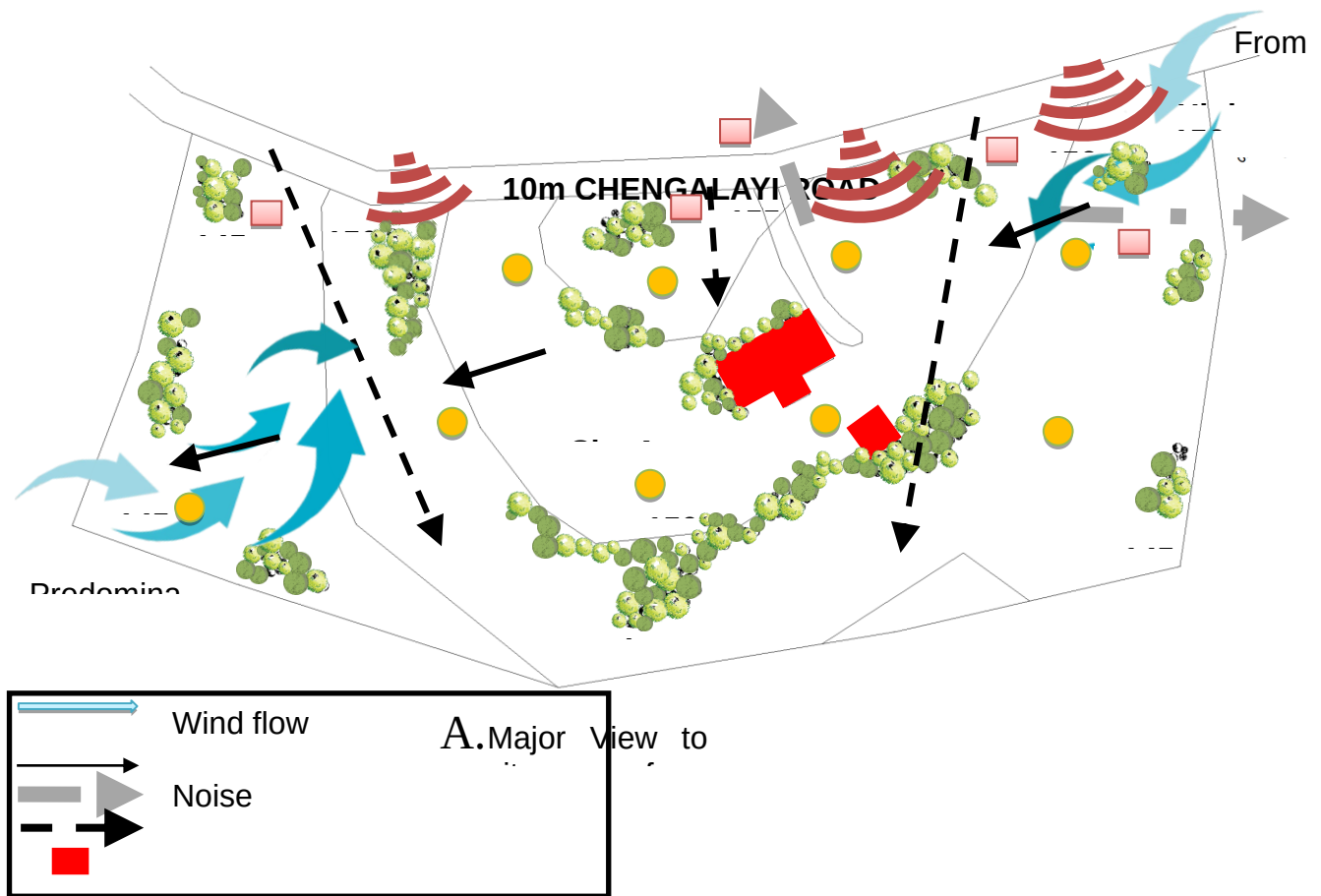


Winter solstice

| STRENGTH                                                                                                        | WEAKNESS                                                                                                              | OPPURTUNITY                                                                                                     | THREAD                                                                                              |
|-----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| 10m wide road.<br>Less pollution.<br>M a t e r i a l<br>availability.<br>Ideal location and<br>developing area. | Drainage system.<br>It take 25mins to<br>reach main city.<br>Site is surrounded<br>by empty plot at<br>all four sides | Due to many<br>other tourist<br>spots it may<br>attract visitors.<br>Walkable distance<br>from near by<br>town. | L a r g e a r e a<br>complicate the<br>security of the<br>site.<br>Danger of getting<br>land slides |



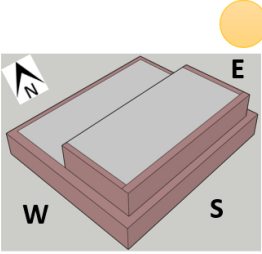
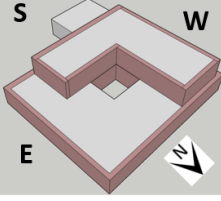
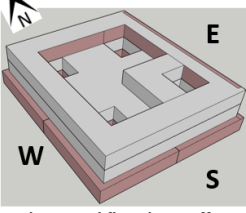
## SITE INVENTORY ANALYSIS



1. Parking – As there is an existing road and parking space it will be extended and used further.
2. Potential to create a focal point for outdoor art gallery. Art Gallery and exhibition space – which attracts people from the main road , Major direction radiation will be cut off by the tree .
3. Outdoor plaza which connects the restaurant and Private zone
4. Potential spot to create Restaurant and outdoor seating area where the direct radiation from south will be cut down. And wind from west to south west will make space cooler and usable through out the day.
5. Potential to create Amphitheatre
6. Buffer zone will be created and all the residential space and cottages will be created on North east.
7. Potential for cottage which also have good view.
8. Potential for garden.
9. Service Area.

## CHAPTER 4 ANALYSIS AND RESULT

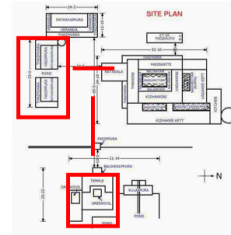
### 4.1 COMPARATIVE CASE STUDY ANALYSIS

| S. N O | PARAMETERS                                                                                                            | PALIAM NALLUKETTU                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | KANIPPAYYUR MANNA ETTUKETTU                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | MARANAT MANA PATHINARUKETTU                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------|-----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1      | <b>PASSIVE DESIGN STRATEGY</b><br>Use of traditional passive strategies to reduce the energy use and carbon emissions | <b>Orientation</b> - faces south<br><b>Internal zoning</b> – <ul style="list-style-type: none"> <li>• <b>South and east</b> - two bed rooms on both sides – verandah, thinnai (are meant for receiving the guests)</li> <li>• <b>North</b> – kitchen, dining and space for ladies</li> <li>• <b>West</b> – place for worship and to store grains</li> <li>• Cross ventilation, Courtyard</li> </ul>  <p style="text-align: center;">100% Buffer Spaces on East West Façade</p> | <b>Orientation</b> - faces south<br><b>Internal zoning</b> – <ul style="list-style-type: none"> <li>• <b>South</b> – walk way, foyer (place to receive all caste people)</li> <li>• <b>North</b> - Kitchen, dining hall</li> <li>• <b>West</b> – store room, day care rooms</li> <li>• <b>East</b> – Dinner hall</li> <li>• <b>South and West</b> – bedroom (1<sup>st</sup> floor)</li> <li>• Cross ventilation, 2 Courtyard, pond</li> </ul>  <p style="text-align: center;">100% Buffer Spaces on East West Façade</p> | <b>Orientation</b> - faces West<br><b>Internal zoning</b> – <ul style="list-style-type: none"> <li>• <b>West</b> – Ara (storage area), machu, verandah which its self act as a buffer space</li> <li>• <b>North</b> - Dining, kitchen</li> <li>• <b>East</b> – place for worship</li> <li>• <b>South</b> - Bedroom</li> <li>• Cross ventilation, 4 Courtyard, pond, 2 well, passive evaporative cooling – water body place in courtyard</li> </ul>  <p style="text-align: center;">Only ground floor has Buffer Spaces on East West Façade</p> <ul style="list-style-type: none"> <li>• Site planning according to contours have been done</li> </ul> |

| S. N O | PARAMETERS                                                                     | PALIAM NALLUKETTU                                                                                                                                                                                                                             | KANIPPAYYUR MANNA ETTUKETTU                                                             | MARANAT MANA PATHINARUKETTU                                                                                                                                                                                                                                                                                                 |
|--------|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|        |                                                                                | <ul style="list-style-type: none"> <li>• Ventilation due to Stack Effect by using strategies such as high-ceiling ventilated roof, attic ventilation and machu which act as layer to reduce the heat entering inside the building.</li> </ul> | <ul style="list-style-type: none"> <li>• Attic ventilation and machu</li> </ul>         |  <p style="text-align: center;"><b>SUMMER</b>      <b>WINTER</b></p> <ul style="list-style-type: none"> <li>• Trees are placed next to critical facades which also reduce the glare.</li> <li>• Attic ventilation and machu</li> </ul> |
| 2      | <b>URBAN HEAT ISLAND Sky view factor</b><br>$SVF = \cos(\arctan((H1 + H2)/W))$ |                                                                                                                                                                                                                                               | $SVF = \cos(\arctan(2H/W)) = \cos[\arctan[2 \times (3 + 6 + 6)/3/(22 + 40)/2]] = 0.398$ | $SVF = \cos(\arctan(2H/W)) = \cos[\arctan[2 \times (9 + 6 + 9)/3/(5 + 8)/2]] = 0.239$                                                                                                                                                                                                                                       |

#### NATIVE TREES IN SITE

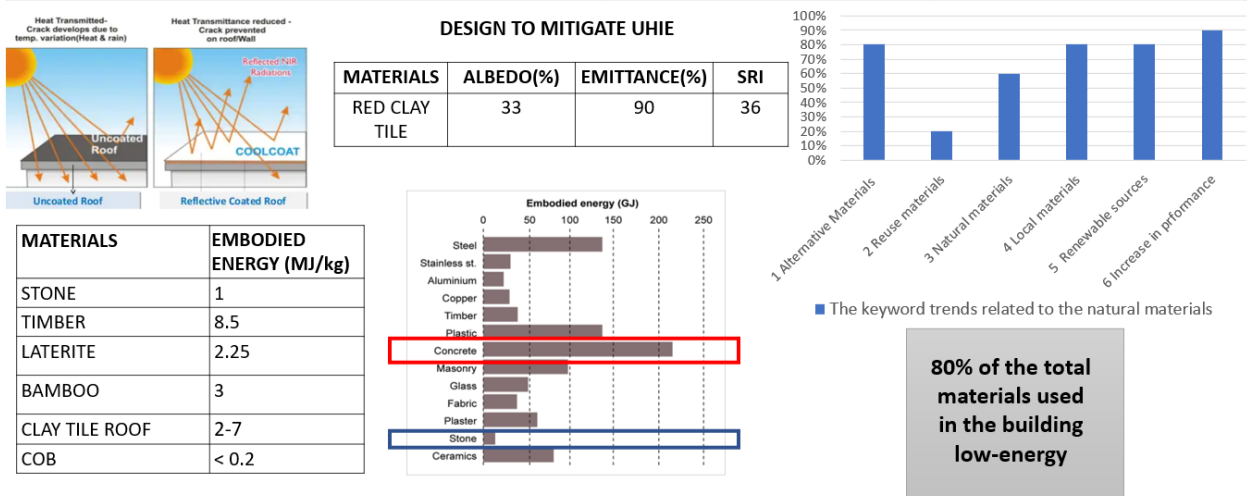
| S.no | Common Name  | LAI value |
|------|--------------|-----------|
| 1    | Neem tree    | 5.5       |
| 2    | Mango tree   | 5.2       |
| 3    | Coconut tree | 5.4       |
| 4    | Peepal tree  | 3.6       |
| 5    | palm tree    | 2.1       |



| S. N O | PARAMETERS                                                                                                                                                            | PALIAM NALLUKETTU                    | KANIPPAYYUR MANNA ETTUKETTU                                                                                           | MARANAT MANA PATHINARUKETTU                                                                                                                                      |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|        | <b>Green plot ratio</b><br>GnPR = (Total tree leaf area + Turf area) ÷ Area of circle (site = 50 m radius)<br>Total tree leaf area = No. of trees × Canopy area × LAI |                                      |                                                                                                                       | Total tree leaf area = 30x 100 x (5.5 + 5.2 + 5.4 + 3.6+2.1 ) = 65400<br>GnPR = (65400 + 2000) / 5000 = 13.5                                                     |
|        | <b>Reduction of Exposed hard paved surface on site</b> - Total paved area = Site area – (building footprint + landscape area)                                         |                                      | Total paved area = 25000- (1600+3000) = 20400                                                                         | Total paved area = 32374- (3319+6500) = 22555                                                                                                                    |
|        | Maintaining tree cover on site                                                                                                                                        | No hard paved surface area           | <ul style="list-style-type: none"> <li>Trees compliance with SVA GRIHA</li> <li>No hard paved surface area</li> </ul> | <ul style="list-style-type: none"> <li>All new trees on site are native.</li> <li>Trees compliance with SVA GRIHA</li> <li>No hard paved surface area</li> </ul> |
| 3      | <b>Good Fenestration design for reducing direct heat gain and glare while maximising Daylight penetration</b>                                                         | 60% WWR as per ECBC as been followed | 60% WWR as per ECBC as been followed                                                                                  | 60% WWR as per ECBC as been followed                                                                                                                             |

| Site Area                        | Number of trees                    |
|----------------------------------|------------------------------------|
| Less than or equal to 250 sq.m.  | 2                                  |
| Between 250 sq.m and 750 sq.m.   | 3                                  |
| Site area greater than 750 sq.m. | 3+1 for every additional 250 sq.m. |

| S. N O | PARAMETERS                            | PALIAM NALLUKETTU                                                                                                                                                                                                                                 | KANIPPAYYUR MANNA ETTUKETTU                                                                     | MARANAT MANA PATHINARUKETTU                                                    |
|--------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 4      | <b>SUSTAINABLE BUILDING MATERIALS</b> | Wall - Laterite with sand filling and lime plastering , clay plastering<br>Window and door frame - Timber<br>Paint- light colors<br>Columns - timber columns<br>Flooring- Surkhi flooring , egg plastering,<br>Roof frame - timber with clay tile | Laterite for external walls, timber for ceiling and roof protects interior from excessive heat. | Laterite and granite stone blocks, lime mortar, timber - roof frame, clay tile |



**Table 4.1 COMPARATIVE ANALYSIS**

## 4.2 POINTS ACHIEVED THROUGH GRIHA

| S.N<br>O | GRIHA CRITERIA                                                                                                  | PALIAM NALLUKETTU | KANIPPAYYUR MANNA<br>ETTUKETTU | MARANAT MANA<br>PATHINARUKETTU |
|----------|-----------------------------------------------------------------------------------------------------------------|-------------------|--------------------------------|--------------------------------|
| 1        | Reduce UHIE and maintain native vegetation cover on site <b>6</b>                                               | <b>6</b>          | <b>6</b>                       | <b>6</b>                       |
| 2        | Passive architectural design and systems <b>4</b>                                                               | <b>2</b>          | <b>4</b>                       | <b>4</b>                       |
| 3        | Good fenestration design for reducing direct heat gain and glare while maximising daylight penetration <b>6</b> | <b>6</b>          | <b>6</b>                       | <b>6</b>                       |
| 4        | Efficient artificial lighting system <b>2</b>                                                                   | <b>0</b>          | <b>0</b>                       | <b>0</b>                       |
| 5        | Thermal efficiency of building envelope <b>2</b>                                                                | <b>2</b>          | <b>2</b>                       | <b>2</b>                       |
| 6        | Use of energy efficient appliances <b>3</b>                                                                     | <b>0</b>          | <b>0</b>                       | <b>0</b>                       |
| 7        | Use of renewable energy on site <b>4</b>                                                                        | <b>0</b>          | <b>0</b>                       | <b>0</b>                       |
| 8        | Reduction in building and landscape water demand <b>5</b>                                                       | <b>3</b>          | <b>3</b>                       | <b>3</b>                       |
| 9        | Rainwater harvesting <b>4</b>                                                                                   | <b>2</b>          | <b>4</b>                       | <b>4</b>                       |
| 10       | Generate resource from waste <b>2</b>                                                                           | <b>0</b>          | <b>2</b>                       | <b>2</b>                       |
| 11       | Sustainable building materials <b>8</b>                                                                         | <b>8</b>          | <b>8</b>                       | <b>8</b>                       |
| 12       | Adoption of green Lifestyle <b>4</b>                                                                            | <b>2</b>          | <b>3</b>                       | <b>4</b>                       |
|          | INNOVATION 2                                                                                                    | <b>0</b>          | <b>2</b>                       | <b>2</b>                       |
|          |                                                                                                                 | <b>1 STAR</b>     | <b>4 STAR</b>                  | <b>4 STAR</b>                  |

**Table 4.2 POINTS ACHIEVED THROUGH GRIHA**

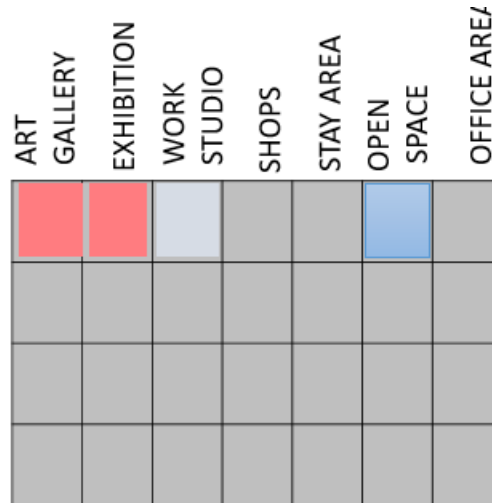
## 4.3 USER GROUP ANALYSIS

**USER 1- STUDENT :** Artist village to create an interest of local as well as other schools and college for teaching their students art as well as to attend workshops and other events.

**AGE GROUP –** Primary school – 35% (5 - 10)

Secondary school – 65% (10-15)

**NUMBER OF USERS –** 50 – 70 Students at a time.

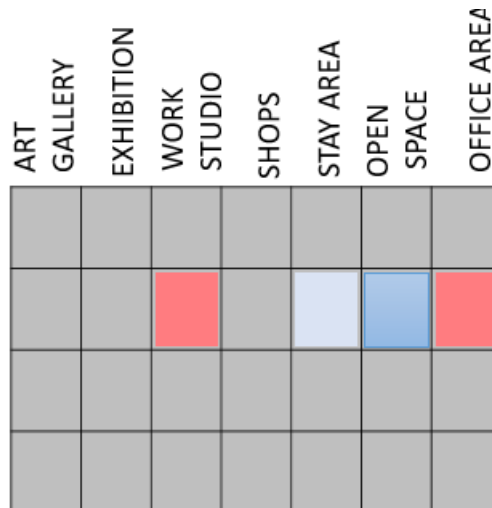


**Fig 4.31 User space groups**  
*The use group of students more active near Art gallery and Exhibitions.*

**USER 2 – ITERNS/STAFF:** The site should create interest for Art graduates to learn about Kerala arts and crafts along with documenting the lives of Artist and craftsmen.

**AGE GROUP –** 20 – 28 Years

**NUMBER OF USERS –** 20 – 30 Interns and Staff

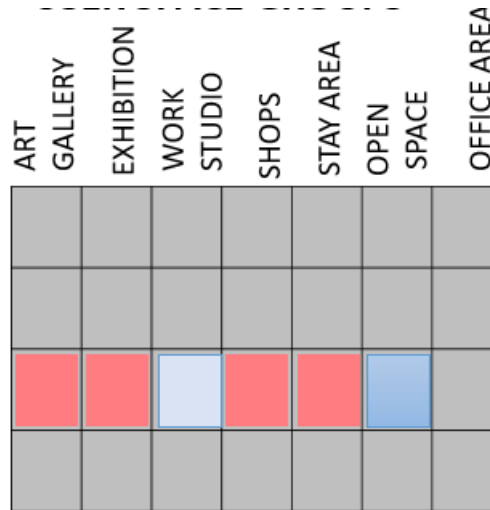


**Fig 4.32 User space groups**  
*The use group of staff more active near Office area and Work studio.*

**USER 3 – TOURIST/ VISITORS:** Number of tourists and visitors who visit Kerala not only interested in buying the products but also learning the process of creating this art form.

**AGE GROUP – 20 – 60 Years**

**NUMBER OF USERS – 60 – 80 Visitors per day**



**Fig 4.33 User space groups**

*The use group of Tourist more active near Art gallery, Stay area and shops.*

**USER 4 – ARTIST / CRAFTSMENT:** Main aim of the site is to create stay area for artist with in India and all around the world which will act as global art platform.

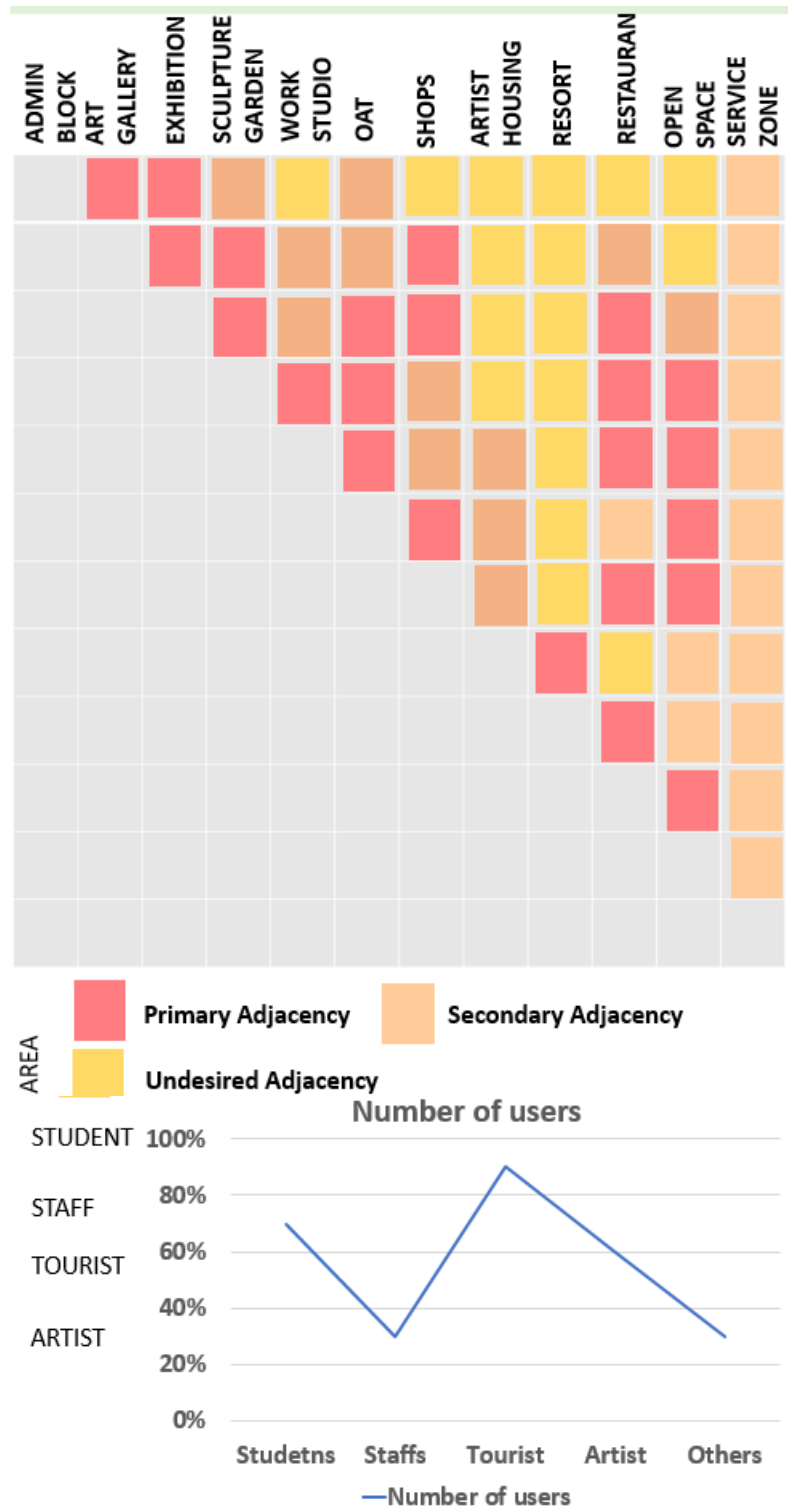
**AGE GROUP – 16 – 50+ Years**

**NUMBER OF USERS – 50 - 70 Artist and crafts men**



**Fig 4.34 User space groups**

*The use group of Artist more active near Work studios and stay area.*



**Fig 4.35 Proximity chart**

## MAHONEY TABLES

### Air temperature:

|                    | Jan  | Feb  | Mar  | April | May  | June | July | Aug  | Sep  | Oct  | Nov  | Dec  |
|--------------------|------|------|------|-------|------|------|------|------|------|------|------|------|
| Monthly Mean max.  | 31   | 31.5 | 32.5 | 32    | 30.5 | 28   | 27.5 | 27.5 | 28   | 28.5 | 29.5 | 30.5 |
| Monthly Mean min.  | 21.5 | 22.5 | 24.5 | 25.5  | 25.5 | 24.5 | 24   | 24   | 23.5 | 24   | 23.5 | 22   |
| Monthly Mean range | 9.5  | 9    | 8    | 6.5   | 10   | 3.5  | 3.5  | 3.5  | 4.5  | 4.5  | 6    | 8.8  |

|      |     |
|------|-----|
| High | AMT |
| 32.5 | 27  |
| 21.5 | 11  |
| LOW  | AMR |

### Relative humidity:

|                   | Jan | Feb | Mar | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|-------------------|-----|-----|-----|-------|-----|------|------|-----|-----|-----|-----|-----|
| Average humidity% | 71  | 70  | 72  | 77    | 81  | 89   | 90   | 89  | 87  | 87  | 82  | 74  |
| Humidity group    | 4   | 4   | 4   | 4     | 4   | 4    | 4    | 4   | 4   | 4   | 4   | 4   |

### Rain Fall

|                          |   |   |    |    |     |     |     |     |     |     |    |    |
|--------------------------|---|---|----|----|-----|-----|-----|-----|-----|-----|----|----|
| Mean total rainfall (mm) | 5 | 4 | 21 | 83 | 231 | 615 | 555 | 362 | 210 | 230 | 75 | 19 |
|--------------------------|---|---|----|----|-----|-----|-----|-----|-----|-----|----|----|

TOTAL:2410mm

|                     | Jan  | Feb  | Mar  | April | May  | June | July | Aug  | Sep  | Oct  | Nov  | Dec  |
|---------------------|------|------|------|-------|------|------|------|------|------|------|------|------|
| Monthly mean max    | 31   | 31.5 | 32.5 | 32    | 30.5 | 28   | 27.5 | 27.5 | 28   | 28.5 | 29.5 | 30.5 |
| Day comfort upper   | 27   | 27   | 27   | 27    | 27   | 27   | 27   | 27   | 27   | 27   | 27   | 27   |
| Lower               | 22   | 22   | 22   | 22    | 22   | 22   | 22   | 22   | 22   | 22   | 22   | 22   |
| Monthly mean min    | 21.5 | 22.5 | 24.5 | 25.5  | 25.5 | 24.5 | 24   | 24   | 23.5 | 24   | 23.5 | 22   |
| Night comfort upper | 21   | 21   | 21   | 21    | 21   | 21   | 21   | 21   | 21   | 21   | 21   | 21   |
| Lower               | 17   | 17   | 17   | 17    | 17   | 17   | 17   | 17   | 17   | 17   | 17   | 17   |
| Thermal stress day  | H    | H    | H    | H     | H    | H    | H    | H    | H    | H    | H    | H    |
| Night               | O    | H    | H    | H     | H    | H    | H    | H    | H    | H    | H    | H    |

Indicators:

|              |   |   |   |   |   |   |   |   |   |   |   |   |
|--------------|---|---|---|---|---|---|---|---|---|---|---|---|
| Humid:<br>H1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| H2           |   |   |   |   |   |   |   |   |   |   |   |   |
| H3           |   |   |   |   | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |   |   |
| Arid:<br>A1  |   |   |   |   |   |   |   |   |   |   |   |   |
| A2           |   |   |   |   |   |   |   |   |   |   |   |   |
| A3           |   |   |   |   |   |   |   |   |   |   |   |   |

TOTAL:

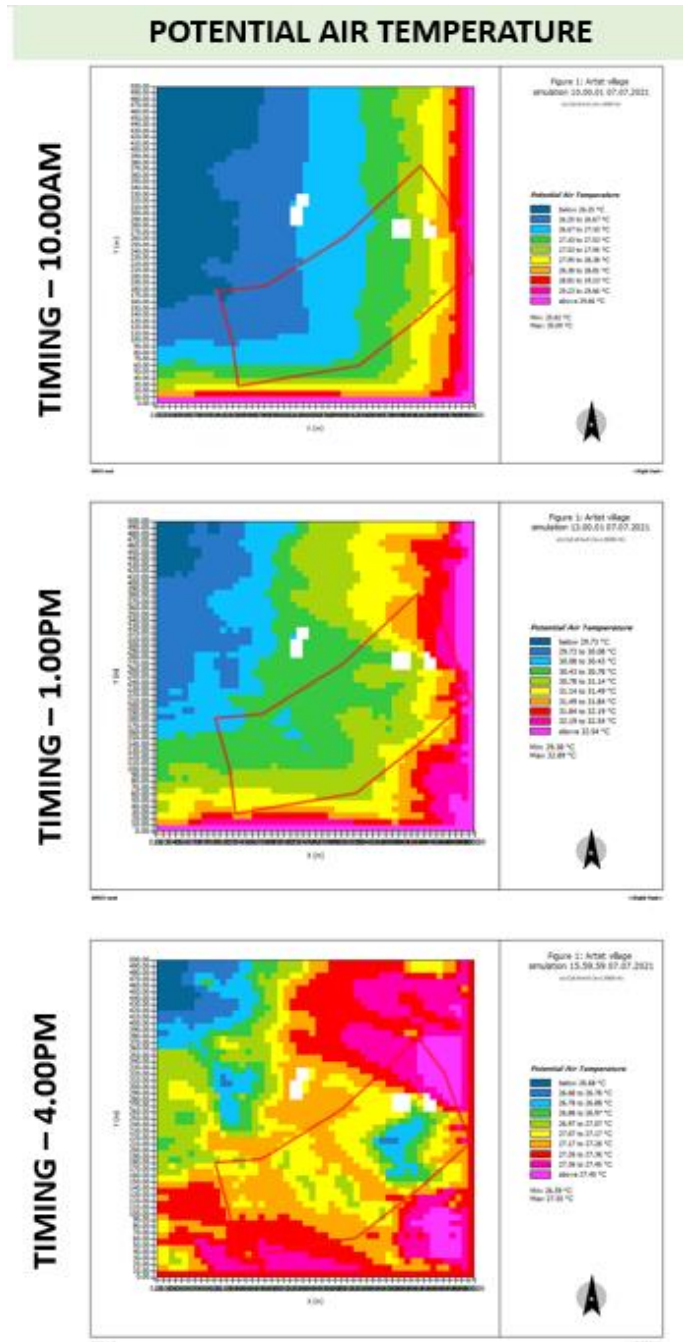
|    |    |    |    |    |    |
|----|----|----|----|----|----|
| H1 | H2 | H3 | A1 | A2 | A3 |
| 12 | 0  | 6  | 0  | 0  | 0  |

**Fig 4.4 Mahoney table**

| S.no                              | Spaces                 | Standard ( Person / m2 ) | Occupancy | No.of units | Total Area ( Sq. . |
|-----------------------------------|------------------------|--------------------------|-----------|-------------|--------------------|
| <b>ADMIN OFFICE</b>               |                        |                          |           |             |                    |
| 1                                 | Office area            | 1.2                      | 5         | 1           | 6                  |
| 2                                 | Meeting room           | 1.5                      | 10        | 1           | 15                 |
| 3                                 | Lobby + Ticket counter | 0.8                      | 20        | 1           | 16                 |
| 4                                 | Waiting area           | 1                        | 30        | 1           | 30                 |
|                                   |                        |                          |           |             | <b>67</b>          |
| <b>RESIDENTIAL COMPLEX</b>        |                        |                          |           |             |                    |
| <b>Artist Residence (type 1)</b>  |                        |                          |           |             |                    |
| 5                                 | Living space           | 3.66 × 5.49              |           | 1           | 20                 |
| 6                                 | Kitchen                | 2.4 m × 3m               |           | 1           | 7                  |
| 7                                 | Dining                 | 7.3m x 5m                |           | 1           | 36                 |
| 8                                 | Bedroom                | 3.65 m x 3.65 m          |           | 1           | 13                 |
| 9                                 | Toilet                 | 1.5m x 1.8m              |           | 1           | 2.7                |
| 10                                | Work space             | 15                       |           | 1           | 15                 |
|                                   |                        |                          |           |             | <b>100</b>         |
| <b>Total units</b>                |                        |                          |           | <b>5</b>    | <b>500</b>         |
| <b>Artist Residence (type 2)</b>  |                        |                          |           |             |                    |
| 11                                | Living space           | 3.66 × 5.49              |           | 1           | 20                 |
| 12                                | Kitchen                | 2.4 m × 3m               |           | 1           | 7                  |
| 13                                | Dining                 | 7.3m x 5m                |           | 1           | 36                 |
| 14                                | Bedroom                | 3.65 m x 3.65 m          |           | 2           | 26                 |
| 15                                | Toilet                 | 1.5m x 1.8m              |           | 2           | 5.4                |
| 16                                | Work space             | 15                       |           | 2           | 30                 |
|                                   |                        |                          |           |             | <b>125</b>         |
| <b>Total units</b>                |                        |                          |           | <b>10</b>   | <b>1250</b>        |
| <b>COTTAGES</b>                   |                        |                          |           |             |                    |
| 17                                | Individual cottages    |                          |           | 1           | 40                 |
| 18                                | Twin cottages          |                          |           | 1           | 55                 |
|                                   |                        |                          |           |             | <b>95</b>          |
| <b>Total units</b>                |                        |                          |           | <b>12</b>   | <b>1150</b>        |
| <b>WORKING STUDIO</b>             |                        |                          |           |             |                    |
| 19                                | Painting studio        | 1.7                      | 35        | 1           | 60                 |
| 20                                | Sculpture              | 2                        | 25        | 1           | 50                 |
| 21                                | Artist studio          | 1.5                      | 30        | 1           | 45                 |
| 22                                | Material storage       | 4                        | 40        | 1           | 160                |
| 23                                | Storage Area           | 5                        | 20        | 1           | 100                |
| 24                                | Common space           | 3.5                      | 10        | 1           | 35                 |
| 25                                | Conference hall        | 1.5                      | 25        | 1           | 38                 |
| 26                                | Toilet                 | 1m x 1.5m                | 60        | 1           | 90                 |
|                                   |                        |                          |           |             | <b>578</b>         |
| <b>GALLERY</b>                    |                        |                          |           |             |                    |
| 27                                | Exhibition space       | 2                        | 100       | 1           | 200                |
| 28                                | Sculpture garden       |                          |           |             | 60                 |
| 29                                | Open air theater       | 1.2                      | 150       | 1           | 180                |
| 30                                | Store room             | 2                        | 40        | 1           | 80                 |
| 31                                | Toilet                 | 1m x 1.5m                | 60        | 1           | 90                 |
|                                   |                        |                          |           |             | <b>610</b>         |
| <b>CAFETERIA &amp; RESTAURANT</b> |                        |                          |           |             |                    |

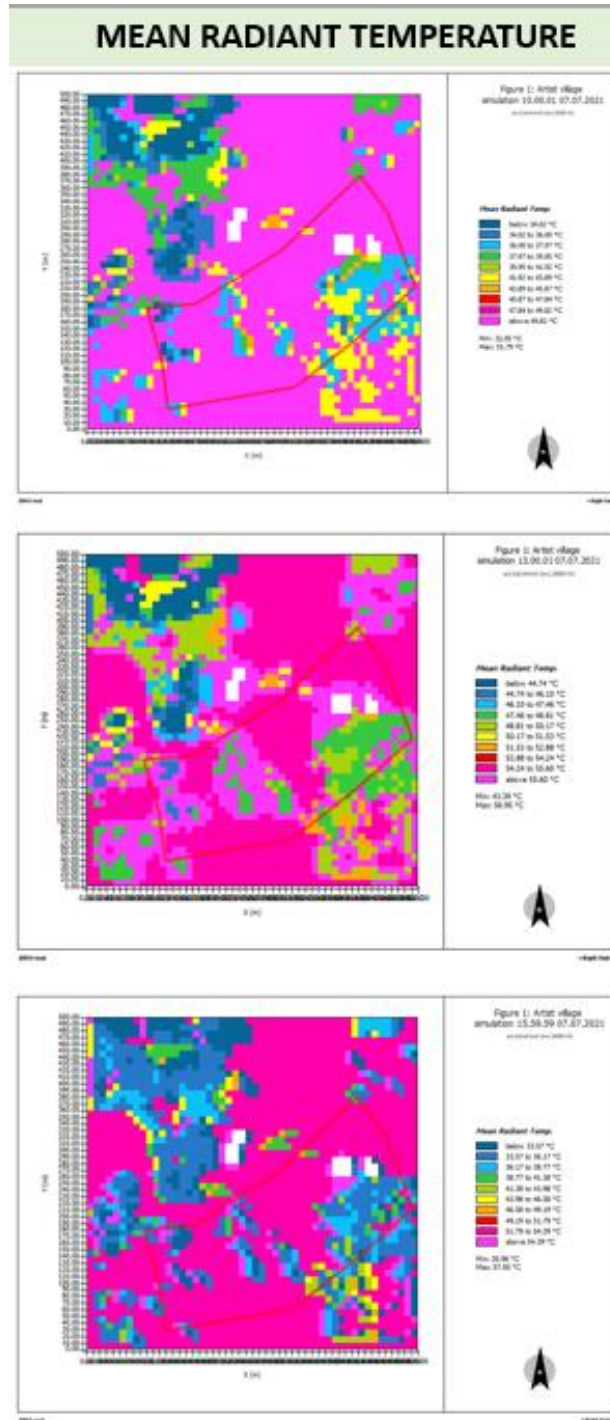
|                        |                             |                          |    |                               |                   |
|------------------------|-----------------------------|--------------------------|----|-------------------------------|-------------------|
| 32                     | Dining Area                 | 2                        | 60 | 1                             | 120               |
| 33                     | Kitchen                     | 2.4 m × 3m (For 2 people | 8  | 1                             | 58                |
| 34                     | Store                       | 3                        | 20 | 1                             | 60                |
| 35                     | Toilet                      | ASD                      | 30 | 1                             | 10                |
|                        |                             |                          |    |                               | <b>248</b>        |
| <b>PARKING</b>         |                             |                          |    |                               |                   |
| 36                     | 2 Wheelers                  | 2.5m x 1.2m              | 40 | 1                             | 120               |
| 37                     | 4 Wheelers                  | 2.7m x 5.5m              | 80 | 1                             | 750               |
|                        |                             |                          |    |                               | <b>870</b>        |
| <b>STAFF FACILITES</b> |                             |                          |    |                               |                   |
| 38                     | Sleeping Area               | 5                        | 10 | 1                             | 50                |
| 39                     | Toilets                     | ASD                      |    | 2                             | 10                |
| 40                     | Pantry                      | 3.3                      | 3  | 1                             | 10                |
| 41                     | Dining Area                 | 1.2                      | 10 | 1                             | 12                |
|                        |                             |                          |    |                               | <b>82</b>         |
| <b>SERVICES</b>        |                             |                          |    |                               |                   |
| 42                     | Mechanical room             |                          |    | 1                             | 50                |
| 43                     | Electrical and AHU room     |                          |    | 1                             | 40                |
| 44                     | Generator room              |                          |    | 1                             | 50                |
| 45                     | Waste water recycling plant |                          |    | 1                             | 50                |
| 46                     | Sewage treatment plant      |                          |    | 1                             | 50                |
| 47                     | Biomass plant               |                          |    | 1                             | 50                |
|                        |                             |                          |    |                               | <b>290</b>        |
|                        |                             |                          |    | <b>TOTAL</b>                  | <b>5700 SQ.M</b>  |
|                        |                             |                          |    | <b>TOTAL SITE AREA</b>        | <b>40468 SQ.M</b> |
|                        |                             |                          |    | <b>PROPOSED BUILT UP AREA</b> | <b>5700 SQ.M</b>  |
|                        |                             |                          |    | <b>10% CIRCULATION SPACE</b>  | <b>570 SQ.M</b>   |

**Table 4.5 Area statement**



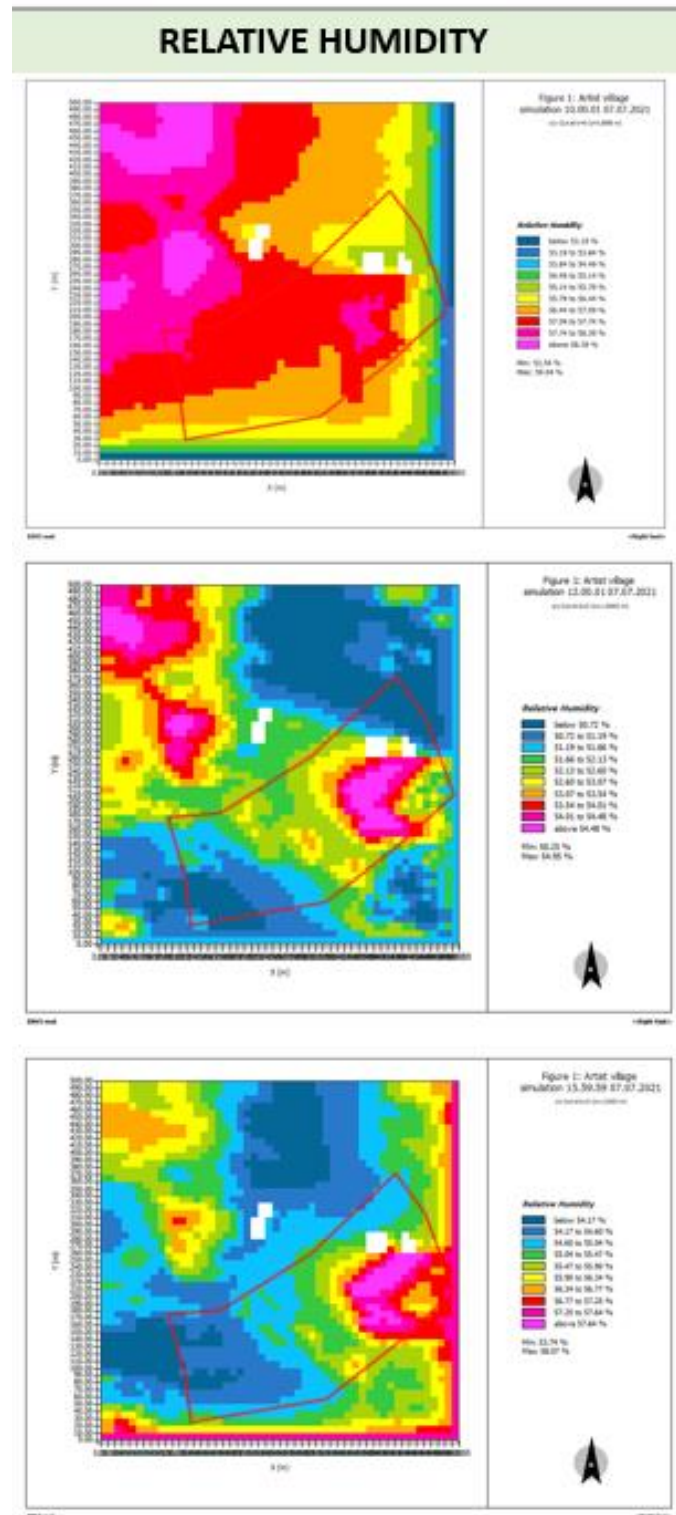
**Fig 4.61 Potential Air temperature**

The air temperature analysis clearly shows that the areas which have trees has temperature range about 27°C. As the site surrounded by empty plot temperature range from 25°C to 32°C.



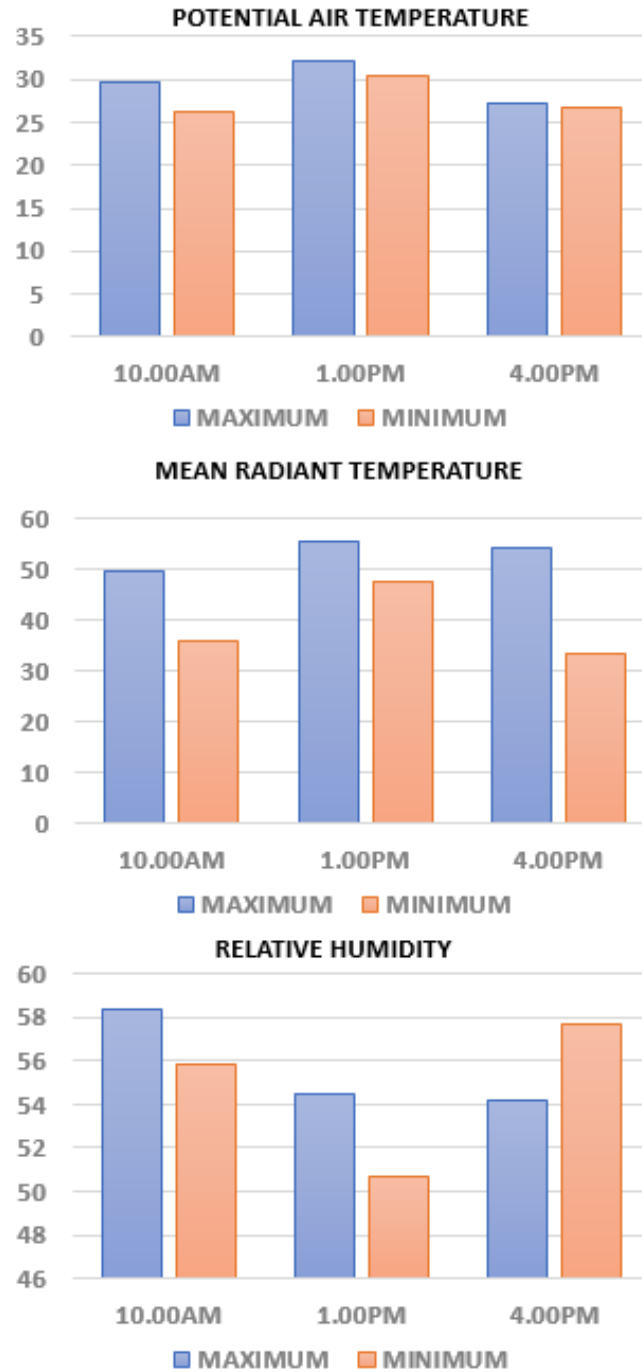
**Fig 4.62 Mean Radiant Temperature**

The mean radiant temperature analysis shows that the heat transfer from trees at the site are lower and temperature is below 35 °c.



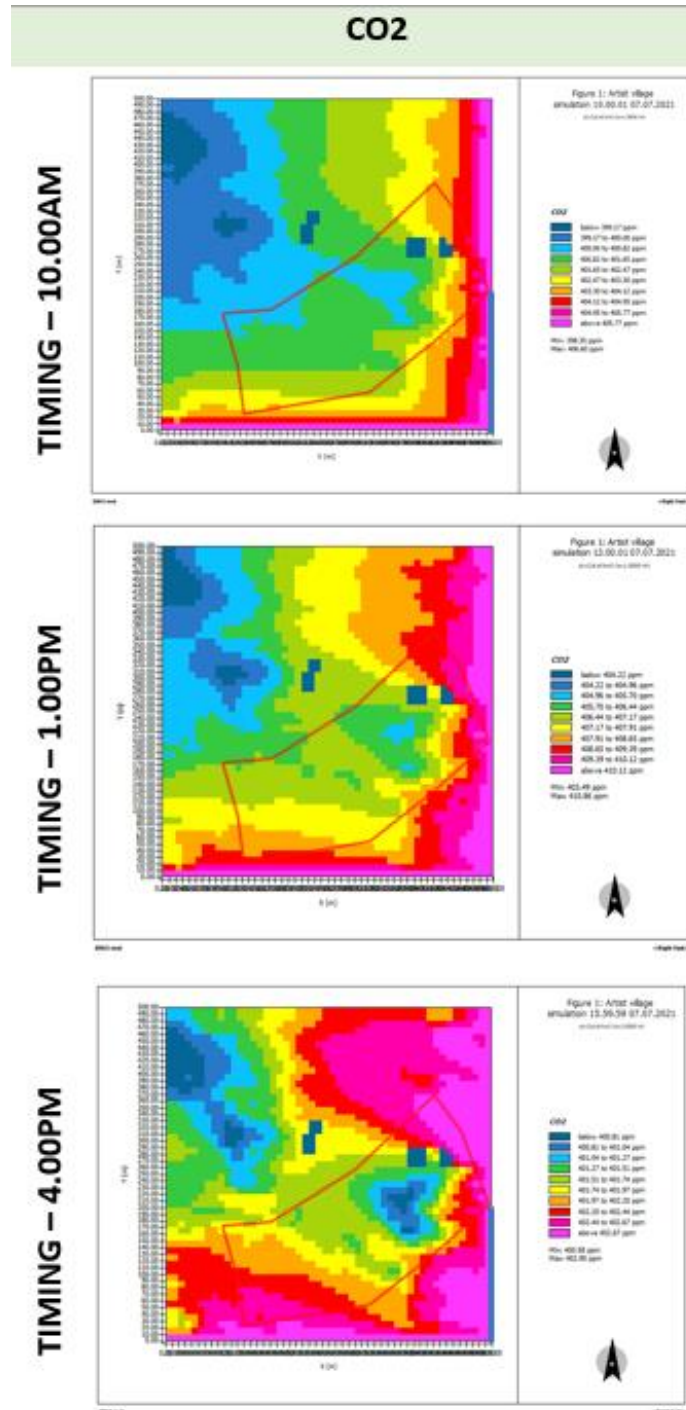
**Fig 4.63 Relative Humidity**

The relative humidity analysis shows that the humidity is more than 58% near the dense trees. Due to densely packed trees at the site, few areas at site also has higher humidity.



**Fig 4.64 Inference**

The open space with out tree has maximum temperature. Spaces with tree has lesser temperature and it is shaded. The maximum temperature is during afternoon.



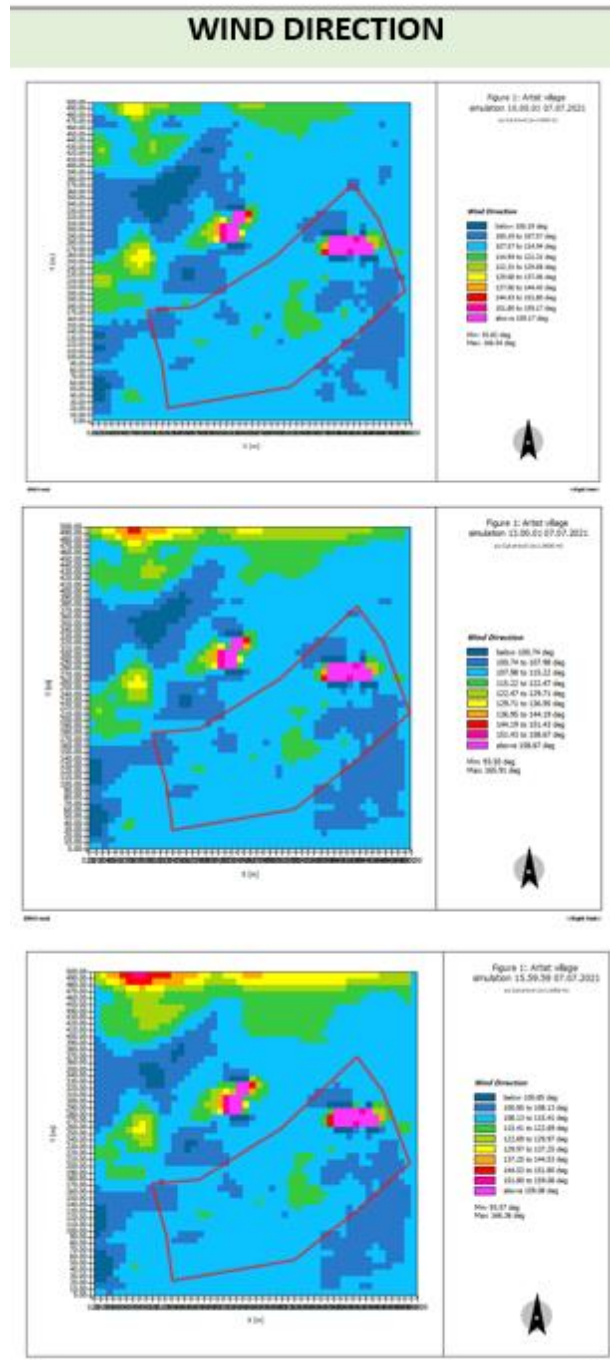
**Fig 4.65 Co<sub>2</sub>**

The CO<sub>2</sub> analysis clearly shows that the areas which have trees has PPM range from below 400 ppm. The minimum values is 401.27 ppm to 402.44 ppm.

# WIND SPEED

**Fig 4.66 Wind speed**

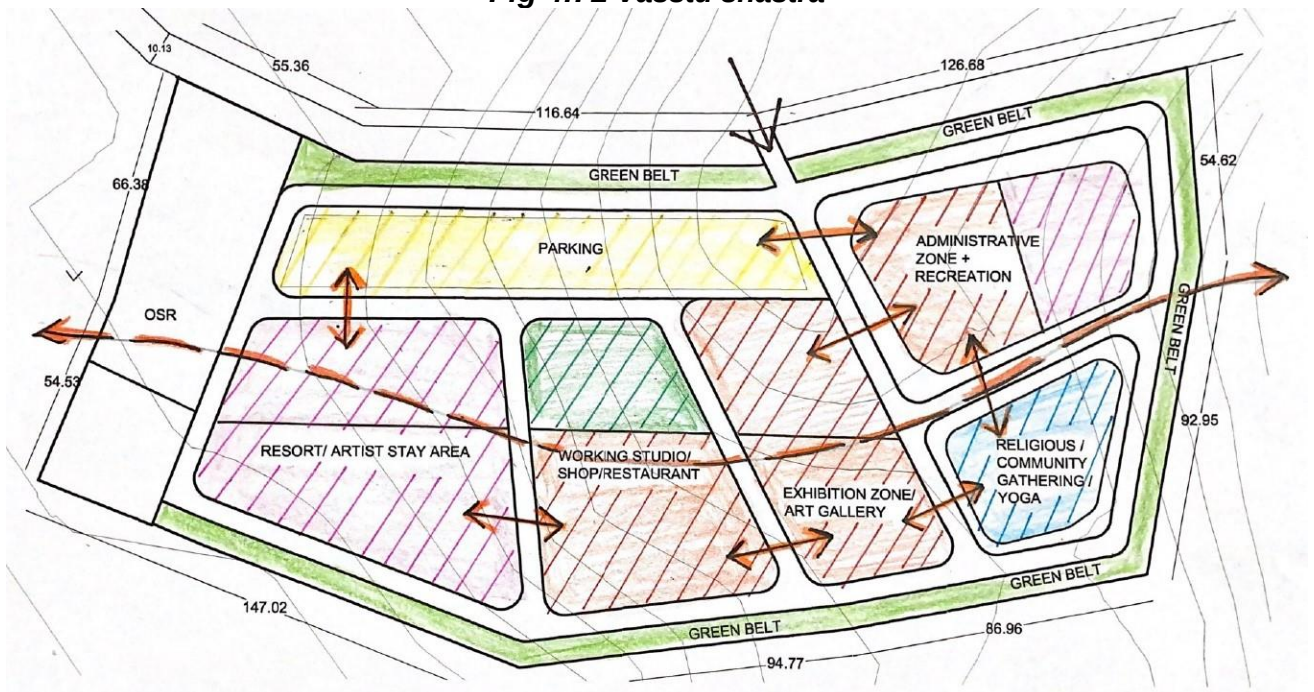
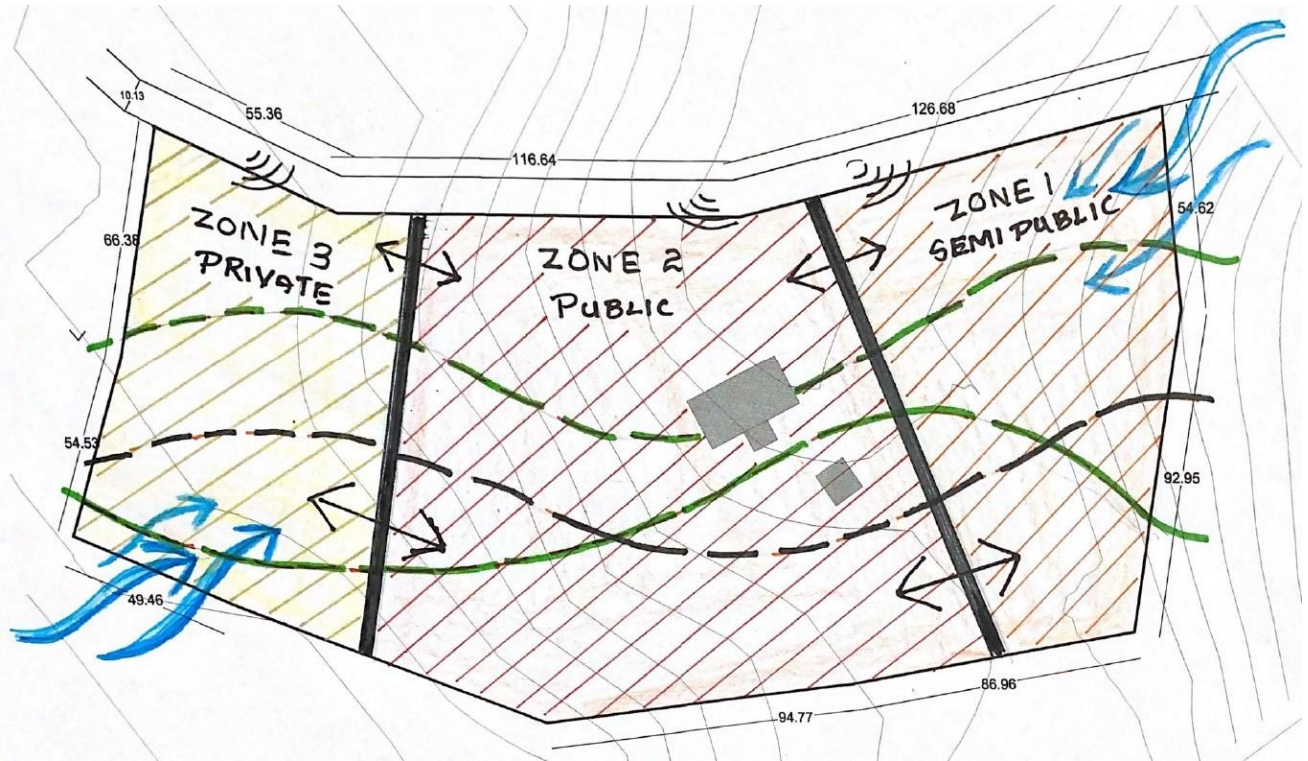
From wind speed analysis, the wind speed is more at the higher contours nearly 5.50 to 6 m/s. Higher wind speed is also seen in areas where there are more trees.

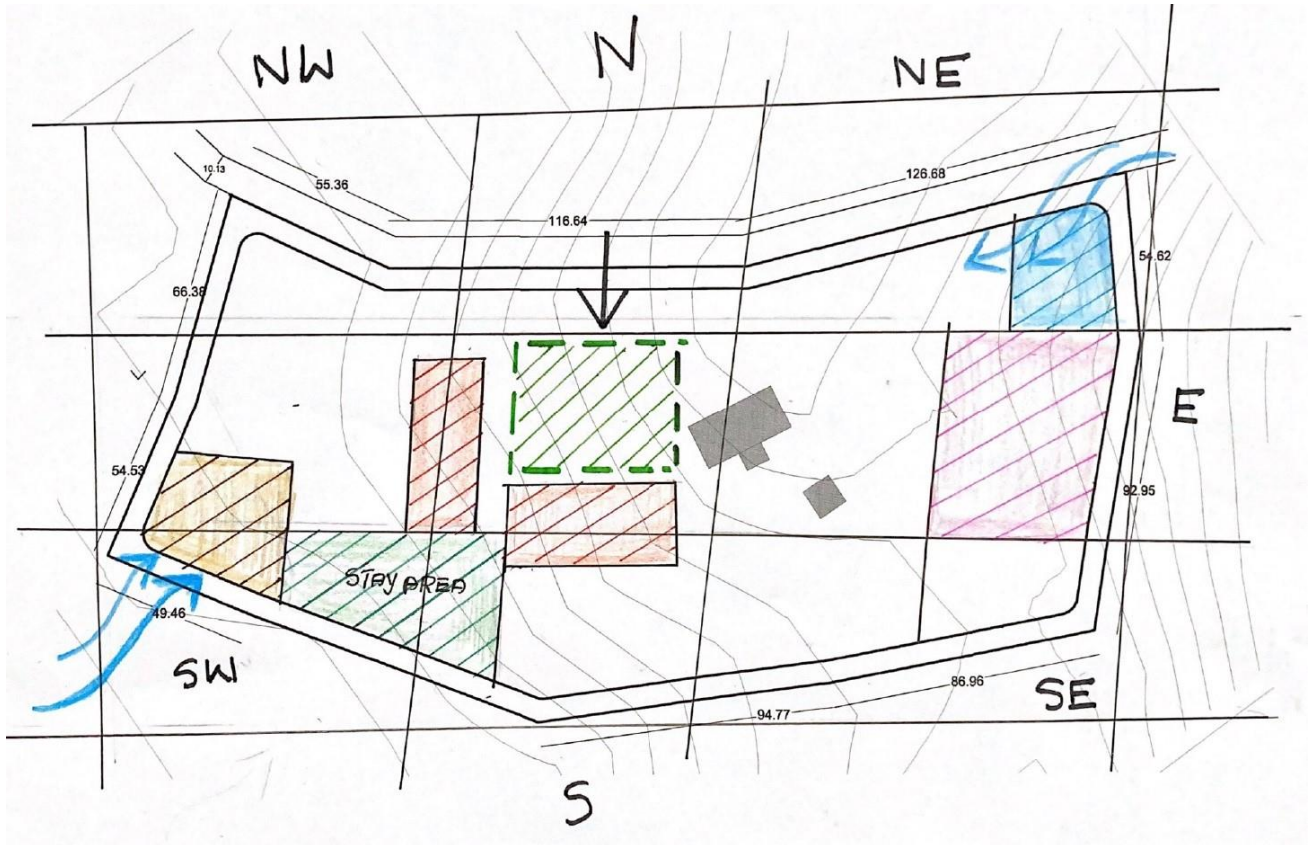


**Fig 4.65 Wind direction**

The most prevailing wind direction at the site is south west monsoon winds. Most of the south west monsoon winds at the site are strong winds.

## 4.7 ZONING



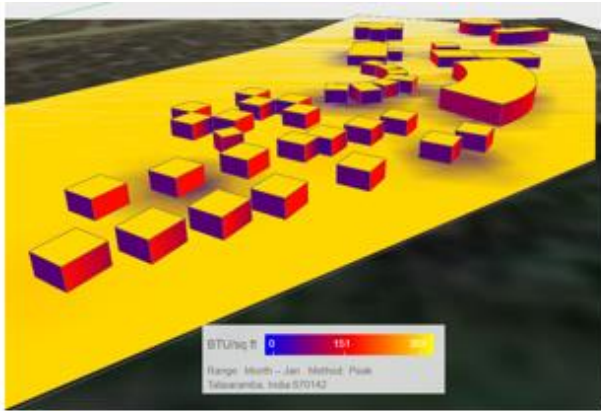


**Fig 4.73**

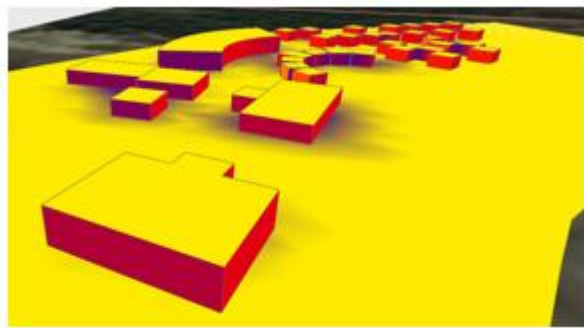
Orienting building in such a way that longer façade on NORTH SOUTH and shorter on EAST WEST .

Traditional Kerala architecture is primarily based on the principles of :

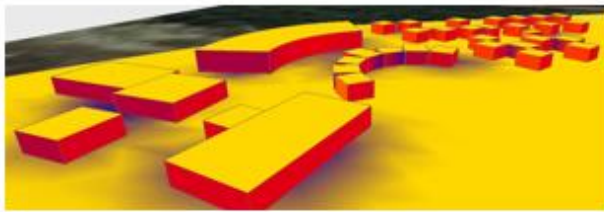
- **Thatchu Shashtra** (Science of carpentry)
- **Vaasthu Shashtra** (Science of architecture and construction)



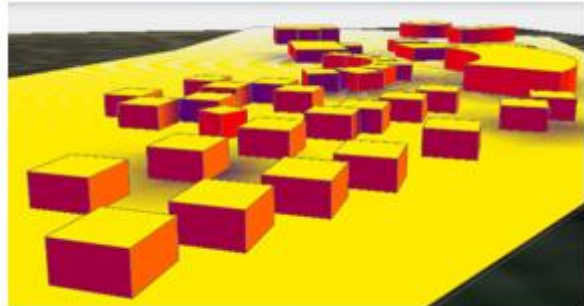
**Fig 4.74 January**



**Fig 4.75 April**



**Fig 4.76 July**

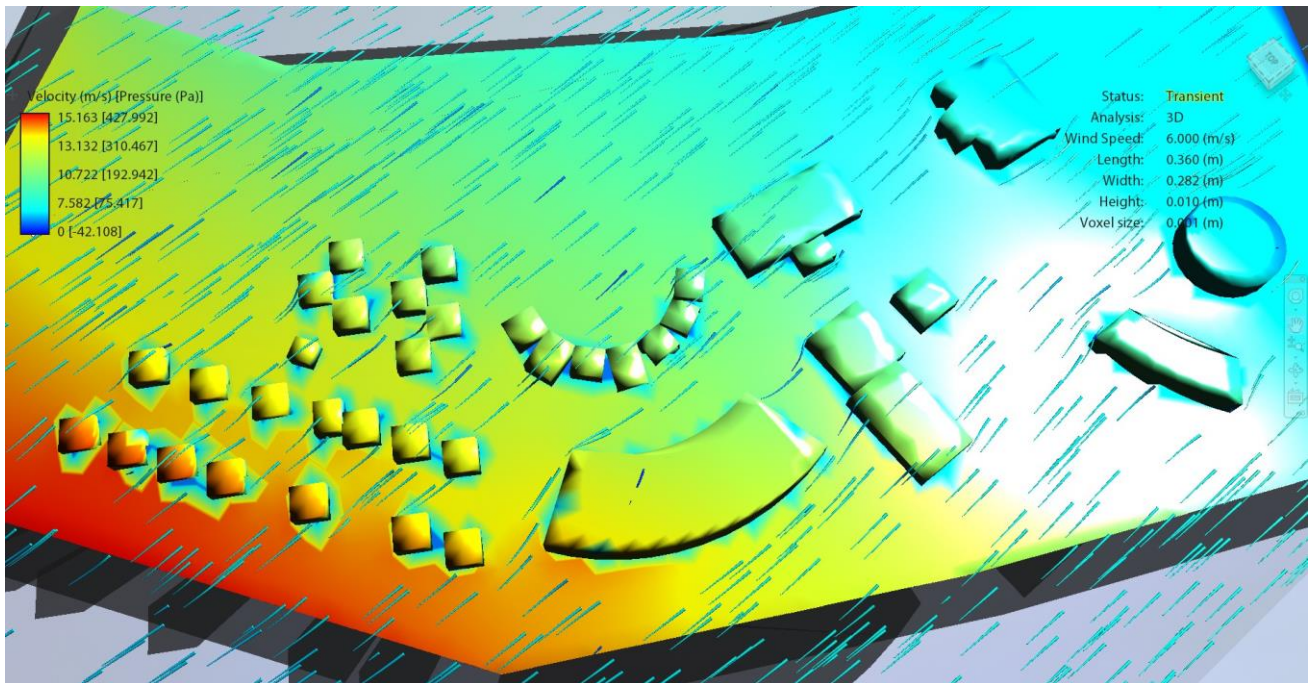


**Fig 4.77 October**

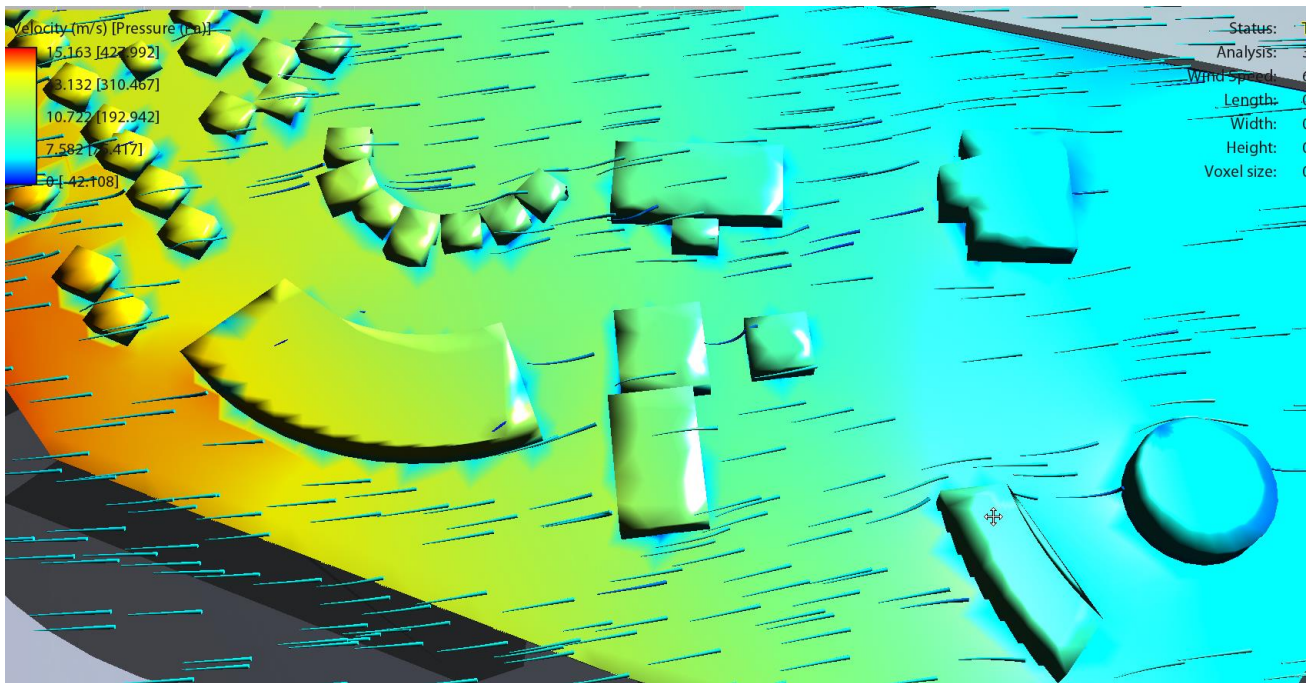
**Reduce heat gain is noted during the evening hours**

Buildings are orientated towards true North though the North and East wall receives lesser radiation compare to the south and west. Block arrangement with spacing Private zone which cast shadow over the adjacent blocks reducing heat gain and also increase the wind movement in between the blocks.

## SOUTH WEST

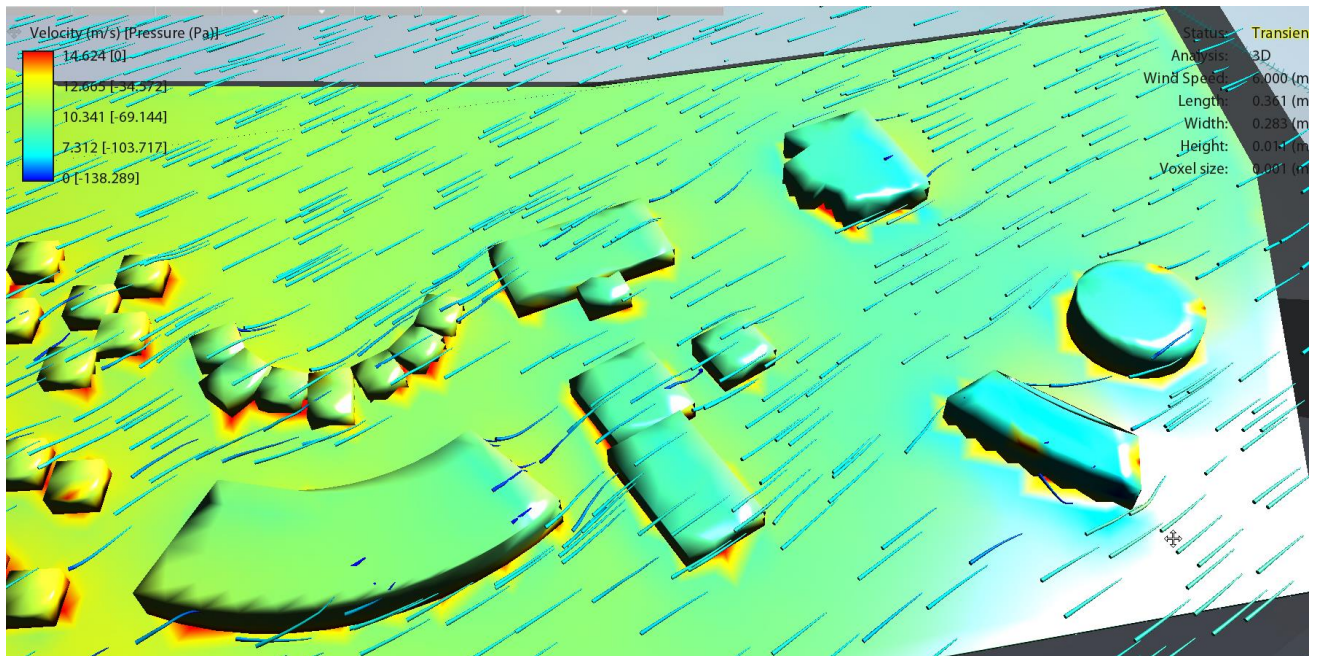


**Fig 4.78** From the result pressure create near the resort is high creating a buffer or the Green belt helps to reduce the pressure

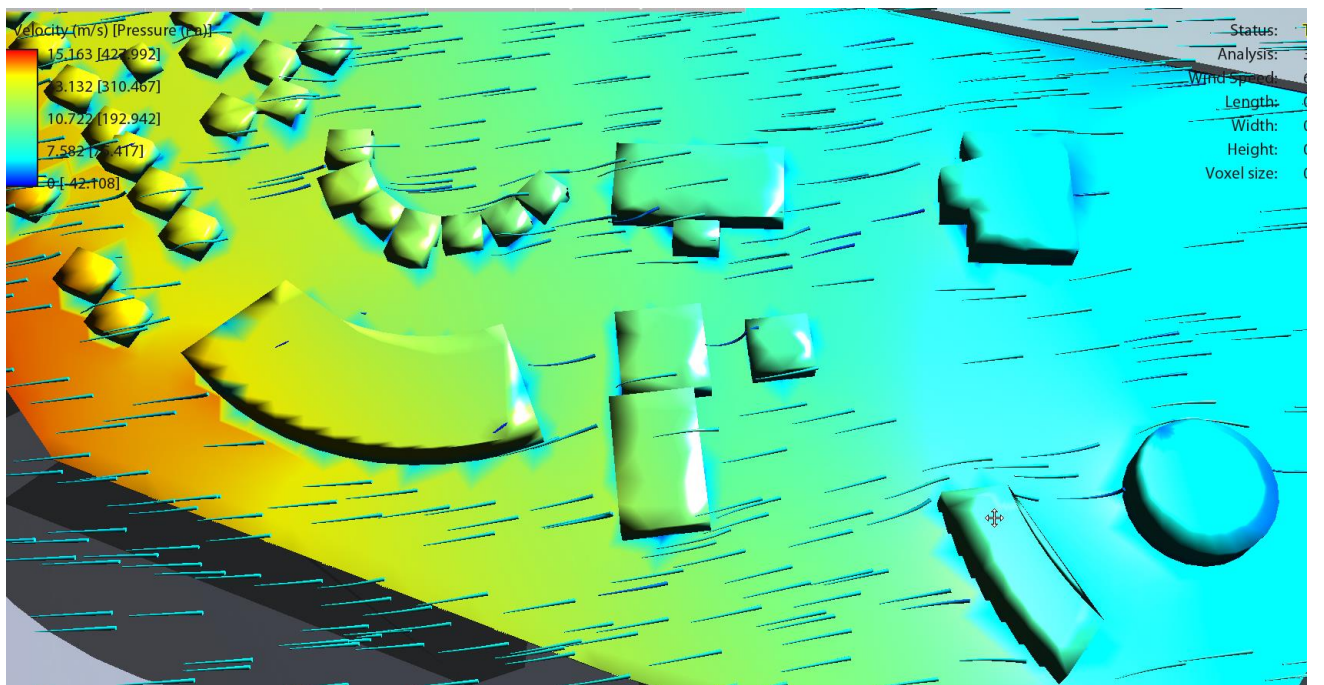


**Fig 4.79** More consideration should be given in community gathering and yoga, As the community gathering does not receives south west wind.

## NORTH EAST



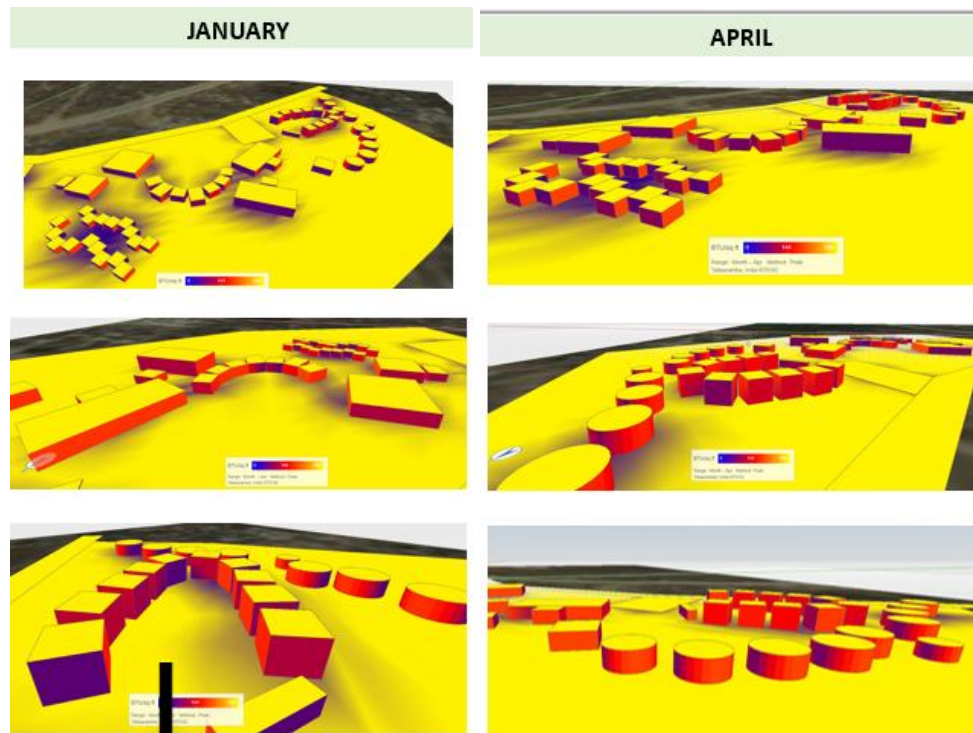
**Fig 4.8** Orientation of restaurant block should also been changed as I received very low air flow compare to the other blocks



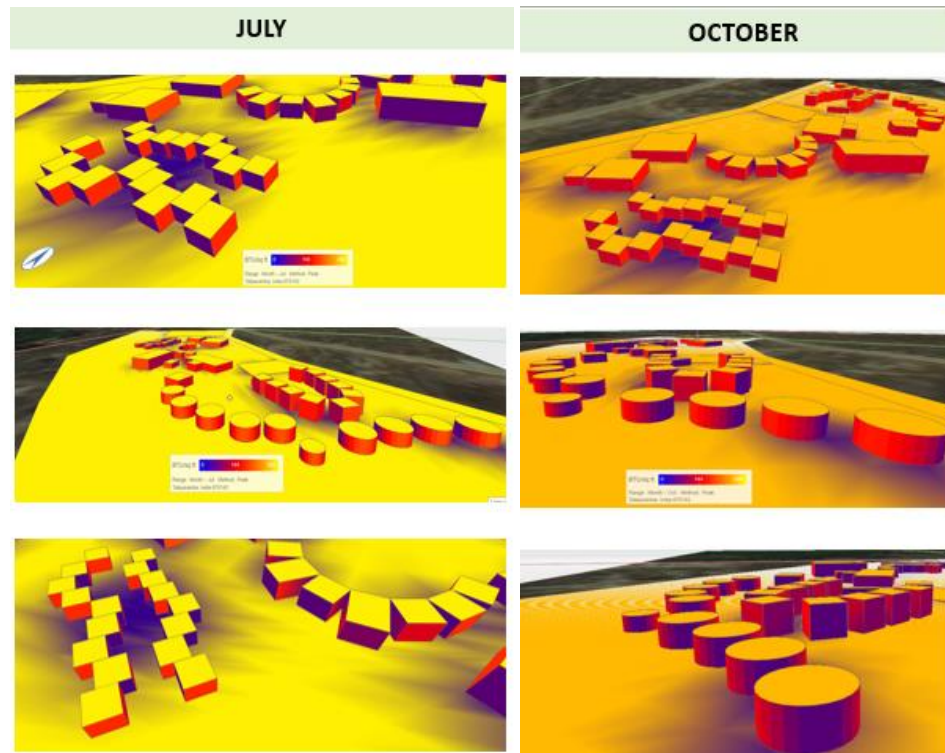
**Fig 4.81** Near the Private zone proper air circulation as been noted at 3m distance between the blocks



**Fig. 4.82 Zoning 2**



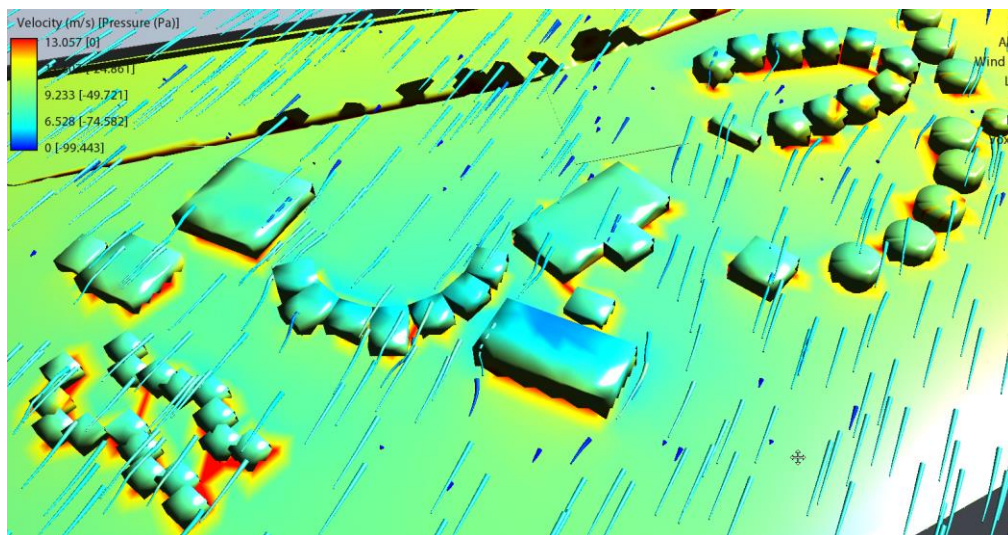
**Fig. 4.83 January and April**



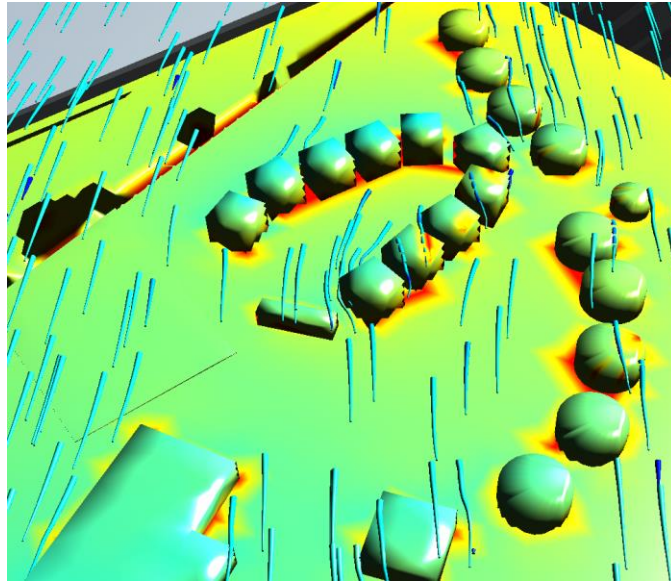
**Fig. 4.84 July and October**

Artist village arranged in a semi circular way where the radiation in all the block are reduced. Blocks are placed 3 meter distance which will be joined to as single block at future studies. Shop are arranged linear which makes the walk way cooler and shaded through out the day.

## SOUTH WEST

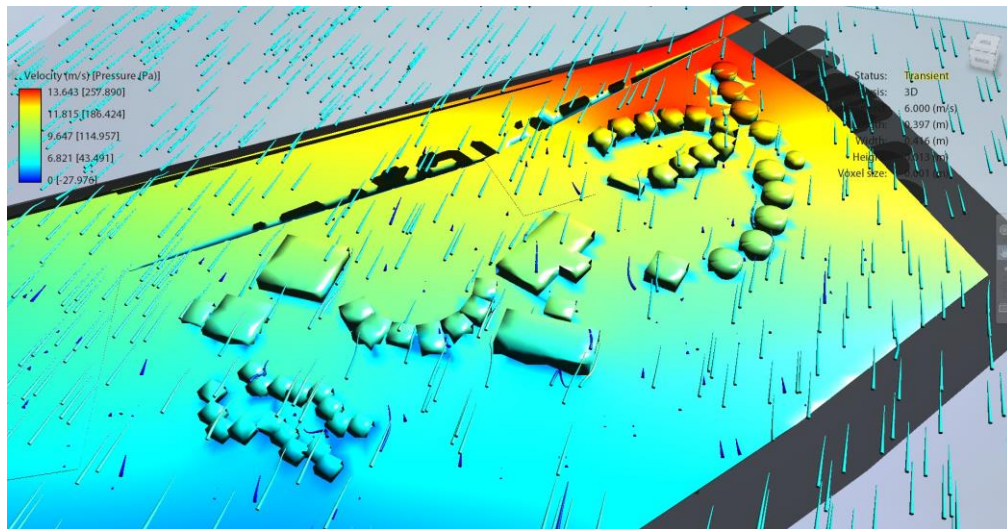


**Fig 4.85**

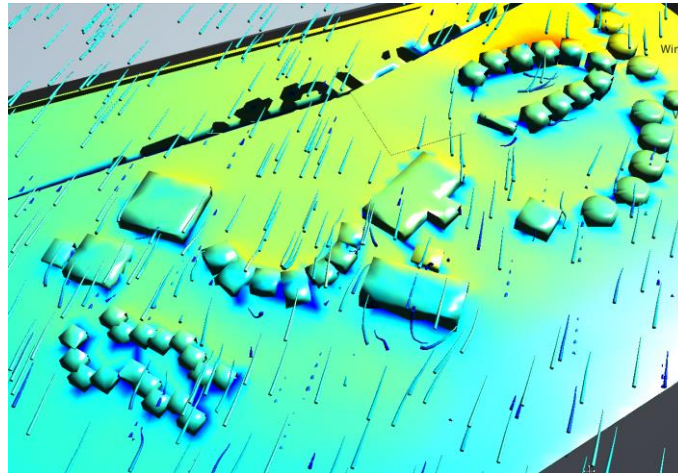


**Fig 4.86**

**NORTH EAST**

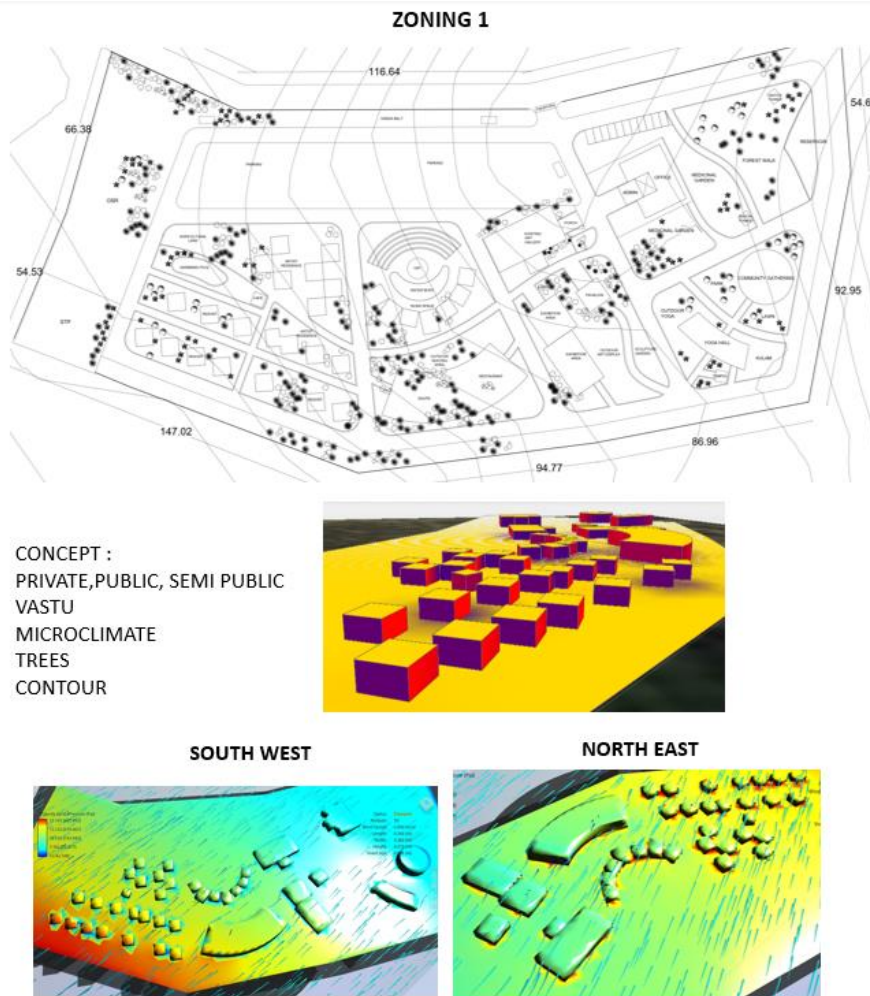


**Fig 4.87**



**Fig 4.88**

## COMPARITIVE ANALYSIS:

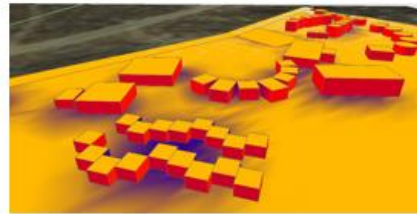


**Fig 4.91 Zoning 1**

## ZONING 2

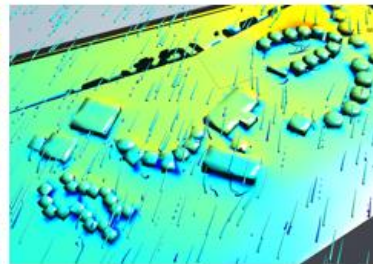
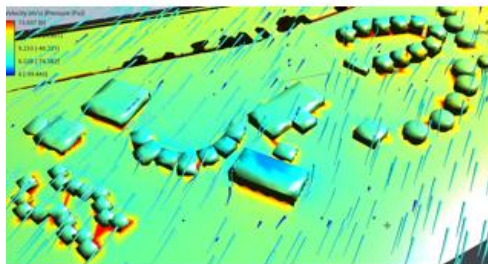


CONCEPT :  
PRIVATE,PUBLIC, SEMI PUBLIC  
MICROCLIMATE  
TREES - Consider but blocks have not  
been merged with trees  
CONTOUR



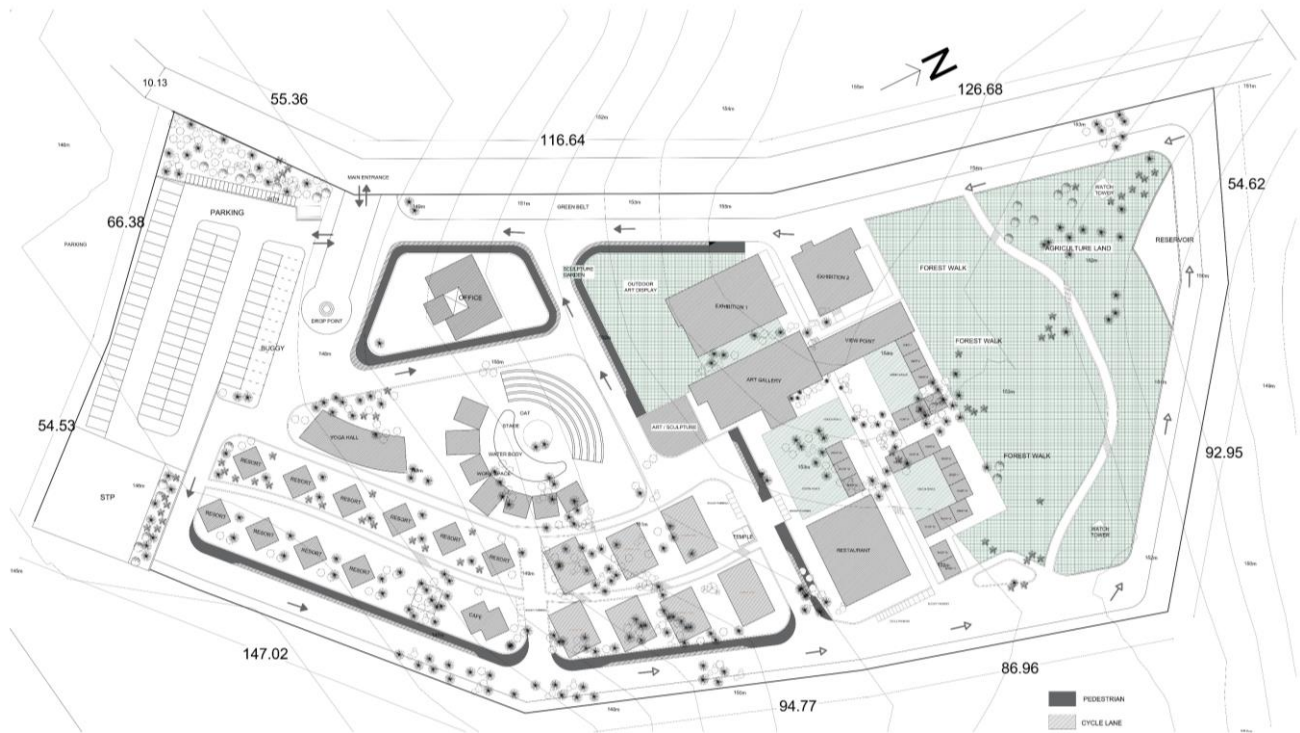
**SOUTH WEST**

**NORTH EAST**



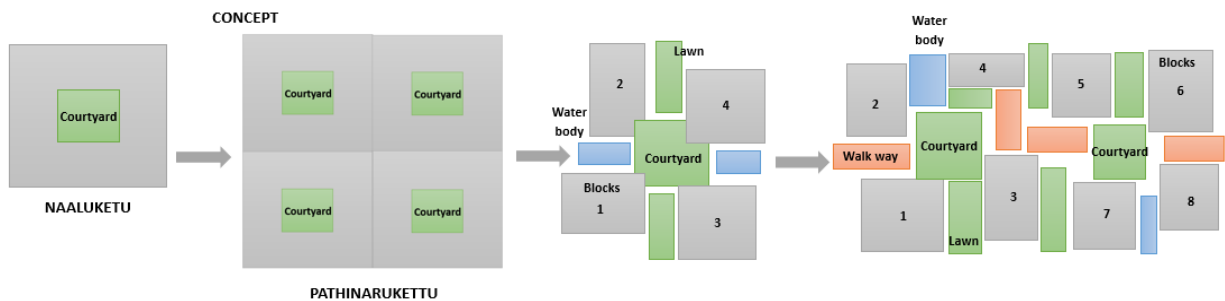
**Fig 4.92 Zoning 2**

## CHAPTER 5 MATERIAL STUDY



**Fig 5.1**

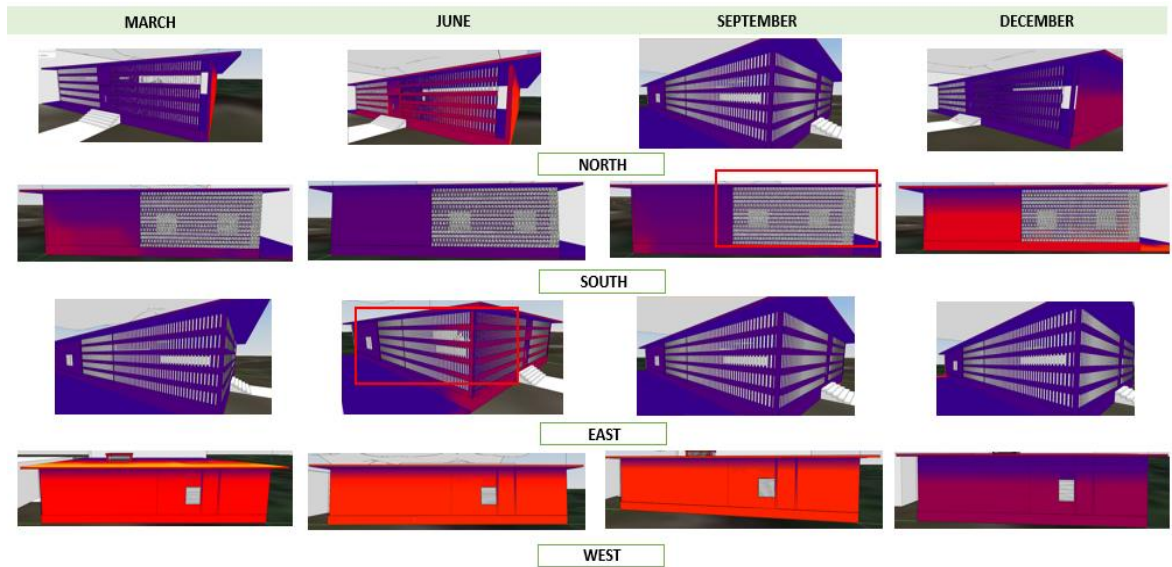
Machu is on of the main concept used in Kerala vernacular architecture. Above the machu thee will be roof. Same concept has been followed the roof layer act as machu and Pavilion act as roof. Air between the ceiling and the roof which act as an insulator that prevents the conduction of exterior heat through roof.



**Fig 5.2 Concept**

- Curtain wall – To bring in the direct sunlight and wind.
- Louvers helps hot air to rise up
- Water body + Plantation helps to cool the air into the building and makes interior cool.

- Stacking sleeved blocks through skewer rods. They wrap around the office room and staircase area and highlight the over all geometry of intersecting lines and solids. Which also helps radiation

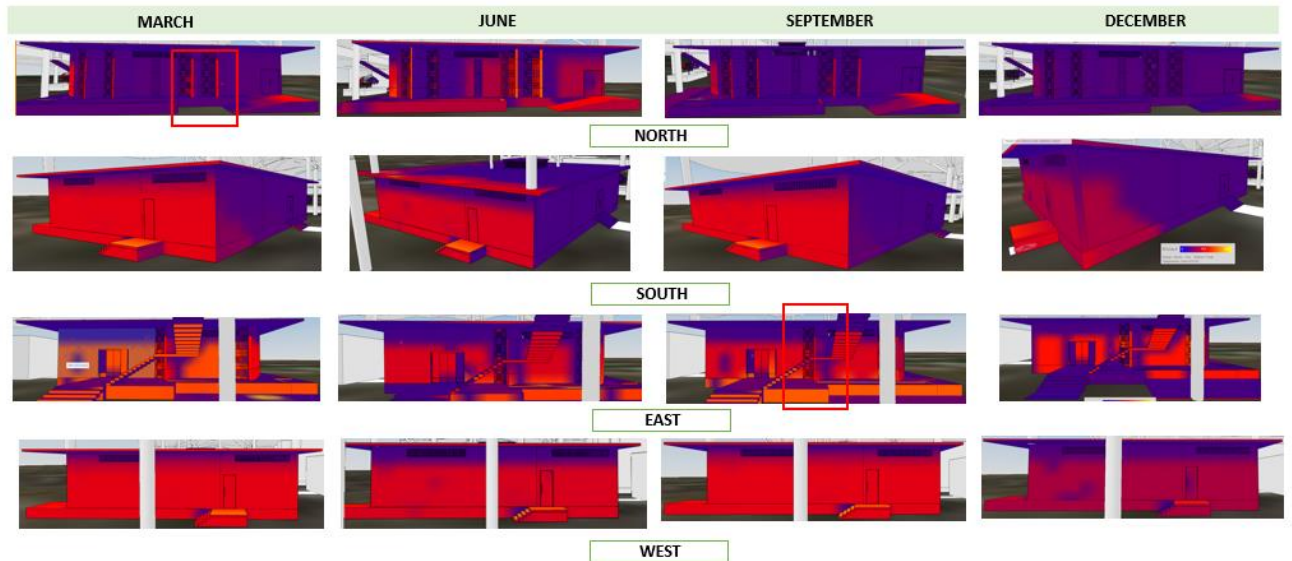


**Fig 5.3 Exhibition Area Block 1 – Radiation Analysis**

- Jali work in west wall which act as screen for the wall and protects from heat entering into the office space.
- Fins in north helps to penetrated day light and cut down the radiation.
- Roof – West side receives higher radiation extending the pavilion will helps to reduce the heat gain.
- And also the wall size is thicker than the other walls which helps to reduce the heat.
- East façade receives minimum radiation.

|           | NORTH | SOUTH | EAST  | WEST  | ROOF  |
|-----------|-------|-------|-------|-------|-------|
| MARCH     | 20.72 | 28.31 | 13.17 | 146.8 | 258.4 |
| JUNE      | 69.58 | 23.05 | 14.71 | 165.1 | 265.1 |
| SEPTEMBER | 19.26 | 27.38 | 14.34 | 163.7 | 247.9 |
| DECEMBER  | 12.47 | 119.8 | 8.86  | 67.46 | 108.3 |

**Table 5.1**



**Fig 5.3 Exhibition Area Block 2 – Radiation Analysis**

As we know the roof receives higher radiation pavilion structure which act as a protective cover for roof it also act as double roof for blocks, pavilion helps to reduce the radiation in the roof. The block arrangement proved efficient in reducing the solar radiation. The west façade is exposed to direct radiation, all the service area as been placed to the west direction. Jali screen in the north allows partial daylighting to pass through.

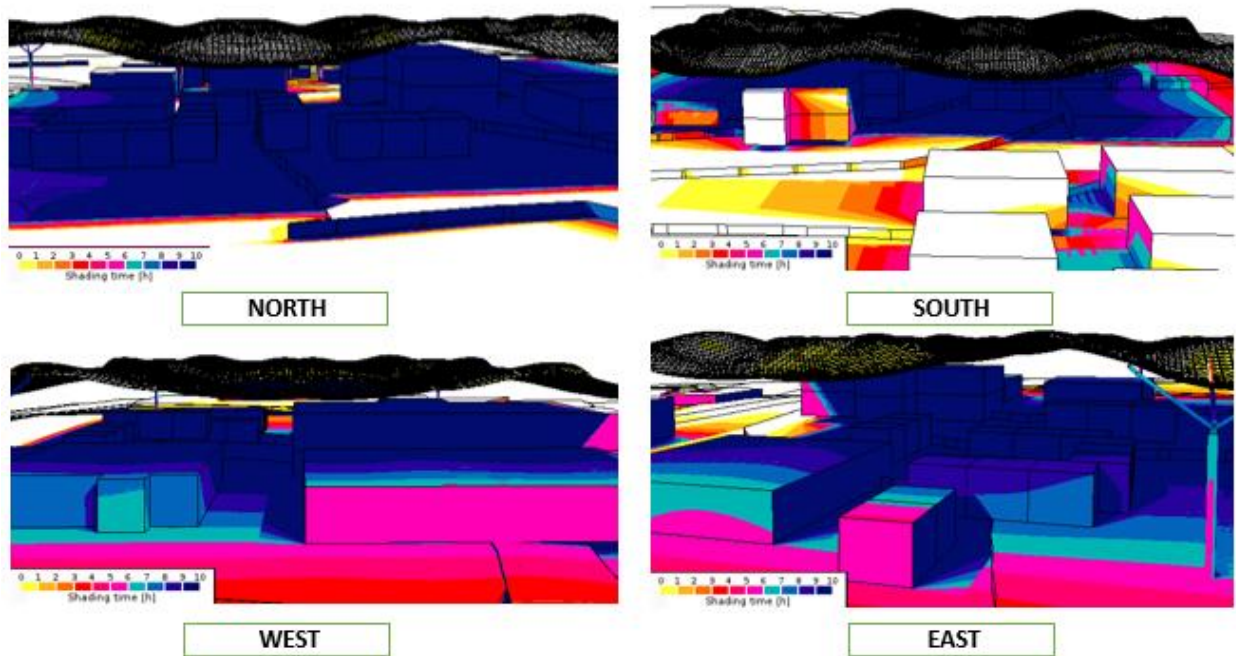
|                         | <i><b>NORTH</b></i> | <i><b>SOUTH</b></i> | <i><b>EAST</b></i> | <i><b>WEST</b></i> | <i><b>ROOF</b></i> |
|-------------------------|---------------------|---------------------|--------------------|--------------------|--------------------|
| <i><b>MARCH</b></i>     | <b>22.95</b>        | <b>20.23</b>        | <b>193.5</b>       | <b>130.3</b>       | <b>12.35</b>       |
| <i><b>JUNE</b></i>      | <b>11.52</b>        | <b>18.3</b>         | <b>131.8</b>       | <b>120.4</b>       | <b>8.32</b>        |
| <i><b>SEPTEMBER</b></i> | <b>15.49</b>        | <b>14.41</b>        | <b>118.4</b>       | <b>128.4</b>       | <b>7.81</b>        |
| <i><b>DECEMBER</b></i>  | <b>22.59</b>        | <b>17.6</b>         | <b>161</b>         | <b>85.09</b>       | <b>6.04</b>        |

**Table 5.2**

## **5.1 SHADOW ANALYSIS:**

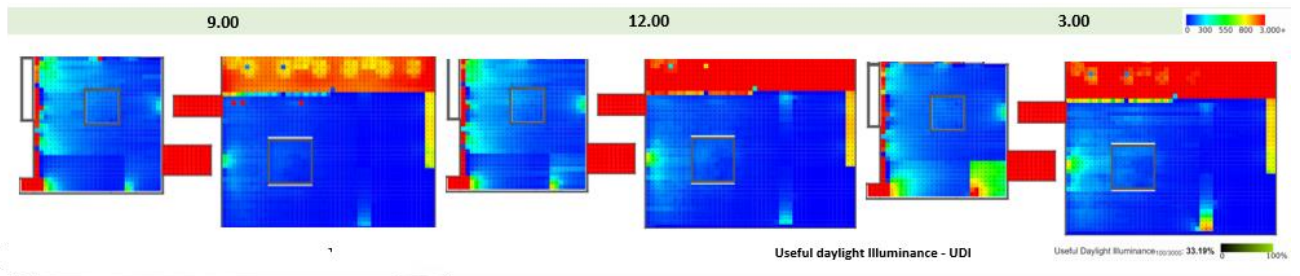
At 9 am the Shadow is observed in the North and West facades respectively. So, the morning hours the critical Façade being the South and East. Pavilion structure and the jail work in the south façade helps to provide proper shade to the interiors. The Shadow analysis during the 12 pm shows that north, west and east side are shaded Still South is not shaded. The art gallery alone receives high sunlight during this time. A play with light and shadow helps to create interest to use the space even in summer as the pavilion helps to

provide shade throughout the day. The Shadow analysis during 3 pm shows that Still East and north are shaded. SW and mainly the West façade receives high radiation. Leading to higher level of heat gain in the Exhibition and Art gallery double walls and Jalli screen helps to screen the South and west portion. Most of the Northern façade remains shaded as the extended portion of pavilion casts its shadow on the recessed part which is shaded though out the day. Art gallery – south wall receives higher radiation services area have been provide to the south and west wall. The block arrangement proved efficient in reducing the solar radiations. Outdoor exhibition, shops and walkway has been shaded throughout the day



**Fig 5.4 Exhibition Area – Day Light Analysis**

## 5.2 DAYLIGHT ANALYSIS:

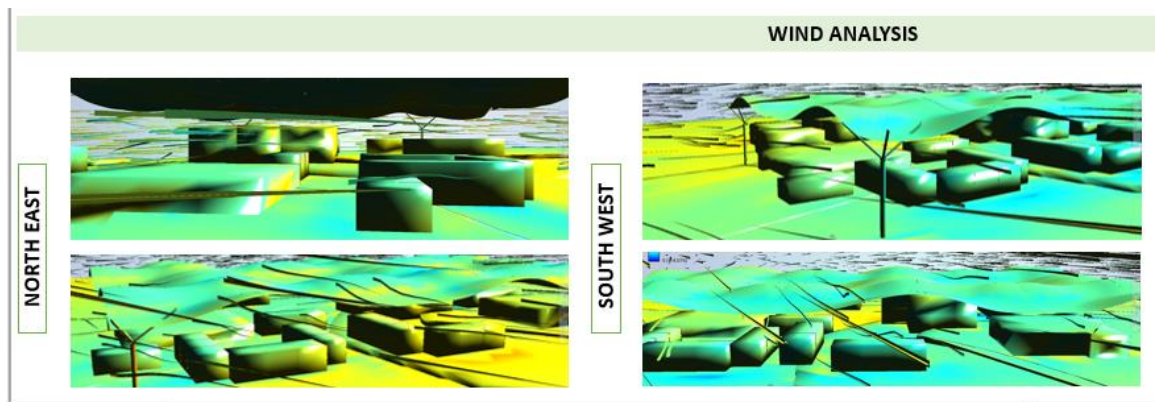


**Fig 5.5 Exhibition Area – Day Light Analysis**

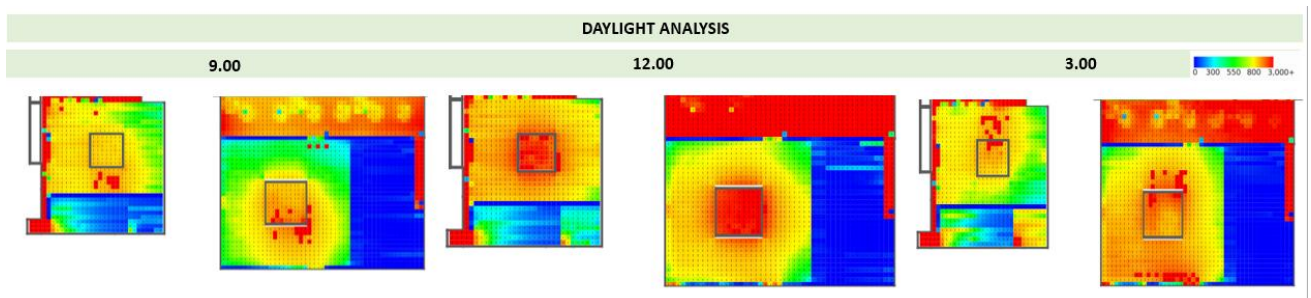
- In Exhibition center for display area the optimal lighting levels are – 300 lux level
- Both exhibition area achieved the lux level with in 100 -300 lux
- Area with jail work receives 250 – 350 lux
- Projection in roof helps to penetrate the Day light inside the display area.
- Tensile fabric which is used above the courtyard helps to provide diffused light inside the display area.
- The UDI is very high in south wall and will cause glare and heat gain through windows in south oriented Rooms . As service area placed in south it does not leads to major issue

### 5.3 WIND ANALYSIS:

- Voids helps to increases the air pressure in outdoor exhibition space and near shops. This makes the space comfortable throughout the day.
- Maximum wind flow is visible in the North façade.
- Minimum wind flow has been noted near exhibition area.
- Approximate wind velocity outside the building is between 4 to 6 m/s.
- All the buildings are sufficiently ventilated.
- Optimum wind flow is achieved for every space through planning strategy.



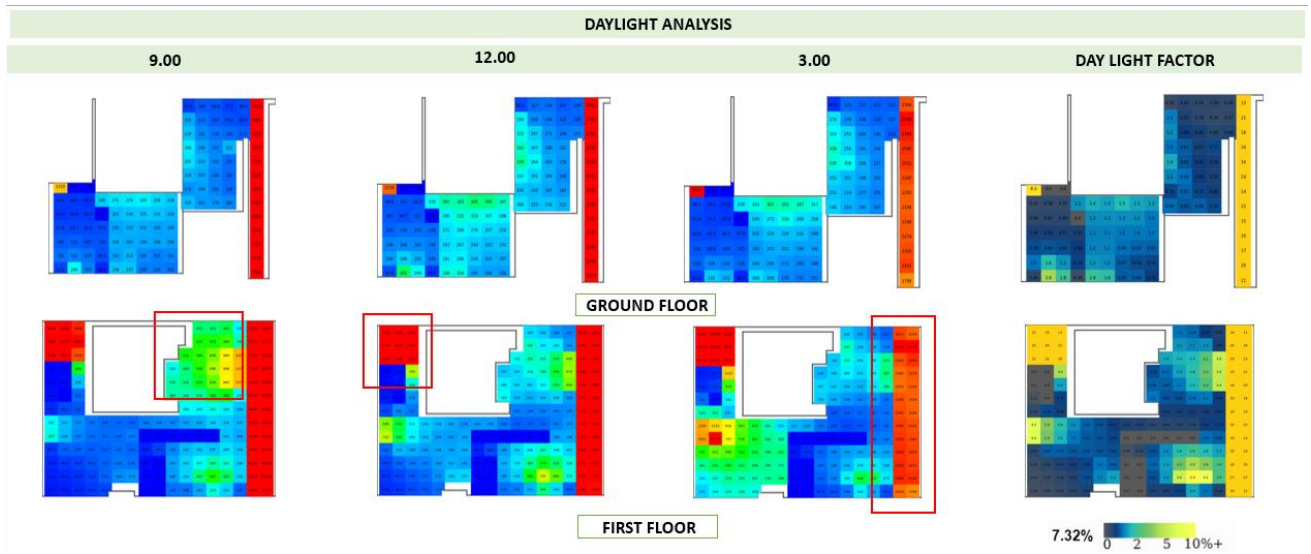
**Fig 5.6 Exhibition Area – Wind Analysis**



**Fig 5.7 Exhibition Area – Day Analysis**

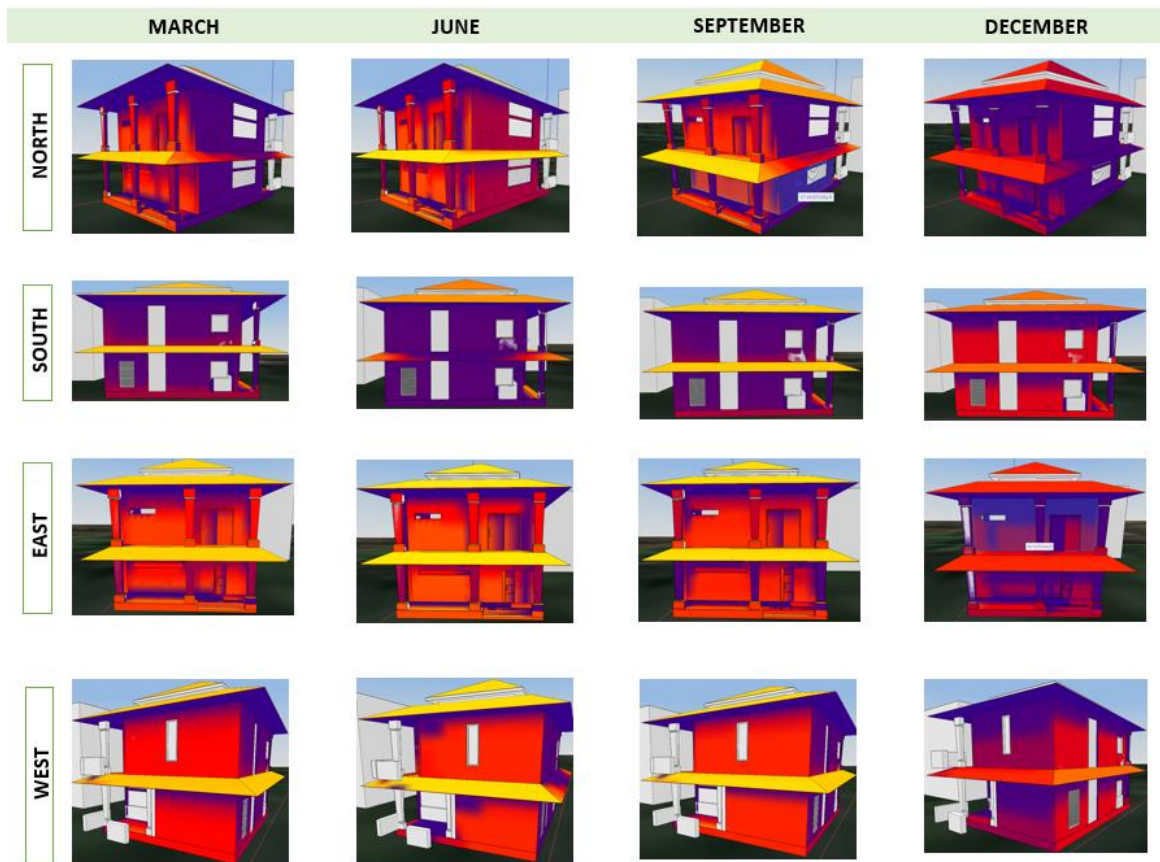
In Residential Context the optimal lighting levels are – 300 for Bedroom and Living spaces & upto 600 lux in the kitchen and spaces for precise activity. All rooms in both floors satisfy the standard lux level.

The DF is higher in East and west façade because of roof projection rooms receives 0 – 2 DF it satisfy the SP 41 standards. Other spaces are within comfort zone.. Sit out and balcony receives higher day light factor



**Fig 5.8 Exhibition Area – Day Analysis**

- Long, steep sloping roof built to protect the house's walls and to withstand the heavy monsoon. Which also control the radiation.
- The southern wall and western wall are 24 centimeters thicker than the rest of walls to protect from intense rays of sun.
- VERANDAH all around the building for protection
- COURTYARD : Openings are fewer towards the exterior and more towards the courtyard taking in less radiation and facilitating air circulation.



**Fig 5.9 Block 2 - Radiation Analysis**

|                         | <i><b>NORTH</b></i> | <i><b>SOUTH</b></i> | <i><b>EAST</b></i>  | <i><b>WEST</b></i>  | <i><b>ROOF</b></i>  |
|-------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| <i><b>MARCH</b></i>     | <i><b>17.22</b></i> | <i><b>26.39</b></i> | <i><b>177.7</b></i> | <i><b>146.8</b></i> | <i><b>260.6</b></i> |
| <i><b>JUNE</b></i>      | <i><b>74.84</b></i> | <i><b>23.06</b></i> | <i><b>186.2</b></i> | <i><b>164.5</b></i> | <i><b>275.2</b></i> |
| <i><b>SEPTEMBER</b></i> | <i><b>17.48</b></i> | <i><b>25.88</b></i> | <i><b>166.5</b></i> | <i><b>163.7</b></i> | <i><b>298.1</b></i> |
| <i><b>DECEMBER</b></i>  | <i><b>11.12</b></i> | <i><b>119.8</b></i> | <i><b>83.74</b></i> | <i><b>36.51</b></i> | <i><b>206.4</b></i> |

**Table 5.3**

- Buildings are orientated towards true North though the North and East wall receives lesser radiation compare to the south and west.
- Block arrangement with spacing Private zone which cast shadow over the adjacent blocks reducing heat gain and also increase the wind movement in between the blocks.
- Extended roof also protects the wall which helps to shade the wall.

## **5.4 INFLUENCE OF CLIMATE**

Kerala has a warm humid climate. The rainfall is very heavy from southwest and northeast monsoons. To keep the rain and sun away from the walls the roofs of the building come down very low. They have veranda all-round the building protecting the external walls from sun and rain. The width of the veranda varies from 2 ft to 12ft. In rooms where people spend most of their time during day the window openings were brought in at ground level otherwise the windows were small so that there was only subdued light inside or had timber jalis to give diffused light without glare. They also have an internal courtyard for better flow of air.

## **5.5 STRUCTURE :**

### **5.5.1**

The most common type of flooring was that of beaten earth polished with cow dung at regular intervals. Black colored traditional flooring used in the more expensive buildings was done with the mixture of lime, sand, coconut shell, white of egg, jaggery, coconut water and other vegetable extracts. The smoothness was achieved by polishing the floor with a particular variety of banana.

### **5.5.2 WALL SYSTEM**

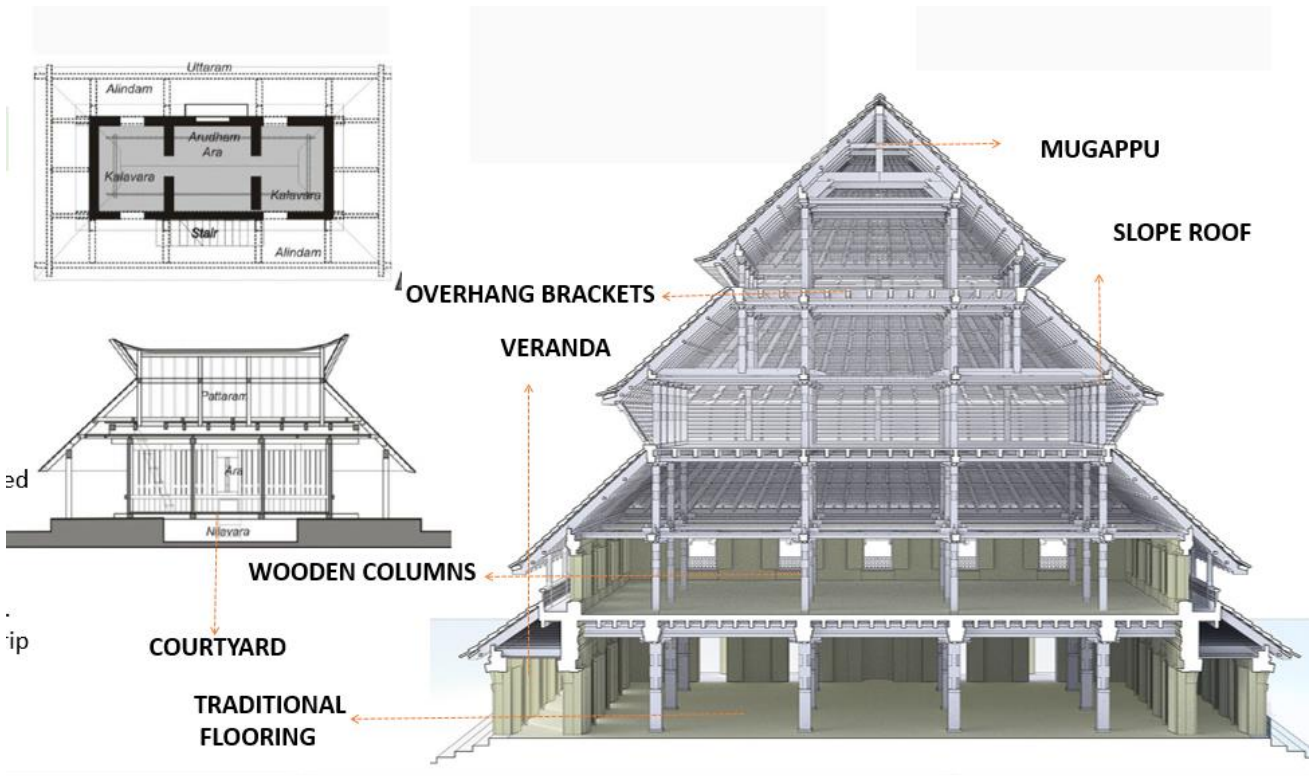
Often the walls were also of timbers abundantly available in Kerala. Gable windows were evolved at the two ends to provide attic ventilation when the ceiling was incorporated for the room spaces. Vernacular Kerala Architecture into two parts, Nalukettu and Ettukettu. Structurally the roof frame was supported on the pillars on walls erected on a plinth raised from the ground for protection against dampness and insects in the tropical climate.

### **5.5.3 ROOFING SYSTEM**

The ridged roof pitched at angles between 30degree to 40degree. The roof with intricately carved gables protruding from the roof with overhangs supported by wooden brackets. The roof is prefabricated that is different members are fixed on the ground and assembled at the top. No nails are used. The roof is kept in position by interlocking with the hole in the rafters.

### **5.5.4 FOUNDATION TYPES**

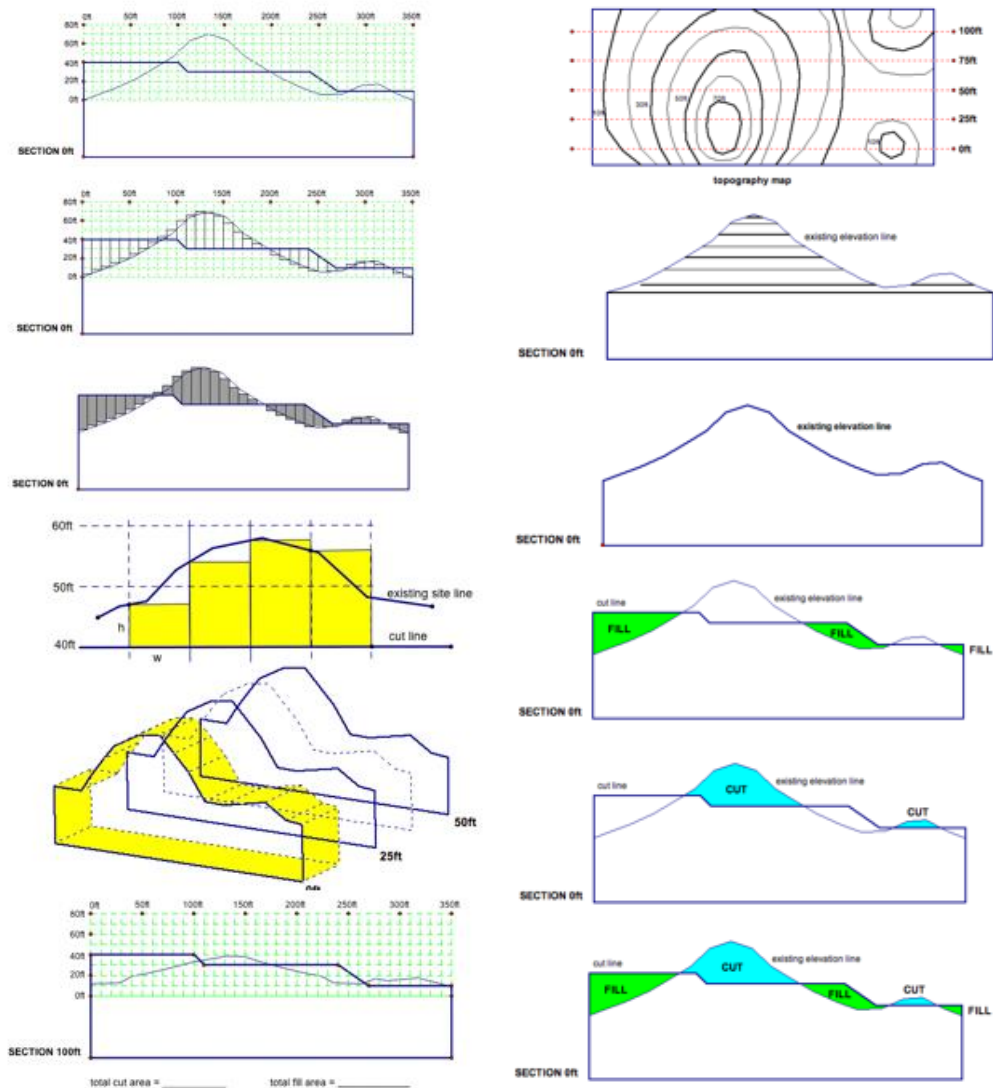
Types of foundation used in Kerala, Rubble Foundation, Pillar Footing Foundation, Raft Foundation (Strip Foundation) & Piling.



**Fig 5.5.1 Material study**

#### 5.5.4 CUT AND FILL TECHNIQUES

Various sections of a Building design will require bringing in earth. Other sections will require earth to be removed. Earth that is brought in is considered Fill while earth that is removed is considered Cut. Generally, designers generate drawings called Cut and Fill Diagrams, which illustrate the cut or fill present at any given site. This drawing is quite standard, being no more than a graph with site location on the X-axis and fill being the positive range of the Y-axis while cut is the negative range of the Y-axis.



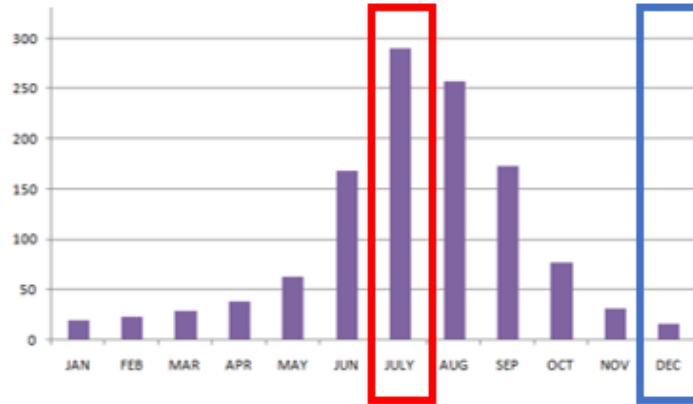
**Fig 5.5.2 Showing Typical Cut And Fill Method**



**Fig 5.5.3 Site plan**

### 5.5.5 RAINWATER HARVESTING

In the total site area 2320 sq.m of area is covered with vegetation on ground. From the total site of 41950 sq.m. 14915 sq.m area is impervious area. Maximum rainfall in the month of July and August. Minimum rainfall in the month of December. Total Rainfall area – 2410mm.



**Fig 5.5.1 Rainfall in mm**

| RAIN WATER HARVESTING IMPERVIOUS AREA CALCULATION |                                  |            |                     |                        |
|---------------------------------------------------|----------------------------------|------------|---------------------|------------------------|
| S.NO .                                            | DESCRIPTION                      | AREA(Sq.m) | Run-off coefficient | Impervious Area (Sq.m) |
| 1                                                 | Vegetation on ground             | 5703       | 0.2                 | 1140                   |
| 2                                                 | Agriculture land and Forest area | 5900       | 0.2                 | 1180                   |
| 3                                                 | Drive way                        | 1791       | 0.95                | 1701                   |
| 4                                                 | Open parking                     | 2865       | 0.95                | 2721                   |
| 5                                                 | Cemented / Tiled roof            | 6040       | 0.95                | 5738                   |
| 6                                                 | Hardscape service area           | 5420       | 0.37                | 2005                   |
| 7                                                 | Mud road                         | 1230       | 0.35                | 430                    |
| Total area                                        |                                  | 28949      |                     | 14915                  |

**Table 5.5.1 Rainwater Harvesting Calculation**

#### RAIN WATER HARVESTING TANK CAPACITY AND CALCULATION

##### ROOF TOP DRAINING AREA CALCULATION :

Rain water harvesting roof= Area of roof x  
coefficient x annual rainfall( in mm),

Area of the total roof=**6040**

Coefficient roof=**0.9**

Annual rainfall of Kannur =**2410mm**

Rain water harvesting from roof = **13,100,760**  
**litres annually.**

For the month of July

( highest rainfall ) = **3,343,140 litres annually.**

Water requirement per person = 135  
litres X 500 visitors per day = 67500 litres  
Tank size = 11m x 10m x 4m = 416cum  
416cum x 500 litres = 208000 litres

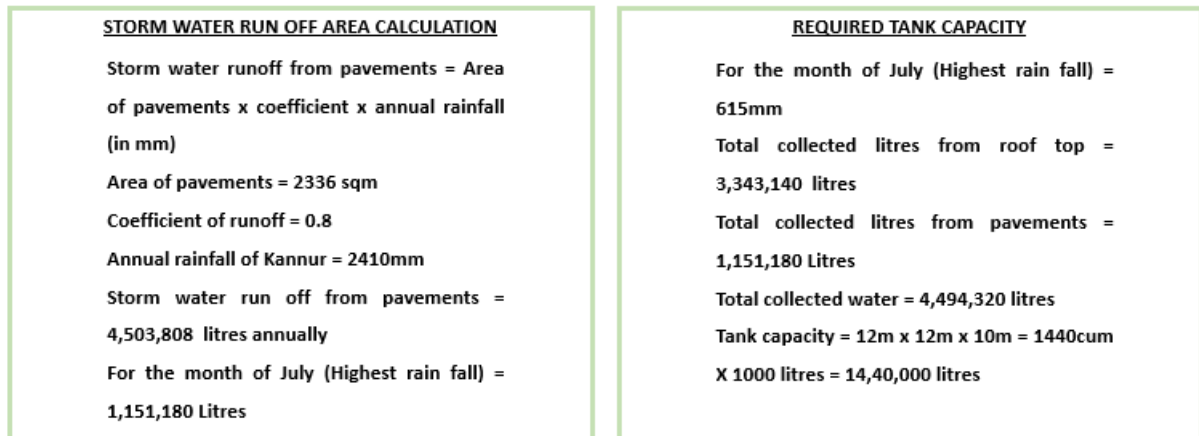
| Type of ground surface       | Coefficient of surface runoff, $F_{i\infty}$ |
|------------------------------|----------------------------------------------|
| Road:                        |                                              |
| Pavement                     | 0.70–0.90                                    |
| Permeable pavement           | 0.30–0.40                                    |
| Gravel road                  | 0.30–0.70                                    |
| Shoulder or top of slope:    |                                              |
| Fine soil                    | 0.40–0.65                                    |
| Coarse soil                  | 0.10–0.30                                    |
| Hard rock                    | 0.70–0.85                                    |
| Soft rock                    | 0.50–0.75                                    |
| Grass plot of sand:          |                                              |
| Slope 0–2%                   | 0.05–0.10                                    |
| Slope 2–7%                   | 0.10–0.15                                    |
| Slope 7%                     | 0.15–0.20                                    |
| Grass plot of clay:          |                                              |
| Slope 0–2%                   | 0.13–0.17                                    |
| Slope 2–7%                   | 0.18–0.22                                    |
| Slope 7%                     | 0.25–0.35                                    |
| Roof                         | 1.00                                         |
| Unused bare land             | 0.20–0.40                                    |
| Athletic field               | 0.40–0.80                                    |
| Park with vegetation         | 0.10–0.25                                    |
| Mountain with a gentle slope | 0.30                                         |
| Mountain with a steep slope  | 0.50                                         |
| A paddy field or water       | 0.70–0.80                                    |
| Farmland                     | 0.10–0.30                                    |

|                          |              |
|--------------------------|--------------|
| <b>Total site area</b>   | <b>41950</b> |
| Total landscape proposed | 5703         |

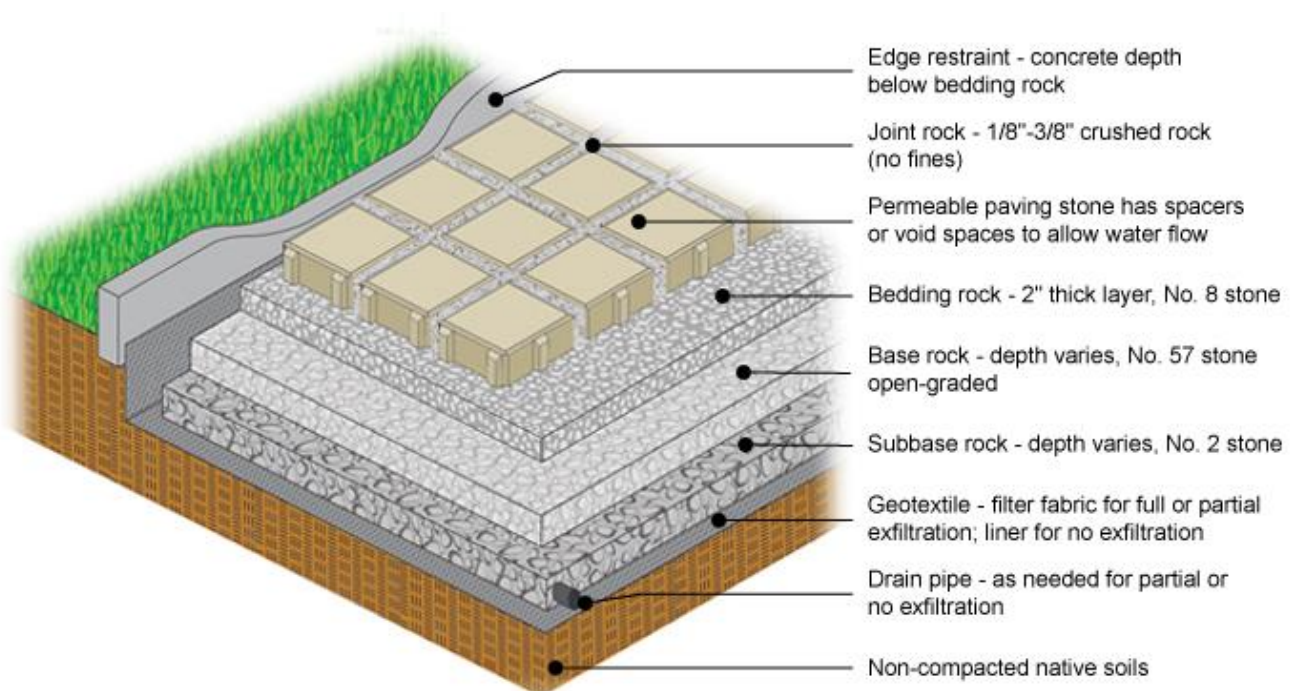
**Fig 5.5.3**

## 5.5.6 STORM WATER

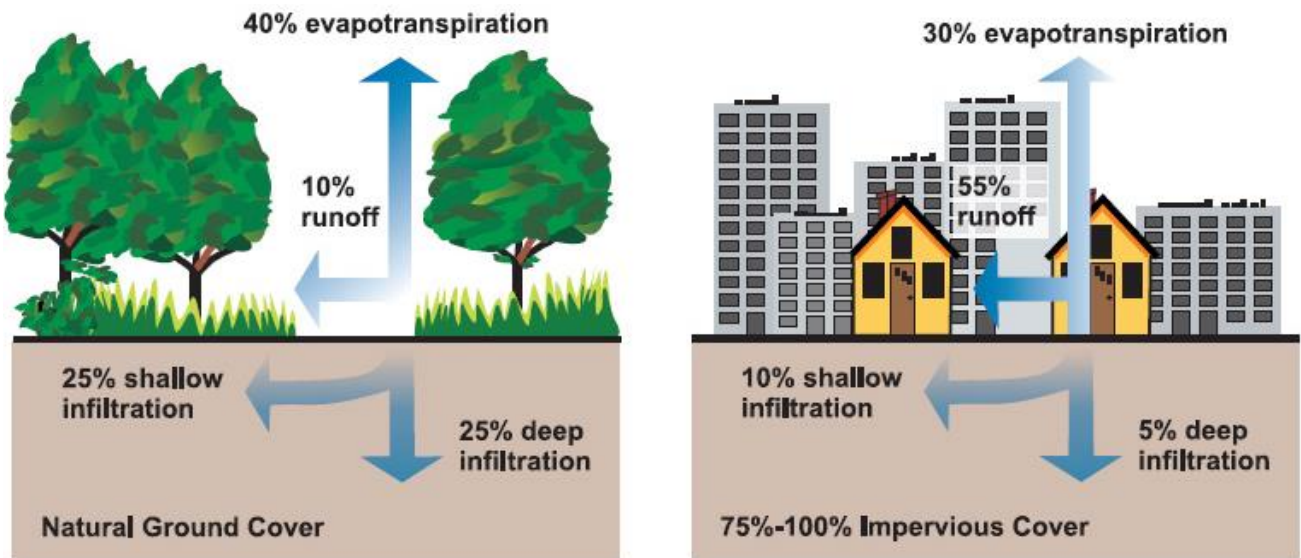
- Open-joint clinkers
- Gravel, stone chippings and shells
- Woodchips and pine bark



**Fig 5.5.4**



**Fig 5.5.5**



**Fig 5.5.6**

### 5.5.7 WASTE WATER

| S.NO.                      | SPACES           | W.C | WASH BASIN | URINALS | KITCHEN | TOTAL WATER PER USAGE |
|----------------------------|------------------|-----|------------|---------|---------|-----------------------|
| 1                          | OFFICE           | 6   | 2          | 2       |         | 13.7                  |
| 2                          | EXHIBITION       | 12  | 6          | 5       | -       | 32.4                  |
| 3                          | ART GALLERY      | 12  | 6          | 5       |         | 32.4                  |
| 4                          | RESTAURANT       | 8   | 5          | 3       | 3       | 29.8                  |
| 5                          | WORKSPACE        | 6   | 3          | 2       |         | 15.7                  |
| 6                          | ARTIST STAY AREA | 26  | 26         |         | 13      | 113.8                 |
| 7                          | RESORT           | 15  | 15         |         |         | 49.2                  |
| TOTAL CONSUMPTION OF WATER |                  |     |            |         |         | 287 Gallons           |

**Table 5.5.2**

|              |                                             |
|--------------|---------------------------------------------|
| WC           | 1.28 gallons per flush                      |
| Wash basin   | 2 gallons/min for 20 seconds = 0.67 gallons |
| Urinals      | 1 gallons per flush                         |
| Kitchen sink | 2.2 gallons per minute                      |

**Table 5.5.3**

#### WASTE WATER TANK CAPACITY

- $(\text{LENGTH} \times \text{WIDTH} \times \text{DEPTH IN FEET}) / 0.1337 = \text{gallons}$
- $(40 \times 30 \times 20) / 0.1337 = 1,79,506$  gallons
- 12m x 9m x 6m is the capacity of sewage tank on the site.
- Utilizing the natural slope on the site for the drain of waste water.
- Locating sewage tank in rear would be helpful while cleaning it and not disturb the main function

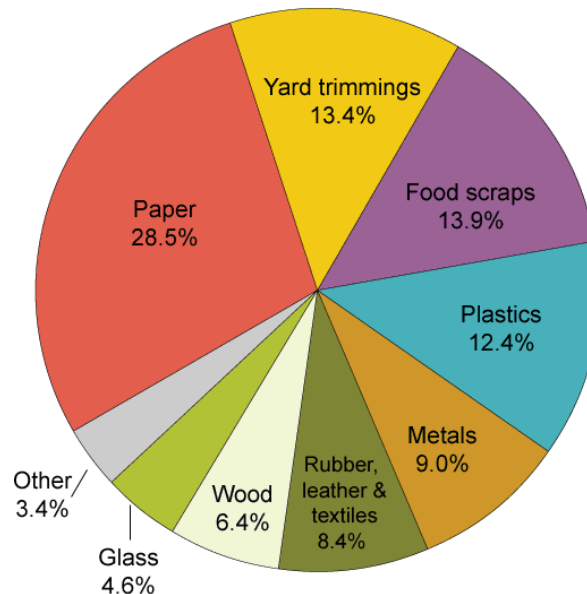
- Assuming 500 persons/day
- 143500 gallons of waste water/ day
- Providing the maximum capacity so that it does not over flow

**Table 5.5.4**

### 5.5.8 SOLID WASTE MANAGEMENT

#### Total MSW Generation (by material), 2010

250 Million Tons (before recycling)



Source: U.S. Environmental Protection Agency, *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2010* (December 2011).

**Fig 5.5.7**

| <b><i>Persons</i></b> | <b><i>Waste produced/ day (kg)</i></b> |
|-----------------------|----------------------------------------|
| <b><i>1</i></b>       | <b><i>0.30</i></b>                     |
| <b><i>3</i></b>       | <b><i>0.89</i></b>                     |
| <b><i>4</i></b>       | <b><i>1.19</i></b>                     |
| <b><i>6</i></b>       | <b><i>1.78</i></b>                     |

**Table 5.5.5**

**Source : Evaluation of household food waste generation and policy implications towards SDGs**

| <b>1BHK</b>             |         |
|-------------------------|---------|
| Number of persons       | 3       |
| Waste generated per day | 0.89kg  |
| Total no of units       | 4nos    |
| Total waste generated   | 3.56kgs |

| <b>2BHK</b>             |         |
|-------------------------|---------|
| Number of persons       | 4       |
| Waste generated per day | 1.19kg  |
| Total no of units       | 4nos    |
| Total waste generated   | 4.76kgs |

| <b>3BHK</b>             |         |
|-------------------------|---------|
| Number of persons       | 6       |
| Waste generated per day | 1.78kg  |
| Total no of units       | 3nos    |
| Total waste generated   | 5.34kgs |

|                                                                                                                                                    |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <p>Total household waste generated from residential units/ day = 13.66 kgs</p> <p>Total food/ kitchen waste generated = 80% of household waste</p> |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------|--|

**Table 5.5.6**

### 5.5.9 ENERGY ANALYSIS

| Solar panel calculation for a Day                                                                                                                  |                          |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|------------|
| Electricity produce by a single solar panel ( <u>wh</u> per day)                                                                                   | 110                      |            |
| Actual performance of solar panel based on climatic                                                                                                | 0.75                     |            |
| Average hours of sunlight per day                                                                                                                  | 5.5                      |            |
| Total electricity produced                                                                                                                         | 453.75                   |            |
| Dimension of single solar panel (standards for commercial)                                                                                         | 77"x39"-<br>30030sq.inch | 1.93sq.m   |
| Total roof area                                                                                                                                    | <b>4440</b>              |            |
| <u>No.of</u> solar panels to be installed – Roof area/Area of single solar panel                                                                   | 2300                     | 230 panels |
| Total generation of electricity in the site through solar panel – Electricity produced by a single solar panel, No of solar panels to be installed | 1,043,625                | <u>Wh</u>  |
| No of solar panels to be installed                                                                                                                 | 1043kWh                  |            |

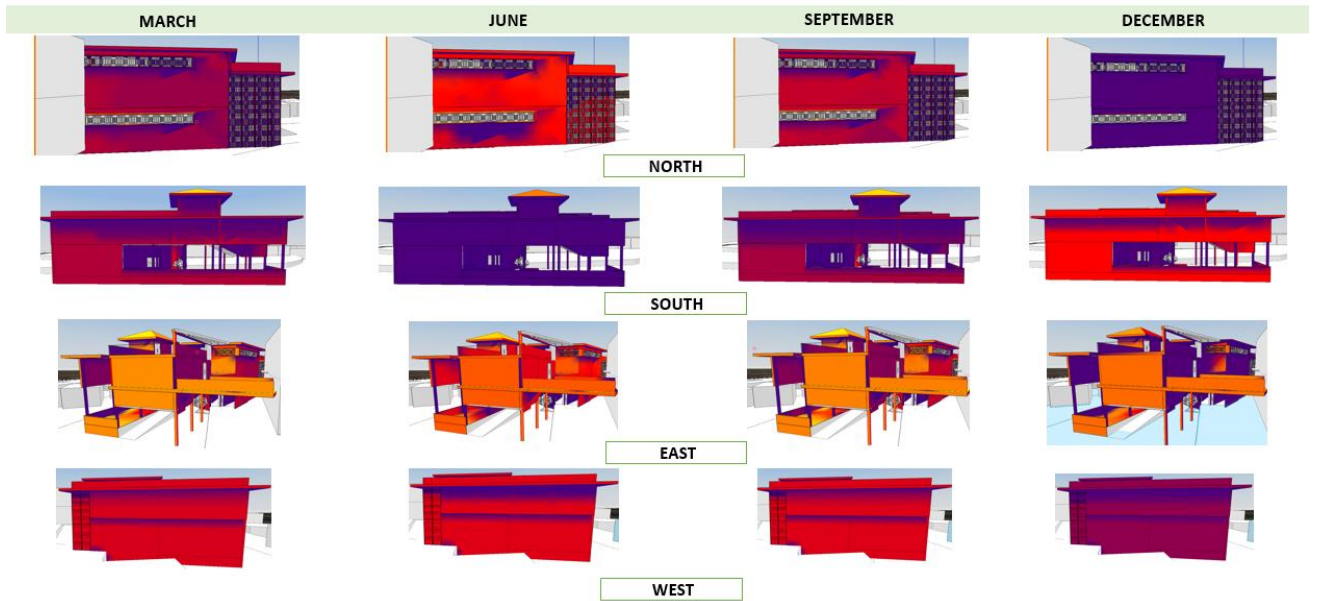
**Table 5.5.7**

| Solar panel calculation for a Day                                                                                                                  |                              |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|------------|
| Electricity produce by a single solar panel ( <u>wh</u> per day)                                                                                   | 110                          |            |
| Actual performance of solar panel based on climatic                                                                                                | 0.75                         |            |
| No of rainy days in a year                                                                                                                         | 74                           |            |
| Average hours of sunlight in a year (291 days)                                                                                                     | 1600.5                       |            |
| Total electricity produced annually                                                                                                                | 460061.25                    |            |
| Dimension of single solar panel ( standards for commercial)                                                                                        | 77"x39"-<br>30030sq.i<br>nch | 1.93sq.m   |
| Total roof area                                                                                                                                    | <b>4440</b>                  |            |
| <u>No.of</u> solar panels to be installed – Roof area/Area of single solar panel                                                                   | 2300                         | 230 panels |
| Total generation of electricity in the site through solar panel – Electricity produced by a single solar panel, No of solar panels to be installed | 1,058,140<br>,875            | <u>Wh</u>  |
| No of solar panels to be installed                                                                                                                 | 1,058,140kWh                 |            |

**Table 5.5.8**

#### 5.5.10 RADIATION ANALYSIS

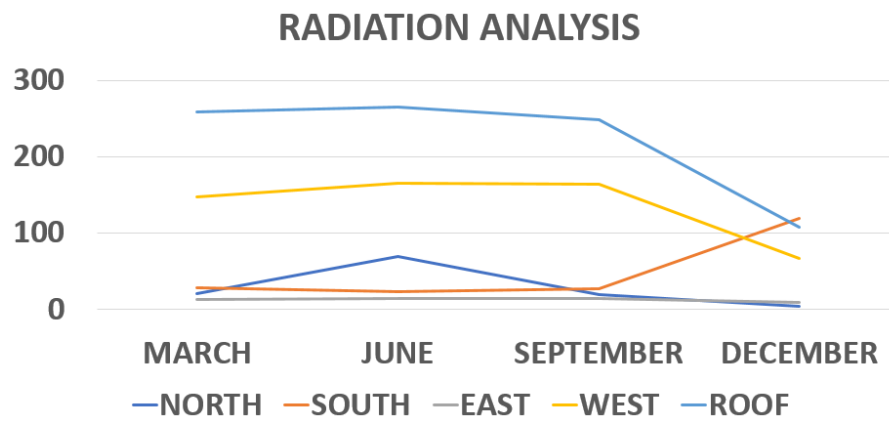
- Waiting area and walk way are provide in the west wall
- Fins in north helps to penetrated day light and cut down the radiation.
- Roof – West side receives higher radiation cool roof helps decrease the radiation entering from the roof.
- And the wall size is thicker than the other walls which helps to reduce the heat.
- East façade receives minimum radiation.



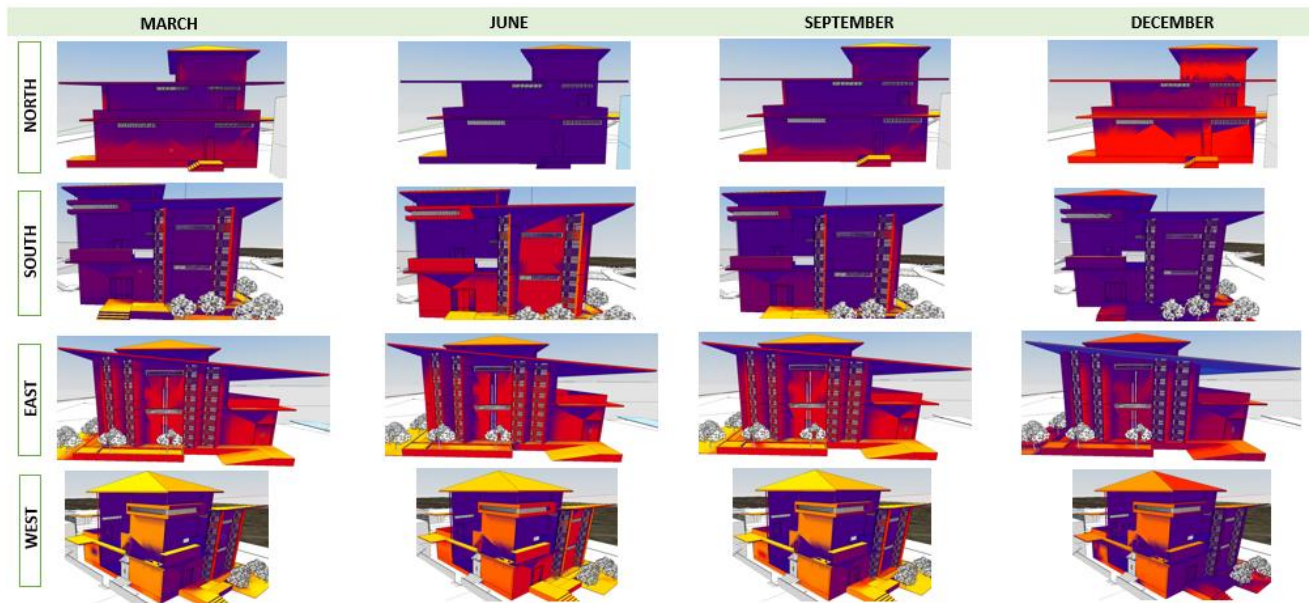
**Fig 5.5.8**  
**Exhibition area block 1 – radiation analysis**

|                  | <b>NORTH</b> | <b>SOUTH</b> | <b>EAST</b> | <b>WEST</b> | <b>ROOF</b> |
|------------------|--------------|--------------|-------------|-------------|-------------|
| <b>MARCH</b>     | 20.72        | 28.31        | 13.17       | 146.8       | 258.4       |
| <b>JUNE</b>      | 69.58        | 23.05        | 14.71       | 165.1       | 265.1       |
| <b>SEPTEMBER</b> | 19.26        | 27.38        | 14.34       | 163.7       | 247.9       |
| <b>DECEMBER</b>  | 12.47        | 119.8        | 8.86        | 67.46       | 108.3       |

**Table 5.5.9**



**Fig 5.5.9**

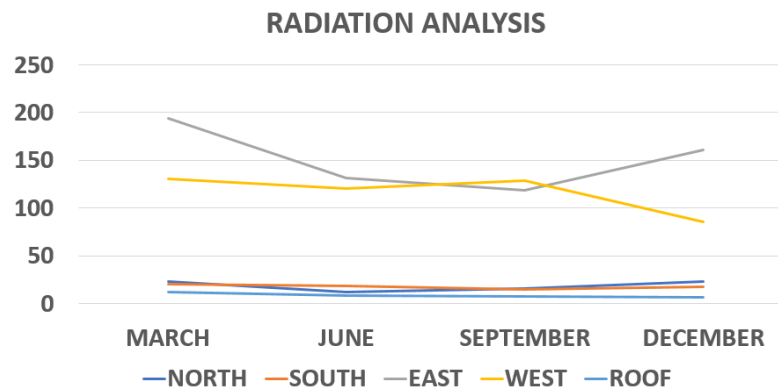


**Fig 5.5.9**  
**Exhibition area block 2 – radiation analysis**

|                  | <b>NORTH</b> | <b>SOUTH</b> | <b>EAST</b>  | <b>WEST</b>  | <b>ROOF</b>  |
|------------------|--------------|--------------|--------------|--------------|--------------|
| <b>MARCH</b>     | <b>22.95</b> | <b>20.23</b> | <b>193.5</b> | <b>130.3</b> | <b>12.35</b> |
| <b>JUNE</b>      | <b>11.52</b> | <b>18.3</b>  | <b>131.8</b> | <b>120.4</b> | <b>8.32</b>  |
| <b>SEPTEMBER</b> | <b>15.49</b> | <b>14.41</b> | <b>118.4</b> | <b>128.4</b> | <b>7.81</b>  |
| <b>DECEMBER</b>  | <b>22.59</b> | <b>17.6</b>  | <b>161</b>   | <b>85.09</b> | <b>6.04</b>  |

**Table 5.5.10**

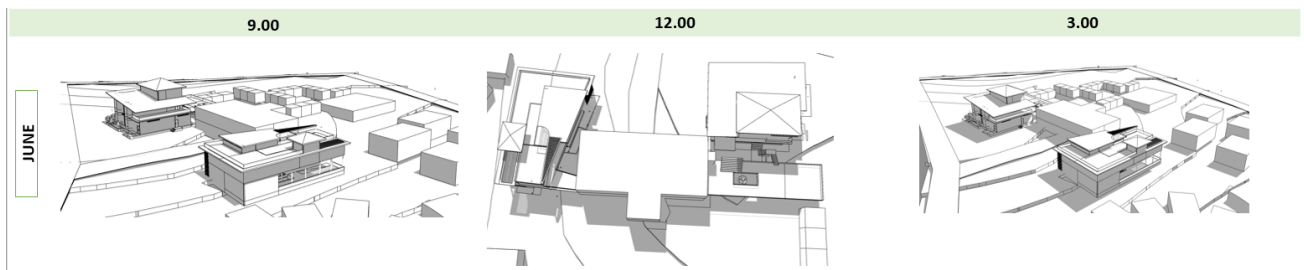
- The block arrangement proved efficient in reducing the solar radiation.
- The west façade is exposed to direct radiation, all the service area as been placed to the west direction.
- Jali screen in the north allows partial daylighting to pass through.



**Fig 5.5.11**

### 5.5.11 SHADOW ANALYSIS

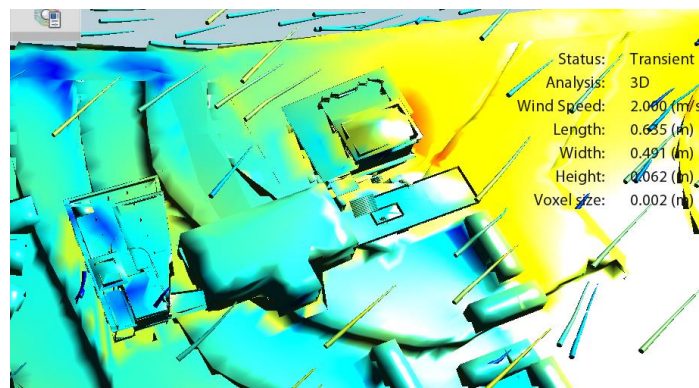
At 9 am the Shadow is observed in the North and West facades respectively. So the morning hours the critical Façade being the South and East. The jail work in the south façade helps to provide proper shade to the interiors. The Shadow analysis during the 12 pm shows that north, west and east side are shaded Still South is not shaded. The art gallery alone receive high sunlight during this time. Block arrangement helps to provide shade through out the day. The Shadow analysis during 3 pm shows that Still East and north are shaded. SW and mainly the West façade receives high radiation. Leading to higher level of heat gain in the Exhibition and Art gallery double walls and Jalli screen helps to screen the South and west portion.



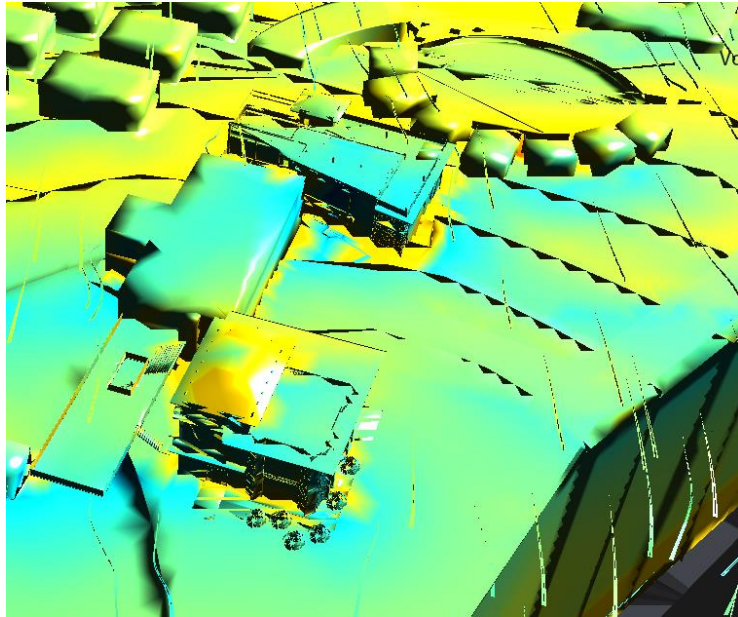
**Fig 5.5.12**

### 5.5.12 WIND ANALYSIS

- Voids helps to increases the air pressure in outdoor exhibition space and near shops . This make the space comfortable through out the day.
- Maximum wind flow is visible in the North façade.
- Minimum wind flow as been noted near exhibition area.
- Approximate wind velocity outside the building is between 4 to 6 m/s.
- All the buildings is sufficiently ventilated.
- Optimum wind flow is achieved for every space through planning strategy.
- 

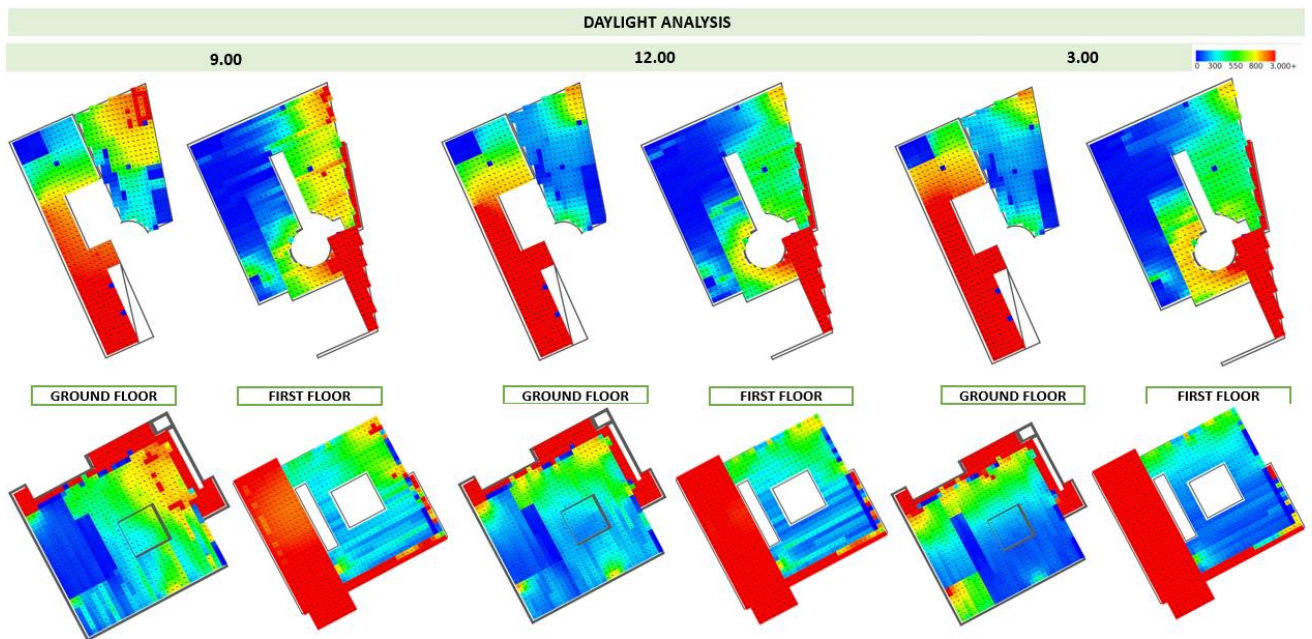


**Fig 5.5.13. North East**



**Fig 5.5.14. South west**

### 5.5.13 DAYLIGHT ANALYSIS



**Fig 5.5.15 Day light**

## TIME LAG

| MATERIALS      | THICKNESS    | TIME LAG       | MATERIALS      | THICKNESS    | TIME LAG        | MATERIALS      | THICKNESS    | TIME LAG       | MATERIALS    | THICKNESS    | TIME LAG        |
|----------------|--------------|----------------|----------------|--------------|-----------------|----------------|--------------|----------------|--------------|--------------|-----------------|
| Cement Plaster | 12.5mm       | 0.3 hrs        | Cement Plaster | 25mm         | 0.26 hrs        | Cement Plaster | 12.5mm       | 0.3 hrs        | Lime Plaster | 12.5         | 0.3 hrs         |
| Mud Brick      | 230mm        | 5.9 hrs        | Fly ash brick  | 230mm        | 8.1 hrs         | AAC block      | 200mm        | 9 hrs          | Rammed earth | 300mm        | 10 hrs          |
| Cement Plaster | 12.5mm       | 0.3 hrs        | Cement Plaster | 25mm         | 0.26 hrs        | Cement Plaster | 12.5mm       | 0.3 hrs        | Lime Plaster | 12.5mm       | 0.3 hrs         |
| <b>TOTAL</b>   | <b>255mm</b> | <b>6.5 hrs</b> | <b>TOTAL</b>   | <b>255mm</b> | <b>8.62 hrs</b> | <b>TOTAL</b>   | <b>255mm</b> | <b>9.6 hrs</b> | <b>TOTAL</b> | <b>255mm</b> | <b>10.6 hrs</b> |

**Table 5.5.11**

## RAMMEDEARTH

The walls of the building are made of rammed earth directly from raw earth with 5% cement stabilization. Not only is the technique highly effective but it is also very strong with dry crushing compressive strength ranging from 6mpa-8mpa.

## INITIAL EMBODIED ENERGY

Rammed earth walls consume 4 times less energy than a fired brick wall:

Embodied energy of Rammed earth wall = 1,112.36 MJ/m<sup>3</sup>

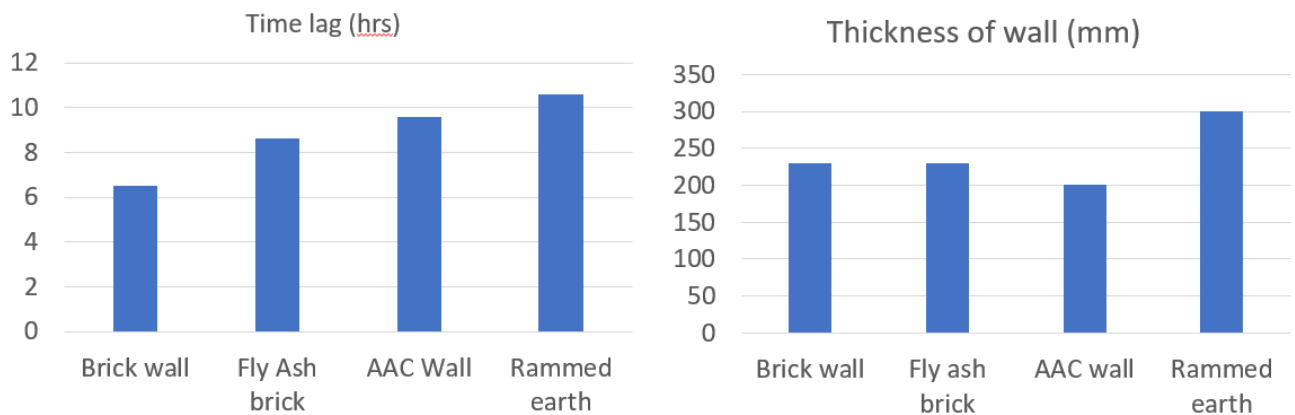
Country fired brick wall = 4,501.25 MJ/m<sup>3</sup>

## CARBON FOOTPRINT

Rammed earth walls are polluting 4 times less than country fired brick walls:

Carbon footprint of Rammed earth wall cement = 110.11 Kg of CO<sub>2</sub> /m<sup>3</sup>

Country fired brick wall = 444.12 Kg of CO<sub>2</sub> /m<sup>3</sup>



**Fig 5.5.16**

### 5.5.14 ROOF ANALYSIS

| Material Layer                         | Thickness t(m) | Thermal conductivity<br>$k(W/m.k)$ | Thermal resistance of material $R=t/k(m^2k/w)$ |
|----------------------------------------|----------------|------------------------------------|------------------------------------------------|
| Internal plaster                       | 0.02           | 0.72                               | 0.03                                           |
| RCC slab                               | 0.15           | 1.58                               | 0.10                                           |
| Cement screed                          | 0.02           | 0.72                               | 0.03                                           |
| Vapour control layer                   | 0.02           | 0.12                               | 0.17                                           |
| Water proofing                         | 0.01           | 0.17                               | 0.09                                           |
| Sum of all material thermal resistance |                |                                    | 0.472                                          |

**Table 5.5.12 Iteration 1- untreated flat roof**

| Material Layer                         | Thickness t(m) | Thermal conductivity<br>$k(W/m.k)$ | Thermal resistance of material $R=t/k(m^2k/w)$ |
|----------------------------------------|----------------|------------------------------------|------------------------------------------------|
| Broken glazed China mosaic tiles       | 0.008          | 1.5                                | 0.005                                          |
| Cement Mortar                          | 0.05           | 0.71                               | 0.070                                          |
| Hollow clay tile                       | 0.1            | 0.78                               | 0.128                                          |
| Cement mortar                          | 0.05           | 0.71                               | 0.070                                          |
| Concrete                               | 0.05           | 1.74                               | 0.029                                          |
| Polyurethane foam(PUF)                 | 0.04           | 0.02                               | 1.739                                          |
| Cement screed                          | 0.02           | 0.72                               | 0.028                                          |
| RCC slab                               | 0.15           | 1.58                               | 0.095                                          |
| Internal plaster                       | 0.02           | 0.72                               | 0.021                                          |
| Sum of all material thermal resistance |                |                                    | 2.186                                          |

| Material Layer                         | Thickness t(m) | Thermal conductivity<br>$k(W/m.k)$ | Thermal resistance of material $R=t/k(m^2k/w)$ |
|----------------------------------------|----------------|------------------------------------|------------------------------------------------|
| RCC Slab                               | 0.003          | 0.17                               | 0.017                                          |
| ceramic fuses                          | 0.08           | 0.800                              | 0.106                                          |
| RCC Slab                               | 0.003          | 0.17                               | 0.017                                          |
| Waterproof layer                       | 0.05           | 0.730                              | 0.068                                          |
| broken china mosaic finish             | 0.01           | 0.721                              | 0.013                                          |
| Sum of all material thermal resistance |                |                                    | 1.871                                          |

**Table 5.5.13 Iteration 2- cool roof**

| Material Layer                         | Thickness t(m) | Thermal conductivity<br>$k(W/m.k)$ | Thermal resistance of material $R=t/k(m^2k/w)$ |
|----------------------------------------|----------------|------------------------------------|------------------------------------------------|
| Clay roof tiles                        | 0.003          | 0.17                               | 0.017                                          |
| 25mm thermal insulation barrier        | 0.08           | 0.800                              | 0.106                                          |
| RCC Slab                               | 0.003          | 0.17                               | 0.017                                          |
| Waterproof layer                       | 0.05           | 0.730                              | 0.068                                          |
| Sum of all material thermal resistance |                |                                    | 1.871                                          |
| Time lag                               |                |                                    | <b>14hrs</b>                                   |

| Material Layer                         | Thickness t(m) | Thermal conductivity<br>$k(W/m.k)$ | Thermal resistance of material $R=t/k(m^2k/w)$ |
|----------------------------------------|----------------|------------------------------------|------------------------------------------------|
| RCC Slab                               | 0.003          | 0.17                               | 0.017                                          |
| ceramic fuses                          | 0.08           | 0.800                              | 0.106                                          |
| RCC Slab                               | 0.003          | 0.17                               | 0.017                                          |
| Waterproof layer                       | 0.05           | 0.730                              | 0.068                                          |
| broken china mosaic finish             | 0.01           | 0.721                              | 0.013                                          |
| Sum of all material thermal resistance |                |                                    | 1.871                                          |
| Time lag                               |                |                                    | <b>14hrs</b>                                   |

**Table 5.5.14 Iteration 1- untreated flat roof**

## **CHAPTER 6**

### **SUMMARY AND CONCLUSION**

The traditional and vernacular architecture gives solutions that are in perfect harmony with nature. Indoor air quality control inside the building is always an important aspect of traditional architecture. Vernacular and traditional architecture and construction are ecologically responsive and energy efficient. Traditional vernacular way of living was inherently energy efficient. A modern lifestyle with strong connectivity to the environmental and climatic context, all the materials and technologies used, and functional distribution of space clearly says that the energy consciousness prevalent in the society. Many of the traditional design element and features which are replicated in modern buildings were the functional utility of the buildings are lost while replicating them. Appropriate planning devices and design strategies like courtyards, suitable orientation, internal zoning, passive strategy, envelope design, materials, construction techniques, responsive roof design and appropriate fenestration design should be employed. The traditional architecture styles and construction techniques gives solution which are in perfect harmony with nature.

Considering indoor Air and Light quality the vernacular style are ecologically responsive and energy efficient. Through the given design and technique we are able to connect people with the outdoor space with ecologically responsive aspects. Taken consideration of the climate change the site and blocks are designed for future aspects. Traditional construction techniques are strong and have travelled its ages which are strong example for believe and learn from the old construction method. A modern life style need modern solution therefore clubbing the traditional and modern factors together balancing the traditional values and modern life style. Benefit of cost cutting and nature friendly design has been seen and achieved. Through the design we were able to achieve both living and giving back to nature aspect are considered. And this will create a great impact in social and ecologically level.

## Reference

- 1) <https://www.irjet.net/archives/V8/i4/IRJET-V8I476.pdf> - A Study of IGBC and GRIHA Rating Systems for Individual Residential Unit
- 2) Journal of Energy Research and Environmental Technology (JERET) p-ISSN: 2394-1561; e-ISSN: 2394-157X; Volume 4, Issue 2; April-June, 2017, pp. 194-198
- 3) <https://www.ijser.org/researchpaper/A-Review-on-various-Green-Building-Rating-Systems-in-India.pdf>
- 4) I.M. Chethana S. Illankoon<sup>a</sup> Vivian W.Y. Tam<sup>ab</sup> Khoa N. Le<sup>a</sup> Liyin Shen<sup>c</sup>  
<https://doi.org/10.1016/j.jclepro.2017.06.206>
- 5) Akadiri, P. O., Chinyio, E. & Olomolaiye, P. (2012) Design of A Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector. Buildings, Volume 2, pp. 126-152.
- 6) Gupta, Neha. (2018). Exploring passive cooling potentials in Indian vernacular architecture.
- 7) Koenigsberger O.H., Ingersoll T.G., Mayhew A. and Szokolay S.V., Manual of tropical housing and building, part 1 – climatic design, Orient Longman, Madras, 1975
- 8) A ventilated courtyard as a passive cooling strategy in the warm humid tropics  
Rajapaksha a, H. Nagai b, M. Okumiya
- 9) Climate responsive Building (SKAT, 1993)
- 10) Vernacular Architecture in the MENA Region: Review of Bioclimatic Strategies
- 11) "Green Building -US EPA". [www.epa.gov](http://www.epa.gov).
- 12) [https://www.grihaindia.org/files/Manual\\_Voll.pdf](https://www.grihaindia.org/files/Manual_Voll.pdf) - The Energy and Resources Institute (TERI)