ECO-VILLAGE FOR THE HOMELESS AT MAHABALIPURAM, CHENNAI

A Thesis

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

By

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MAY 2022

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BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **SHIFANA FATHIMA.V (40890016)** who carried out the Thesis entitled "**ECO-VILLAGE FOR THE HOMELESS AT MAHABALIPURAM, CHENNAI**" under our supervision from January 2022 to May 2022.

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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. Krithikha Muthukrishnan ,** (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. Sanghavi .V.V** 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

There has been a rise in homeless people in Chennai for the past years and they are in this situation due to various reasons one of which is the affordability of the houses (higher rent aspects) so they prefer to be living on the streets to survive . To eradicate this issue there are few ways such as providing them compact (mico-living/co-living) spaces,a long term job solutions and other basic requirement which is currently not provided to them.This study aims to To design an **eco-village** for the homeless community in mahabalipuram, Chennai. Eco-village by the term is understood to be a community based living which creates minimal impact towards the environment and to provide a hollistic approach. The location (Mahabalipuram) is selected through the result of the homeless survey conducted in the location. As the design requires a revenue generation, tourist accomodations and other revenue generating spaces are provided in the eco-village. This study mainly concentrates on four important building typology in the eco-village.

TABLE OF CONTENTS

CHAPTER No.	TITLE	PAGE No.
	ABSTRACT	**v**
	LIST OF TABLES	**ix**
	LIST OF FIGURES	**xi**
1	**INTRODUCTION**	**1**
	1.1 INTRODUCTION	1
	1.2 AIM	1
	1.3 RESEARCH QUESTIONS	1
	1.4 OBJECTIVE	1
	1.5 NEED FOR THE STUDY	1
	1.6 SCOPE AND LIMITATIONS FOR THE STUDY	2
2	**DESIGN APPROACH - METHODOLOGY**	**3**
	2.1 METHODOLOGY OF THE THESIS	3
3	**BACKGROUND STUDY**	**4**
	3.1 INTRODUCTION	4
	3.1.1 Definition of eco-village	4
	3.1.2 Need for an eco-village	4
	3.1.3 Attributes of an eco-village	4

3.2 HISTORY 4

3.3 PRINCIPLES OF AN ECO-VILLAGE 4

3.4 CHARACTERISTICS OF AN ECO-VILLAGE 5

3.5 ECO-VILLAGE AS A SUSTAINABLE COMMUNITY 5

3.6 FUNDING ASPECTS OF THE ECO-VILLAGE 6

3.7 CHALLENGES OF AN ECO-VILLAGE AND SOLUTIONS 7

4 LITERATURE STUDY 8

4.1 LOCATION DETAIL 8

4.2 POTENTIAL SITE IDENTIFICATION 8

4.3 COASTAL REGULATION ZONE 8

4.4 CODES & STANDARDS TO BE FOLLOWED 9

4.5 RATING SYSTEM ANALYSIS 10

4.6 SITE ANALYSIS 11

4.7 LIVE CASE STUDY 15

4.7.1 LIVE CASE STUDY – Kanchi eco-village, Kanchipuram 15

4.8 LITERATURE CASE STUDY 19

4.9 COMPARITIVE ANALYSIS OF THE CASE STUDIES 23

4.10 MACRO AND MICEO CLIMATE ANALYSIS 26

4.11 SITE ZONING 30

4.12 DETAILED MATERIAL ANALYSIS 33

4.13 DESIGN IDEOLOGIES AND SPACE PLANNING 44

5 VENTILATION, THERMAL AND IGBC TOWNSHIP RATING

CALCULATION **58**

5.1 VENTILATION CALCULATION 58

5.2 INDOOR WIND SPEED CALCULATED FOR ALL THE MONTHS 59

5.3 THERMAL ANALYSIS 60

5.4 IGBC TOWNSHIP RATING STUDY 62

6 CONCLUSION: SUSTAINABLE DEVELOPMENT GOALS **68**

6.1 SUSTAINABLE DEVELOPMENT GOALS 68

6.2 CONCLUSION 70

REFERENCES **71**

APPENDICES **72**

LIST OF TABLES

TABLE No.	TITLE	PAGE No.
1.6.1	Previous study, research, formulation and designing of the thesis	2
3.7.1	Challenges in an eco-village and their possible solution	7
4.4.1	Codes and standards to be followed	9
4.5.1	Research paper : Indian green rating system	10
4.5.2	Comparative table of the three rating categories	10
4.6.1	SWOT Analysis of the site	11
4.8.1	Home types, floors and units	20
4.9.1	Comparative analysis of all the case studies	23
4.9.2	Takeaways from the case studies for the proposal	25
4.9.3	Arrival of spaces through survey analysis	25
4.10.1	Comprehensive table of temperature, humidity and wind speed	27
4.10.2	Micro climate analysis of Solstice & Equinox	28
4.11.1	Justification of Zoning 1 & 2	32
4.11.2	Activity mapping	33
4.12.1	Research paper – Earth material analysis	34
4.12.2	Comparison between CSEB blocks and Rammed earth blocks	35
4.12.3	Window detail	38
4.12.4	Research paper: Passive cooling roof study	39
4.12.5	Transmittance of roof - 1	40
4.12.6	Transmittance of roof – 2	40
4.12.7	Research paper: Sloped roof study	40

4.12.8 Material sourcing table 43

4.12.9 Area statement 44

4.13.1 5 Different planning ideologies, Form factor & solar insolation analysis 46

4.13.2 Homeless accommodations shadow and solar insolation analysis 47

4.13.3 Homeless accommodations daylight analysis 48

4.13.4 ECBC Samhita calculations for homeless accommodations 48

4.13.5 5 Different planning ideologies, Form factor & solar insolation analysis 49

4.13.6 Tourist accommodations shadow and solar insolation analysis 51

4.13.7 Tourist accommodations daylight analysis 52

4.13.8 Children dormitory shadow and solar insolation analysis 54

4.13.9 Children dormitory daylight analysis 54

4.13.10 Common house shadow and solar insolation analysis 57

5.1.1 Ventilation calculation of all the four buildings 58

5.2.1 Acceptable wind speed compared to the achieved wind speed 59

5.3.1 Outdoor average temperature from ecotect thermal analysis result 61

5.4.1 IGBC Township rating feasibility report 62

5.4.2 Energy calculation 65

5.4.3 IGBC Township rating feasibility report – Innovation and total points Achieved 66

6.1.1 Tabulated result from the wheel of SDG's 69

6.2.1 Objective and research questions answered 70

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
1.1.1	Justification for the need for an eco-village	1
2.1.1	Design approach - Methodology	3
3.2.1	Timeline representing the emergence of eco-villages over the world	4
3.6.1	Steps regarding the cash flow generation	6
3.6.2	Details regarding the project's cost and revenue generation model	6
4.1.1	Mahabalipuram tourist's potential, census and literacy data	8
4.2.1	Site Identification and Selection	8
4.3.1	Coastal regulation zone map	9
4.6.1	Site proximity from the shore temple	12
4.6.2	Site Proximity details	12
4.6.3	Traffic pattern analysis	13
4.6.4	Traffic pattern analysis graph	14
4.6.5	Contour section	14
4.6.6	Contour in plan	15
4.7.1.1	Temperature and humidity of Kanchipuram	15
4.7.1.2	Live case study checklist	16
4.7.1.3	Site plan of Kanchi eco-village	16
4.7.1.4	Cottage plan of Kanchi eco-village	17
4.7.1.5	Solar insolation analysis of the cottage	17

4.7.1.6 Wall material comparison 18

4.7.1.7 Lighting analysis of the cottage 18

4.7.1.8 View of kanchi eco-village 19

4.8.1 Climate of Bangalore 19

4.8.2 Site plan of Malhar eco-village 20

4.9.1 Scale of the proposed eco-village 24

4.9.2 Passive strategies 26

4.10.1 Temperature of Chennai 26

4.10.2 Humidex value 27

4.10.3 Uncomfortable hours of temperature and humidity 27

4.10.4 Nicol Graph 28

4.10.5 Site after the addition of the temperature, humidity and wind layers 29

4.11.1 Site zoning, option – 1 31

4.11.2 Site zoning, option – 2 32

4.12.1 6 Different earth materials 34

4.12.2 CSEB block material composition and different sizes 36

4.12.3 CSEB Wall composition for different building 37

4.12.4 Foundation detail 37

4.12.5 Conventional roof composition 38

4.12.6 Filler slab details 39

4.12.7 Roof composition details 41

4.12.8 Flooring details in tourists 41

4.12.9 Staircase, railing and baluster details 42

4.12.10 Stone column and Sloped roof details 42

4.12.11 Stone column and Sloped roof details 43

4.13.1 Design Concept 44

4.13.2 Ideology behind planning & section 45

4.13.3 Understanding the mind of the homeless 45

4.13.4 Spatial planning of ground and first floor plans 47

4.13.5 Exterior views of homeless accommodations 49

4.13.6 Tourist accommodation ground floor plan 50

4.13.7 Tourist accommodation first floor plan 51

4.13.8 Tourist accommodation exterior views 52

4.13.9 3 different form evolution and conceptual planning 53

4.13.10 Form-3 planning evolution 53

4.13.11 Spatial planning of Children dormitory 53

4.13.12 Exterior view of children dormitory 55

4.13.13 Common house conceptual planning and section 55

4.13.14 Conceptual view and roof ideas 56

4.13.15 Spatial planning of common house and daylight analysis 56

4.13.16 Exterior view of the common house 57

5.1.1 Daylight analysis in children dorm space after window additions 59

5.1.2 SP41 Ventilation standards 59

5.3.1 Critical space identified to do the thermal analysis and the results

	Tabulated	60
5.3.2	Indoor average temperature of every month on critical day and time	61
5.3.3	Native tree species identified from kanchipuram district data	62
5.4.1	Rain water run-off calculation	64
5.4.2	Daily domestic water demand calculation	64
5.4.3	Bio gas plant study	65
5.4.4	Cost and payback study	66
5.4.5	Overall site plan	67
6.1.1	SDG’s – Culture and economy	68
6.1.2	SDG’s – Ecology and social	68
6.1.3	SDG’s – Result	69

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

In today's time, the main challenge is to address is the climate change caused by environmental pollution (air, water, land and noise) which are very crucial and we need strategies to reduce them, the negative impact towards the environment is caused by the human interventions. This has also contributed towards worsening the health of the people, as per world health organization report, it is estimated that there are 7 million people are killed worldwide every year due to air pollution and due to the raising issues related to this, people have started to create sustainable community development which intends towards reducing the negative impact towards the nature and these types of communities are called eco villages.

Eco-village is an integrated community development which are created either by like-minded people or formed by any organization or an individual who are interested to provide a sustainable community.

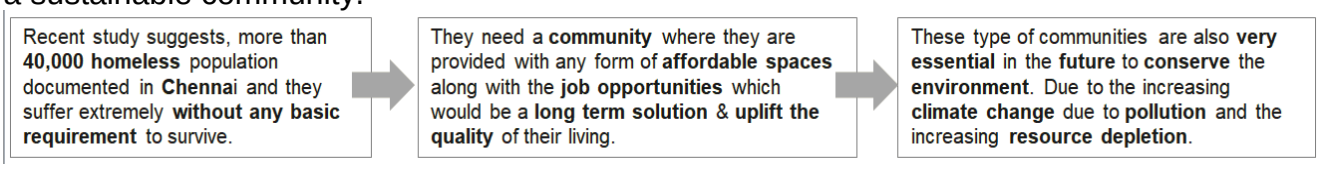


Fig 1.1.1: Justification of the need for eco-village

1.2 AIM

To design an **eco-village** for the homeless community in mahabalipuram, Chennai.

1.3 RESEARCH QUESTIONS

1. Which rating system would be appropriate and beneficial to be followed for the eco village?
2. What are all the long term sustainable solutions developed in this community?
3. What are the different revenue generating aspects created in the eco-village?

1.4 OBJECTIVE

1. To design an eco-village in such a way that the ecological footprint is reduced as much as possible.
2. To incorporate co-living/co-housing strategies in the space planning for the focused user groups.
3. To involve essential energy alternatives and passive strategies to the eco-village by understanding the site and the requirement.
4. To provide a divergent user experience for the people.

1.5 NEED FOR THE STUDY

As there is an increase in the social, cultural and economic crisis in many areas in the world, it's only fitting that there has to be some changes in the lifestyle. In India, Delhi is

responsible for being the first highest carbon dioxide emitting cities and Chennai lies in the fourth as per a research by energy and wetland research group. So, eco-villages can be perceived as a more positive movement towards the sustainable future. Affording a home has become a crisis for most of the people, due to reasons like increasing population high rent, high land cost & land crunch in most of the location and other related issues. The most affected people are the lower income and the homeless communities. They need a community where they are provided with any form of affordable spaces along with the job opportunities which would be a long term solution & uplift the quality of their living. These types of communities are also very essential in the future to conserve the environment. By understanding the concept of sustainable communities like eco-villages and the opportunities offered in them, their need can be satisfied.

1.6 SCOPE AND LIMITATIONS OF THE STUDY

Table 1.6.1: Previous study, research, formulation and designing of the thesis

PREVIOUS STUDIES	Study about **eco-villages and smart eco-villages** through relevant **case studies and research paper**, Study related to the **homeless population in Chennai** and identifying **homeless shelter** and finding mahabalipuram **needs an eco-village** than the other place, **Socio economic demographics** of the homeless group is analyzed through **survey analysis and finally suitable** site is identified.
RESEARCH	Detailed study regarding the **sustainable solutions & passive strategies** suitable for the eco-village.
FORMULATION	To formulate **design brief** along with the **area statement** & other **essential requirement**.
DESIGNING	Designing an **eco-village** by incorporating all the studies which are done earlier, which will be **Quantified** through **simulation** wherever necessary.

The limitations of the study are as follows,

1. The eco-village is exclusively designed for the primary (Homeless) and secondary user (tourists) groups.
2. The entire site selected will not be built, as per the requirement only part of it will be built.
3. The eco-village will not be a net zero/positive energy community but will follow a green rating in terms of energy conservation.

CHAPTER 2
DESIGN APPROACH - METHODOLOGY

2.1 METHODOLOGY OF THE THESIS

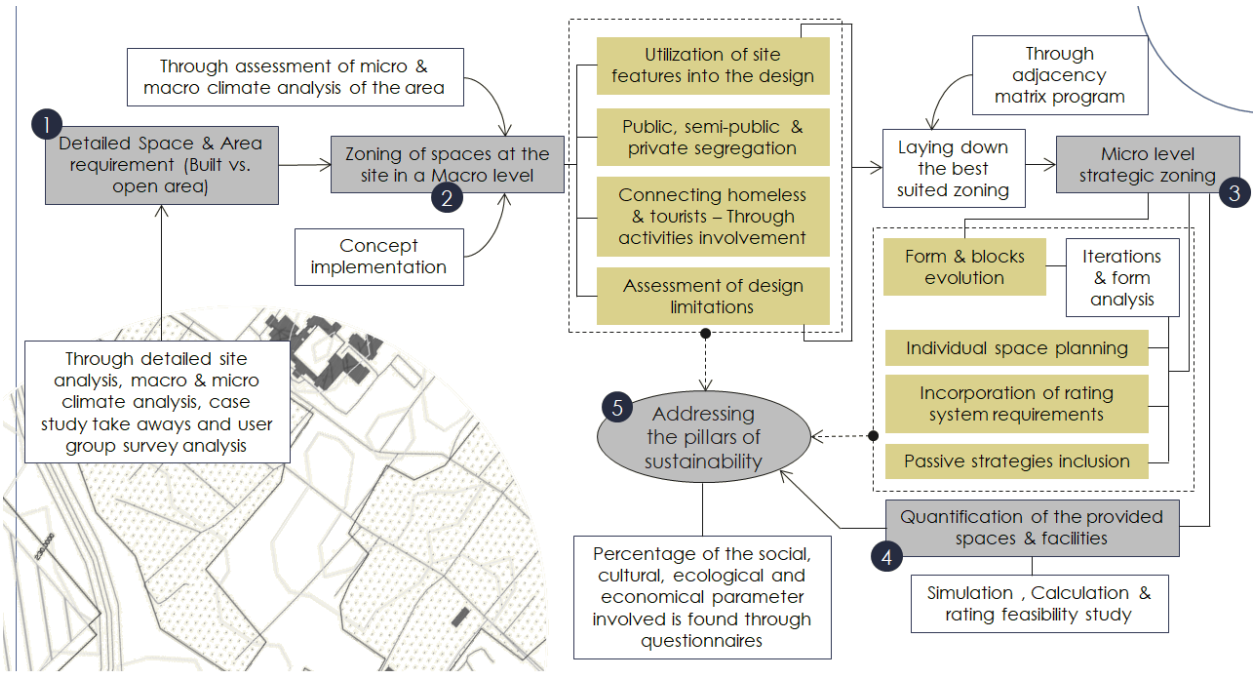


Fig 2.1.1: Design approach - Methodology

Through detailed site analysis, macro & micro climate analysis, case study take away and user group survey analysis, detailed space & area requirement with built vs. open area (Stage 1) followed by the zoning of spaces of the site in a macro level which is done through the assessment of micro and macro climate analysis of the area. Concept ideologies are also incorporated in this stage (Stage 2). Zoning of spaces are also done using utilization of site features into the design, Public, semi-public and private segregation, Connecting homeless and tourists through the activities involvement and assessment of design limitations. After identifying the best suited zoning which is done through the space adjacency matrix program followed by the micro level strategic zoning (Stage 3) which is done through form & block evolution by various iterations and form analysis, Individual space planning, Incorporation of rating systems requirements and passive strategies inclusion. Stage 4 involves quantification of the provided spaces and facilities through simulation, calculation and rating feasibility study. In stage 5, addressing the pillars of sustainability through the percentage of the social, cultural, ecological and economical parameter involved is found through self-evaluated questionnaires.

CHAPTER 3
BACKGROUND STUDY

3.1. INTRODUCTION

3.1.1 Definition of eco-village :

An eco-village is an integrated community living space, setting up a goal towards becoming more socially, economically and environmentally sustainable. Mainly seeking way to reduce the negative impact towards the environment by restoring & regenerating resources, through building design and through people's life style choices, In terms of finding alternative for electrical energy, water usage & food production, transportation, waste treatment systems and incomes such as shared local community bank facilities.

3.1.2 Need for an eco-village :

1. To improve the quality of the people.
2. To reduce the resource depletion.
3. To provide more connection between the people and the environment.
4. To reduce the carbon emission and urban heat island.
5. To understand the value of the community by living in a shared space.

3.1.3 Attributes of an eco-village :

1. Community preference
2. Participation of the citizens
3. Working with their own resources and embracing the shared values
4. Educational facilities and training facilities

3.2 HISTORY

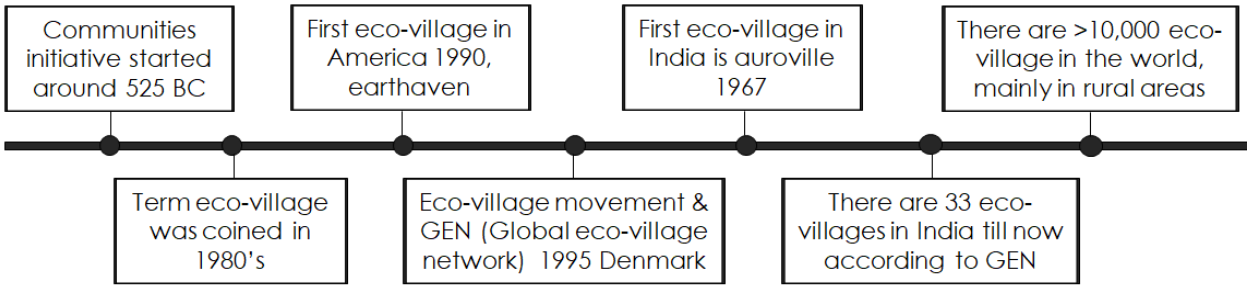


Fig 3.2.1: Timeline representing the emergence of eco-villages over the world

3.3 PRINCIPLES OF AN ECO-VILLAGE

The principles of eco-village are,

1. Achieving a sustainable lifestyle.
2. Proper management of the resources.
3. Proper water, waste management and efficient agricultural practice.
4. Preserving the environment.
5. Importance towards health and well-being.
6. Social, cultural and economic development.

3.4 CHARACTERSTICS OF AN ECO-VILLAGE

The characteristics of an eco-village are,

1. Permaculture design: There are certain set of principles involved in creating a permaculture design there, maximum maintenance and minimum waste of water, providing diverse features, Multifunctional aspects, No harm towards the environment and self-sufficient community.
2. Construction of buildings using local and natural materials.
3. Off-grid power supply production.
4. Providing alternative technology and using renewable energy.
5. Sustainable agricultural practices and food production.
6. Projects associated with earth-restoration.
7. Providing service to specific those who are in need: Identifying the foremost important user group who would be benefited by this initiation.
8. Usage of local currency.
9. Cottage industries in site.
10. Community participatory deciding process.
11. Proper management in terms of conflict resolution.
12. Providing connection between the community members and skill developments.

3.5 ECO-VILLAGE AS A SUATAINABLE COMMUNITY

Ecology:

1. Sustainable agriculture: Growing seeds and food production.
2. Better water management.
3. Renewable energy production and alternative energy transportation.
4. Green building techniques and innovative ideas.
5. Energy from waste generated.

Social:

1. Nurture variety and concord for thriving communities.
2. Develop fair, powerful and accountable institutions.
3. Practice struggle facilitation, communiqué and peace constructing skills.
4. Empower collaborative management and participatory selection making.
5. Ensure identical and lifetime get right of entry to education for sustainability.
6. Promote health, recovery and wellbeing for all.

Economy:

1. Reconstruct the principles of wealth, paintings and development Commit to accountable production, consumption and trade.
2. Cultivate social entrepreneurship for local regeneration.
3. Increase monetary justice through sharing and collaboration.
4. Ensure equitable get entry to land and resources.
5. Use banks and currencies that strengthen communities.
6. Biodiversity and repair ecosystems.

Culture:

1. Clarify imaginative and prescient and better purpose.
2. Nurture mindfulness and self-reflection.
3. Enrich existence with artwork and celebration.

4. Honor indigenous awareness and welcome fine innovation.
5. Engage actively to shield groups and nature.
6. Reconnect to nature and embody low-impact lifestyles.

3.6 FUNDING ASPECTS OF THE ECO-VILLAGE

These are the steps which should be followed in ordered to run a successful eco-village

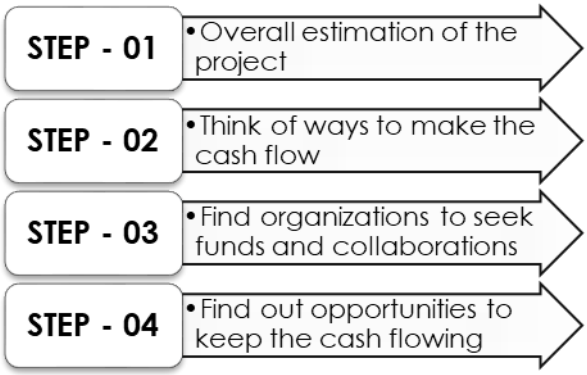


Fig 3.6.1: Steps regarding the cash flow generation

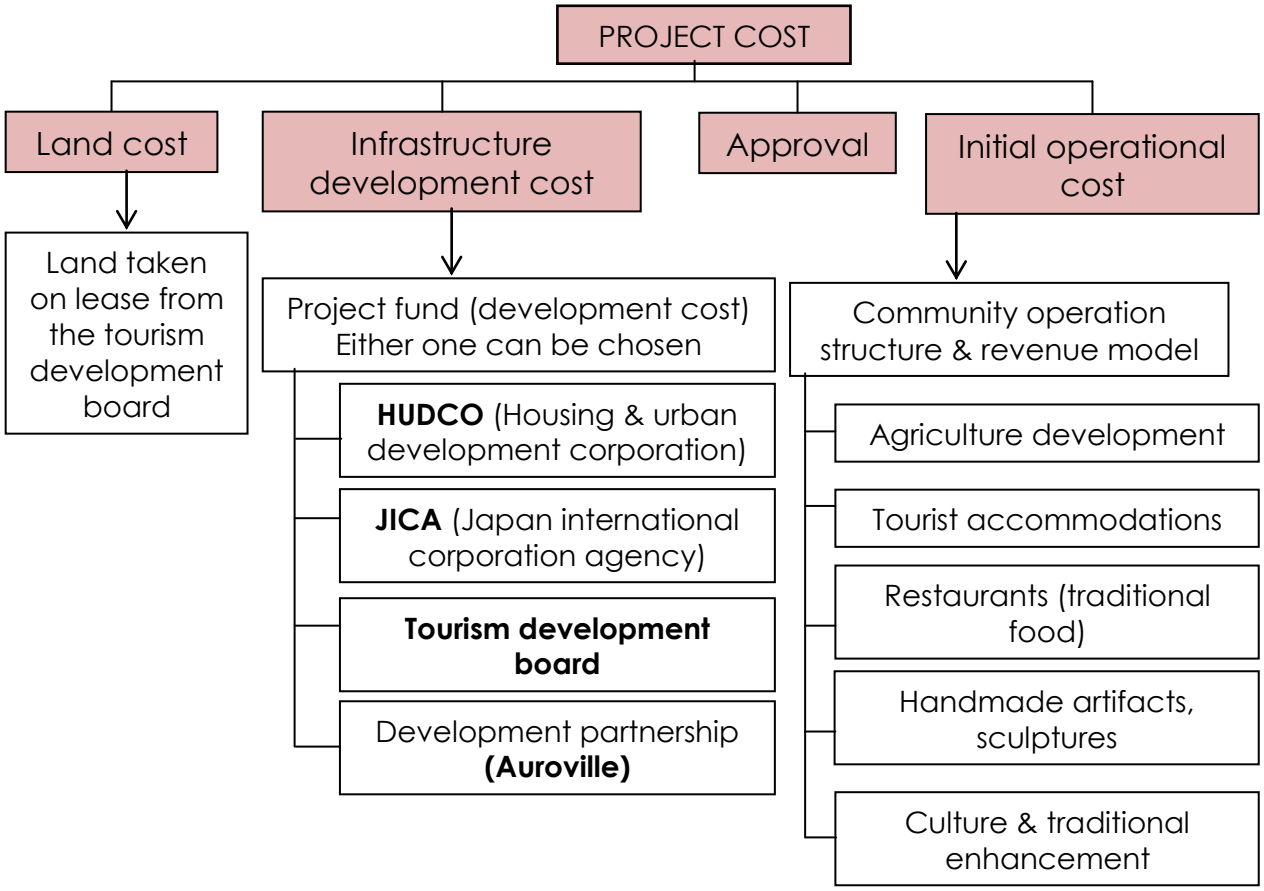


Fig 3.6.2: Details regarding the project's cost and revenue generation model

3.7 CHALLENGES IN AN ECOVILLAGE AND SOLUTIONS

Table 3.7.1: Challenges in an eco-village and their possible solution

S.No	CHALLENGES IN AN ECO-VILLAGE	POSSIBLE SOLUTION
01.	Economically dependent on the surrounding organizations.	A strong vision relating to the funding aspect needs to be laid down for long term solution.
02.	Type of people – Generally, people choose to live there and they can leave at any point of time & depending upon the user the some sacrifices would be made.	Choosing the type of users who will be staying there is very crucial, basic contract needs to be laid down with which the community can thrive better.
03.	Decision making would be disturbed as there is variety of user group involved.	A proper governance and sub monitoring people should be assigned right from the beginning.
04.	Balance between the personal and communities as most of the spaces will be shared – religious conflict for example	The aim of the community should be based on peace and harmony between the individuals and there shouldn't be any barriers to differentiate each individual.
05.	Experimental eco-villages may lead to failure at times.	Needs a proper organizational support & risk assessment strategies needs to be done.

CHAPTER 4
LITERATURE STUDY

4.1 LOCATION DETAILS

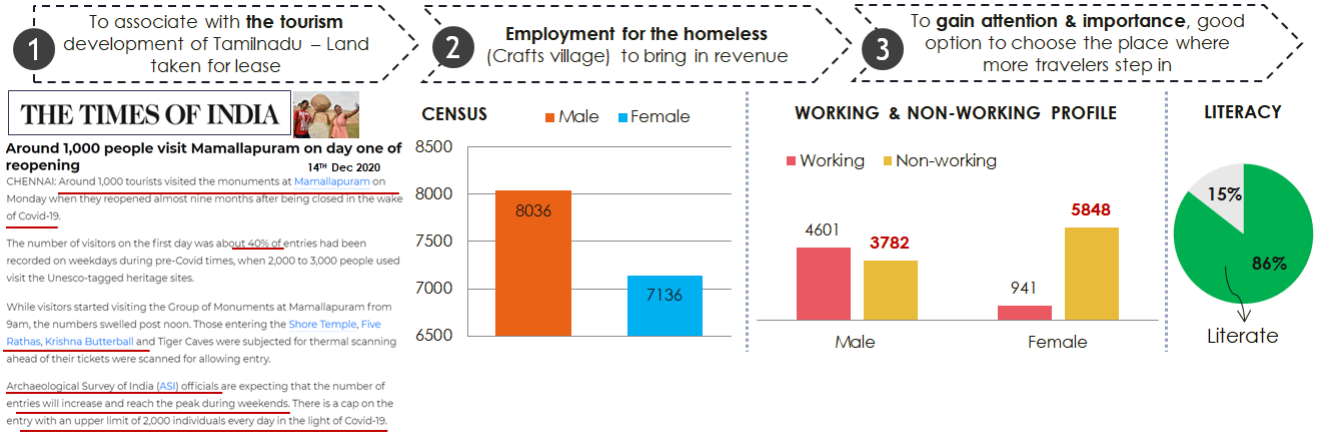


Fig 4.1.1: Mahabalipuram tourist's potential, census and literacy data

4.2 POTENTIAL SITE IDENTIFICATION

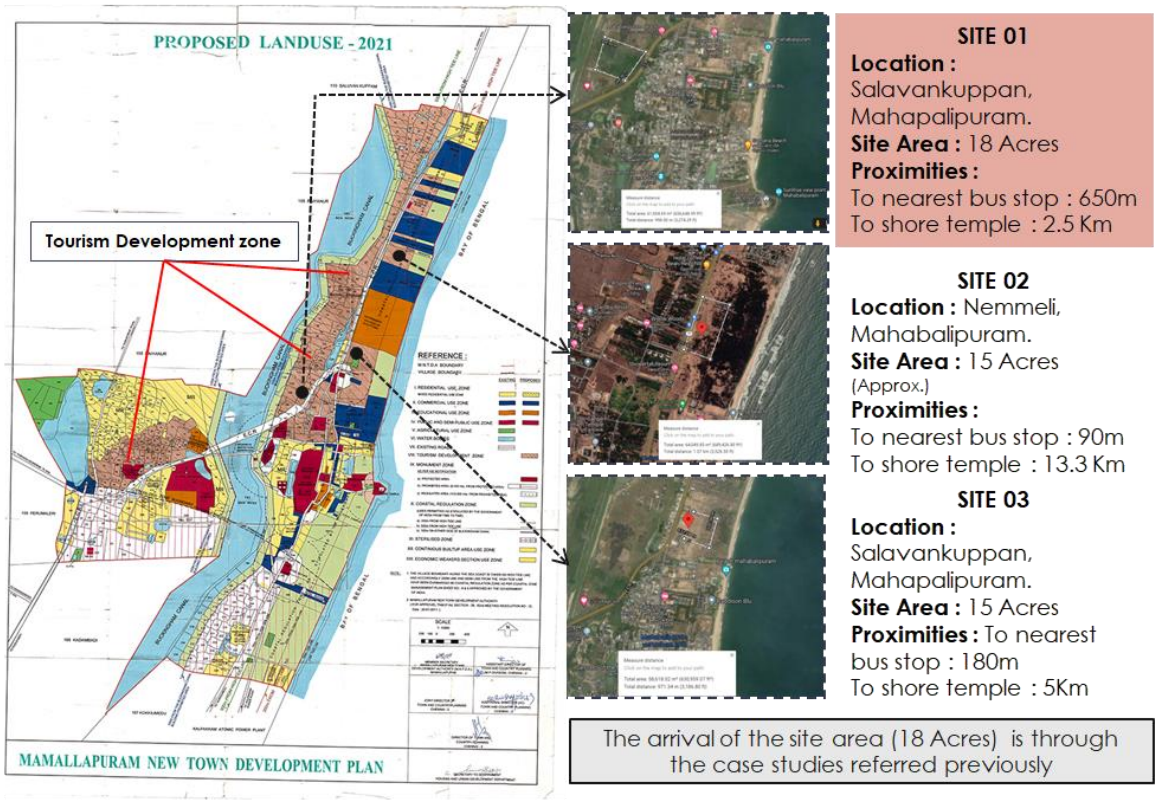


Fig 4.2.1: Site Identification and Selection

4.3 COASTAL REGULATION ZONE

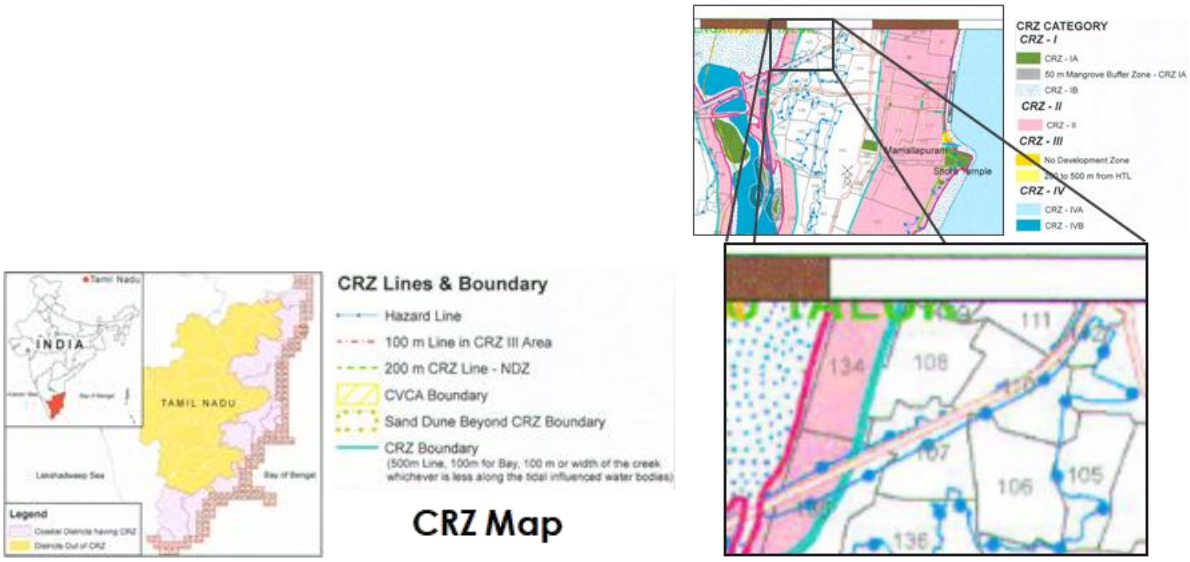


Fig 4.3.1: Coastal regulation zone map

The site area is not affected by the CRZ zone and is free of restrictions and the developments can be proceeded.

4.4 CODES AND STANDARDS TO BE FOLLOWED

Table 4.4.1: Codes and standards to be followed

S.No	CODES & STANDARDS	PARAMETERS TO BE FOLLOWED
01.	TNCDR (Tamilnadu Combined Development Rules - 2019)	Development regulations, Minimum road width, FSI set back regulations, Corridor & verandah widths, Provisions for disabled, Solar panel guidelines, Wind energy guidelines, Transformer room guidelines, Mezzanine floor guidelines, Parapet, Lighting & ventilation, Stairway requirements, Septic tanks, Grey water reuse, Storm water drainage, Water conservation, Tree preservation, Parking requirement, Stall sizes, Drive way & aisle widths, Sanitation requirements, Protection from Cyclonic wind damage , flooding or tsunami guidelines, High rise restrictions are referred.
02.	CRZ Regulations	Through government website regulations, crz maps are referred.
03.	NBC	Building services, Lighting & ventilation requirements are referred
04.	ECBC Eco niwas Samhita	Complete code provisions are referred, WFR, VLT, Thermal transmittance of roof, RETV for building envelope, thermal transmittance of building envelope.

06.	SP41	Required & relevant code provisions are referred.
07.	Passive strategies	Through relevant research papers or case studies,
08.	Architectural standards	Time saver standards for planning requirements are referred.

4.5 RATING SYSTEM ANALYSIS

Table 4.5.1: Research paper : Indian green rating system

AUTHOR	AIM	METHODOLOGY
Himanshu Agarwal, Hari Kumar Singh, Sanjay Vashishtha	Three primary rating systems prevailing in India are selected and analyzed with the aim of providing insights into the current situations; highlighting the strengths, weaknesses, successes, and failures; and making recommendations for future improvements.	The major focus is given upon LEED, IGBC and GRIHA in Indian Context. Maximum and Mandatory Points of each theme has been calculated. Along with this a case study has been taken to make a comparative analysis.

Table 4.5.2: Comparative table of the three rating categories

COMPARATIVE ASPECTS OF ALL THE 3 CATEGORIES			RECOMMENDATIONS
LEED	IGBC	GRIHA	-Emergency Services and Code Compliance -Smooth Communication system for efficient running of the building facilities -Electronic Key & Access Service -Space Information -Management System -Waste Heat Recovery -Growing of plants within the building premises to maintain indoor air quality
-USGBC is more descriptive and also focuses on refrigerant management and emission reduction. -USGBC uses slightly more descriptive approach and projects are internationally recognized.	-IGBC system covers additional domains like local building regulations and basic facilities for construction workforce. -IGBC considers ozone depletion substances as a mandatory requirement. -IGBC also signify importance of commissioning	-It shows site selection is a critical criteria and need to verify through maximum aspects as prescribed in IGBC rating system. -GRIHA denies ozone depletion contribution in system. -GRIHA considers general requirements; this	

	plan for building equipment and systems which will further assist in improving energy monitoring. -IGBC criteria is distributed in specific requirements. -IGBC uses slightly more descriptive approach and projects are internationally recognized.	major head of rating system is to be evaluated under post occupancy stage. -GRIHA provides extra Floor Area Ratio (FAR) for their projects achieving 4-Stars or above ratings.	

CONCLUSION: 3 rating studied under thematic approach, though all intend to achieve sustainability, they all differ in their approach.
INFERENCE: By considering the comparative analysis and other considerations, GRIHA LD & IGBC Township can be considered; GRIHA LD has min. social aspects & requires more quantification, so IGBC Township is selected.

4.6 SITE ANALYSIS

Table 4.6.1: SWOT Analysis of the site

STRENGTH	WEAKNESS	OPPURTUNITY	THREAT
- Site located in the tourism developments attracts lot of tourists. - Located on the high way so it's easily accessible. - Located amidst the low & mid-rise settlements to be away from the urban area.	- The site is accessible only from one side of the plot. - There are no existing trees at present in the site.	- Existing views which can be provided to the buildings created. - Very mild contour which can be shaped according to the design. - Future expansion is possible on either sides. - Many programs & volunteering aspects are expected due to the exposure towards foreigners.	- As the site is located in the highway, possibilities of noise pollution.

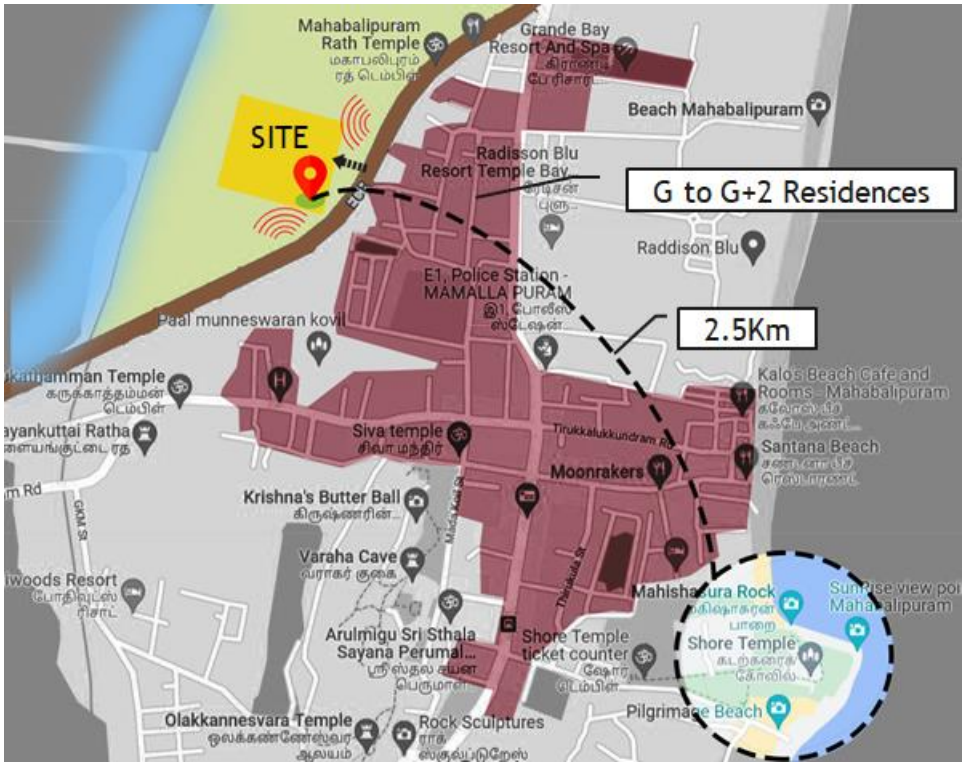


Fig 4.6.1: Site proximity from the shore temple

SITE PROXIMITIES

Access road **:** State highway 49

Nearest bus stop **:** 700m (1 min)

Attractions **:** Shore temple

Walk score **:** 57 Somewhat walkable

Basic amenities **:** According to the IGBC township guidelines, 10 amenities

Fig 4.6.2: Site Proximity details

BASIC AMENITIES: 800M radius

1. ATM
2. Clinic
3. Pharmacy
4. Parks with walking tracks
5. Internet café (450 m)
6. Grocery store : Jaya stores
7. Restaurant : A2B (800m)
8. Hardware store : Annai (500m)

9. Coffee shop: Café coffee day (600m)
10. Spa/Beauty salon: F5 salon (800m)

BASIC AMENITIES: 2Km radius

1. Police station : E1 Station (1.4Km)
2. School : St. Mary's CBSE (1.2 Km)
3. Bank : Kanchipuram Cooperative bank (1.7 km)
4. Government post office (1.6 Km)

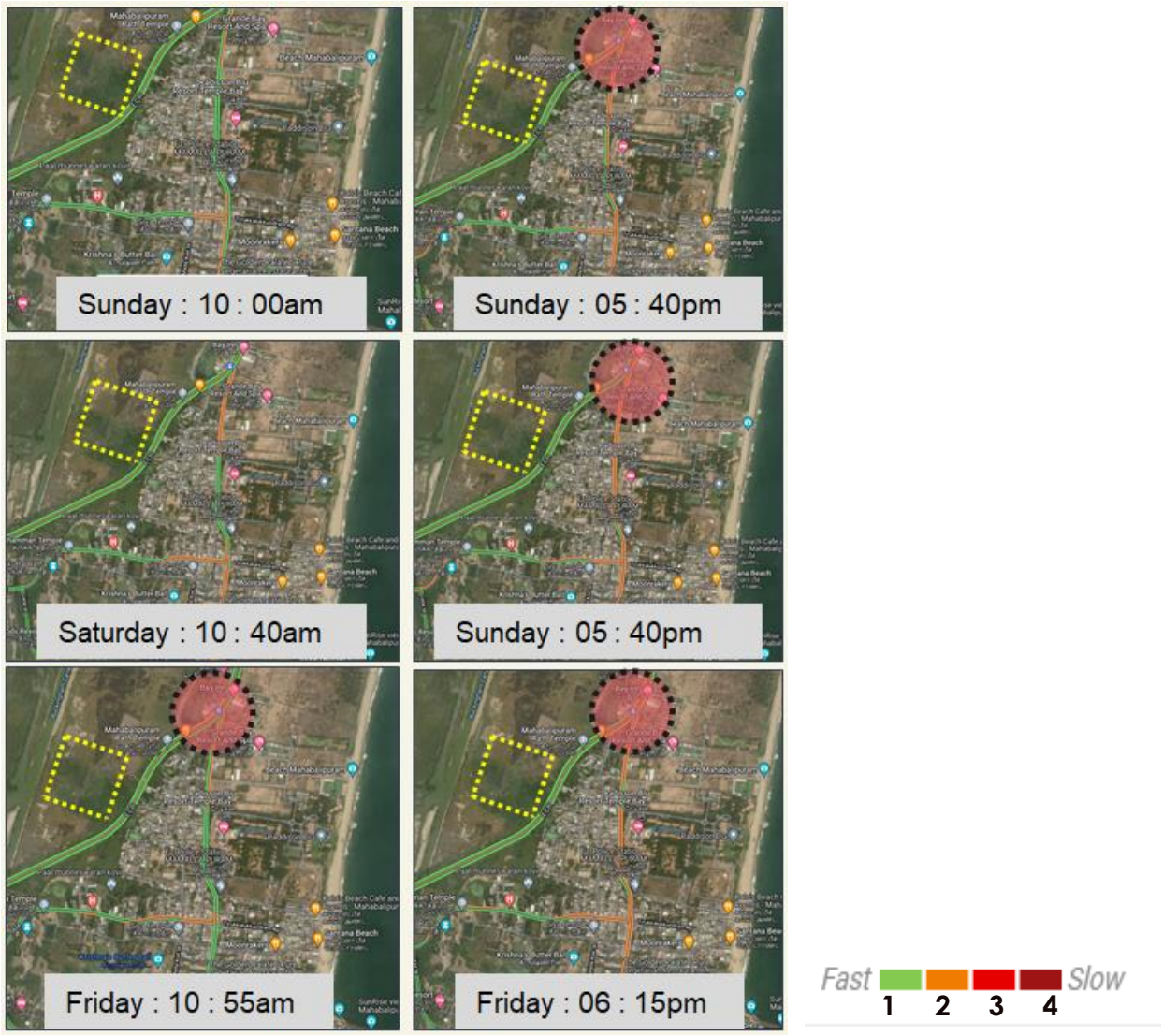


Fig 4.6.3: Traffic Pattern analysis

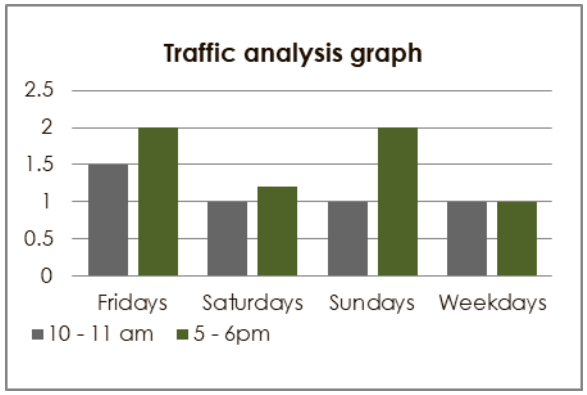


Fig 4.6.4: Traffic Pattern analysis graph

INFERENCE

- Overall, the traffic is very minimum in this area and the critical timing is found to be 10 – 11am & 5 – 6pm as the visitors arrive the area during this period of time.
- Fridays and Sundays during 5 – 6 pm seems to have mild traffic towards the junction and one entry & exit is enough to control the movement.

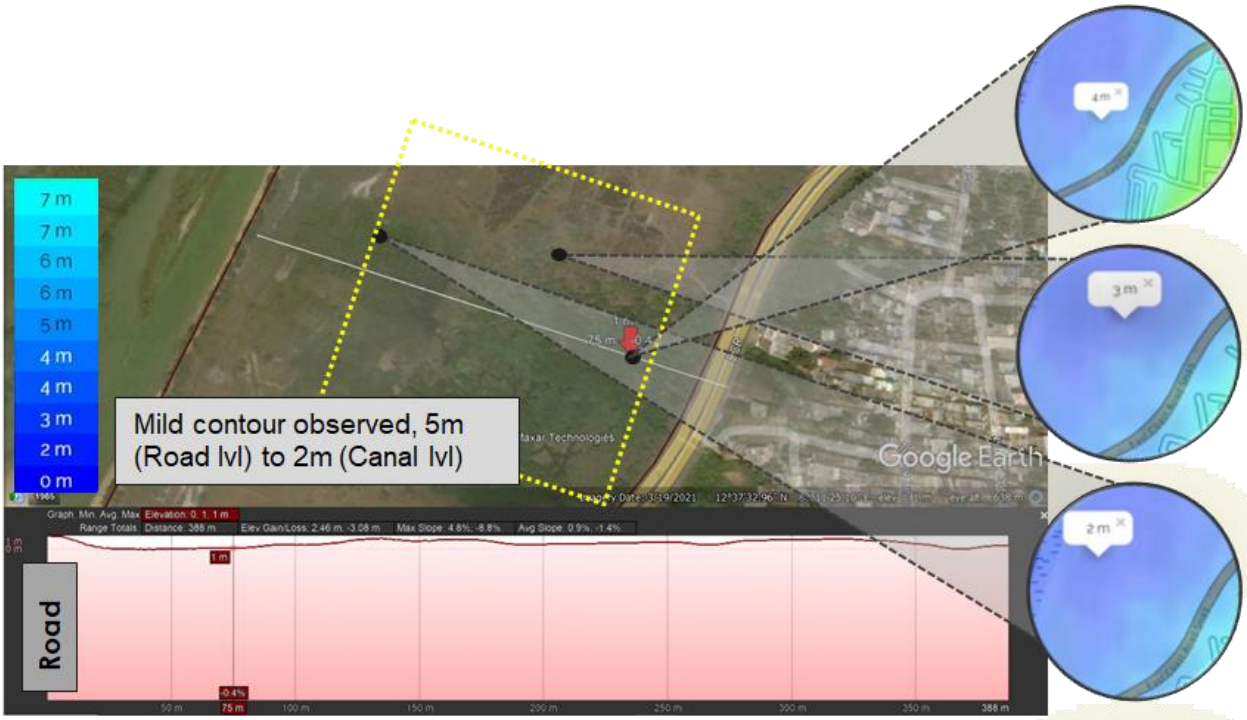


Fig 4.6.5: Contour section

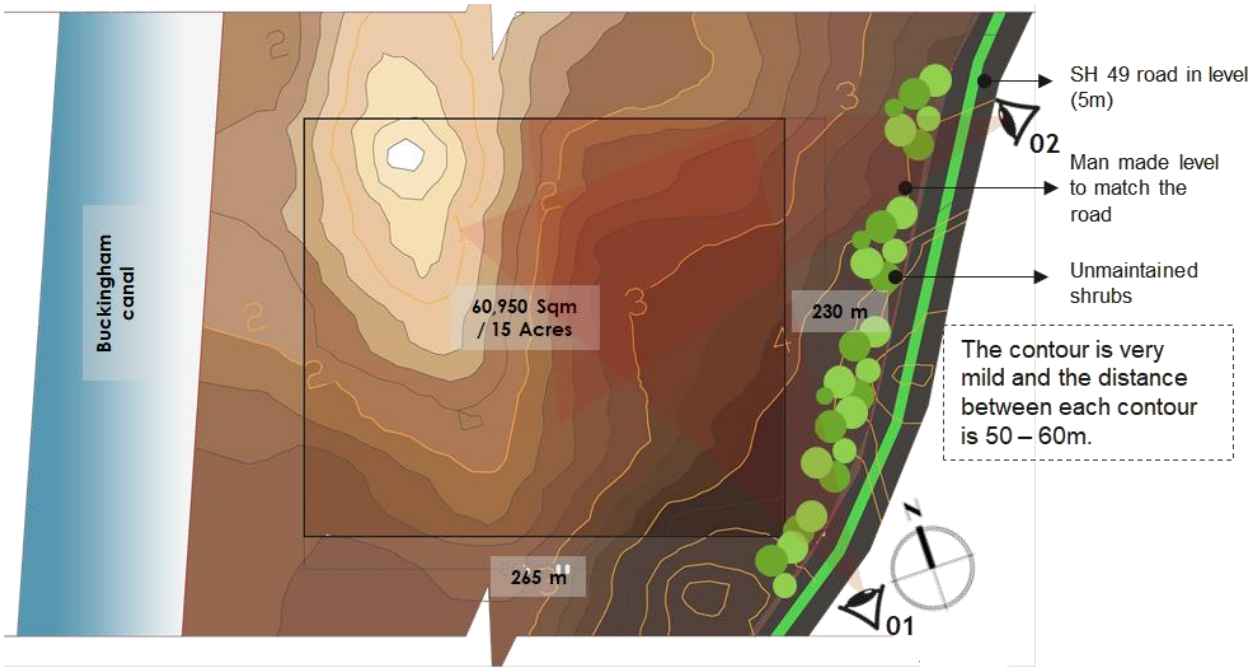


Fig 4.6.6: Contour in plan

4.7 LIVE CASE STUDY

4.7.1 LIVE CASE STUDY – Kanchi eco-village, Kanchipuram

Location: Kanchipuram, 87Km from Chennai
Type: Indigenous; Climate: warm & humid
Area: 18 Acres
Open vs. built – 75% open
Started by: 2010
Status: Under development
Current development: 3 Types of cottages.

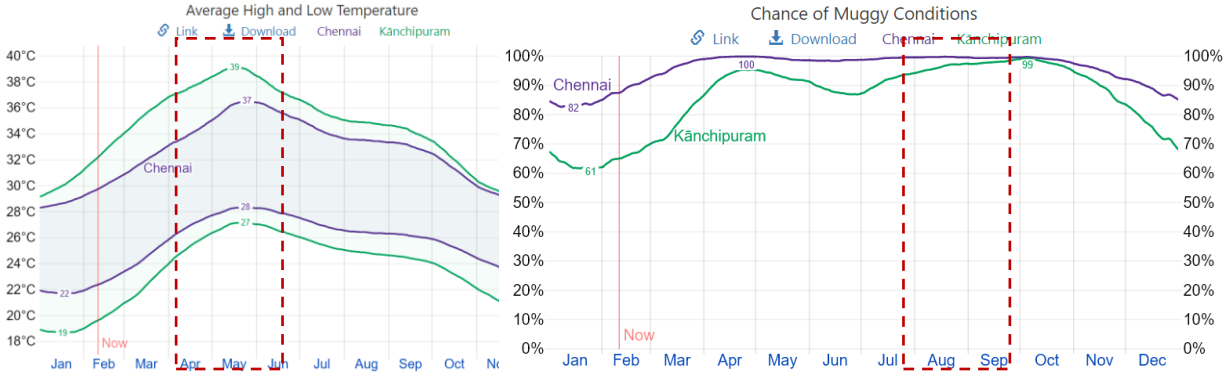
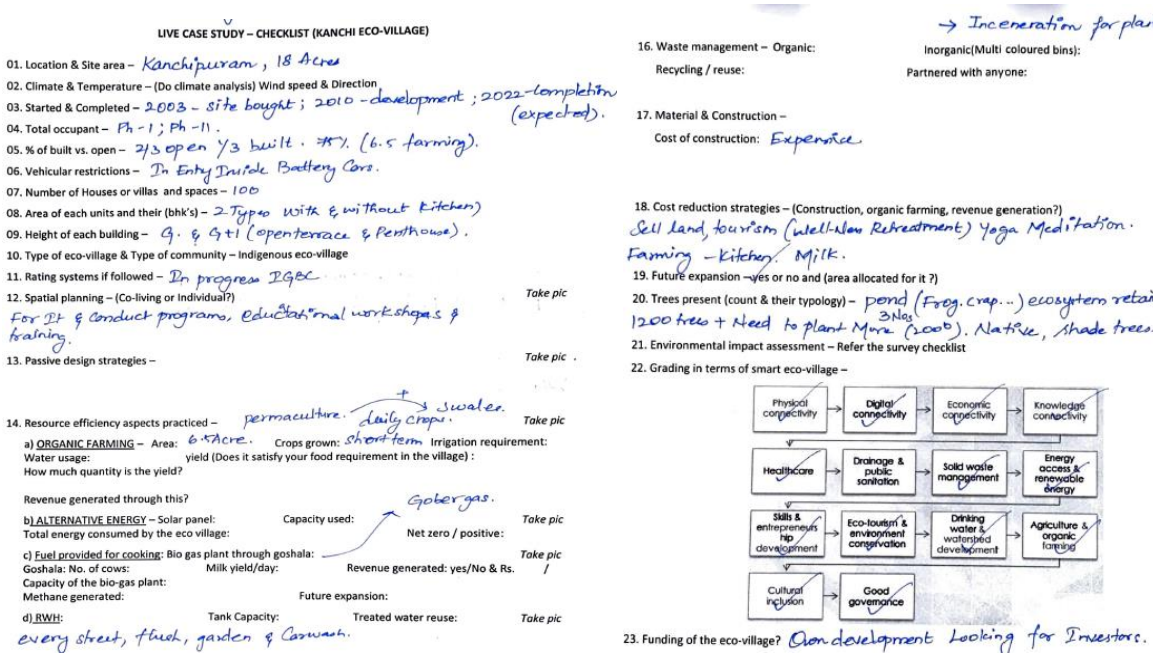


Fig 4.7.1.1: Temperature and humidity of Kanchipuram

SITE DEVELOPMENTS & OBSERVATION AT PRESENT

- CSEB compound wall completed for 18 Acre boundary
- Placement of trees, 3 cottages are completed , 1 cottage is under construction
- Through the discussion with the owner was able to understand the goals and intentions for the future.



LIVE CASE STUDY – CHECKLIST (KANCHI ECO-VILLAGE)

01. Location & Site area – Kanchipuram , 18 Acres
02. Climate & Temperature – (Do climate analysis) Wind speed & Direction
03. Started & Completed – 2003 - site bought ; 2010 - development ; 2022 - completion (expected).
04. Total occupant – Ph - I ; Ph - II .
05. % of built vs. open – 2/3 open 1/3 built . 7% (6.5 farming).
06. Vehicular restrictions – In Entry Inside Battery Cars.
07. Number of Houses or villas and spaces – 100
08. Area of each units and their (bhk's) – 2 Types with & without Kitchen)
09. Height of each building – G. & G+1 (open terrace & Penthouse).
10. Type of eco-village & Type of community – Indigenous eco-village
11. Rating systems if followed – In progress IGBC
12. Spatial planning – (Co-living or Individual?) Take pic
For IT & conduct programs, educational workshops & training.
13. Passive design strategies – Take pic
14. Resource efficiency aspects practiced – permaculture. + daily crops. + Swales. Take pic
a) ORGANIC FARMING – Area: 6 Acre. Crops grown: short term Irrigation requirement:
Water usage: yield (Does it satisfy your food requirement in the village) :
How much quantity is the yield?
Revenue generated through this?
b) ALTERNATIVE ENERGY – Solar panel: Capacity used: Gobergas. Take pic
Total energy consumed by the eco village: Net zero / positive:
c) Fuel provided for cooking: Bio gas plant through goshala: Take pic
Goshala: No. of cows: Milk yield/day: Revenue generated: yes/No & Rs. /
Capacity of the bio-gas plant:
Methane generated: Future expansion:
d) RWH: Tank Capacity: Treated water reuse: Take pic
every street, thick, garden & Carwash.

16. Waste management – Organic: → Incineration for plastic.
Recycling / reuse: Inorganic(Multi coloured bins): Partnered with anyone:
17. Material & Construction –
Cost of construction: Expensive
18. Cost reduction strategies – (Construction, organic farming, revenue generation?)
Sell land, tourism (well-like Retreatment) Yoga Meditation.
Farming - kitchen. Milk.
19. Future expansion – yes or no and (area allocated for it ?)
20. Trees present (count & their typology) – pond (Frog. crap...) ecosystem retain. 3Nos
1200 trees + Need to plant More (200). Native, shade trees.
21. Environmental impact assessment – Refer the survey checklist
22. Grading in terms of smart eco-village –

23. Funding of the eco-village? Own development Looking for Investors.

Fig 4.7.1.2: Live case study checklist

Fig 4.7.1.3: Site plan of Kanchi eco-village

TAKE AWAYS FROM THE CASE STUDY

- More % of open than built.
- Individual plots allotted for the development. (300 Sqm/plot approx.)
- Community spaces incorporated in the middle for the closer proximity to both the developments.
- Poultry and goshala located near the club house.
- Sites low level has been created as a pond for for the irrigation purpose.
- Size of the organic farms for approximately 400 residents

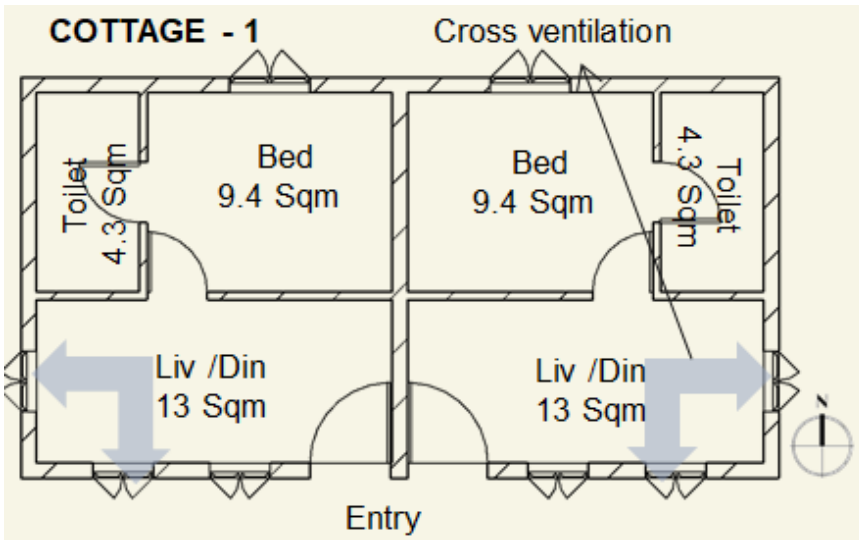
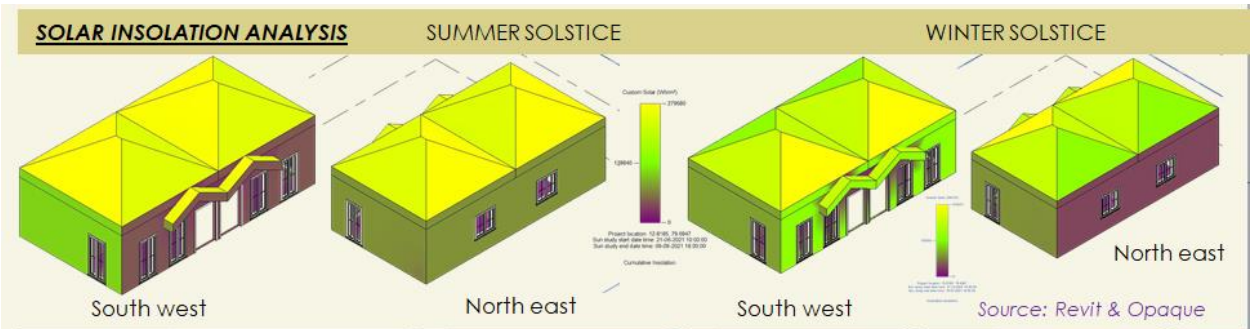


Fig 4.7.1.4: Cottage plan of Kanchi eco-village



	North 4	South 2	East 3	West 1
Summer	104.88 Kwh/m2	34.96 Kwh/m2	104.88 Kwh/m2	139.84 Kwh/m2
Winter	39.56 Kwh/m2	158.26 Kwh/m2	79.13 Kwh/m2	150 Kwh/m2

Fig 4.7.1.5: Solar insolation analysis of the cottage

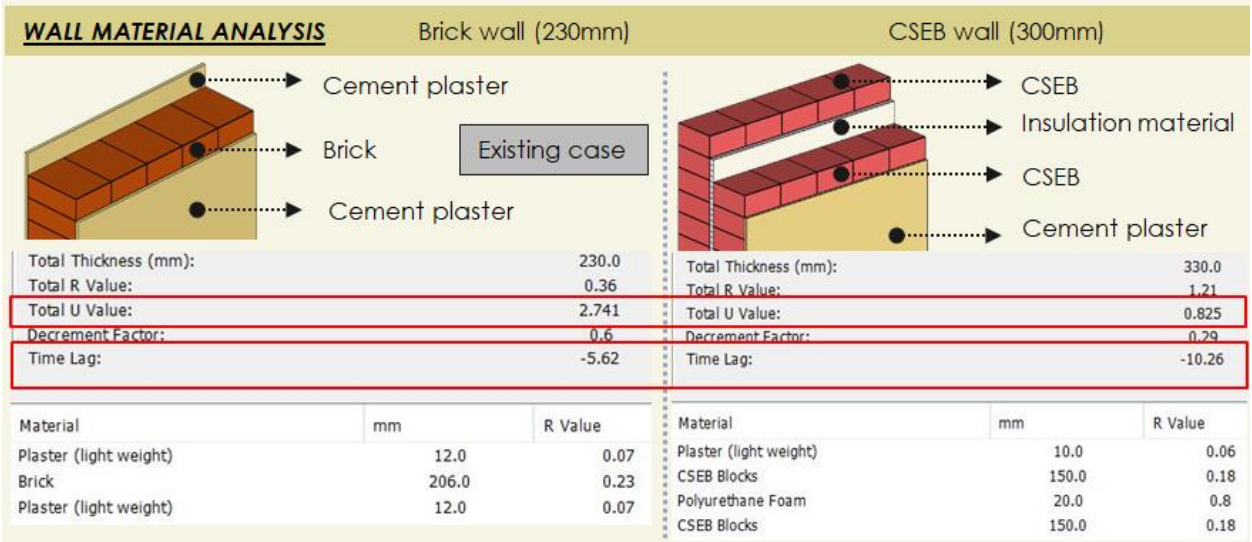


Fig 4.7.1.6: Wall material comparison

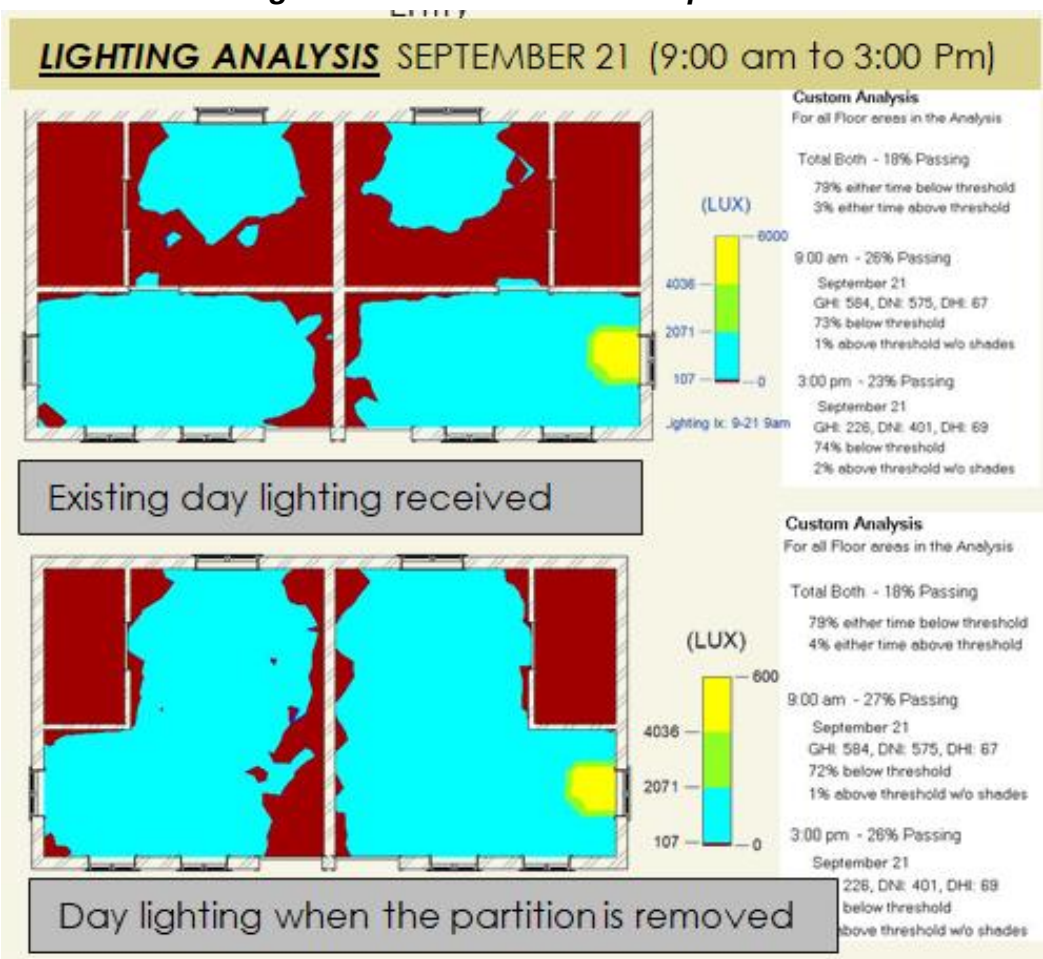


Fig 4.7.1.7: Lighting analysis of the cottage

Fig 4.7.1.8: View of the kanchi eco-village

4.8 LITERATURE CASE STUDY

Type: Indigenous
Area: 4 Acres (Medley)
Started by: 2021
Status: Under development
Development: Townhouse, apartments, villaments & walk-up homes.
Malhar – Medley is selected for the study as it is very recently designed
Climate: Moderate

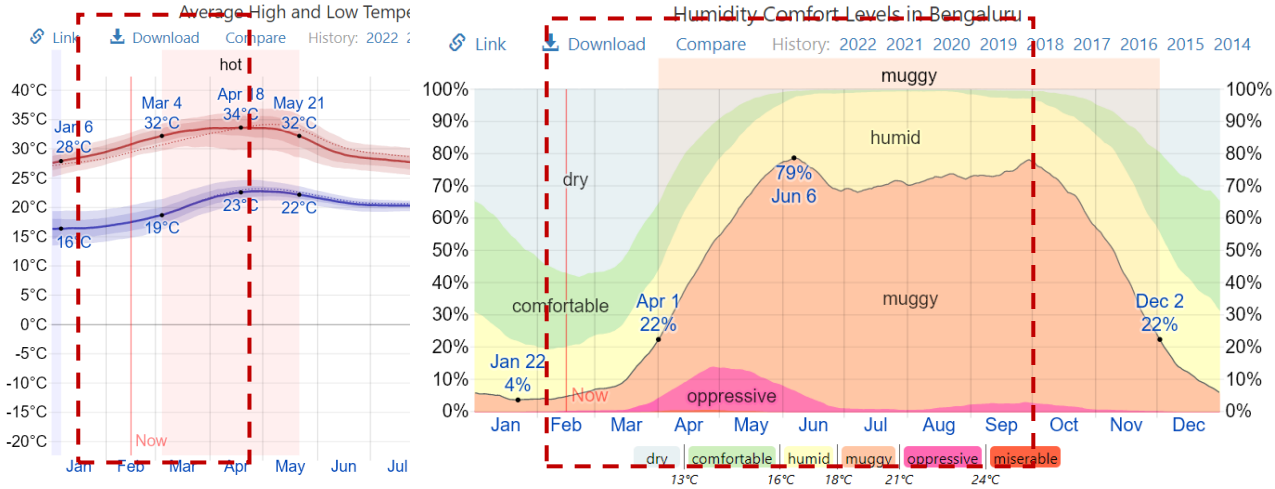


Fig 4.8.1: Climate of Bangalore

Fig 4.8.2: Site plan of Malhar eco-village

KEY FEATURES:

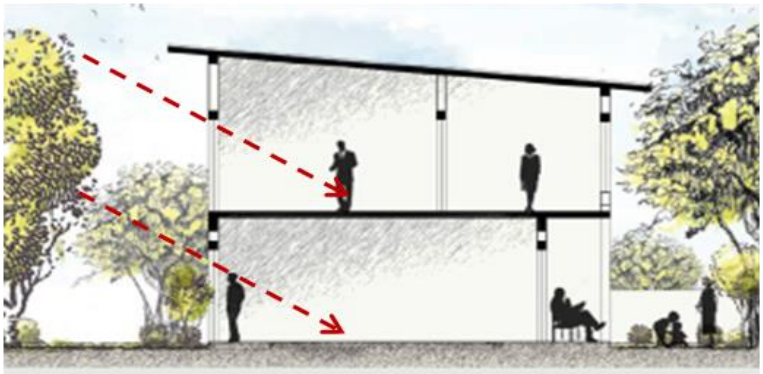
- Use of topography
- Homes, parks and open spaces are placed in a different level to provide a richer spatial experience.
- Homes are places in clusters around the parks with meandering streets connecting the entire neighborhood.
- They have individual and also community bonding activities.
- Access to kengeri metro.
- Each building in medley faces the own cluster park, the parks turn into the looping streets that connects the neighborhood.
- Vehicular free streets
- 2 level underground parking near the entry and people access through elevators.
- Trees are for social interactions.

Table 4.8.1: Home types, floors and units

HOME TYPES	TYPOLOGY	FLOORS	UNITS
Townhouse	4	G+1	29
Villaments	1	G	25
Walk-up homes	Duplex	FF & SF	25
Apartments	2 & 3 bed	G+4	40

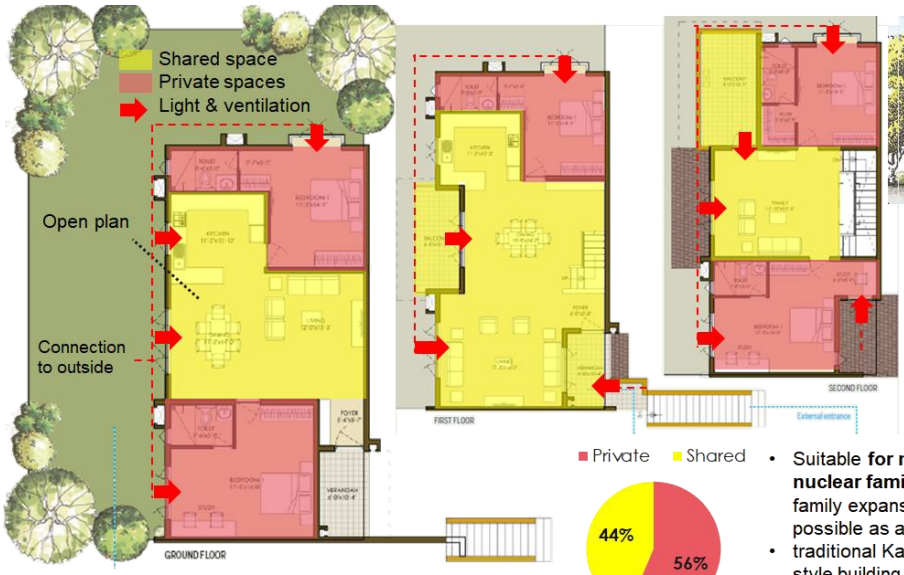
TOWNHOUSE : 2 Floored homes with front and rear gardens

Front & rear gardens provides ample light into the space.

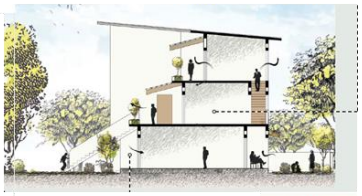


Aspects	Features
Built up area	1600 – 1900Sq ft
Landscape	Front & rear garden spaces
Planning	Seamless, uninterrupted flow of space, to invite light ventilation

VILLAMENTS : Ground floor & **WALK UP HOMES** : First & Second floor (Duplex house)



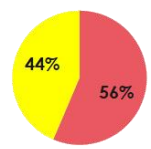
WALK – UP HOMES



VILLAMENTS Section

Walk-up FF

Villament ground floor



- Suitable **for non-nuclear families,** family expansion is possible as a whole.
- traditional Karnataka style building.
- No cross ventilation

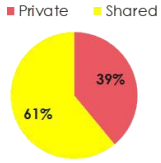
Built up area : 1000 Sq ft and the gardens about 500 to 600 Sqft

APARTMENTS : 2 & 3 bhk apartments G+4 floors ; Central

Type	Built-up Area (ft²)	Carpet Area (ft²)
A301, A304, B301, B304	1430.00	930.31

Type	Built-up Area (ft²)	Carpet Area (ft²)
A401, A404, B401, A404	1334.27	846.27

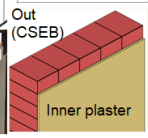
- low rise **2 & 3 bhk** with **central atrium** space along with **private terrace** gardens.
- Almost **all** the spaces has **cross ventilation** provided.



MATERIAL

Super structure	Earth blocks	Soil used from excavating the basement with water and mouled into a block. This reduces the embodied energy.
	Stone	Locally available & aesthetical
Roofs , slab & interior walls	RCC & cement plaster	
Door, window and flooring	Wood, Flooring & Paints	• Timber plants replanted in the site to promote the renewable energy, used for doors and windows. • Wood, stone and clay & vitrified tiles. • Non-toxic, lead-free and low-VOC .
Plastering	Cement plastering	• Exterior : Exposed CSEB • Interior : Plastered and painted.

Average 2.5 °C difference

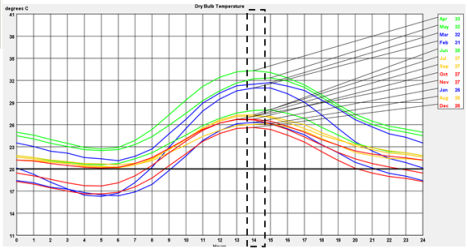


Total Thickness (mm):	212.7
Total R Value:	0.47
Total U Value:	2.134
Decrement Factor:	0.47
Time Lag:	-6.54

Material	mm	R Value
Inside Air Film (wall)	0.0	0.12
Plaster (light weight)	12.7	0.07
CSEB Blocks	200.0	0.24
Outside Air Film	0.0	0.04

Source: Opaque software

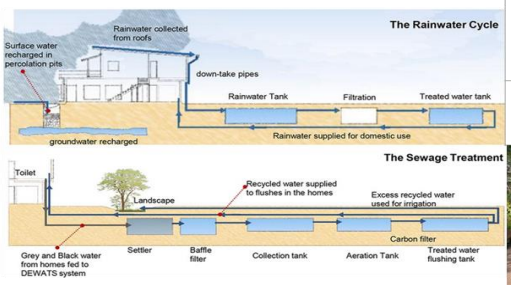
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max Temp	29.0	33.0	34.1	36.6	35.7	31.6	30.9	29.7	30.1	30.0	28.8	28.5
Min Temp	13.8	13.1	18.0	20.4	19.5	18.7	18.2	19.0	19.0	16.9	13.0	13.1



Temperature difference

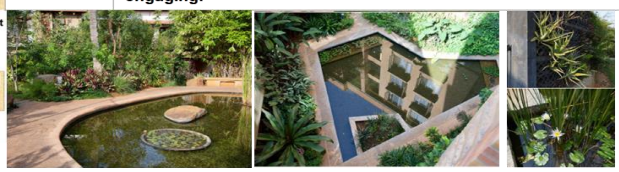
Jan	29°C	26°C	**3°C**
Feb	33°C	31°C	2°C
Mar	34°C	32°C	2°C
Apr	36°C	32°C	2°C
May	35°C	32°C	**3°C**
Jun	31°C	28°C	**3°C**
Jul	30°C	27°C	**3°C**
Aug	29°C	26°C	**3°C**
Sept	30°C	27°C	**3°C**
Oct	30°C	27°C	**3°C**
Nov	28°C	27°C	1°C
Dec	28°C	26°C	2°C

Energy	All the homes have been designed with **adequate natural light and cross ventilation**. Large windows, wide verandahs, air channels for circulation, and **thermally conducive materials** are all features which **reduce** the necessity for **artificial light and ventilation.**
Solar energy	The use of **solar energy** for lighting and water heaters is an important part of Malhar's
Rain water harvesting	**Rainwater conservation** takes on a **special significance**. Rainwater is harvested and the **ground water** is recharged through well **spread out percolation** channels across the development. **Roof water** will also be channeled through pipes, passed through a **series of filters and collected** in the water tank.
Water recycling	An on-campus **sewage treatment** plant recycles all **waste water** generated at Malhar. The waste water from the kitchens and bathrooms is collected and treated in a **centralized treatment plant** to emerge clean. This water is then used for **gardening and for toilet flushing**.



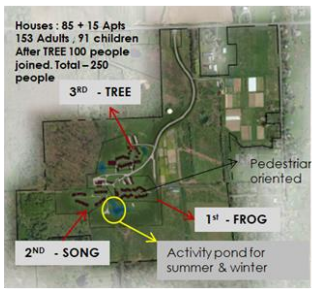
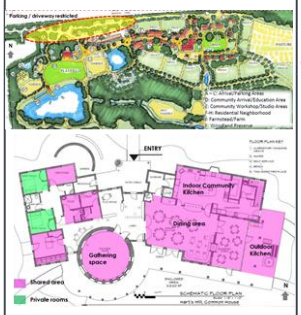
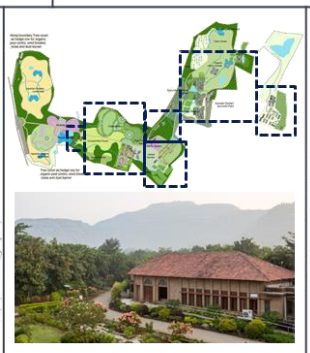
Section of the rain water harvesting & sewage treatment

Waste	Spaces are provided for an **efficient garbage disposal** system that separates **solid and non-biodegradable** waste from organic waste. The community is actively involved in **organic waste composting and its use as manure.**
Eco - scape	**Trees and plants** are **local** and of a **variety** that can withstand **low water conditions**. The environment will be **interactive** and **engaging.**



4.9 COMPARITIVE ANALYSIS OF THE CASE STUDIES

Table 4.9.1: Comparative analysis of all the case studies

PARAMETERS	ITHACA SUSTAINABLE COMMUNITY	COMMON GROUND ECO VILLAGE	GOVARDHAN ECO VILLAGE	MALHAR MEDLEY ECO-VILLAGE
LOCATION & SITE AREA	New york, USA ; **175** Acres	North Carolina, USA ; **112** Acres	Thane, Maharashtra, India ; **70** Acres	Bangalore, India ; **4** Acres
CLIMATE & TEMPERATURE	Humid Subtropical climate Temperature **: - 8°C to 28°C** Rarely below : – 18°C & above 32°C	Humid Subtropical climate Temperature : **0°C to 31°C** rarely below: -7°C to above 35°C	Warm & Humid climate Temperature : **18°C to 34°C** rarely below : 14°C or above 38°C	Moderate climate Temperature : 16°C to 34°C and rarely below 13°C and above 37°C
WIND SPEED & DIRECTION	**3.5**m/s Feb & **1.7**m/s Aug ; SW	**3.1**m/s March & **1.9**m/s Aug ; W	**6.1**m/s July & **2.8**m/s Oct ; W	6.4 m/s Jun & 2.9 m/s Oct & predominantly from west
STARTED & COMPLETION	1991- 2015	2017 – Still in progress	2003 - 2012	2021 – Still in progress
TOTAL OCCUPANT	250 + Diverse residents	Planned for 80 to 100 resident	350+ Diverse residents	450 + residents expected
% OF BUILT & OPEN SPACES	**90%** open space & **10%** buildings	**90%** open space & **10%** buildings	**80%** open space & **20%** buildings	**62%** buildings & **38%** open
VEHICULAR RESTRICTIONS	Vehicles stopped in a distance	Parking isolated to one portion	Ring road around site & not inside	Restricted in the entrance & only walk ways inside
NUMBER OF BLOCKS & OTHER SPACES	**100 homes** (85 individual homes & 15 apartments)	**30 homes** & 1 common house	Temple, gurukul, 4 private cottages, 2 Community cottages, Amenities block, Ayurveda block, Dormitory, yoga hall & services	Total 119 homes, Townhouse – 29 units, Villaments – 25 units, Walk-up homes – 25 units & apartment – 40 units & club house & guest space
GREEN RATING	**LEED – Platinum** (TREE)	Not followed	**GRIHA** – 5 star rating	Not followed
HEIGHT OF THE BUILDING	**G & G+1** & Apartment : **G+3**	G & G +1	G & G+1 (High ceiling)	G, G+1, G+2 & apartment : G+4
TYPE ECO VILLAGE & TYPE OF COMMUNITY	**Intentional eco village** & Coliving & private houses.	**Indigenous eco village** & coliving & private houses.	**Spiritual eco village** & community & private living	**Intentional eco village** community & private units
SPATIAL PLANNING	**Apartment** – Community living , shared spaces in ground floor , Individual house can be coliving.	**Common house** – Community living , shared spaces., Individual house can be coliving.	high ceiling, Separate co-living cottages for each typology of users.	4 types of units, verandahs and large gardens in individual houses and also in the middle of the site
SITE PLANNING				
PASSIVE DESIGN STRATEGIES	**Orientation** (Longer NS), Maximum windows (**triple pane**)on south with shading, Double wall with cellulose & foam insulation.	**Orientation** (Longer NS), Maximum windows (**triple pane**)on south with shading, Clearstory windows in south for maximum light.	**Orientation**, maximum façade oriented **towards the north**, Mud walls produced within site. High roofs & cross ventilation.	**Orientation (NS),** Large openings on the sides available, cross ventilation, Local material, CSEB blocks, atrium in the middle of the apartment.

ENERGY REDUCTION	**40%** reduction in **home energy use** compared to other homes, **53%** reduction in **electricity**, **71%** (Led star rated fixtures) reduction in **water usage**. Some buildings are net zero.	Pv panel for each house (**30**) & common house (1) to save on electricity bill (net zero) & vertical axis in windmill powering the lights in the common house.	**Alternative energy** : Biogas plant , Pv panels, ADPM is used .Locally sourced material reducing the embodied energy .	Traditional materials, ample opening for ventilation and this reduces the overall energy consumptions and water consumption by rain water harvesting.
ENERGY EFFICIENCY	**Solar panel** - *FROG* : 50Kw panel (30 homes) ; *SONG* : 14 homes out of 30 has pv panels ; *TREE* : Individual homes (25), 4KW Pv panels & domestic hot water. **Other features** : Sustainable landscaping, semi-permeable stone around house, native wildflowers & grass, retaining walls to prevent erosion, bio-swales, rain garden & retention pond.	**Electrical energy** : Net zero target **Thermal energy:** Active & Passive energy for cooling & heating design. **Human energy:** Design in terms of pedestrian, bicycle cart. **Transportation energy :** Solar vehicles **Other features: Reduce footprint** by communal space & **conservation** of resources. Fresh food& Sustainable agriculture.	**Biogas plant** : Slurry, cow dung – methane used for cooking & electricity generation (30 m³ floating dome & 6m³ fixed dome with future explanation, 15KW generator runs on biogas plant, & Use of **photovoltaic panels** for alternate energy consumption.	**Electrical energy** : Solar panel & solar water heating **Thermal energy:** Passive strategy for comfort. **Human energy:** Design in terms of pedestrian walking. **Other features: Incorporation of gardens** & **conservation** of resources. **Embodied energy :** Reduced by in-site CSEB production and use of locally sourced materials (wood).
WASTE MANAGEMENT	**Composting** of garbage residents have cut **75%** of garbage services.	Reduce waste, re-use, recycle & compost. utilizing **multiples of 4'** to **reduce construction waste.**	ADPM, 2 bulls rotate a lever , 7000-8000 L/h at 60ft depth (equivalent to 5hp pump) operated more than 12 hours a day with multiple bulls , SBT, Zero waste community.	Waste will be **segregated at source** into solid and bio-degradable, organic waste generated will be **composted and used as manure.**
COST REDUCTION STRATEGIES	Due to **airtight insulation**, the heating **cost** is reduced , **electricity** cost is reduced.	the common house, **the cost is also reduced** as it is **shared** among others. Laundry & Common food cost reduced.	**Revenue generated** in farming, cows, Tourist accommodation, Water treatment, Shared spaces reduces cost.	Use of Locally available materials, reducing the dependency on artificial lighting and inclusive of solar energy alternative.
MATERIALS & CONSTRUCTION	**Wall** : double 2x4 stud wall with 5" gap(Total wall depth=12 ") **Roof** : Metal roof, **Windows:** Triple pane, low-e, U=0.17,SHGC=0.62	Durable, long lasting, Easy maintenance, **non toxic**, **low embodied energy** & locally sourced, Concrete structure, Metal roofs, Heavily treated wood, **sustainably harvested** , **recycled or reclaimed**, **natural earth materials** – adobe, rammed earth, cob wall, straw bale, bamboo, etc.	**Wall:** Stabilized mud blocks, Mud, Quarry dust, lime & cement. **Plaster :** Cement & Red mud plaster. **Roof :** Arch panel with mud tiles & Mangalore tiles	**Wall :** CSEB blocks & stone, with cement plaster & paint. **Roof & slab :** Mangalore tiled and RCC slabs & flat roofs **Flooring :** Tiles & clay
FUTURE EXPANTION	Yes, there is scope for **future expansion** & the plans are **flexible in terms of co-living** and **shared spaces**.			No, future expansion, compactly designed
ENVIRONMENTAL IMPACT ASSESSMENT Assessed in terms of the **17 goals** established in **SDG** Depending upon the survey – self **(64 questions)** taken the results are obtained and analyzed.	Sustainable development goals achieved in **eco village at Ithaca :** **OBERVATION :** Certain aspects such as **health care, sustainable education, participation of the low-income, sharing & teaching principles** are **not addressed** in this eco-village.	Sustainable development goals achieved **govardhan eco-village:** **OBERVATION** : Through observation, **all the goals of SDG** is seemed to be achieved in the govardhan eco-village. Overall 9 points are given for all the goals.	Sustainable development goals achieved **Malhar eco-village** **OBERVATION :** Certain aspects such as **health care, sustainable education, participation of the low-income, sharing & teaching principles** are **not addressed** in this eco-village.	

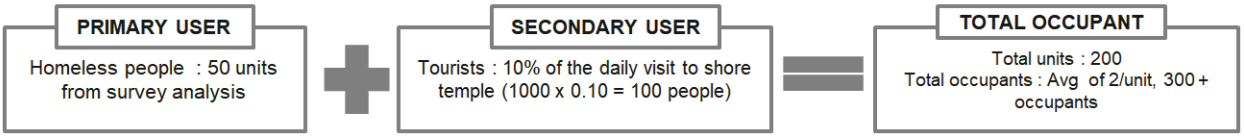


Fig 4.9.1: Scale of the proposed eco-village

Table 4.9.2: Takeaways from the case studies for the proposal

PARAMETERS	TAKEAWAYS
TOTAL OCCUPANT INTENDED	400 + considering the user groups
% OF BUILT & OPEN SPACES	75 – 80% open space & 20 – 25% built.
VEHICULAR RESTRICTIONS	Towards the entrance with parking area
NUMBER OF BLOCKS & OTHER SPACES	Cluster planning and connectivity between each space with transition space.
GREEN RATING	Relevant rating for development
HEIGHT OF THE BUILDING	Low – rise & Mid rise development , horizontal spread.
TYPE ECO VILLAGE & TYPE OF COMMUNITY	Intentional eco-village to be created for the user as the prime importance.
SPATIAL PLANNING	Various combination Co-living spaces, Individual spaces with Connectivity for interaction and activity involvement.

PARAMETERS	TAKEAWAYS
SITE PLANNING	Segregation of public, semi-public & private areas.
PASSIVE DESIGN STRATEGIES	Orientation (NS in longer axis), cross ventilation, double glazing, reduce opening in EW. Use of earth materials for comfort.
ENERGY REDUCTION	By incorporation of various energy alternatives, locally sourced materials.
ENERGY EFFICIENCY	By passive & human energy, solar transportation, use of renewable energy.
WASTE MANAGEMENT	Source separation and composting.
COST REDUCTION STRATEGIES	Locally sourced materials and revenue generation at the eco-village.
MATERIALS & CONSTRUCTION	Locally sourced.
FUTURE EXPANTION	Provisions for future expansion is essential as there will be a need for it.

Table 4.9.3: Arrival of spaces through survey analysis

ISSUES IDENTIFIED THROUGH SURVEY		SPACES REQUIRED
		PRIMARY SPACES REQUIRED
01.	Shelter	For the primary user identified (Homeless people), Community living based concept incorporating micro space & cost saving spaces will be created for the user with all the basic amenities which is involved .
02.	Food production	In ordered to produce food , Solar community kitchen will be organized additionally agriculture will also be practiced (by identifying the cultivation patterns the food will be grown).
03.	Job creation	Connection with the tourism development, craft villages, service & maintenance of the eco-village, community kitchen, other tourism enhancing markets can generate revenue for the occupants.
		SECONDARY SPACES REQUIRED
04.	Education	As per the survey, the children needs to be provided with the basic homeschooling facilities.
05.	Health care	As per the survey, few are suffering from certain health issues where they require a basic free clinic and insurance if incase, they needed to be taken to the nearby hospitals.
	*These **5 aspects** would provide them a **perfect solution** for the **primary user** to survive and **enhance their quality of life***	
06.	Transport & tourists accommodations	Basic transit faculties inside the eco-village will be given enhanced with non-fuel electric & solar alternative. As per the tourists flow , tourist accommodation will be provided .
		OTHER SPACES WHICH WILL BE OFFERED TO ENHANCE THE ECO-VILLAGE
07.	SWM, Alternative energy production & Water saving	In order to make the eco-village a sustainable development, alternative energy production (solar tree etc.,), SWM,STP, Bio-gas plant and water harvesting measures will be created.
SCALE OF THE ECO-VILLAGE : As per earlier studies , the eco village will be created for the **user in mahabalipuram**, around **100 to 150 units** will be created (Low rise – co-living); Tourist (Scale as per detailed requirement - Mid-rise : Co-living); other spaces in correspondence with the primary & secondary user spaces.		

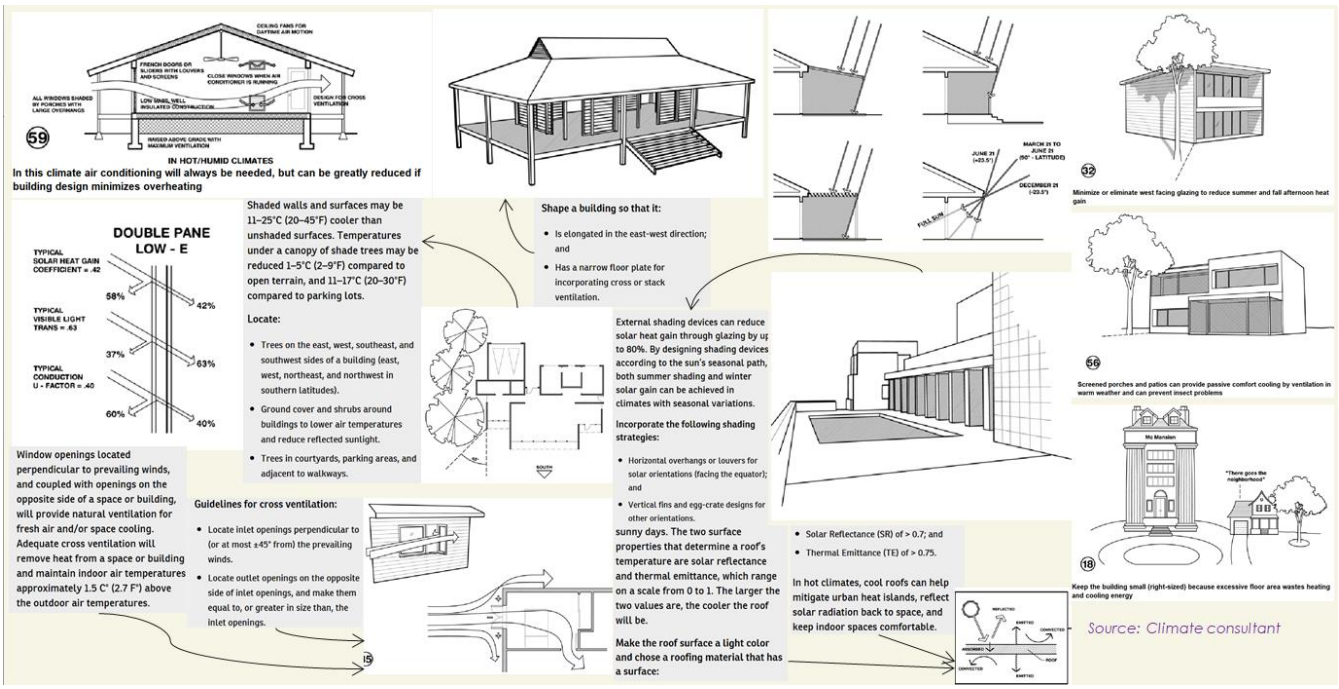
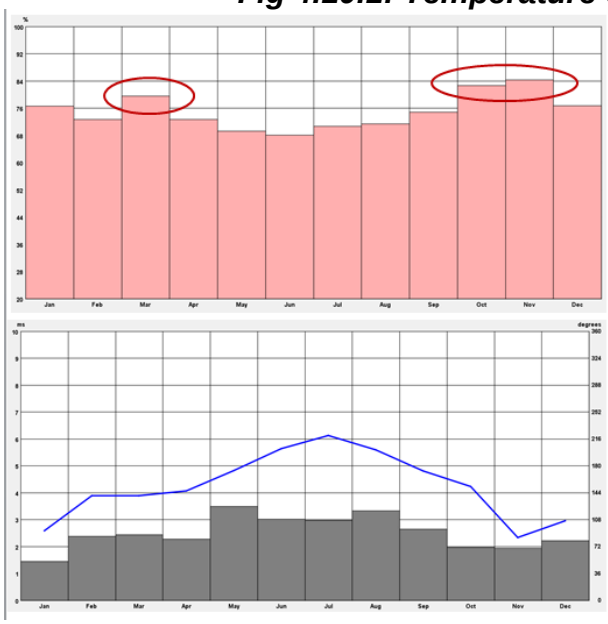


Fig 4.9.2: Passive strategies

4.10 MACRO AND MICRO CLIMATE ANALYSIS

Dry-bulb temperature (in °C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	33	35	36	37	40	39	37	37	36	35	31	31
Mean	24	26	28	30	32	31	30	29	29	28	26	25
Minimum	15	19	22	24	23	23	24	23	24	23	21	20

Fig 4.10.1: Temperature of Chennai



Variants affecting the thermal comfort, Temperature, humidity, Mean radiant temperature, wind speed , light & sound.

Temperature : Higher in most of the months, March to September (Higher).
Humidity : Above 60% in all the months higher in march, October & November.
Acceptable level : 30 to 50%
Wind : May to sept : SW ; other months are NE average wind speed : 2m/s. Predominant : SW

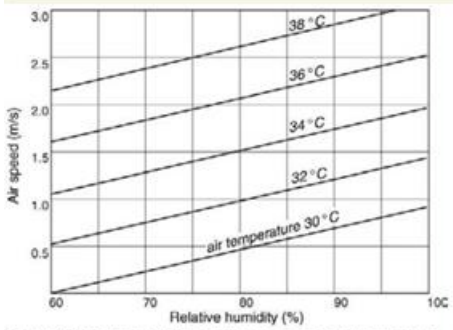


Figure 2.25 Estimated minimum air speed required to restore thermal comfort for a range of air temperatures and relative humidity values.

Table 2.1 Human response to a range of Humidex values

Range of Humidex values	Degree of comfort/ discomfort
20–29	comfortable
30–39	varying degrees of discomfort
40–45	almost everyone uncomfortable
46 or higher	many types of activities must be restricted

Fig 4.10.2: Humidex value

In higher humid areas, **wind provides comfort**.

Normally, the wind speed is higher than required but it will wary towards the micro climate.

Humidity index: Designed to calculate how or humid weather feels to average person.

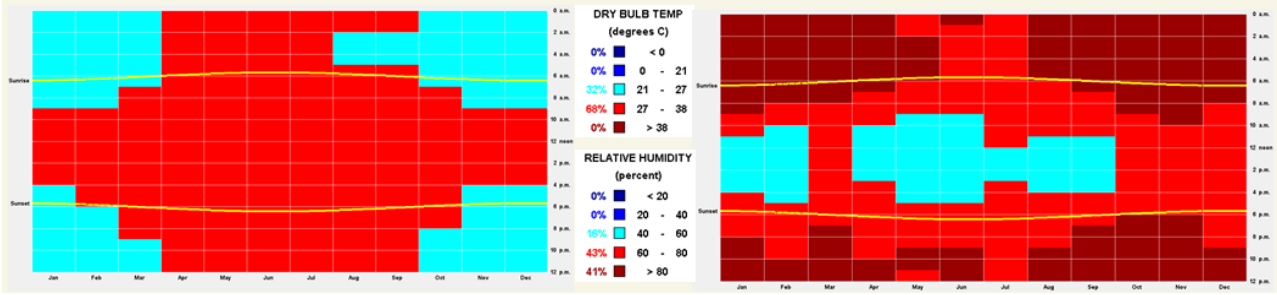


Fig 4.10.3: Uncomfortable hours of temperature and humidity

Comfortable hours *Dry bulb temperature* – 32% (8pm to 8pm)Oct to march

***Humidity* – 16%** (10am to 4pm) Jan, March and from April to September. Discomfort during the day.

Table 4.10.1: Comprehensive table of temperature, humidity and wind speed

MONTHS	MONHTLY AVG TEMP.	MONHTLY AVG HUMIDITY	HUMIDEX VALUE	ASHRAE COMFORT RANGE	WIND DIRECTION	WIND SPEED	WIND PRESSURE	ACCEPTABLE MINIMUM WIND SPEED	WIND SPEED FOR THERMAL COMFORT
JANUARY	24°C	76 %	31	25.4°C	E	1 m/s	- 0.182	-	-
FEBRUARY	26°C	72 %	34	25.9°C	E	2 m/s	0.485	-	-
MARCH	28°C	79 %	39	26.3°C	SE	2 m/s	-0.005	-	-
APRIL	30°C	72 %	41	27.4°C	SE	2 m/s	-0.005	-	0.24 m/s
MAY	32°C	69 %	44	27.7°C	S	3 m/s	5.610	0.29 m/s	2.26 m/s
JUNE	31°C	68 %	42	27.6°C	W	3 m/s	5.050	-	1.04 m/s
JULY	30°C	70 %	41	27.7°C	W	2 m/s	0.709	-	0.24 m/s
AUGUST	29°C	71 %	39	27.1°C	W	3 m/s	5.050	-	-
SEPTEMBER	29°C	74 %	40	27.1°C	W	2 m/s	0.709	-	-
OCTOBER	28°C	82 %	39	26.5°C	E	1 m/s	- 0.182	-	-
NOVEMBER	26°C	84 %	36	25.8°C	N	1 m/s	0.766	-	-
DECEMBER	25°C	76 %	33	25.5°C	NE	2 m/s	-0.773	-	-

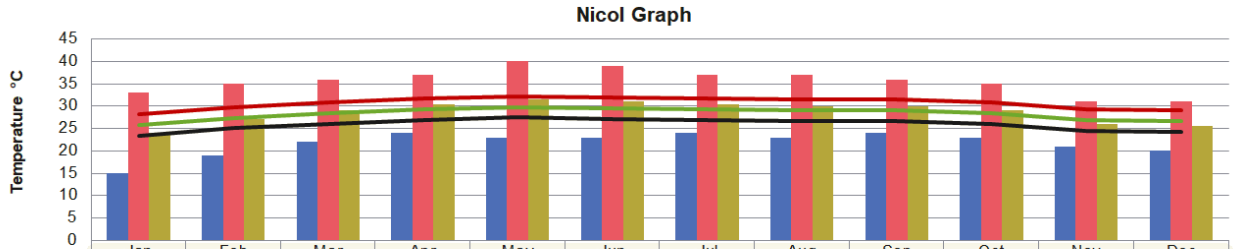
AIR TEMPERATURE : °C	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	High/low	AMT
Monthly mean max.	29	30.5	32.5	34.5	37	37	35	34.5	34	32	29.5	28.5	37	29
Monthly mean min.	21	22	24	26.5	28	27.5	26	25.5	25.5	24.5	23	21.5	21	16
RELATIVE HUMIDITY : %														
Humidity a.m.	81	80	78	74	67	64	70	73	77	82	83	81		
Humidity p.m.	67	66	67	70	68	63	65	66	71	76	76	71		
EFFECTIVE TEMPREATURE : ET°C														
Maximum ET	26.5	27.5	29	31	33	32.5	31	30.5	31	29.5	27.5	26.5		
Minimum ET	19.5	21	22.5	24.5	25.5	24.5	24	24	24	23.5	22	20.5		

STEPS TO CALCULATE THE COMFORT BAND WIDTH			
Step 1	Calculate the AMT (highest air temp mean max. + Lowest air temp mean min)/2		29
Step 2	Calculate the position of center of comfort - AMT > 10°C = AMT/4+17.2 =		24.5°C ET
Step 3	Calculate the AMR (highest air temp mean max .- Lowest air temp mean min)		16
	Calculate the width of the comfort zone (16-18) comfort zone range = 3.5		3.5
Step 4	Upper comfort band limit - (24.5+3.5/2)	26.25	
	Lower comfort band limit - (24.5-3.5/2)	22.75	

The comfort band is 22°C to 26°C by calculating the effective temperature through the 10 year weather data.

- According to the **Ashrae standard 55**, the comfort band is **19° to 27°C** which is not possible to achieve in all the months for Chennai.
- The formula driven **Nicol graph** provides **acceptable Upper and lower limit** of comfort band for each month which can be achieve.
- The nicol graph comfort band ranges from **23°C to 32°C for Chennai.**
- The **average temperature** without the requirement of **Air conditioning is 28.31°C.**

Source:, Ashrae standards 55,



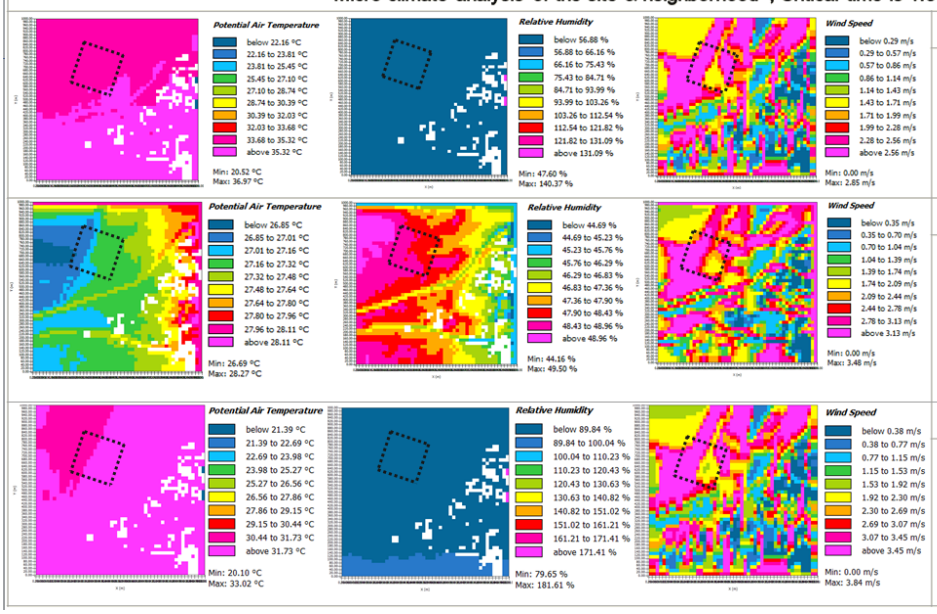
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min .temp	15	19	22	24	23	23	24	23	24	23	21	20
Max.temp	33	35	36	37	40	39	37	37	36	35	31	31
Avg.temp	24	27	29	30.5	31.5	31	30.5	30	30	29	26	25.5
Netural	25.79	27.41	28.49	29.3	29.84	29.57	29.3	29.03	29.03	28.49	26.87	26.6
Lower Limit	23.41	25.03	26.11	26.92	27.46	27.19	26.92	26.65	26.65	26.11	24.49	24.22
Upper Limit	28.17	29.79	30.87	31.68	32.22	31.95	31.68	31.41	31.41	30.87	29.25	28.98

Fig 4.10.4: Nicol Graph

MICRO CLIMATE ANALYSIS

Table 4.10.2: Micro climate analysis of Solstice & Equinox

Micro climate analysis of the site & neighborhood ; Critical time is 1:30pm



Summer solstice : Data (Site) June

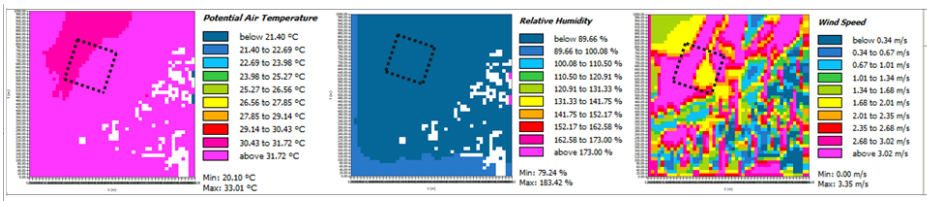
Temperature : 34.5°C
Relative humidity : 57 %
Wind speed : 2m/s Avg
Wind direction : Majorly from SSE

Winter solstice : Data (Site) December

Temperature : 27°C
Relative humidity : 48.69%
Wind speed : Near canal, 3m/s, near road, 2.2m/s Avg
Wind direction : Majorly towards E

Spring Equinox : Data (Site) March

Temperature : 31.7°C
Relative humidity : 89.8%
Wind speed : 2.9m/s Avg
Wind direction : SSW

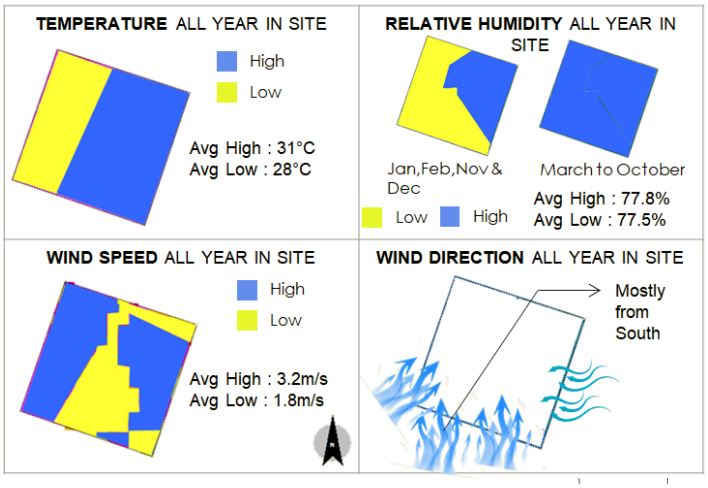


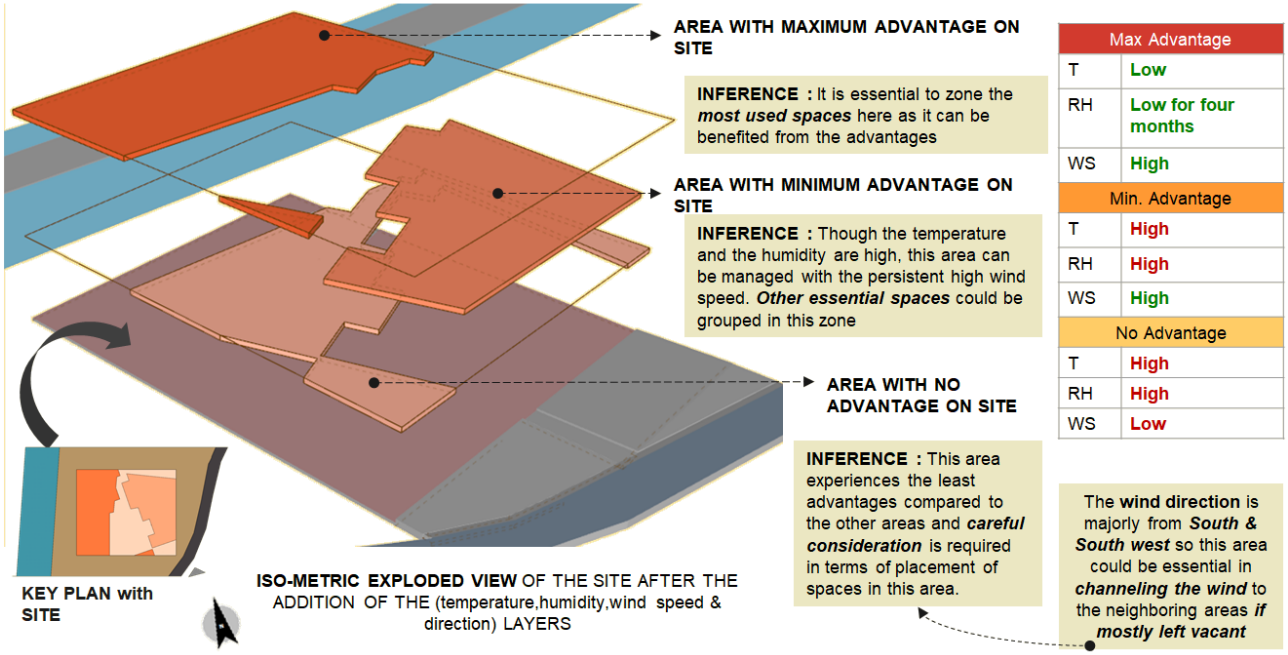
Autumn equinox : Data (Site)

Temperature : 31°C
Relative humidity : 89.6%
Wind speed : Near canal, 3m/s; Near road, 2.35m/s
Wind direction : Majorly towards South

Average values of the site from micro-climate analysis

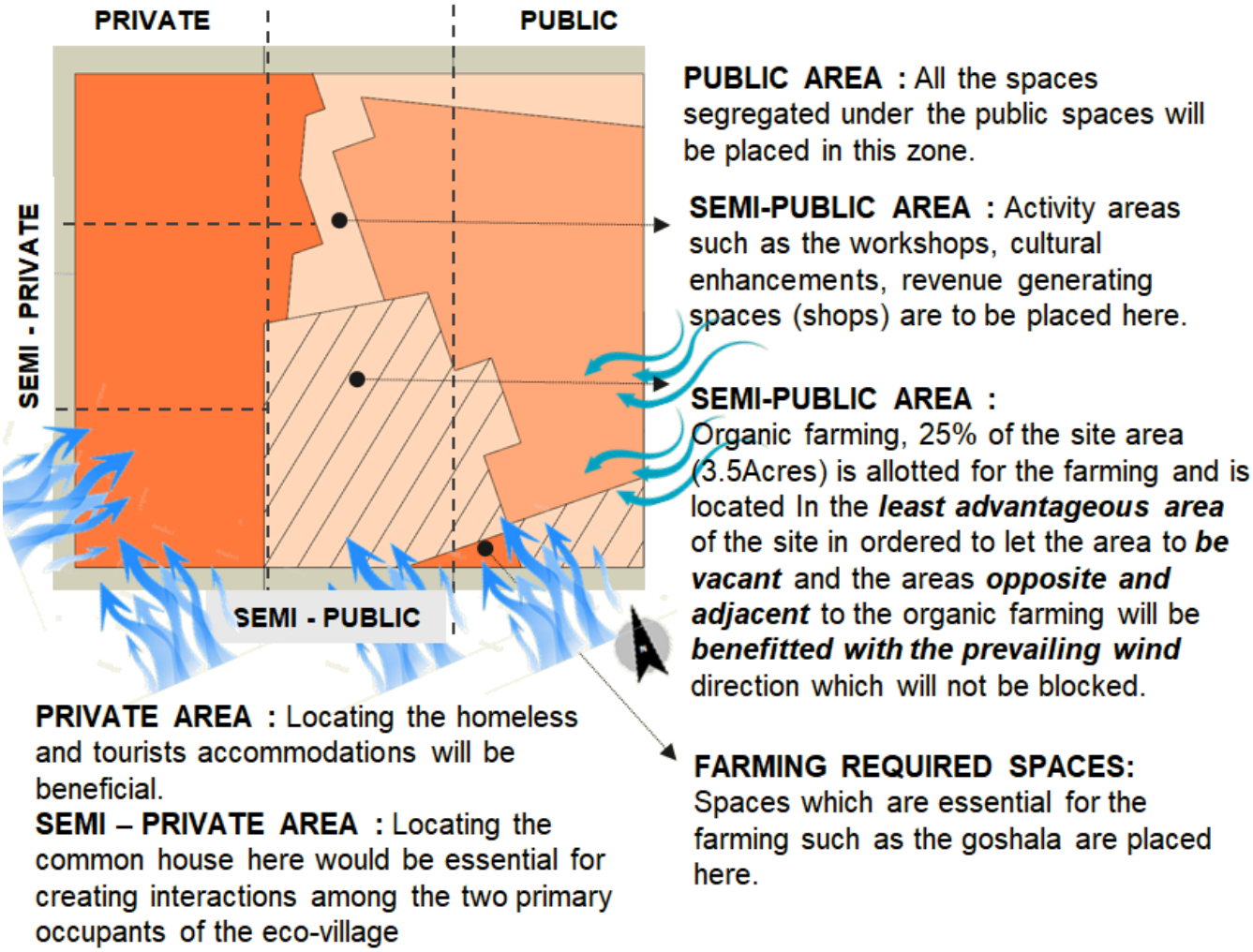
Months	Temp. °C	RH %	W.Speed m/s	W.Direction
Jan	27.7°C	68.2%	2.4m/s	E
Feb	29.3°C	75.4%	2.4m/s	E
Mar	31.7°C	89.8%	2.8 m/s	S
Apr	33.4°C	94.5%	2.9m/s	S
May	34.5°C	57%	2m/s	S
Jun	32.9°C	91.8%	3.1m/s	S
Jul	33.5°C	93.2%	3.1m/s	W
Aug	32.1°C	93.3%	3m/s	W
Sept	31°C	89.6%	2.3m/s	S
Oct	30.8°C	90%	2.2m/s	SW
Nov	28°C	77%	3m/s	E
Dec	27°C	48.6%	2.6m/s	E





Max Advantage	
T	Low
RH	Low for four months
WS	High
Min. Advantage	
T	High
RH	High
WS	High
No Advantage	
T	High
RH	High
WS	Low

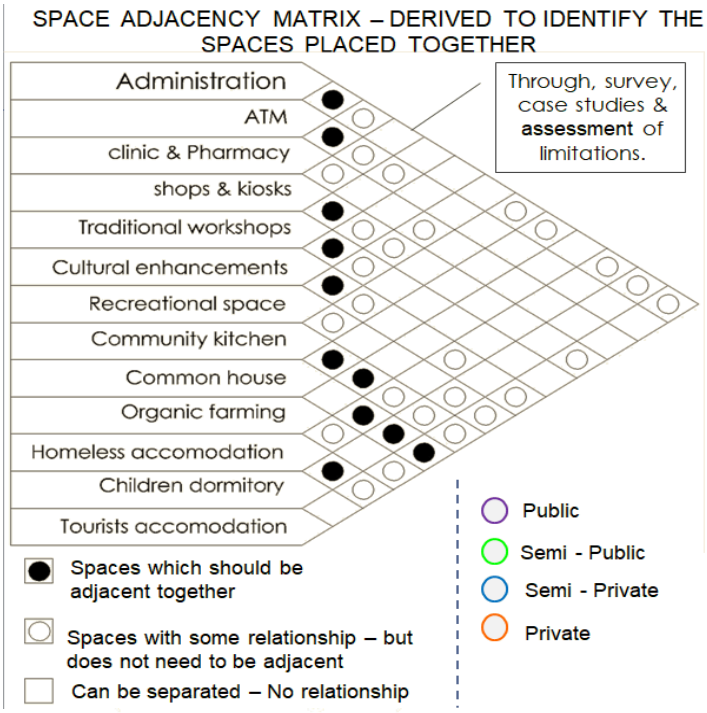
Fig 4.10.5: Site after the addition of the temperature, humidity and wind layers



4.11. SITE ZONING

ESSENTIAL STRATEGIES REQUIRED AT SITE LEVEL

Orientation: Longer axis towards north and south
Shading: Through native shading trees and solar shading devices.
Ventilation: Opening towards the prevailing wind direction. Providing cross ventilation.
Other strategies: Roofs with high SRI, reduction in paved pathways, Compact structures to reduce the exposed surface areas. Use of earth construction materials to reduce the embodied energy and the carbon emission. The lowest point on the site is made into a water harvesting pond which will be used by the community.
Humidity control: Efficient use of prevailing wind in the site.



MACRO-LEVEL ZONING ON TO THE SITE (IN THE MOST USEFUL AREA OF THE SITE) – ZONING – OPTION - 1

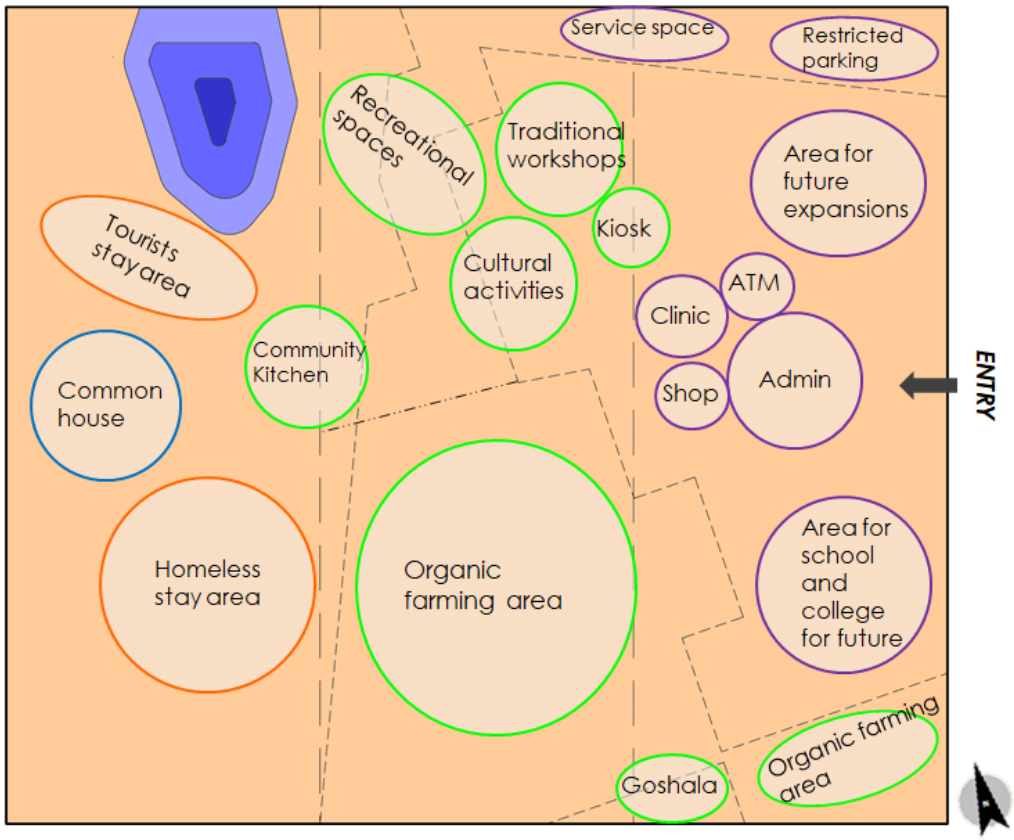


Fig 4.11.1: Site zoning, option - 1

ZONING – OPTION 2 : Negative aspects observed in Zoning 1 are improvised

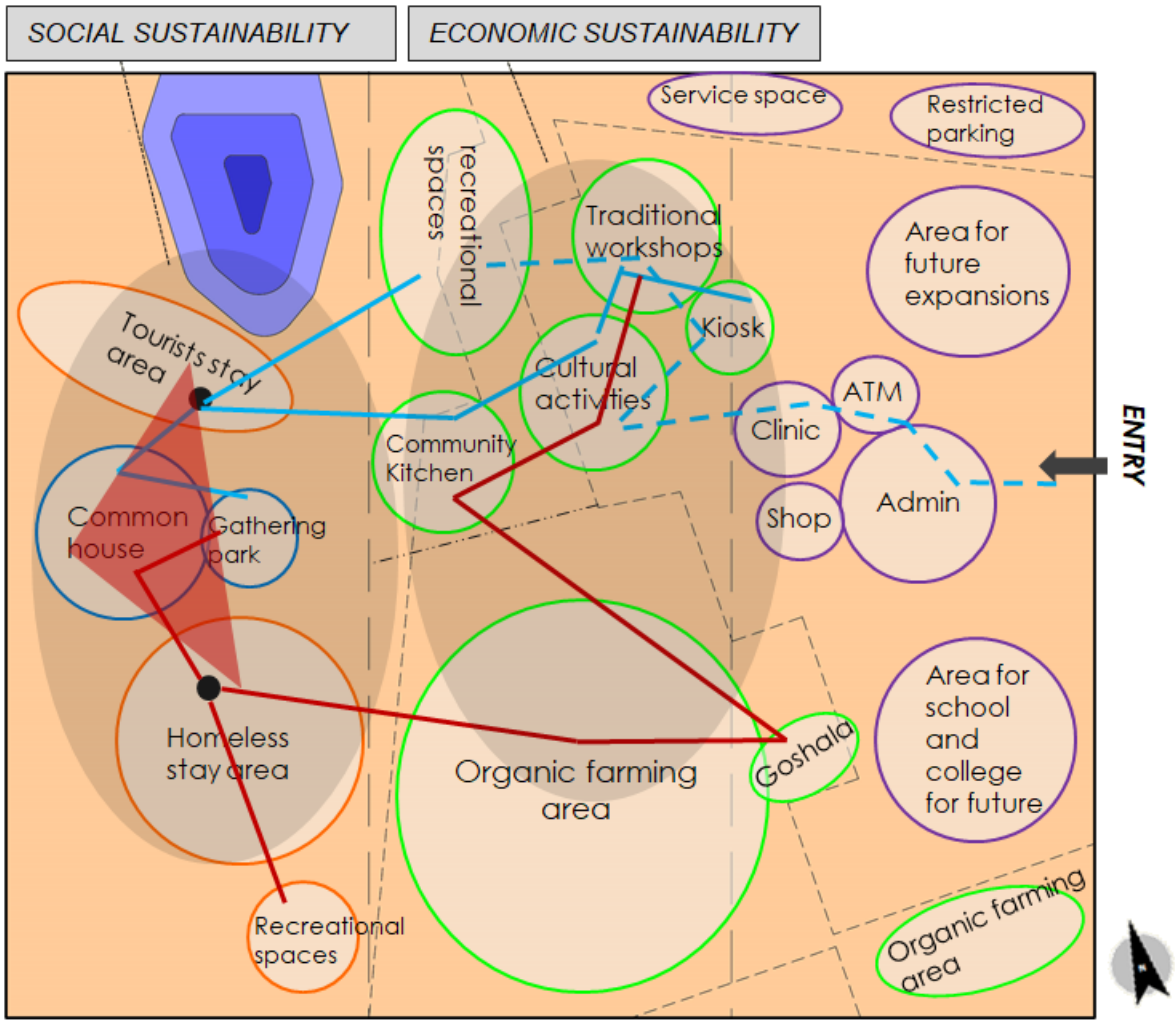


Fig 4.11.2: Site zoning, option – 2

Table 4.11.1: Justification of Zoning 1 & 2

ZONING - 1	JUSTIFICATION ZONING - 2
Negative aspect observed • Distance towards the recreational spaces and the homeless stay was longer. • Goshala was placed in the southern end.	• Break up of recreational space : Private recreational space for homeless people, semi-public recreational space near the tourist stay & semi-private gathering space to interlink the homeless and the tourists. • Goshala moved near the homeless stay & kitchen.

ACTIVITY MAPPING: UG – 1 : Homeless circulation; UG – 2 : Tourists visitors who stay ;UG– 3 : Visitors who just spend the day; Typical day user activity is marked ; (UG-User Group)

Table 4.11.2: Activity mapping

UG – 1	UG - 2	UG - 3
Private stay buffered through the common house. Work in the workshop, goshala, community kitchen.	Private stay with separate recreational space, activities involved are in workshops & community kitchen	Activities are restricted until the semi-public areas beyond which they cannot be accessed.

WHY A COMMON HOUSE THOUGH THERE ARE MULTIPLE SPACES OF INTERACTION IN THE ECO-VILLAGE?

Others: Created mainly for **revenue & skill developments**

Common house: Mainly for spiritual (Meditation hall) , festivities, volunteering and gathering between the homeless & tourists.

4.12.DETAILED MATERIAL ANALYSIS

TO ADDRESS THE ENVIRONMENTAL SUSTAINABILITY :

In ordered to answer the proposed SDG's and to follow the ecological aspects,

1. We promote local and regional food security by growing our own food and seeds.
2. We grow and/or obtain our food in ways that regenerate soils and ecosystems.
3. All our wastewater is safely reused or treated in ways that benefit the local ecosystem
4. We harvest and use water sustainably
5. All our energy comes from renewable sources
6. We choose modes of transport that minimize the use of fossil fuels
7. We cultivate and spread green building skills and methods
8. **We build or retrofit using low impact, natural, locally appropriate and renewable materials .**
9. All our waste is treated as a resource through reusing, recycling, refurbishing or composting
10. We eliminate waste by paying attention to the types and amounts of goods and materials we consume
11. We increase the diversity and varieties of species and habitats in our territory
12. We engage actively in ecosystem regeneration

TO BUILD USING :

To build with materials that are unprocessed and of the earth, having **zero or very low embodied energy**.

Example : Wood, earth, straw , stone etc…

- Modern construction has evolved into a **complicated process** including highly **processed materials** and fittings from a vast global economy.
- **Reclaiming power at a local level** and **valuing what our local** settings have to offer urges us to **employ natural materials** found in our **surroundings.**
- Built to **reflect the local terrain and traditions**, such structures often **blend in with their surroundings** and feel like they **belong there.**
- **Natural insulating materials** are less efficient than **synthetic produced insulation**, thus natural builders should compensate by **thickening walls, floors, and roofs**.
- Reducing the energy use is an Crucial for any building.

Fig 4.12.1: 6 Different earth materials

Table 4.12.1: Research paper – Earth material analysis

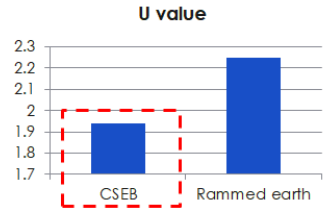
TOPIC	AUTHOR	AIM	METHODOLOGY	REASON	CONCLUSION
Various types of earth buildings	Hamed Niroumand M.F.M Zain Maslina Jamil Published: 2013	This paper describes various types of earth buildings in the world. Rammed earth, Cob, Adobe, wattle & Daub & Poured earth concrete.	All five materials are explained in terms of **their efficiency and their beneficial aspects** towards the environment	To know about various earth materials and their efficiency and to identify the best material.	According to this paper, **Rammed earth** houses are high performing building in earth buildings and are developed in various countries.

BUILDING MATERIALS	IMPORTANCE & BENEFITS
ADOBE BRICK BUILDING Square brick : 280 x 280 x 130 mm Floor tile : 280 x 280 x 40mm 	Adobe bricks can be used in **hot & dry climate** and places with **minimal rain**, the advantages are **low sound transmission** levels through walls, **solidity** and **security.** Suitable for **heating, ventilating and cooling systems, Fireproof** and investment of energy is basic material is low. The **major disadvantage** are the **thickness of the external wall thickness** that considerably decreases the ratio between the total building space and the usable interior spaces.
RAMMED EARTH Formwork length is Between 150 to 300 cm & Height is 50 to 100 cm Ratio of wall thickness to Wall height 1:8 & 1:12 Wall can be thin as 30cm 	Man-made equivalent for **sedimentary rocks** is rammed earth. It Is built in **more damp and humid climates**. The construction of rammed earth is **highly sound** and **economical**. The soil is same as the adobe bricks. **Durability** and **waterproof** are based on the content of the clay in it, **Higher clay** content is preferred. The **moisture content** in rammed earth is **much lower** therefore rammed earth are subjected to **less shrinkage on drying**.

COB WALL About 61cm thick		The **simplest** of all earth-building technologies is called **cob.** This technique requires very few tools and no formwork. The cob mix is similar to that of mud bricks and its stiffer due to **higher straw content**, which helps the **mud hold** the form, After the **occurrence of Tsunami** , the construction of **cob houses** have **increased** and another added benefit is that its **easily constructed** so its opted all around the world.
WATTLE & DAUB 76 mm to 101 mm thick Straight & about 1.8m Length, Oak & chestnut Are the best wood.		One of the **oldest earth-building technologies** in the world. Tree branches are the **most common construction** material at the time to build the structural framework and mud plastered into the nest of interwoven branches it ensure **protection from sun** and other **unfavorable weather conditions**. Wattle and daub structures overpowers the more permanent structures constructed using mud bricks or rammed earth. They are **highly earthquake resistant** because it is extremely **flexible.**
POURED EARTH CONCRETE Maximum percentage Of earth and minimum Percentage of concrete		Each of the **four earth construction** techniques mentioned comprises earth un framework and allowed it to dry. In case of wattle used for an **exterior or interior** wall, the resulting **gap is filled with mud**. The rammed earth construction requires laborious tamping where the **resulting shape is achieved** when the mud is completely dry. Based on the traditions prevalent in a region, the framework can serve as the primary structural support to the building. **Low-cost disaster housing** is a radical take on poured earth traditions.
INFERENCE : All these earth materials are **sustainable and efficient** if sourced from or **very close proximities** to the **site** as providing the material from far can **increase the embodied energy** of the material, All the materials mentioned here are **labor intensive and requires high labor cost. These materials cannot be used for high rise developments**. In addition all these materials **require constant maintenance** and are load bearing walls. So, **For low rise development** from all the materials, **rammed earth can be chosen** for further details from this study from the materials.		

Table 4.12.2: Comparison between CSEB blocks and Rammed earth blocks

Parameters	CSEB	RAMMED EARTH
Components of materials	A mixture of water with three main materials such as Ordinary Portland Cement (OPC), soil, and sand.	70% of sand & 30% of clay and about 10% of water is required
Insulation, Durability , Stability & Fire resistance	**High durability** They naturally cut down sound transmission, Structural strength is more than adobe bricks, Strong enough to withstand good loads, heavy rains & snow. Fire resistance property is good.	Great sound absorption, Strong and stable, highly durable but needs protection from heavy rains and exposure to moisture. The fire resistance aspect is good (4 hour resistant).
U value & R value	U value : **1.94** W/m².K (500mm wall) ; R value : 1.19 to 0.76 m².K/W	U value : 3 W/m².K ; R value : 0.8 m².K/W
Moisture resistance	Good	Good
Compressive strength	**3.92 – 5.88** N/mm²	50 to 20 N/mm²
Thermal conductivity	0.84 – 1.3 W/m.k	1.25 W/m.K
Maximum height	2 floors can be built without RCC frame structure	2 floors can be built without RCC frame structure.
Cost & benefit	40% cheaper then conventional brick, 20₹/piece	If procured from site, its cheaper
Labor	Moderate	Labor intensive
Availability	**5 to 10 manufacturers** identified in Chennai	**2 Manufacturing** unit found in Chennai
Workability & construction	Requires **low to moderate skilled labor**, Simple three step manufacturing process & construction.	Requires **a lot of labor** and four steps involved in construction process.
Construction time	14 days (70% - 80%)	70% strength achieved In 7 days
Embodied energy	572MJ/m³ (Country fried bricks 6122MJ/m³)	0.033 MJ/m^3 and 0.36 MJ/m^3

Sustainability & affordability	Provides **opportunity for unskilled, unemployed people**, Cheaper than bricks, if demolished and disposed-off properly in soil, the humus can break CSEBs down and thus giving back soil to the earth.	Locally available materials, Low environmental impact, **Job opportunity for unskilled labor**, non-toxic, Generate very little waste and affordable if sourced near by.
Environmental impact	Are **eco-friendly alternative to clay bricks**. Material content is natural and no chemicals	Eco-friendly , Low greenhouse gas emission, Breathable wall
Maintenance	Requires **very minimum maintenance**	
Energy efficiency	• Are made in-situ, reducing the **carbon footprint** • Due to their thermal mass quality, they can save up to **10-15% on heating & cooling costs.** • Pollution emission **is 2.4 to 7.8 times less than bricks**	• Most of the **energy used** in the construction is in quarrying the **raw material and transporting** it to the site . On site can reduce energy . • High thermal mass, Reduces heating & cooling cost
Per Sft CO^2 emission	51.5 Kg/m² (10.7 times less than country fried bricks)	Lower carbon emission
Water requirement	**High**, 28 days curing required	
Disadvantage	Restricted to **low rise**	Limited insulation & limited to low-rise
Comparison of thermal transmittance and cost for two wall typologies		**COST** CSEB is considered in terms of piece of brick whereas, rammed earth wall is considered per area of wall and **rammed earth costs generally more than CSEB**. **OVERALL INFERENCE** While comparing the cost, efficiency & other factors, **CSEB blocks are best suitable material** compared to Rammed earth as the advantages and **availability is observed to more in Chenna**i and this material can be used to construct **low rise affordable houses.**

SOURCE : Building the future with earth using Compressed stabilized earth blocks, auroville earth institute

SOIL REQUIREMENT : Only the deeper soil is used for blocks and not the top soil. A good soil for CSEB is more sandy than clayey, It has these proportions.

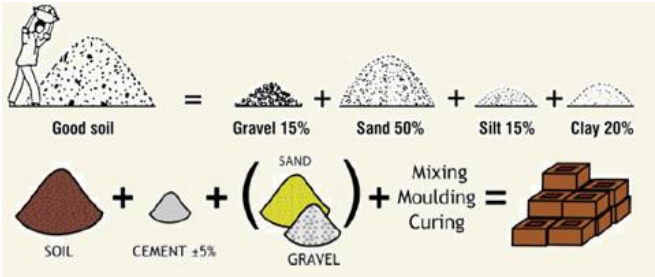


Fig 4.12.2: CSEB block material composition and different sizes

Type of Soil	Places in District
Read Loam	Kancheepuram, Uthiramerur Blocks
Lateritic Soil	Pleatus in the district
Sandy Coastal Alluviam	Some Places Thirukazhukundram,Thiruporur, St.ThomasMount.
Red Sandy Soil	Kancheepuram, Urban Blocks

SOIL TYPE IDENTIFICATION : It is identified that the soil typology of mahabalipuram is **Sandy coastal alluvium** and they are generally consist of in **silt, sand, clay, and gravel** and often contains a good deal of organic matter. It therefore yields very fertile soils. According to a study, these soil are not suitable for cement stabilization so, lime can be used for the stabilization to create CSEB blocks.

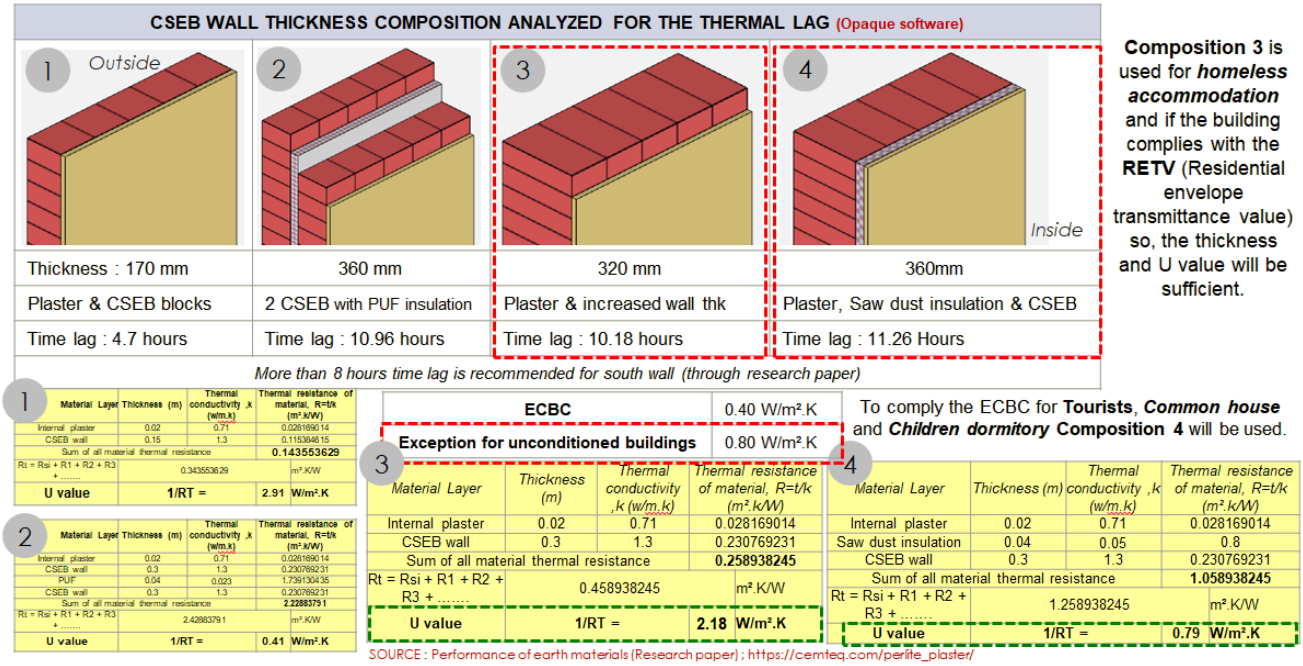


Fig 4.12.3: CSEB Wall composition for different building

FOUNDATION: ISSUES RELATED TO THE FOUNDATION WHILE USING CSEB BLOCKS: The two main issues related to the foundation are the structural issues and problems related to the humidity.

THE FOUNDATION WHICH WILL BE FOLLOWED:

Isolated footing with **RCC (1.8m Approx.)** until **the plinth** of the building **which will be 0.45 m** (Ground level beam tie & plinth level beam tie) and this **would be sufficient structurally** for the building to withstand without columns as the buildings are all going to be in the **maximum height of 7m height** (G+1).

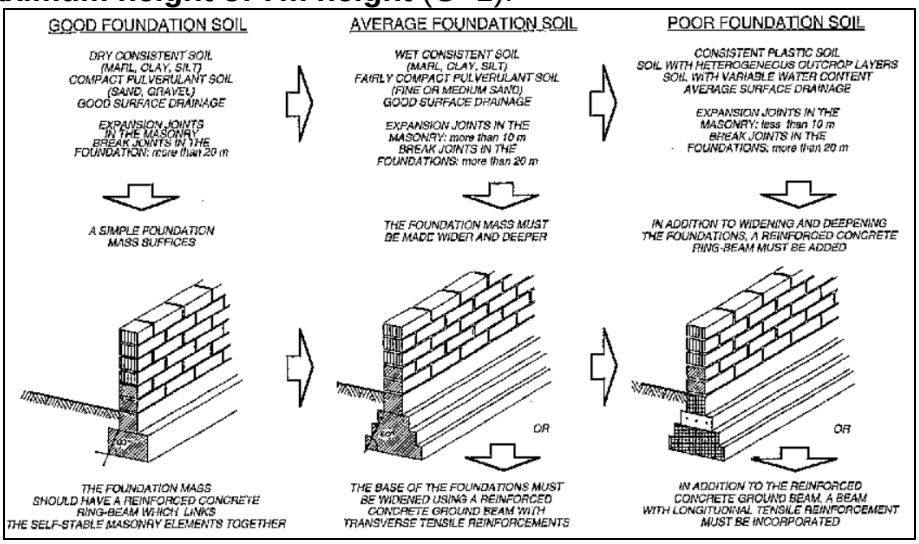


Fig 4.12.4: Foundation detail

Table 4.12.3: Window detail

High performance glass	It reduces the heat ingress at the same time allows higher penetration of daylight.
Benefits of high performance glass	Energy saving up to 35 – 40%, payback period is 3-4 years & provides occupant comfort.
The specifications	Low U value, Low SHGC and High VLT
Values As per ECBC, SHGC : 0.27 W/m²°K VLT : 0.27 U value : 3 W/m²°K	**Property** / **Range** Shading Coefficient: 0.1 – 0.4 W/m² deg K U-Value: 1.7 – 3.0 W/m² deg K Visual Light Transmittance: 40-60%
Types of glazing	Insulated (Triple glazing), Gas filled double glazing, Heat absorbing, Low emissivity, Spectrally selective and reflective coating.
Selected glazing	Gas filled double glazing casement window
Frames selected	Upvc over wood or aluminum due to many use.

S. No.	Governing Factor	Wood	Steel	Aluminium	uPVC with Steel
1	Dimensional Stability	*	***	***	****
2	Environmental Stress/ Crack Resistance	*	**	**	****
3	Basic Structural Strength/Modulus of Elasticity/Flexural Strength	**	****	**	****
4	Material Fatigue	**	****	***	****
5	Electromagnetic Shielding	****	***	**	***
6	Impact Resistance	***	****	**	****
7	Chemical Resistance	**	*	**	****
8	Fire Resistance	*	***	**	***
9	Thermal Transmittance Resistance	**	*	*	****
10	Sound Insulation	**	*	***	****
11	Air Tightness	*	*	*	****
12	Operational Easiness	*	*	**	****
13	Periodic Maintenance	*	*	*	****
14	Aesthetic Value	***	*	***	****
	Ratings: Poor	** Good	*** Very Good	**** Excellent	

Cost	450 ₹/ Sqft Approx.
Availability	Venes window manufactures nearest about 6Km from the site.
Door	Refurbished doors from Shollignallur.

SOURCE : Bulletin, high performance glazing from Indian green building council.

ROOF : Cool roofs: Roof coating, colors, textures, finishes such as china mosaic tiles.

- Cool roofs are **not to be seen** as an **alternative** to the thermal transmittance requirement of the roof (Uroof).
- It's better to have **high SRI** value, (Both solar reflectance & emittance in single value, A standard white surface of reflectance 0.8 & emitance 0.9).
- IGBC Green Homes requires a minimum **SRI value of 78** for roof slopes with gradient **≤1:6** and **29 for steeper roof.**
- According to **ECBC 2017 cool roof** requirement, roofs with slopes less than 20 degrees. Shall have an initial **solar reflectance** of at **least 0.6** and an initial **emittance of 0.9**.
- Thickness : 300 mm

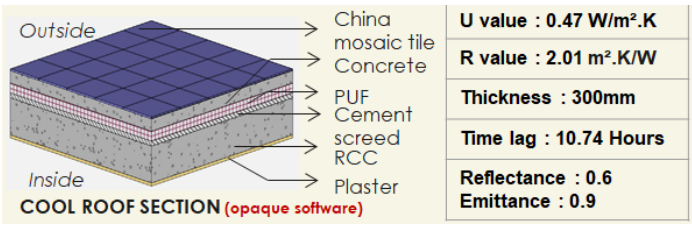
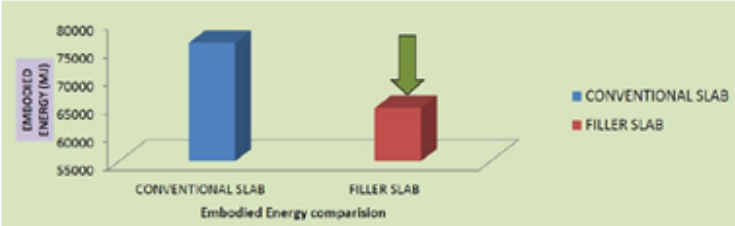


Fig 4.12.5: Conventional roof composition

Table 4.12.4: Research paper: Passive cooling roof study

TOPIC	AUTHOR	AIM	METHODOLOGY	CONCLUSION
Passive cooling techniques through reflective and radiative roofs in tropical houses in Southeast Asia : A literature review	KaramM.Al-Obaidin, MazranIsmail,AbdulMalekAbdulRahman Published: 2014	**Reflective & radiative** processes are the methods used to **decrease heat gain** by facilitating the elimination of **excess heat** in a building's interior to maintain a **comfortable environment**. This study reviews the physical characteristics of these approaches to guide architects and building designers.	In the passive cooling methods for energy efficient buildings, **one of the method is heat dissipation technique** and in that **radiative cooling** and **paints** are studied in this paper.	Implementing **reflective** and **radiative** approaches in roofing systems will enhance environmental sinks for heat dissipation, there by minimizing the effect of heat penetrating, as well as contributing to the reduction of internal gains through day lighting and appliances. These strategies constitute the most **cost-effective methods** for creating an optimally cool environment.



Reduction in embodied energy in filler slab than conventional slab.

FILLER SLAB : A cost effective passive roof techniques to replace the conventional slab with synthetic insulation. Research paper**(1)**

OBJECTIVE	CONCLUSION
To verify the **feasibility of filler slabs** acting as **a solution for** ECBC based roof compliance for building in different climatic zones of India and for the different levels of ECBC. This research will help **reduce the heat transfer** through the roof component of the building envelope, **reducing** the energy consumption by **HVAC systems.**	• Though the filler slabs help **reduce** the thermal transmittance by **24% - 52%,** it is not enough to comply with the requirements of ECBC. • **Additional thermal insulations** must be used along with the filler slabs to achieve the **desired U value** specified in ECBC. • Slabs with **300mm** Thickness can comply with ECBC.

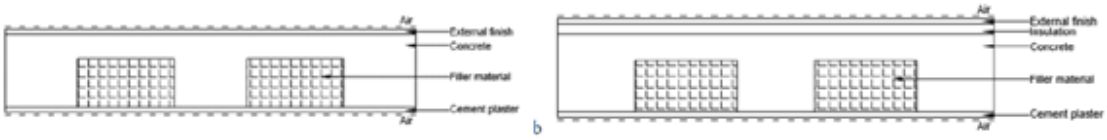


Fig. 3 (a) scenario 1 - section of filler slab; (b) scenario 2 - section of filler slab with external insulation

SOURCE : http://mansi-shah.weebly.com/cool-roofing-demonstration-project.html ; ECBC samhita Uroof Transmittance calculation, CARBSE, Research paper : Optimization based feasibility study for filler slabs as a response towards the ECBC roof compliance with respect to thermal transmittance for five climatic zones of India.**(1)**

Fig 4.12.6: Filler slab details

Table 4.12.5: Transmittance of roof - 1

STEP -3	Thermal transmittance of roof (Uroof)			
TABLE-21	*Roof construction details*			
Material Layer	**Thickness,t (m)**	**Thermal conductivity ,k (w/m.k)**	**Thermal resistance of material, R=t/k (m^2.k/W)**	
Internal plaster	0.019	1.21	0.015702479	
Filler material	0.075	0.033	2.272727273	
RCC slab	0.15	1.58	0.094936709	
Weathering tile	0.012	0.63	0.019047619	
White paint				
Sum of all material thermal resistence			2.40241408	
Total Thermal resistance,				
Rt = Rsi + R1 + R2 + R3 + ...	2.61241408			m^2.K/W
Thermal transmittance of roof,	*Uroof = 1/RT =*		**0.38**	W/m^2.K
This is **less** than the maximum Uroof value of 1.2 W/m^2.K, Hence **it complies** with this requirement				

<u>INFERENCE :</u> The **RCC roof with PUF insulation** is replaced by the **filler material (Earthen pots)** and there is a **22.4% reduction** from the previous roof, This u roof transmittance value **(0.38 W/m^2.K)** is **sufficient** for **complying with the ECBC Samhita** for (*homeless and tourists accommodation spaces*), In ordered to achieve the **u value of ECBC**, **additional insulation** has to be added and instead of using synthetic insulation, **Saw dust** is used, which makes **further 13.1% reduction in u value** and the estimated **time lag is 10.57 Hours**.

Table 4.12.6: Transmittance of roof – 2

STEP -3	Thermal transmittance of roof (Uroof)			
TABLE-21	*Roof construction details*			
Material Layer	**Thickness,t (m)**	**Thermal conductivity ,k (w/m.k)**	**Thermal resistance of material, R=t/k (m^2.k/W)**	
Internal plaster	0.019	1.21	0.015702479	
Filler material	0.075	0.033	2.272727273	
RCC slab	0.15	1.58	0.094936709	
Insulation (Saw dust)	0.02	0.05	0.4	
Weathering tile	0.012	0.63	0.019047619	
White paint				
Sum of all material thermal resistence			2.80241408	
Total Thermal resistance,				
Rt = Rsi + R1 + R2 + R3 + ...	3.01241408			m^2.K/W
Thermal transmittance of roof,	*Uroof = 1/RT =*		**0.33**	W/m^2.K

Table 4.12.7: Research paper: Sloped roof study

RESEARCH PAPER : Sustainable roofs for warm and humid climate for residential units in Madurai

AUTHOR	AIM	CONCLUSION
A.Madhumitha, S. Radhakrishnan & R.Shanthipriya	To Identify which roofing techniques are essential to achieve the thermal comfort in the residential units in Madurai.	Madras terrace roof and the **sloped reinforced concrete roof with clay tiles covering with air gap in between** are best suited roof for **thermal comfort** and the thermal performance of the above can be improved better by the addition of insulation materials such as cellulose or glass wool in the air cavity space.

Material Layer	Thickness,t (m)	Thermal conductivity ,k (w/m.k)	Thermal resistance of material, R=t/k (m^2.k/W)	
Internal plaster	0.02	1.21	0.016528926	
RCC slab	0.15	1.58	0.094936709	
Air cavity	0.04	0.025	1.6	
Clay tile	0.015	0.63	0.023809524	
White paint				
Sum of all material thermal resistence			1.735275158	
Total Thermal resistance,				
Rt = Rsi + R1 + R2 + R3 + ...	1.945275158			m^2.K/W
Thermal transmittance of roof,	**Uroof = 1/RT =**		**0.51**	**W/m^2.K**

Material Layer	Thickness (m)	Thermal conductivity ,k (w/m.k)	Thermal resistance of material, R=t/k (m^2.k/W)	
Internal plaster	0.02	1.21	0.016528926	
RCC slab	0.3	1.58	0.189873418	
Saw dust insulation	0.05	0.05	1	
Air cavity	0.04	0.025	1.6	
Clay tile	0.015	0.63	0.023809524	
White paint				
Sum of all material thermal resistence			2.830211867	
Total Thermal resistance,				
Rt = Rsi + R1 + R2 + R3 + ...	3.040211867			m^2.K/W
Thermal transmittance of roof,	**Uroof = 1/RT =**		**0.33**	**W/m^2.K**

INFERENCE : As per the **ECBC Compliance**, the roof should be **0.33W/m².K** u value and just with the cavity the u value was not able to be achieved and a extra layer of insulation and by increasing the size of the roof from 0.15m to 0.3m , the sloped roof is able to achieve the roof compliance from the ECBC code.

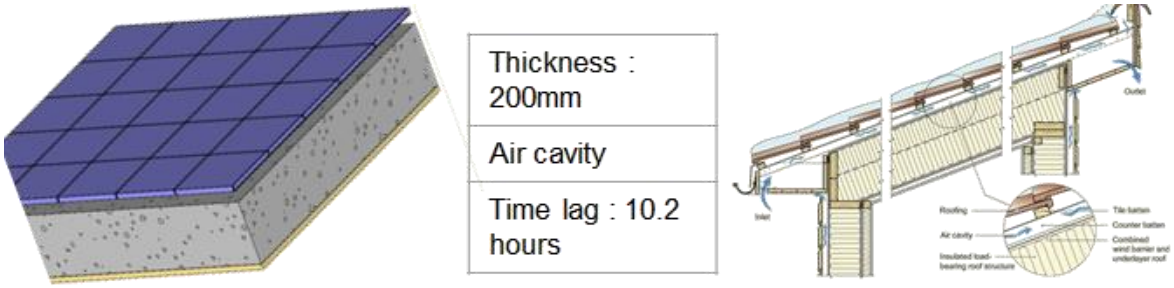


Fig 4.12.7: Roof composition details

FLOORING:

Flooring material used for the buildings (Homeless, Tourist, Common house and the children dormitory):

Cost-effective	Durable flooring	Easy maintenance
Ideal for warm tropical locations	Lustrous finishes get better with time	

Laying of red oxide flooring: (1:3) of oxide to cement for darker shade & increasing the grey cement ratio will provide lighter shade.

APPLICATION: 7 days to be completed

Apply	Sprinkle for every 2 hours	Wait 4 days & wax coated

If skilled labor not procured, Red oxide tiles (with various colors) can be laid easily.

COST : Cheaper than many options**, 80 to 90** ₹/ Sq. ft. View of studio unit of the tourist accommodation

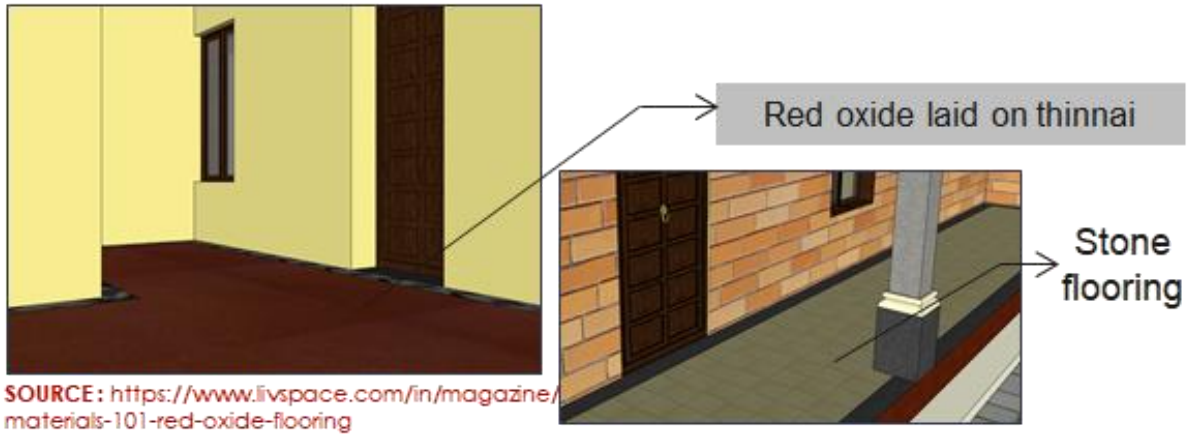


Fig 4.12.8: Flooring details in tourists

STAIRCASE: CSEB blocks and stone treads placed above. Image showing the Staircase of the private Unit in the tourist's accommodation.

Fig 4.12.9: Staircase, railing and baluster details

View showing the first floor railing of tourist accommodation.
RAILING: Concrete baluster painted brown.

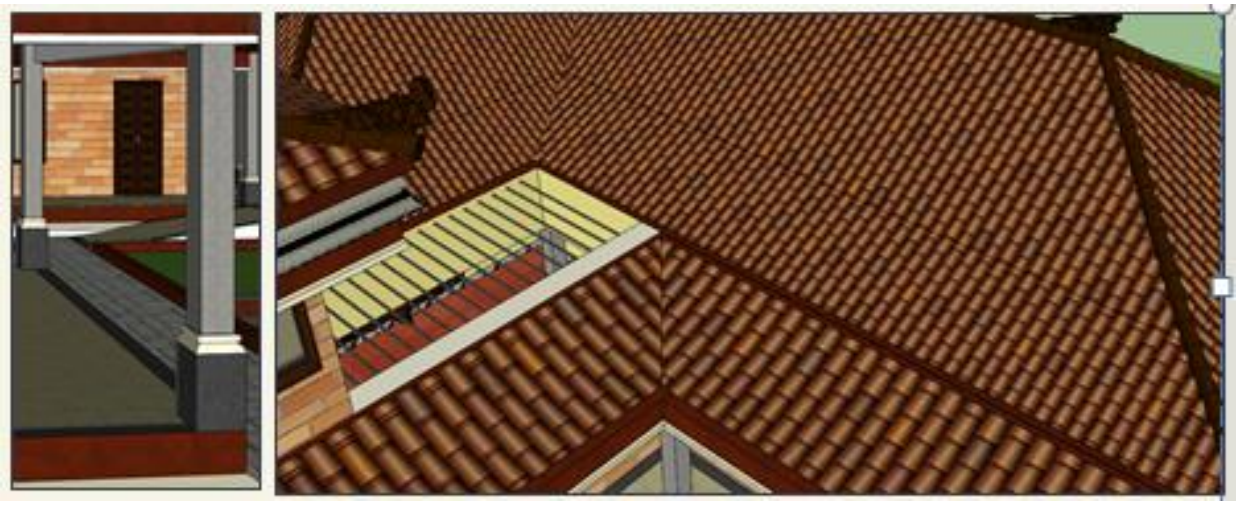


Fig 4.12.10: Stone column and Sloped roof details

Concrete sloped roof with clay tile on top with an air gap in between.

To reduce the overall carbon footprint, **100% of the materials** were sourced from **50Km** radius from the site. This reduces the fuel usage, cost and pollution.

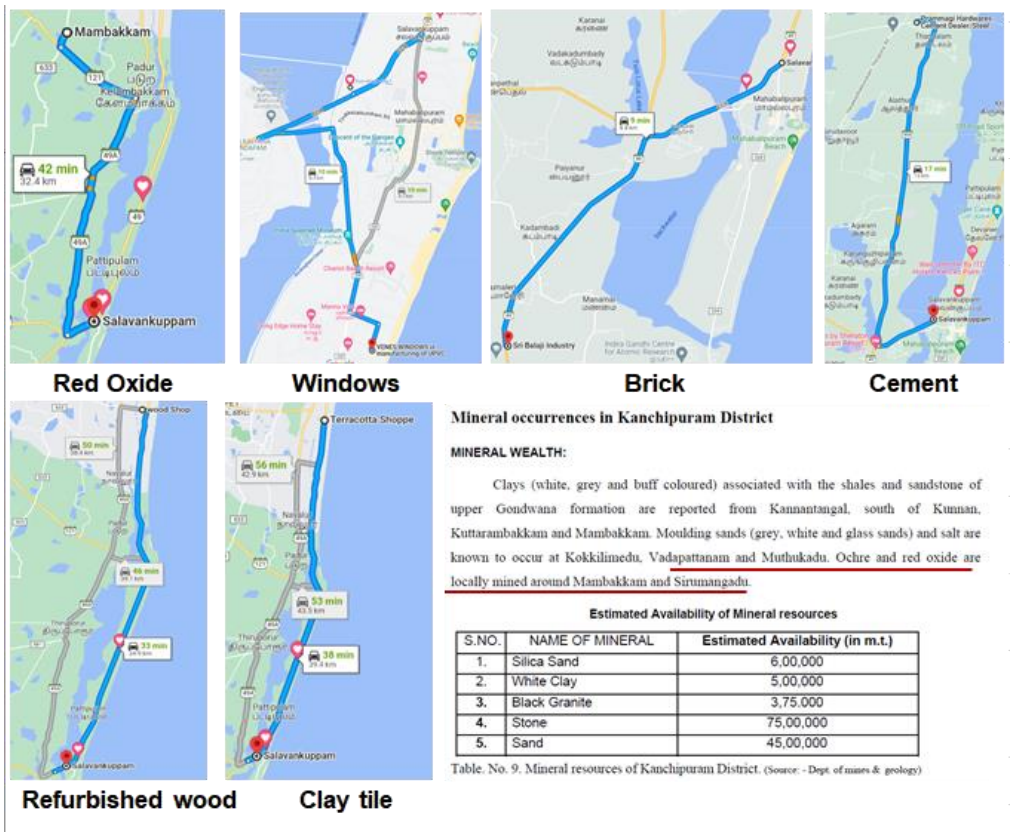


Fig 4.12.11: Stone column and Sloped roof details

Table 4.12.8: Material sourcing table

MATERIALS	FOR (TOURIST, HOMELESS ACCOMMODATION, COMMON HOUSE & DORMITORIES)	DISTANCE FROM SITE
Wall material	CSEB Blocks & brick wall for toilets to conserve materials.	From site CSEB & 8.8 Km (9 mins) - brick
Plaster	Lime stabilization for CSEB & Cement plaster for wall.	Local vendor, mahabalipuram
Roof material	Filler slab, Mangalore tile sloped roof in certain areas.	39.4 Km (38 mins)
Window	Double glazing window	6.3 Km (10 mins)
Door	Refurbished wooden doors	34.9 Km (33 mins)
Flooring	Red oxide flooring, granite flooring (boarder).	32.4 Km (42mins)
Staircase & railing	CSEB blocks & stone treads for staircase & terracotta tile for railing	Local vendor, mahabalipuram
Column	Stone columns	Mahabalipuram

Table 4.12.9: Area statement

Public Spaces	No.	Area	T.Area
Car parking	50	12.5	1250
Bike parking	100	1.6	160
Bus parking	5	35	175
Security spaces	2	6.25	12.5
Admin office	1	300	300
Clinic & Pharmacy	1	100	100
ATM	2	6.25	12.5
Institution (1 Acre)	Land allotted future development		
Workshops & revenue	1	5359	5359
Public park	1	2058	2058
Semi-Public spaces	*Community kitchen*		
Kitchen	1	135	135
Cold storage	1	22	22
Dining space	1	250	250
Storage space	1	20	20
Change rooms	2	5	10
Toilet & Hand wash	2	5	10

DETAILED PLANNING OF SPACES				
	Semi-Private spaces	*Common house*		
	Lobby	1	27	27
	Informal living	1	100	100
	Guest rooms	5	17	85
	Toilets	7	4	28
	Multipurpose hall	1	145	145
	Class rooms	2	32	64
	Meditation hall	1	46	46
	Organic farming : 25% of the site area = 3.5 Acres farming			
	Private spaces	*Homeless & Tourists accommodations*		
	Family co-living space (Homeless)	3 Blocks	1348.9	4,047
	Male children dorm (20 person)	20 bed (1)	511.3	511.3
	Female children dorm (20person)	20 bed (1)	511.3	511.3
	Tourists accommodations	7 blocks	430	3,010
	Recreational park (tourists & homeless)			
	Total built-up area in Sqm			**18,448**
	OSR area in Acres			1.8

*FSI which will be achieved is (18,448 / 74,057) = **0.24** (Allowable is 2)*
Open space is76% and the built is 24 % . (All values in the table are in Sqm)

4.13.DESIGN IDEOLOGIES & SPACE PLANNING

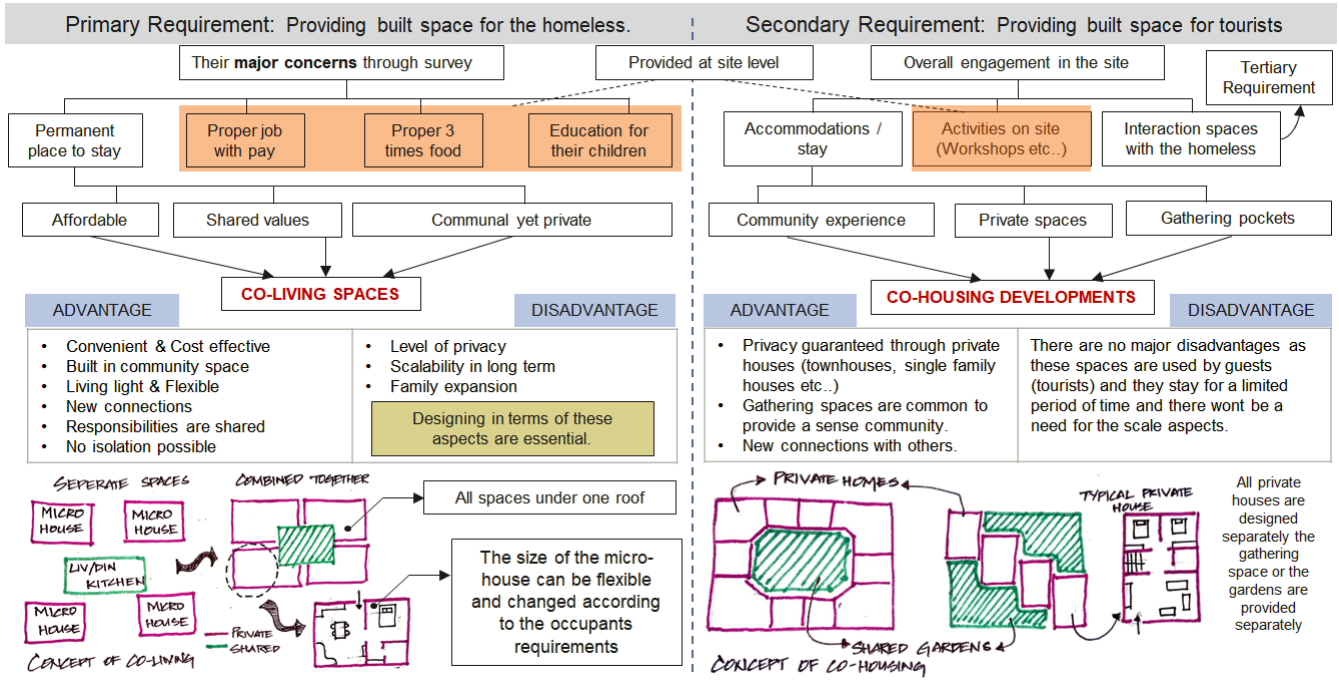


Fig 4.13.1: Design Concept

PLANNING IDEOLOGIES FOR FAMILY CO-LIVING: Homeless Accommodations

CONCEPT: Co-Living
REQUIRED: Compact units: Studio, 2 and 3 bedroom spaces.
BUILDING LEVEL: G+1 maximum (7m height); WHY: To create spaces more closer to ground and provide horizontal spread.
DESIGN IDEOLOGY: Introvert planning – Concealed with privacy and secluded without compromising in the interactive space.
WHAT TYPE OF SOCIAL INTERACTION SPACES CAN BE PROVIDED FOR THE OCCUPANTS: Apart from the revenue generating works they are involved in the eco-village, their accommodations are the most important aspect of the eco-village, they are planned with,

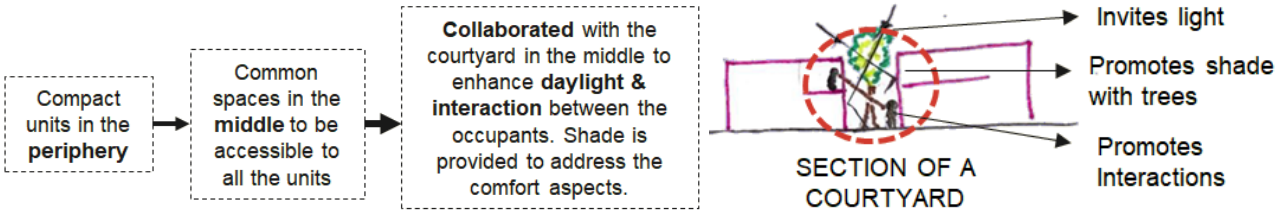


Fig 4.13.2: Ideology behind planning & section

The units are decided and will be designed based on the **future expansion of families** so they are flexible to use.

- According to the **ministry of urban and housing affairs, government of India**, the **occupant load** in a **residential** development is **8 per 100 Sqm.**

In a **single floor plate**, **8 units to 10 units** of **different sizes** are planned, according to the units the **occupants capacity** are decided; Source : https://mohua.gov.in/

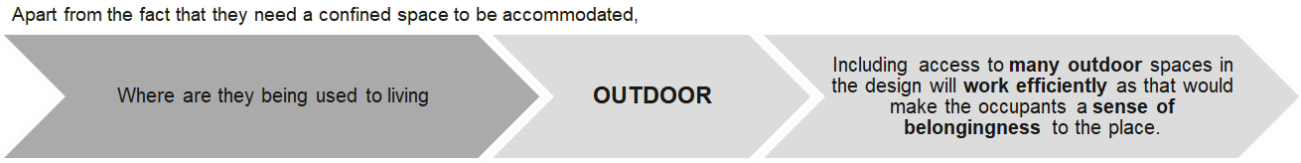


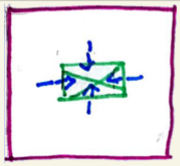
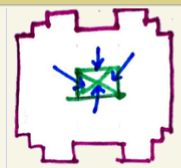
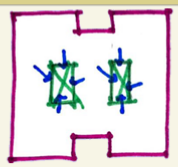
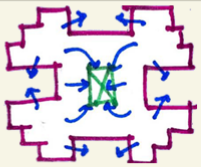
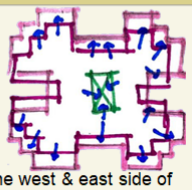
Fig 4.13.3: Understanding the mind of the homeless

FORM FACTOR ANALYSIS: Homeless Accommodations
As heat will enter through the building gradually and **reduced surface area** (**Compact buildings**) will have **less heat entering** inside the building, so **form factor** is very important to determine in the **early stage itself.** Two ways of finding buildings form factor :

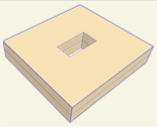
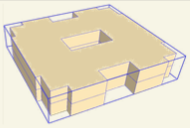
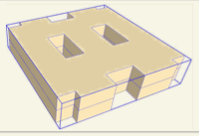
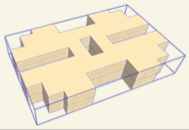
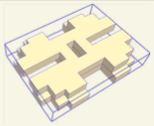
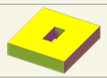
- **Heat Gain form factor (HGFF)** = Buildings envelope area **(EA)/**Net floor area **(NFA)** HLFF is generally between **0.5 to 5**, the lower the number more compact it is. Recommended passive house FF is **3.**
- **Surface to volume ratio (SVR)** = Building's envelope area (EA)/Volume (V). The recommended passive house **SVR is ≤ 0.8 1/m**. or **is 0.5 1/m** in some other source.

Table 4.13.1: 5 Different planning ideologies, Form factor & solar insolation analysis

5 PLANNING IDEOLOGIES : By incorporating the co-living concept with courtyards in many different ratios and planning.

1	2	3	4	5
				
Compact planning : G+1. the courtyard is placed in the center as a place of interaction, the size of the courtyard is 10m x 5m.	Different unit sizes placed to provide light & ventilation for all the spaces along with the courtyard size : 10m x 5m.	Two courtyards of size 4m x 8m is placed in the center of the floor plate and the shared spaces are placed in between.	2 units are placed in each corner of the four sides and 4 open spaces introduced in between with a courtyard 3mx6m.	The west & east side of ground floor plans open space is made bigger to get the advantage of balcony for all the spaces.

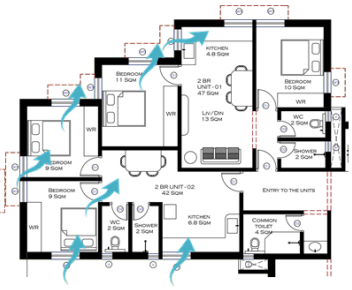
All the **5 modules are modeled in modelur** to arrive at the **form factor & further analyzed in terms of solar insolation** & **1 efficient form** is selected.

Specifications	FORM - 1	FORM - 2	FORM - 3	FORM - 4	FORM - 5
Form Factor Analysis					
Built-up area (m²)	749.20 m²	663.80 m²	625.40 m²	508.60	**608.60**
Gross floor area (m²)	1498.40 m²	1327.60 m²	1250.80 m²	1017.20	**1117.20**
HGFF	2.25	2.43	2.59	3.1	**3.0**
SVR (1/m)	0.52	0.57	0.6	0.72	**0.7**
Envelope area (m²)	2,357.6 m²	2,258.8 m²	2,266.0 m²	2205.2	**2,453.2**
Solar Insolation Analysis – NS					
Cumulative insolation	6,463 Kwh	5,980 Kwh	5,971 Kwh	6,055 Kwh	5,826 Kwh
Solar Insolation Analysis – NS 15° Tilt					
Cumulative insolation	6,392 Kwh	5,932 Kwh	5,865 Kwh	6,004 Kwh	**5,731 Kwh**
Solar Insolation Analysis – NS 30° Tilt					
Cumulative insolation	6,447 Kwh	5,944 Kwh	5,899 Kwh	6,069 Kwh	5,804 Kwh

GROUND FLOOR PLAN
Carpet area : 591 Sqm

FEATURES IN THE PLANNING

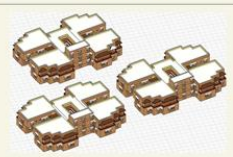
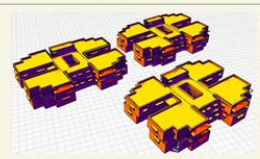
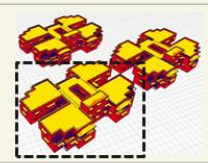
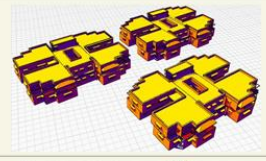
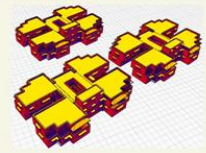
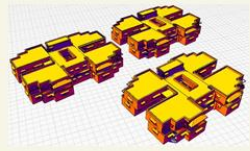
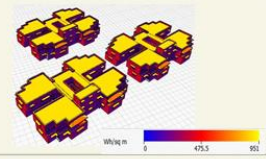
- Two units of **two bedroom** in each cluster
- Common separate **WC** and **bath** for each unit.
- Bedrooms designed **with ample space**.
- **Private kitchen** and a **compact** private **dining space** provided for each unit.
- All the **most usable spaces** such as the bedroom are provided with **cross ventilation.**
- **Common toilets** are provided near the **cluster 1 & 2**.



ZOOMED PLAN OF ONE OF THE TYPICAL CLUSTERS (CLUSTER – 1)

Fig 4.13.4: Spatial planning of ground and first floor plans

Table 4.13.2: Homeless accommodations shadow and solar insolation analysis

	SHADOW ANALYSIS		SOLAR INSOLATION ANALYSIS	
	North East	South West	North East	South West
MARCH				
APRIL				
MAY				

INFERENCE : Most affected area observed towards the SW staircase and the Two corner bedroom areas during the month of march other than that Area The other areas receives less radiation.

When checked in the **interior wall** of the SW activity room, it **is 46 Wh/m²**, which is ideal according to **SP41. Additionally tree shade can be provided for these spaces**

Table 4.13.3: Homeless accommodations daylight analysis

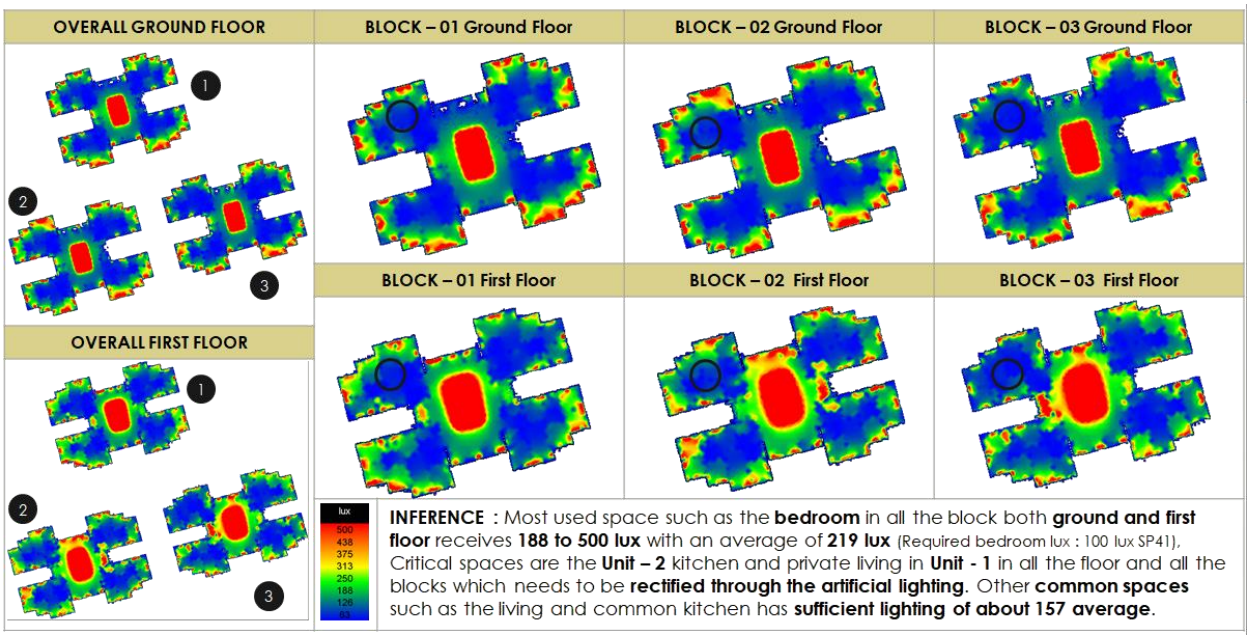


Table 4.13.4: ECBC Samhita calculations for homeless accommodations

TABLE-19 — Openable area calculation

Opening Name	Opening area (m²)	Openable area (m²)	Remark
D1	1.89	1.52	90% OPENABLE
D2	1.6	1.22	
GD2	2.5	2.13	
W3	1.08	0.7	
W4	0.9	0.52	
W5	1.44	1	
Openable area (m²) for each Unit		235.10	
Openable area for 1 units		235.095	

STEP -1	(WFR) op Calculation		
Calculation of total carpet area			
Acarpet=No.of DUs x Carpet area of 1DU(1X(559+549))m²		1108	
Calculate the openable window-to-floor area ratio			
WFRopenable = Aopenable/Acarpet (235.095/1108)		0.212179603	21%

STEP -2	Visible Light Transmittance (VLT)					
TABLE-20	Calculation of window-to-wall ratio					
Orientation	Opening name	Opening area (m²)	Glass area in opening (m²)	No. of openings	Total opening area (m²)	Total Glass area in opening (m²)
North	W3	1.08	0.7	6	6.48	4.2
North	W4	0.9	0.52	4	3.6	2.08
North	W5	1.44	1	24	34.56	24
South	W3	1.08	0.7	4	4.32	2.8
South	W5	1.44	1	27	38.88	27
East	W3	1.08	0.7	20	21.6	14
West	W3	1.08	0.7	20	21.6	14
Total					124.56	83.88
WWR = Anon-opaque/Aenvelope (83.88/804.8)					0.20	

STEP -3	Thermal transmittance of roof (Uroof)		
TABLE-21	Roof construction details		
Material Layer	Thickness (m)	Thermal conductivity ,k (w/m.k)	Thermal resistance of material, R=t/k (m².k/W)
Internal plaster	0.019	1.21	0.021
Filler material	0.13	0.033	0.095
RCC slab	0.12	1.58	1.739
Weathering tile	0.012	0.63	0.029
White paint			
Sum of all material thermal resistance			1.884
Total Thermal resistance,			
Rt = Rsi + R1 + R2 + R3 + ...	2.094		m².K/W
Thermal transmittance of roof,	Uroof = 1/RT =	0.48	W/m².K

TABLE-24 — Calculation of 3 terms of RETV formula

Calculation for term I

Orientation	Component	(a)Area (m²)	(b)U Value (W/m².k)	(c) Orientation factor, w	(a)x(b)x(c)
North	Opaque area 1 (CSEB wall)	186.2	2.1	0.659	257.6897915
North	Opaque area 2 (uPVC panel in doors and windows)	14.4	2.3	0.659	21.765452
South	Opaque area 1 (CSEB wall)	187.6	2.1	0.966	380.6576613
South	Opaque area 2 (uPVC panel in doors and windows)	13.4	2.3	0.966	29.77212
East	Opaque area 1 (CSEB wall)	150.0	2.1	1.155	363.752235
East	Opaque area 2 (uPVC panel in doors and windows)	7.6	2.3	1.155	20.1894
West	Opaque area 1 (CSEB wall)	150.0	2.1	1.156	364.067172
West	Opaque area 2 (uPVC panel in doors and windows)	7.6	2.3	1.156	20.20688
				Term-I Total	1458.1

Calculation for term II

Orientation	Component	(a)Area (m²)	(b)U Value (W/m².k)	(c) Orientation factor, w	(a)x(b)x(c)
North	Non-Opaque (glass) area	30.3	1.5	0.659	29.93178
South	Non-Opaque (glass) area	29.8	1.5	0.966	43.1802
East	Non-Opaque (glass) area	14.0	1.5	1.155	24.255
West	Non-Opaque (glass) area	14.0	1.5	1.156	24.276
				Term-II Total	121.6

Calculation for term III

Orientation	Component	(a)Area (m²)	(b)Equivalent SHGC	(c) Orientation factor, w	(a)x(b)x(c)
North	W3	6.48	0.205	0.659	0.8754156
North	W4	3.6	0.192	0.659	0.4555008
North	W5	34.56	0.205	0.659	4.6688832
South	W3	4.32	0.675	0.966	2.816856
South	W5	38.88	0.675	0.966	25.351704
East	W3	21.6	0.675	1.155	16.8399
West	W3	21.6	0.735	1.156	18.352656
				Term-III Total	69.4
RETV =(804.8X(6.06X1456.1)+(1.85X146)+(68.99X69.4)	0.001242497	7809.218666	159.3523038	4522.025306	15.0

Compliance	INFERENCE
WFR	This building complies with WFR, required is 16.66% & 21% achieved
WWR	This building complies with WWR, & the VLT used is 40 – 60% (min 27%)
Uroof	This building complies with the Uroof achieved is 0.48w/m².k, required is maximum 1.2W/m².k
RETV	Required : 15 W/m² & the Achieved is 15 W/m².K

01 – View showing South side of the building
02 – View showing the west side entrance of the building
03 – View showing the pathway between the buildings.

Fig 4.13.5: Exterior views of homeless accommodations

PLANNING IDEOLOGIES: Tourists accommodations
CONCEPT: Co-housing
REQUIRED: Compact units (1 & 2 bhk) for the occupant.
BUILDING LEVEL: G+1 maximum (7m height); WHY: To create spaces more closer to ground and provide horizontal spread.
DESIGN IDEOLOGY: Extrovert planning – Open spatial layout with more flexibility to public/private spaces focusing on social gathering**.**
WHAT TYPE OF SOCIAL INTERACTION SPACES CAN BE PROVIDED FOR THE OCCUPANTS: In spite of many activities offered for the tourists to engage in the eco-village, the accommodations provided for them is planned with,

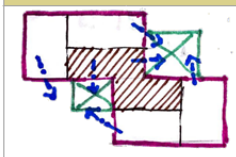
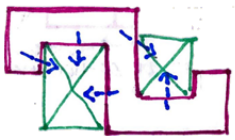
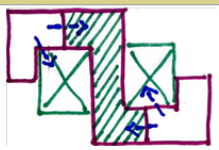
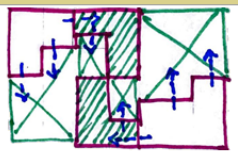
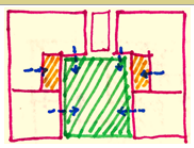
Shared values

Social gathering / communal interaction space – Major importance

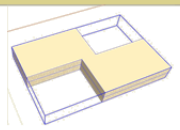
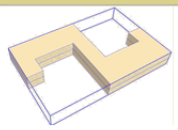
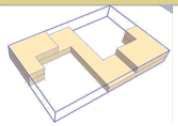
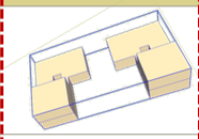
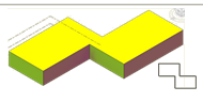
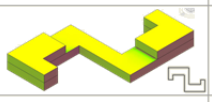
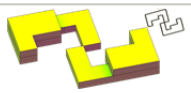
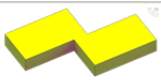
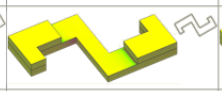
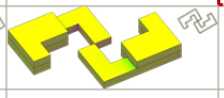
Contribute positive to comfort outdoor with trees shades

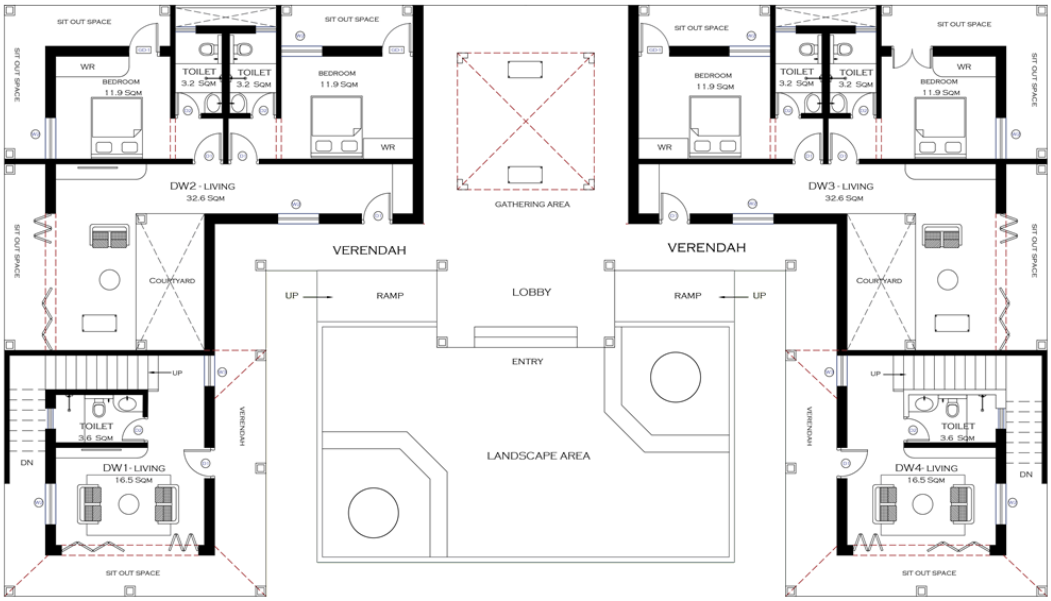
Table 4.13.5: 5 Different planning ideologies, Form factor & solar insolation analysis

5 PLANNING IDEOLOGIES : By incorporating the co-housing concept with many possibilities of interactive communal garden pockets.

1	2	3	4	5
				
Compact **2 & 1bhk** with outdoor gardens and indoor **common interaction spaces** for G+1.	Compact units planned in a way that **all the units** are provided with sufficient the **interaction space**. (G+1).	Compact units designed with **level difference** with units in the **ground and first floor** has a shared space. **4 units (G+1).**	Similar to the planning 4 but few aspects modified to **provide more interactive pockets** for the occupants. (G & G+1).	Compact design with **overlooking central** gathering space & **courtyard** on either side on respective units. First units are alone G+1.

All the **5 modules are modeled in modelur** to arrive at the **form factor & further analyzed in terms of solar insolation** & **1 efficient form** is selected.

Specifications	FORM - 1	FORM - 2	FORM - 3	FORM - 4	FORM - 5
Form Factor Analysis					
Built-up area (m²)	910 m²	718.13 m²	718.13 m²	670.13 m²	320 m²
Gross floor area (m²)	1820 m²	1436.26 m²	1436.26 m²	1340.26 m²	640.46 m²
HGFF	2.21	3.05	3.05	3	2
SVR (1/m)	0.51	0.71	0.71	0.71	0.74
Envelope area (m²)	2,810 m²	2,390.21 m²	2,390.21 m²	2,402.21 m²	1,245.11 m²
Solar Insolation Analysis – NS					
Cumulative insolation	7,659 Kwh	6,704 Kwh	6,242 Kwh	6,208 Kwh	3,374 Kwh
Solar Insolation Analysis – NS 15° Tilt					
Cumulative insolation	7,377 Kwh	6,571 Kwh	6,123 Kwh	6,115 Kwh	**3,302 Kwh**
Solar Insolation Analysis – NS 30° Tilt					
Cumulative insolation	7,510 Kwh	6,639 Kwh	6,216 Kwh	6,173 Kwh	3.312 Kwh

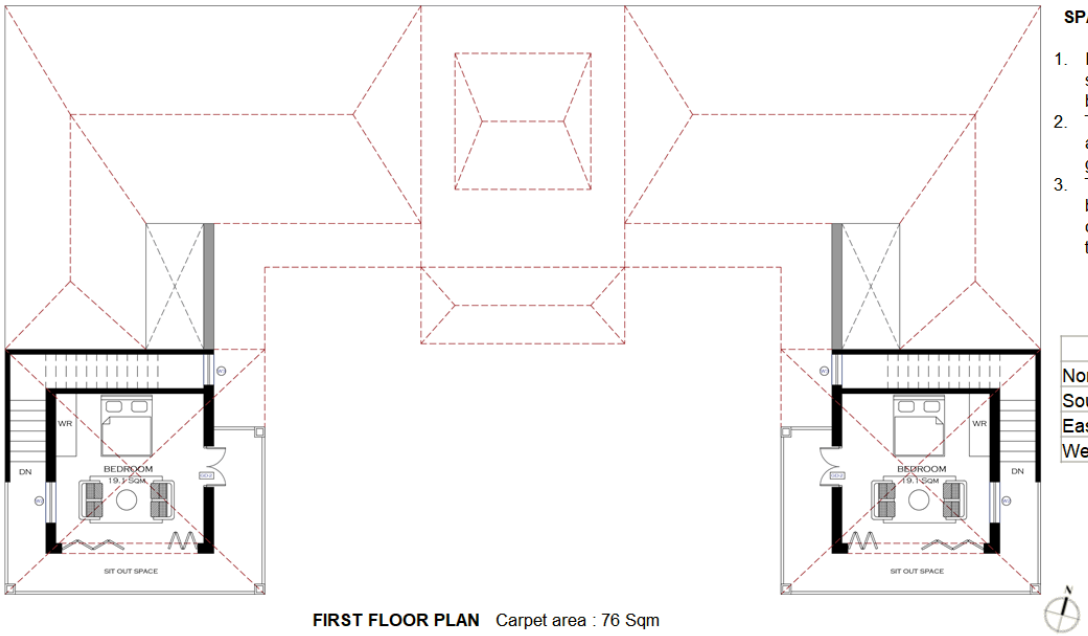


GROUND FLOOR PLAN Carpet area : 330 Sqm

SPACE PLANNING :

1. **Total DU : 4** per block, all the dwelling units are buffered a **minimum of 1.5m** from the outer periphery to create a **shade** for all the spaces in the building.
2. All the spaces are provided with **cross ventilation.**
3. All the spaces are designed with **the access to the sit out space**.
4. There is a **gathering space provided in** between the units
5. **Brick** is used in the toilet walls to **conserve the materials**.

Fig 4.13.6: Tourist accommodation ground floor plan



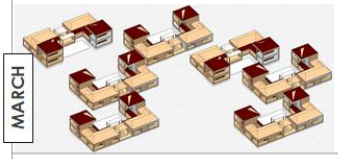
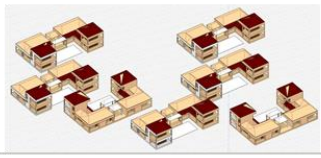
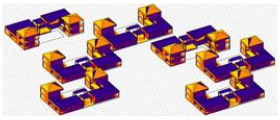
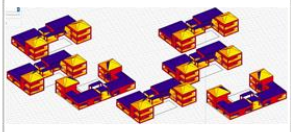
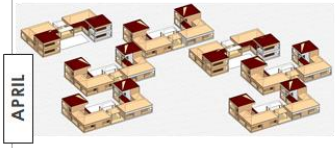
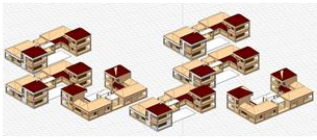
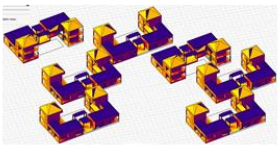
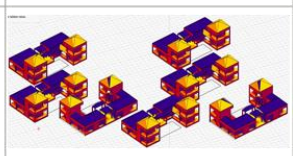
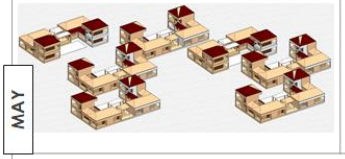
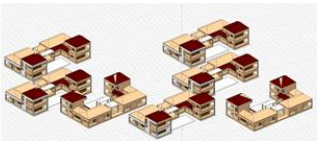
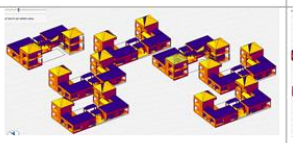
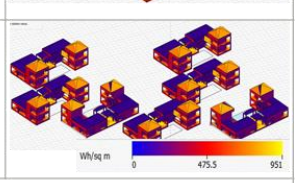
SPACE PLANNING :

1. In the first floor, the studio spaces bedroom is placed.
2. The other spaces are restricted to the ground level.
3. The studio areas bedroom has a spill over foldable door to the sit out space.

WWR	
North	21 %
South	32 %
East	23 %
West	23 %

Fig 4.13.7: Tourist accommodation first floor plan

Table 4.13.6: Tourist accommodations shadow and solar insolation analysis

	SHADOW ANALYSIS		SOLAR INSOLATION ANALYSIS	
	North East	South West	North East	South West
MARCH				
APRIL				
MAY				

INFERENCE : According to the **shadow analysis** done for the three critical months, it is observed that the **most usable spaces** are **not affected** as they are covered with the **offset of 1.5m buffer** and according to the **solar insolation analysis**, it is observed that In the **south west** direction, **all the blocks sit out spaces** are affected and in the **north east** area **east areas sit outs are affected.**

Table 4.13.7: Tourist accommodations daylight analysis

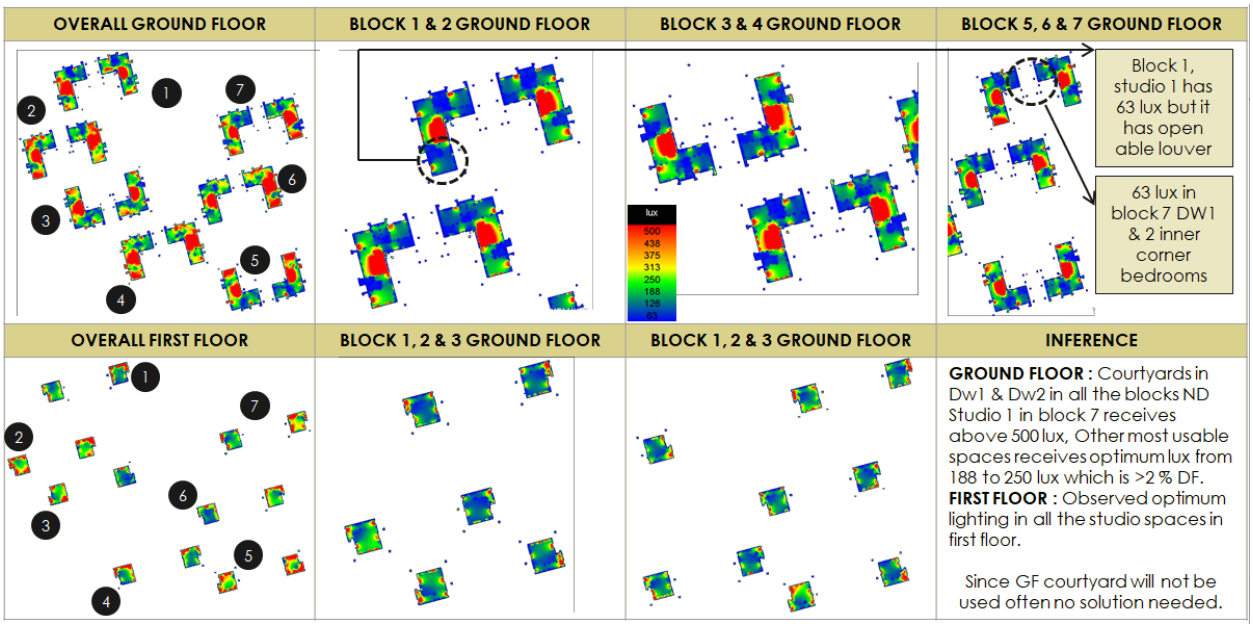
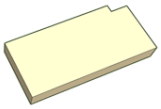
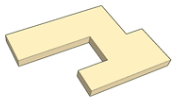
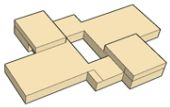


Fig 4.13.8: Tourist accommodation exterior views

PLANNING IDEOLOGIES: Children dormitory

Children dormitory are designed since there were quiet few orphan children found during the survey analysis done and it would be essential to provide a proper dormitory with a study space provided for those children

SPECIFICATIONS	FORM - 1	FORM - 2	FORM - 3
Form Factor Analysis			
Built-up area (m²)	250 m²	874.90 m²	803.97 m²
Gross floor area (m²)	250 m²	874.90 m²	1599.09 m²
HGFF	4.03	3.8	3
SVR (1/m)	0.94	0.86	0.83
Envelope area (m²)	705.53 m²	2,268.96 m²	2,356.18 m²
Design choice	Individual	Combined yet private (girls & boys)	

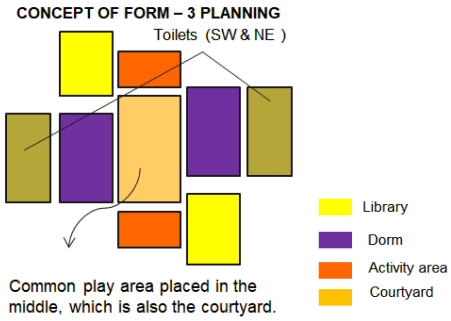


Fig 4.13.9: 3 different form evolution and conceptual planning

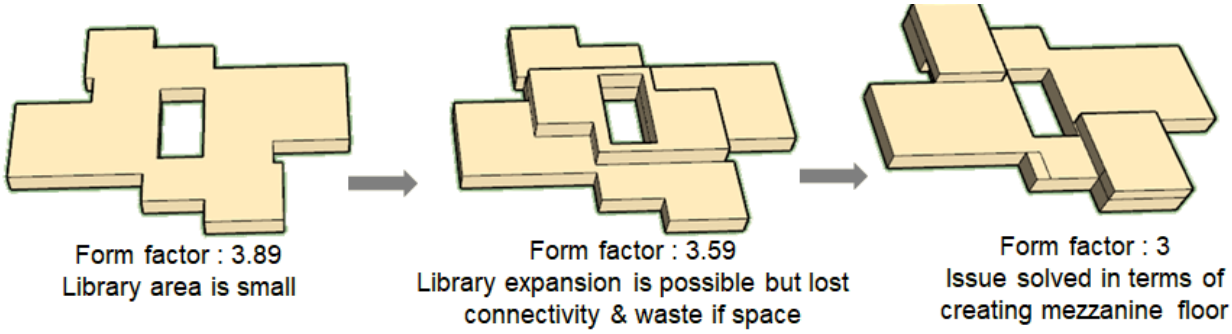


Fig 4.13.10: Form-3 planning evolution

Additional features: Building oriented **15° to** reduce the energy consumption and apart from the central common play area, individual private play space accessible from each of the activity room.

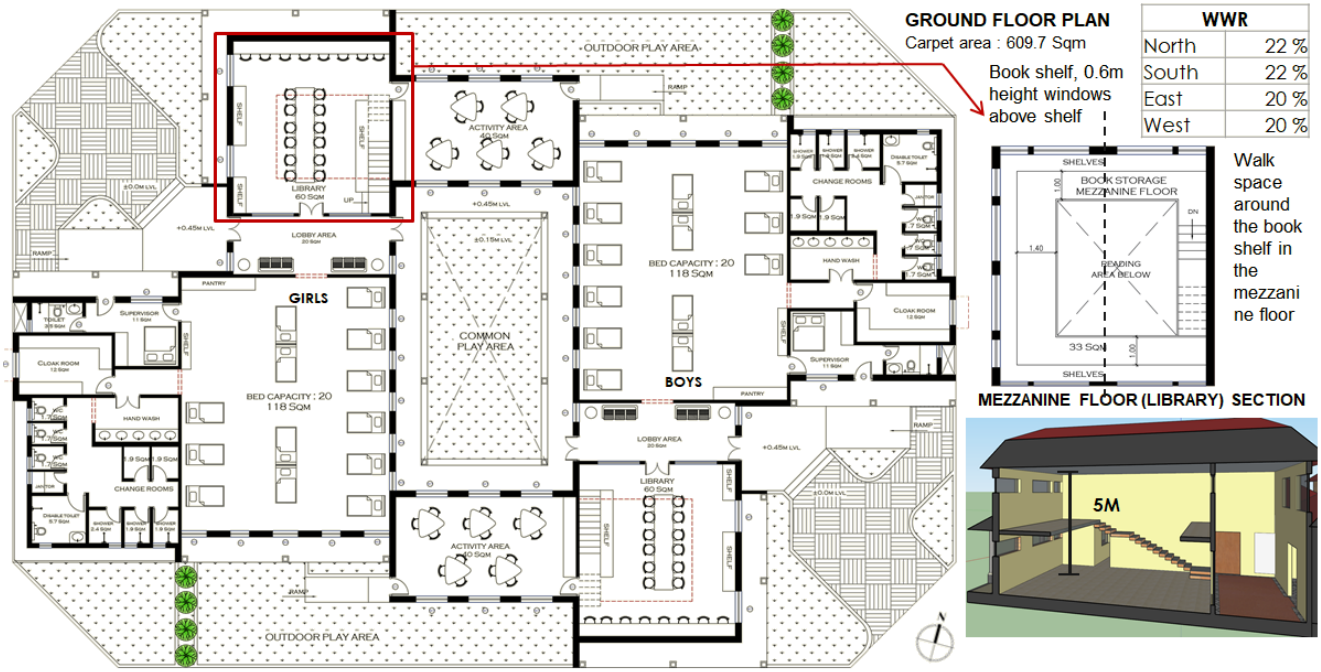


Fig 4.13.11: Spatial planning of Children dormitory

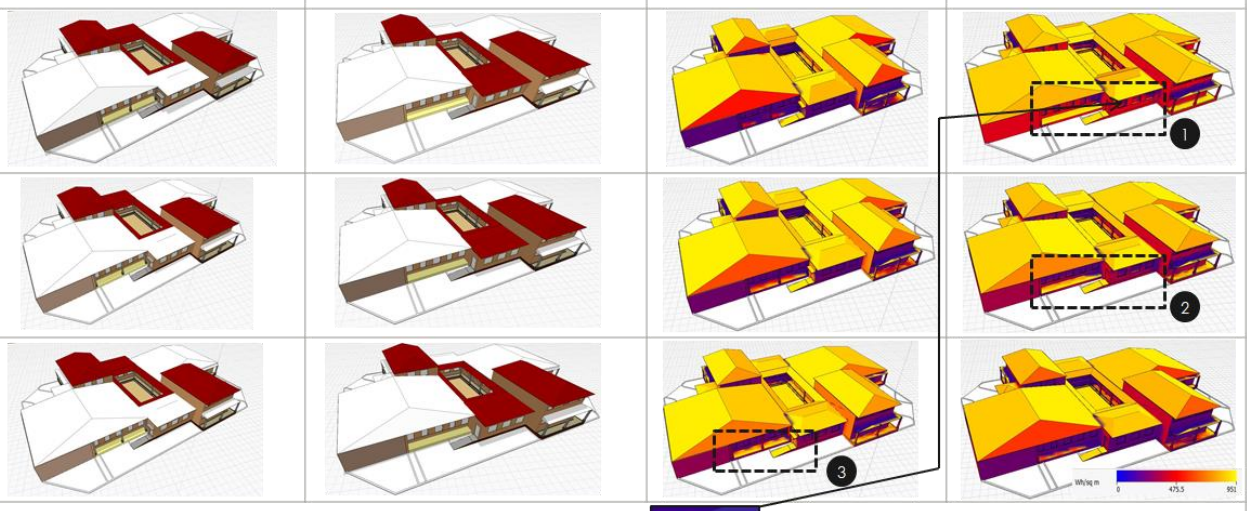
Table 4.13.8: Children dormitory shadow and solar insolation analysis

SHADOW ANALYSIS		SOLAR INSOLATION ANALYSIS	
North East	South West	North East	South West

MARCH

APRIL

MAY

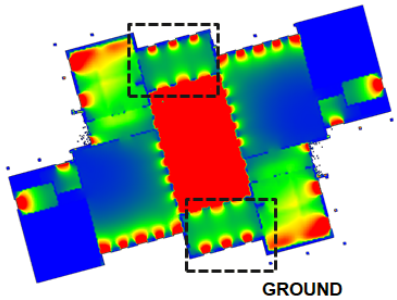


INFERENCE : 1&2 Depicts the **most affected area** in South west, boys dorm activity area & girls sit out area (not accessible directly thus not used often)3 depicts the sit out area in boys dorm (not usable space).

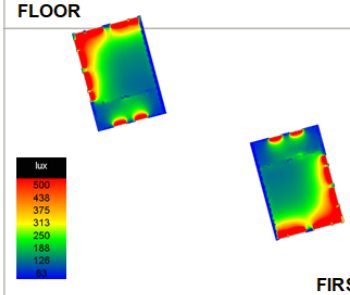
When checked in the **interior wall** of the SW activity room, it **is 46 Wh/m²**, which is ideal according to **SP41. Additionally tree shade can be provided for these spaces**

Table 4.13.9: Children dormitory daylight analysis

INITIAL	LUX LEVEL STANDARDS (SP41)	ITERATION – 1



GROUND FLOOR



FIRST FLOOR

Libraries

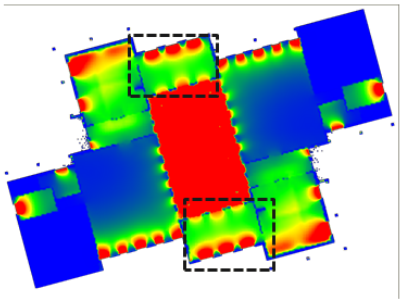
Shelves (stacks)	70 to 150*
Reading rooms (newspapers and magazines)	150 to 300
Reading tables	300 to 700†
Binding and bookrepair	300 to 700†
Cataloguing, sorting, stock-rooms	150 to 300

Class and lecture rooms:

Desks	300
Blackboards	200 to 300 †

Spaces	Required lux	Initially achieved	Improved after iteration
Library GF reading	150 - 300	188 – 250	-
Library Mezzanine (shelf)	70 - 150	313 - 500	-
Activity	300	188 - 250	**250 - 313**
Dorm	-	63 - 126	-

As, dormitory is used only for sleeping purpose the day lighting is not considered since its rarely used space in the morning.



Both activity room exterior **window sizes** have been **increased to allow more light inside**

INFERENCE : Most critical spaces are the dormitory area which has the lighting lux ranging between **63 to 126 lux** but it does **not need any intervention** since its **rarely used** in the mornings and the other critical space is the activity room which receives less than required lux level which is solved by increasing the exterior window from **0.9m width to 1.5m width**.

Fig 4.13.12: Exterior view of children dormitory

PLANNING IDEOLOGIES: Common house

REQUIRED FOR: A space which is provided for the interaction between the homeless and the tourists. IMPORTANCE: As social sustainability being the crucial aspect of the design, the common house serves the purpose of interconnection and involvement of the two varied occupants. SPACES PROVIDED: Educational space, meditation space, guest rooms, living/gathering space and garden spaces

FORM: Circular form & concentric planning

CONCEPT: Circle depicts the totality, wholeness, focus, infinity, unity in architecture. Apart from these, circular form also contributes positively towards the energy efficiency due to the less exterior wall area exposed to ambient.

OTHER ADVANTAGES OF THE FORM:

- A circular building has fewer walls which contribute in the lesser wall materials.
- Boundary of a circular building is less
- Optimal exposure to daylight.

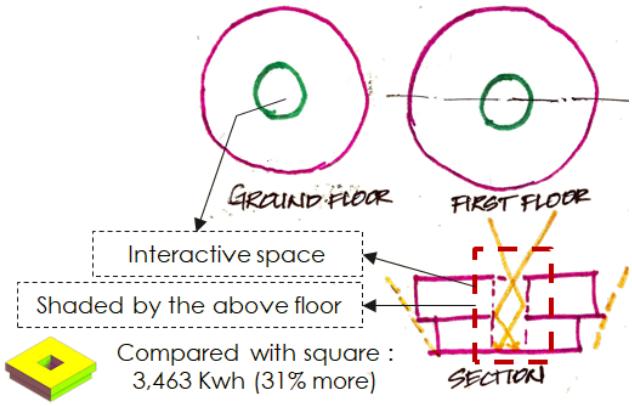


Fig 4.13.13: Common house conceptual planning and section

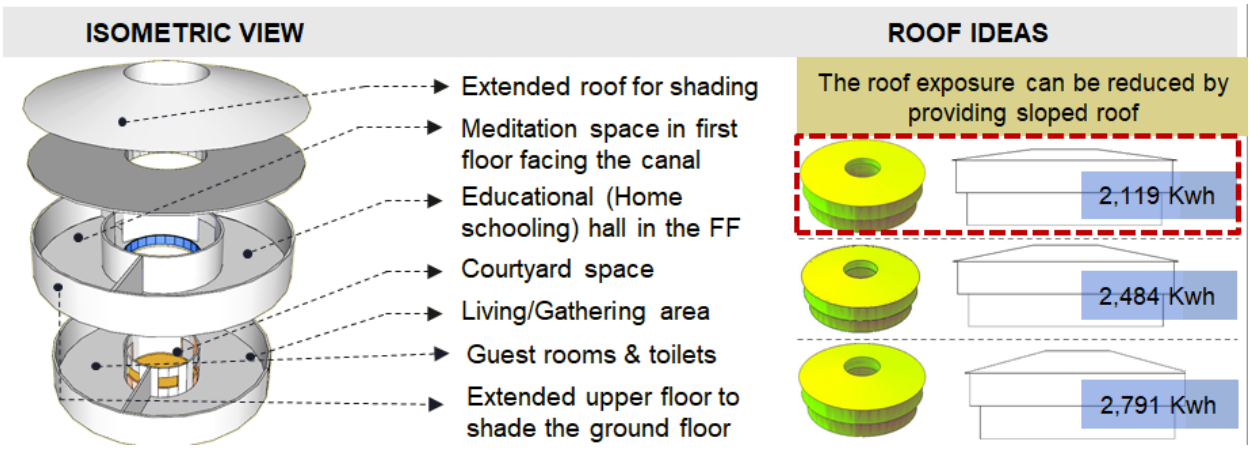
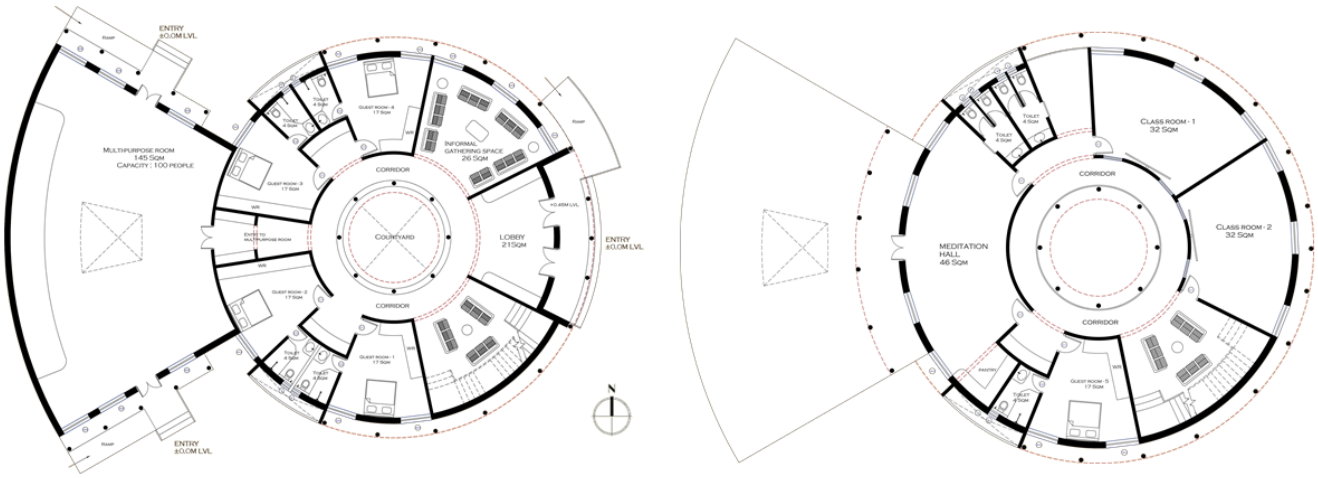


Fig 4.13.14: Conceptual view and roof ideas

GROUND FLOOR PLAN ; Carpet area : 362Sqm

FIRST FLOOR PLAN ; Carpet area : 252 Sqm



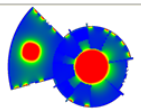
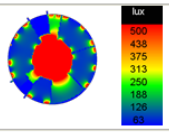
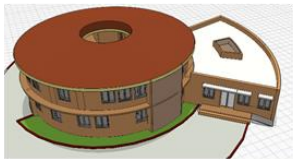
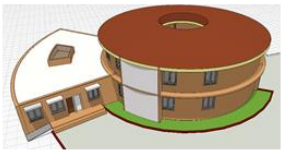
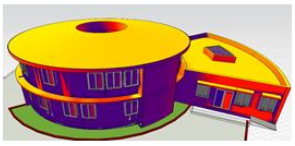
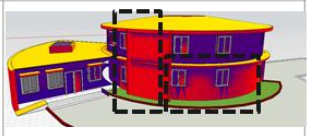
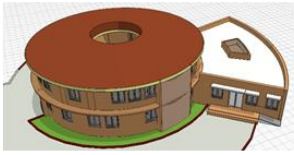
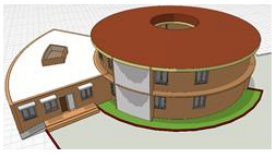
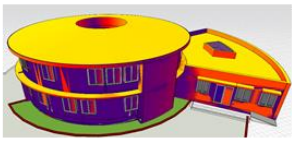
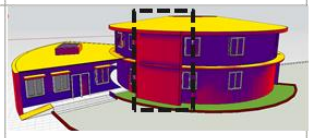
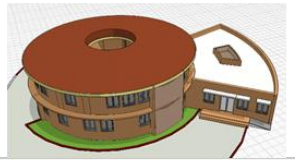
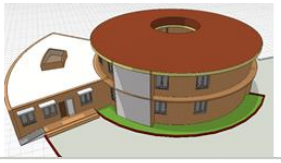
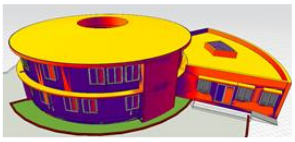
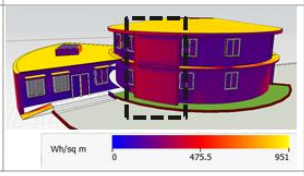
GROUNF FLOOR DAYLIGHTING	FIRST FLOOR DAYLIGHTING	INFERENCE	SOLUTION
		GF : Guest room 2 & 3 receives 63 lux which is critical. FF receives optimum lux level in all the space.	As the room is deeper , and the window is located near the multipurpose room, It is optimum to provide artificial light to increase the lux in that particular space.

Fig 4.13.15: Spatial planning of common house and daylight analysis

Table 4.13.10: Common house shadow and solar insolation analysis

SHADOW ANALYSIS		SOLAR INSOLATION ANALYSIS	
North East	**South West**	**North East**	**South West**
			
			
			

INFERENCE : Since the shape of the building is circle, the heat ingress is less on the surface and in the shadow analysis and solar insolation it is observed that the south side ground floor windows are affected and the toilet buffers are affected , this can be mitigated by the placement of deciduous tree with high canopy.

01 & 02 – View showing South west side of the building towards the multipurpose hall
03 & 04 – View showing the entrance of the building.

Fig 4.13.16: Exterior view of the common house

CHAPTER 5
VENTILATION, THERMAL AND IGBC TOWNSHIP RATING CALCULATION

5.1. VENTILATION CALCULATION

Regularly occupied spaces are the bedroom, living rooms in a residential building and the no-regularly occupied spaces are the toilets, storage spaces etc...
Calculations are performed for all the four building as mentioned in the requirement and the percentages are recorded, Some of the spaces has **opening more than 30%** of the floor area, In that case as mentioned above, **40% of the outdoor** speed will be received in the **indoor area.**

Table 5.1.1: Ventilation calculation of all the four buildings

VENTILATION CALCULATION - HOMELESS ACCOMODATION (1 corner unit - typical)						
SPACES	*Floor area*	*OA- 1*	*OA-2*	*OA-3*	*Total*	*OA % of FA*
3 Bedroom Unit						
BR-1	10	1.08	1.44		2.52	**25**
BR-2	10.2	1.08	1.44		2.52	**25**
BR-3	11	1.08	1.44		2.52	**23**
2 Bedroom Unit						
BR-1	9	1.08	1.44		2.52	**28**
BR-2	9	1.08	1.44		2.52	**28**
Studio						
Studio	9	1.08	1.44		2.52	**28**
LIV/DIN	175	3.6	5.04	46.92	55.56	**32**

VENTILATION CALCULATION - TOURIST SPACES						
SPACES	*Floor area*	*OA- 1*	*OA-2*	*OA-3*	*Total*	*OA % of FA*
Studio GF Living	16.9	1.8	1.08	1.89	4.77	**28**
Studio FF Bedroom	19.1	1.8	0	2.52	4.32	**23**
DW1						
BR-1	10	1.8	1.89	0	3.69	**37**
BR-2	11.6	1.8	1.89	0	3.69	**30**
Living	32.6	1.8	8.4	0	10.2	**30**

VENTILATION CALCULATION - COMMON HOUSE						
SPACES	Floor area	OA- 1	OA-2	OA-3	Total	OA % of FA
G.Room -1	17	2.7	2.7		5.4	**32**
G.Room -2	17	2.7	1.89		4.59	**27**
G.Room -3	17	2.7	1.89		4.59	**27**
G.Room -4	17	2.7	2.7		5.4	**32**
G.Room -5	17	2.52	2.52		5.04	**30**
M.Room	145	21.6	7.56		29.16	**20**
CR-1	32	2.7	2.7	2.7	8.1	**25**
CR-2	32	2.7	2.7	2.7	8.1	**25**
Meditation	46.2	10.8	2.52		13.32	**29**

OA – Opening area; FA – Floor area
BR - Bedroom
G.Room – Guest Room
CR : Class room

VENTILATION CALCULATION - CHILDREN DORMITORY									
SPACES	*Floor area*	*OA- 1*	*OA-2*	*OA-3*	*OA-4*	*OA-5*	*OA-6*	*Total*	*OA % of FA*
Cloak room	12.3	1.44	1.89					3.33	**27**
Supervisor	11	1.8	1.89					3.69	**33**
Dorm	118	5.4	5.4	2.7	**3**	**0.6**	**5.67**	22.77	**20**
Lobby	20.3	5.04						5.04	**25**
Library	60	3.6	14.4					18	**30**
Activity room	40	10.8						10.8	**27**

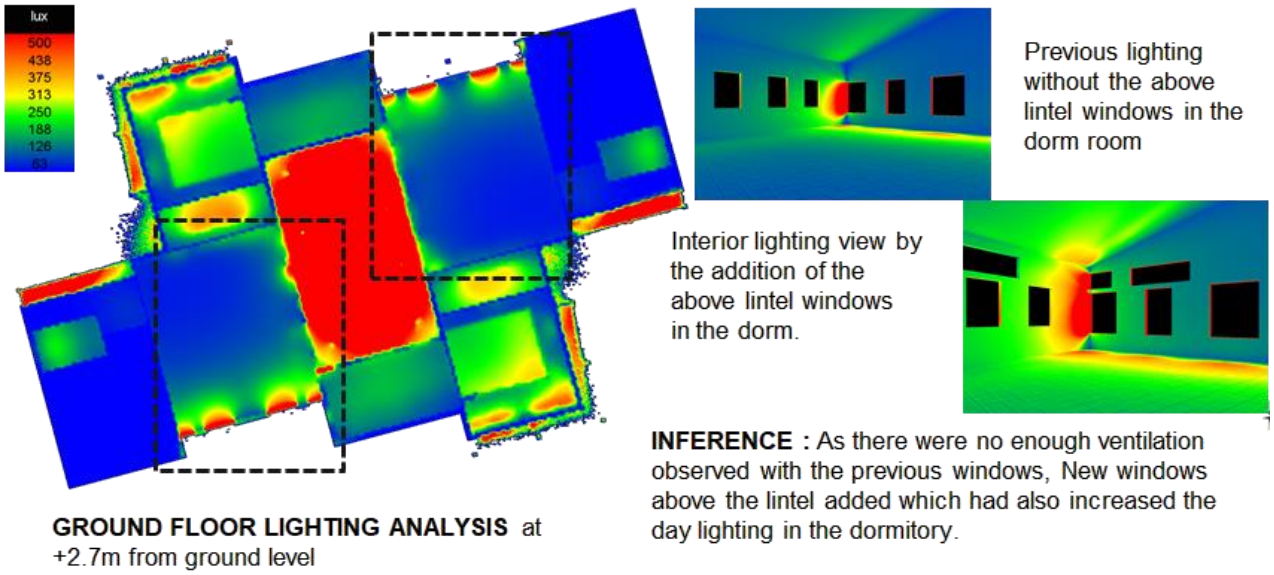


Fig 5.1.1: Daylight analysis in children dorm space after window additions

TABLE 1 DESIRABLE WIND SPEEDS FOR THERMAL COMFORT CONDITIONS

(*Clause* 4.3.1)

Dry Bulb Temperature °C	Relative Humidity (Percent) 30	40	50	60	70	80	90
	*Wind Speed, m/s						
28	*	*	*	*	*	*	*
29	*	*	*	*	*	0.06	0.19
30	*	*	*	0.06	0.24	0.53	0.85
31	*	0.06	0.24	0.53	1.04	1.47	2.10
32	0.20	0.46	0.94	1.59	2.26	3.04	+
33	0.77	1.36	2.12	3.00	+	+	+
34	1.85	2.72	+	+	+	+	+
35	3.2	+	+	+	+	+	+

*None
+Higher than those acceptable in practice.

TABLE 2 MINIMUM WIND SPEEDS FOR JUST ACCEPTABLE WARM CONDITIONS

(*Clause* 4.3.1)

Dry Bulb Temperature °C	Relative Humidity (Percent) 30	40	50	60	70	80	90
	Wind Speed, m/s						
28	*	*	*	*	*	*	*
29	*	*	*	*	*	*	*
30	*	*	*	*	*	*	*
31	*	*	*	*	*	0.06	0.23
32	*	*	*	0.09	0.29	0.60	0.94
33	*	0.04	0.24	0.60	1.04	1.85	2.10
34	0.15	0.46	0.94	1.60	2.26	3.05	+
35	0.68	1.36	2.10	3.05	+	+	+
36	1.72	2.70	+	+	+	+	+

*None
+Higher than those acceptable in practice.

Fig 5.1.2: SP41 Ventilation standards

5.2. INDOOR WIND SPEED CALCULATED FOR ALL THE MONTHS

Table 5.2.1: Acceptable wind speed compared to the achieved wind speed

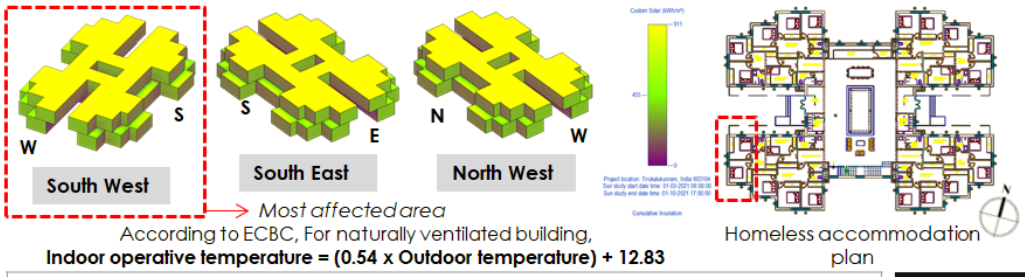
MONTHS	MONHTLY AVG TEMP. IN MAHABALIPURAM	MONHTLY AVG HUMIDITY IN MAHABALIPURAM	WIND DIRECTION	OUTDOOR WIND SPEED	ACCEPTABLE MINIMUM WIND SPEED	WIND SPEED FOR THERMAL COMFORT	INDOOR WIND SPEED 30% (OWS)	INDOOR WIND SPEED 40% (OWS)
JANUARY	25°C	73%	E	3.52 m/s	-	-	1.05 m/s	1.40 m/s
FEBRUARY	26°C	70%	E	3.19 m/s	-	-	0.95 m/s	1.27 m/s
MARCH	29°C	66%	S	3.30 m/s	-	-	**0.99 m/s**	**1.32 m/s**
APRIL	31°C	64%	S	3.97 m/s	-	**0.53 m/s**	**1.19 m/s**	**1.58 m/s**
MAY	34°C	55%	S	4.33 m/s	**0.94 m/s**	**> 0.94 m/s**	**1.29 m/s**	**1.73 m/s**
JUNE	33°C	51%	S	4.36 m/s	**0.24 m/s**	**2.12 m/s**	**1.30 m/s**	**1.74 m/s**
JULY	32°C	55%	W	4.16 m/s	-	**0.94 m/s**	**1.24 m/s**	**1.66 m/s**
AUGUST	31°C	61%	W	3.72 m/s	-	**0.53 m/s**	**1.11 m/s**	**1.48 m/s**
SEPTEMBER	30°C	67%	S	3.08 m/s	-	**0.06 m/s**	**0.92 m/s**	**1.23 m/s**
OCTOBER	28°C	72%	SW	2.88 m/s	-	-	**0.86 m/s**	**1.15 m/s**
NOVEMBER	27°C	77%	E	3.66 m/s	-	-	1.09 m/s	1.46 m/s
DECEMBER	25°C	76%	E	4 m/s	-	-	1.2 m/s	1.6 m/s
INFERENCE : Except for the month of June, other months indoor wind speed are comfortable. June will also be comfortable since its rainy month.								

SOURCE : SP41 ; https://www.worldweatheronline.com/mahabalipuram-weather-averages/tamil-nadu/in.aspx ; https://www.weather-atlas.com/en/india/mahabalipuram-weather-may?c%2Cmm%2Cmb%2Ckm#wind

Monthly average (temperature, humidity, wind speed and wind direction), from table 1 & 2 the acceptable wind speed and wind speed for thermal comfort is compared with the achieved indoor speed. (30% & 40% of outdoor speed).

5.3. THERMAL ANALYSIS

As, all the four buildings are designed with CSEB material, the most important building (*Homeless accommodation*) is selected and from that one critical space is selected and simulated in ecotect to find the indoor temperatures.



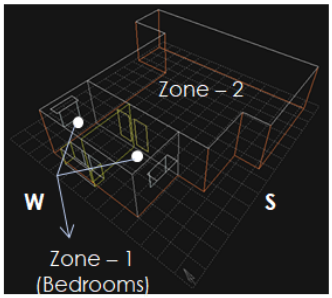
According to ECBC, For naturally ventilated building,
Indoor operative temperature = (0.54 x Outdoor temperature) + 12.83

Wall material	CSEB wall : 300mm wall
Window material	Double glazing window
Time lag & decremental factor	10.23 hours and 0.23 decremental factor
Comfort band	Ashrae standard 19°C to 27°C

Monthly high values taken from the software

CRITICAL TIME	CRITICAL DAY	OUTDOOR TEMPERATURE	OPERATIVE INDOOR TEMPERATURE	ACHIEVED INDOOR TEMPERATURE	TEMP DIFF THAN INDOOR OPERATIVE TEMP	TEMP DIFF THAN OUTDOOR TEMP
1 pm	Jan-05	27.6°C	27.7°C	26.9°C	- 0.834°C	0.7°C
11am	Feb-21	32.5°C	30.3°C	29.7°C	- 0.68°C	2.8°C
11am	**Mar-22**	**35.1°C**	**31.7°C**	**30.7°C**	- 1.084°	**4.4°C**
12 noon	**Apr-30**	**37.1°C**	**32.8°C**	**32.9°C**	**+ 0.036°C**	**4.2°C**
12 noon	**May-12**	**38.7°C**	**33.7°C**	**34.2°C**	**+ 0.472°C**	**4.5°C**
11am	**Jun-01**	**38.3°C**	**33.5°C**	**34°C**	**+ 0.488°C**	**4.3°C**
12 noon	**Jul-24**	**35°C**	**31.7°C**	**33.3°C**	**+ 1.57°C**	**1.7°C**
1pm	**Aug-18**	**35.2°C**	**31.8°C**	**32.3°C**	**+ 0.462°C**	**2.9°C**
11am	**Sep-25**	**35.1°C**	**31.7°C**	**31.8°C**	**+ 0.016°C**	**3.3°C**
12 noon	**Oct-22**	**34.5°C**	**31.4°C**	**29.9°C**	- 1.56°C	**4.6°C**
10am	Nov-10	29.6°C	28.8°C	28.1°C	- 0.714°C	1.5°C
1pm	Dec-31	28.4°C	28.1°C	27.3°C	- 0.866°C	1.1°C

Indian adaptive model is **± 2.38°C**



Modeled in ecotect software and the zone – 1 is analyzed

Fig 5.3.1: Critical space identified to do the thermal analysis and the results tabulated

INFERENCE: From April to September, the achieved indoor value is a bit higher than the acceptable range but its adaptable by the rule in ECBC where, **± 2.38°C** of indoor temperature.

Table 5.3.1: Outdoor average temperature from ecotect thermal analysis result

DATE	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	25.7	24.4	26.2	29.5	31.9	**32.7**	30.6	30.2	29.7	28.2	27.3	25.4
2	25.4	24.4	26.6	29.8	32.1	32.6	30.2	29.1	29.5	28.6	26.3	25.1
3	25.2	24.8	27.1	29.6	32.1	32.3	29.4	28.4	29.7	28	25.7	24.8
4	25.4	24.9	27.5	29.1	32.2	31	28.8	28	29.3	27.5	25.8	24.9
5	**25.5**	24.8	27.9	29	32	30.2	28.6	28.3	29.4	27.1	26.4	24.8
6	25.2	24.5	28.2	29.2	32	29.8	28.2	28.3	29	27.2	26.5	24.5
7	25.1	24.1	28.3	29.9	32	30.4	28.2	28.8	29.4	26.8	26.4	24.3
8	25.1	23.9	28.5	30.3	32.2	30.3	27.6	29.1	29.5	26.1	26.4	24
9	25.4	24	28.5	30.5	32.5	29.9	27.7	29.5	29.6	26.4	26.7	24
10	25.2	24.4	28.1	30.6	32.6	30.1	28.2	29.4	29.5	27	**26.9**	24
11	24.8	24.6	27.6	30.7	32.8	31.3	29.3	28.7	29.3	28	26.2	24.4
12	23.8	24.8	27.3	30.8	**32.8**	32.4	29.6	28	29.3	27.3	25.3	25
13	23.5	25.3	27.2	30.9	32.7	32.2	30.5	27.9	29	27.3	24.6	25.5
14	23.1	25.8	27.1	30.9	32.3	30.6	30.7	28.8	28.7	26.9	24.6	25.9
15	23.3	26.2	27.1	31.1	30.6	29.5	31	29.7	28.6	27.6	25	25.8
16	23.1	26.6	27.2	31	30	29.4	30.7	30.6	28.8	27.7	25.6	25.7
17	23.1	26.8	27.4	29.6	29.6	30.3	30.1	30.9	29	28	25.7	25.3
18	23	27.2	27.8	29.9	30.6	30.8	30.2	**31**	29.2	28	25.7	25
19	23.1	27.6	28.3	28.5	31	31	30.2	30.9	29.5	28	25.4	24.5
20	23.4	28.1	28.9	29.4	30.3	31.1	30.8	30.9	29.9	28	25.7	24.3
21	23.7	**28.3**	29.3	29.9	30.2	31.4	30.9	30.9	30.3	28.3	25.7	24.3
22	24	27.9	**29.4**	30.1	29.7	31.6	31.6	30.7	30.3	**28.6**	25.8	24.6
23	24	27.2	29.1	30.3	30.4	31.6	31.9	30.6	30.4	28.5	25.6	24.6
24	24	26.2	28.6	30.2	30.7	31.6	**32.1**	30.4	30.4	28.3	25.3	24.7
25	24.1	25.7	28.5	29.4	31.1	31.8	32	29.9	**30.5**	28.1	25.2	24.4
26	24.2	25.6	28.6	29	31.8	31.7	32	29.5	30.2	28.2	25.2	24.7
27	24.4	25.7	28.9	29	31.1	31.5	32	28.9	28.9	28.2	25.2	25.2
28	24.4	25.7	29	30.1	31.3	31.3	31.5	28.8	27.3	28.1	25.3	25.7
29	24.4		28.8	30.8	31	31.2	31.3	28.9	26.5	27.9	25.4	25.8
30	24.4		28.8	**31.5**	32.2	31.3	31.1	29.4	27.1	28	25.5	26
31	24.2		29		32.4		31.2	29.5		27.9	25.7	**26**
	753.2	719.5	870.8	900.6	976.2	932.9	938.2	914	877.8	859.8	798.1	773.2
	24.29677	**25.69643**	**28.09032**	**30.02**	**31.49032**	**31.09667**	**30.26452**	**29.48387**	**29.26**	**27.73548**	**25.745161**	**24.941935**

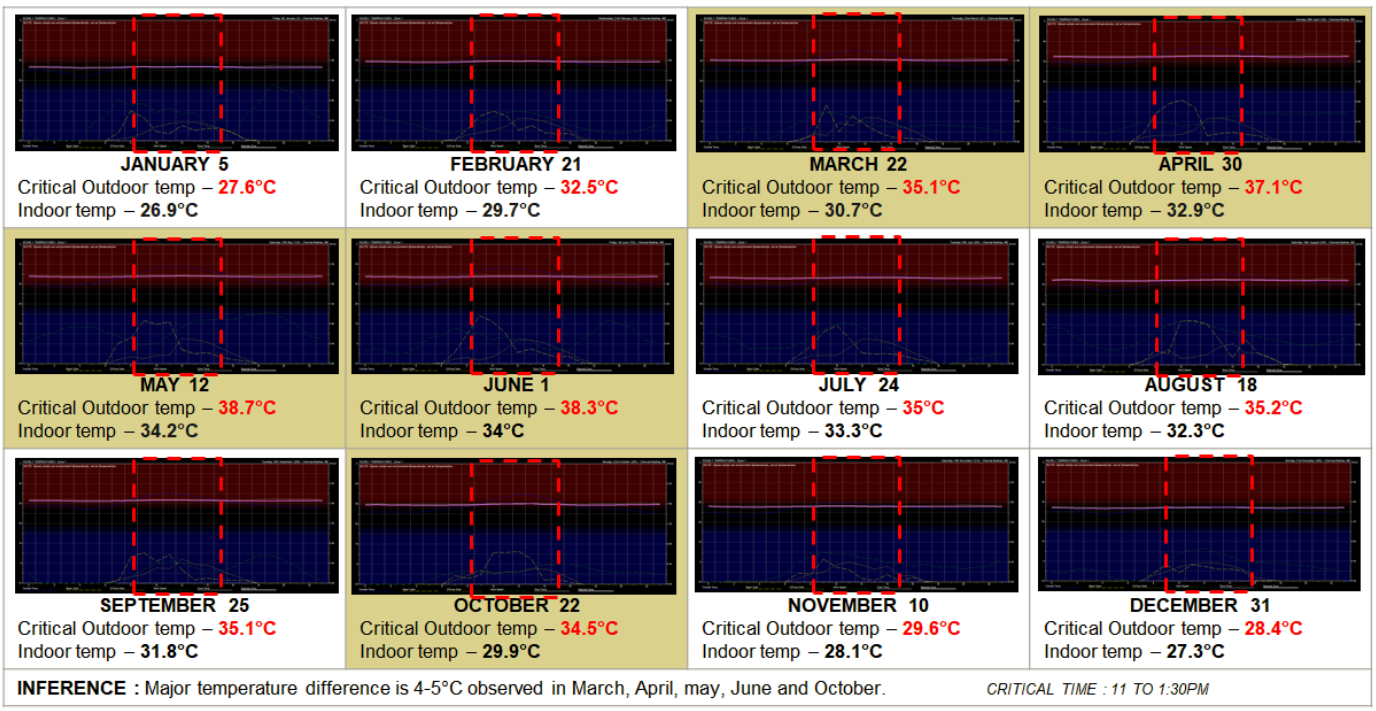


Fig 5.3.2: Indoor average temperature of every month on critical day and time

Characteristic species

- *Manilkara hexandra*
- *Mimusops elengi*
- *Albizia amara*
- *Memecylon umbellatum*
- *Diospyros ferrea* syn *maba buxifolia*

Top Canopy

- *Mimusops elengi*
- *Diospyros ebenum* (occasional)
- *Strychnos nux vomia* (occasional)
- *Strychnos potatorum* (occasional)
- *Diospyros chloroxylon* occasional)
- *Drypetes sepiarea* (rare)
- *Syzygium cumini*
- *Canthirum decoccum* (frequent)
- *Ziziphus glaberrima* (frequent)
- *Acacia leucophloea* (frequent)
- *Catunaregam spinosa* (frequent)
- *Buchanania lanzan* (occasional)
- *Sapinda emarginatus* (occasional)
- *Albizia amara*
- *Albizia lebbek*
- *Tamarindus indica*
- *Azadirachta indica*
- *Borassus flabellifer*

Under wood

- *Carissa carandas* (abundant)
- *Flacourtia indica* (locally abundant)
- *Diospyros ferrea* (frequent)
- *Grewia* sp. (abundant)
- *Gymnosporia* sp. (frequent)
- *Ixora arborea* (frequent)
- *Tarenna ascatica* (frequent)
- *Memecylon umbellatum*
- *Garcinia spicata*

Shrubs

- *Strobilanthus*
- *Dodonaea viscosa* (abundant)
- *Glycosmis pentaphylla*
- *Ochna squarrosa*
- *Gmelina asiatica*

Herbs

- *Hemidesmus indicus*

Tropical dry evergreen scrubs

- *Diospyros ferrea*
- *Ziziphus glaberrima*
- *Calliea cinerea*
- *Catunaregam spinosa*
- *Carissa spinarum*
- *Albiziz amara*
- *Buchanania lanzan*
- *Dodonaea viscosa*

NATIVE TREES IN THE KANCHIPURAM DISTRICT	CATEGORY / DRAUGHT TOLERENT	TREE/SHRUB HEIGHT CANOPY SIZE	PLACEMENT IN SITE
1.Albizia lebbek	Tree / Yes	18 – 30m / 1m wide	South façade blocks
2. Tamarindus indica	Tree / Yes	30m Tall / 2m wide	
3. Azadirachta indica	Tree / Yes	15 – 20m / 1.2m wide	
4. Ziziphus glaberrima	Tree / Yes	4 – 12m / 0.5m wide	West façade blocks
5. Acacia leucophloea	Tree / Yes	25 m Tall / 1.5m wide	Drive way
6. Dodonaea viscosa	Shrub / Yes	9m Tall / 0.5cm wide	West façade blocks
7. Catunaregam spinosa	Shrub / Yes	4m Tall / 1m spread	Drive ways & pathways
8. Carissa carandas	Shrub / Yes	5m Tall / 2.5 m spread	
9. Ixora arborea	Shrub / yes	10m / 0.5 – 0.75 m	West façade blocks
10. Diospyros ferrea	Shrub / Yes	4m Tall / 0.5 – 1m	

EFFICIENT TREES

SOUTH	Deciduous trees with high canopy
WEST	Trees with crown lower to the ground
DRIVEWAY	Large bush & hedges

ADDRESSING THE SHADING ISSUES FACED BY THE FOUR BUILDING TYPOLOGIES

BUILDING TYPOLOGY	SHADING ANALYSIS CRITICAL	IMPLEMENTATION ON SITE TO IMPROVISE SHADING
Homeless stay	Cluster 2 & 4 left side bedrooms	tree (6) near the 2&4 cluster .
Tourists accommodation	South west side of all the 7 blocks	Shrub (10) & Tree (4), (6).
Children dormitory	South side of the boys activity room	Shrub (10)
Common house	South side, guest bedroom 1 & 5	tree (1 or 2 or 3).

SOURCE : District survey reports of kanchipuram ; https://kancheepuram.nic.in/about-district/ ; https://www.energy.gov/energysaver/landscaping-shade

Fig 5.3.3: Native tree species identified from kanchipuram district data

5.4. IGBC TOWNSHIP RATING STUDY

Table 5.4.1: IGBC Township rating feasibility report

CREDIT	COMPLIANCE REQUIREMENT	MAX. POINTS	CURRENT STATUS	ACHIEVED
		SITE SELECTION & PLANNING		
SSP Mandatory Requirement 1	Local Building Regulations	Mandatory	This project **complies with the local government** regulations & codes such **as the TNCD,CRZ**.	
SSP Mandatory Requirement 2	Avoid Development of inappropriate sites	Mandatory	The site area intended for this project does **not fall under the ecologically sensitive area.**	
SSP Mandatory Requirement 3	Soil erosion control plan	Mandatory	**Open areas** are either vegetated or provided with the permeable **pavers to avoid soil erosion.**	
SSP Credit 1	Preserve existing trees & water bodies	6	**Trees are planted** on the site according to the **shading requirements** . Sparsely grown shrubs available in site which are of no use.	6
SSP Credit 2	Retain natural topography	6	**50% of the site** slope is maintained.	6
SSP Credit 3	Public Landscape areas	6	**35% of the total area of residential** area is provided for **public landscape area**	6
SSP Credit 4	Redevelopment of contaminated areas	6	- Not applicable -	-
SSP Credit 5	Local fruits & vegetable produce	8	**25%** of the site area is allotted for growing vegetable (organic farming). **(3.5 Acres)**	6
SSP Credit 6	Urban heat island effect	8	**95%** of the site area are either under tree, high reflectance material or open grid paver	8
MAXIMUM POINTS FOR SSP		**40**	**POINTS ACHIEVED IN THIS CREDIT**	**32**

CREDIT	COMPLIANCE REQUIREMENT	MAX. POINTS	CURRENT STATUS	ACHIEVED
		LAND USE PLANNING		
LP Mandatory Requirement 1	Land use optimization	Mandatory	**24%** of the total built-up is residential area in the eco-village	
LP Mandatory Requirement 2	Basic facilities for construction workforce	Mandatory	Construction labors are provided with healthy and safe conditions.	
LP Mandatory Requirement 3	Basic amenities within the community	Mandatory	Except ATM, Clinic, Pharmacy & parks with jogging track others are provided within 800m from site and exceptions are provided in the site.	
LP Credit 1	Mixed use development	10	Mixed use developments & residential areas provided in the site	10
LP Credit 2	Housing typologies	8	Housing for homeless (EWS) & tourists (HIG) are provided	8
LP Credit 3	Green buildings	12	- Not following as of now -	
LP Credit 4	Employment opportunities (Post occupancy)	8	Employment opportunities for all the homeless people within the site	8
LP Credit 5	Social & Cultural initiatives	6	**Area for school, organic farming** with local farmers, adequate drinking facilities, social & cultural initiatives , clinic & local craft.	6
MAXIMUM POINTS FOR LP		**44**	**POINTS ACHIEVED IN THIS CREDIT**	**32**
		TRANSPORTATION PLANNING		
TP Mandatory Requirement 1	Long term transportation plan	Mandatory	**Transportation provided** within eco-village	
LP Mandatory Requirement 2	Design for differently abled	Mandatory	Designed for differently abled	
TP Credit 1.1	Public transportation facilities	6	Bus stop provided near to the site	2
TP Credit 2.2	Eco-Friendly transportation services	6	**Eco-friendly transportation provided** , eco-friendly public bus shuttle & **75% eco-friendly** refueling stations	6
TP Credit 2	Road & street network	6	**Roads & streets** and network according to the local bye-laws	6
TP Credit 3	Bicycle lane network	6	**Bicycle lane** provided within the site	6
TP Credit 4	Pedestrian network	6	**Pedestrian network provided**, shaded pathways & adequate street lighting with appropriate **lux is provided.**	6
MAXIMUM POINTS FOR TP		**44**	**POINTS ACHIEVED IN THIS CREDIT**	**26**
		INFRASTRUCTURE RESOURCE MANAGEMENT		
IRM Mandatory Requirement 1	Rainwater harvesting, 50%	Mandatory	Required cu.m of run-off to be conserved is **300 Cum (50%)** Achieved is **575.4 Cu.m**	
IRM Mandatory Requirement 2	Segregation of waste (Post - occupancy)	Mandatory	**Color coded dustbins** are placed near all the stays and the wastes are segregated.	
IRM Credit 1	RWH 75% , 95%	6	Required cu.m of run-off to be conserved is 450 Cum **(75%) ; 567 Cu.m(95%)** Achieved is **575.4 Cu.m**	6
IRM Credit 2	Waste water treatment, 100%	6	On-site STP provided	6
IRM Credit 3	Waste water Reuse, 75% , 95%	6	**100% of the treated water** will be reused for watering the landscape areas.	6
IRM Credit 4	Energy efficiency infrastructure equipment	8	Energy efficient lighting , water pumps and motors are provided as prescribed.	8
IRM Credit 5	On- site Renewable Energy	16	Solar panels and bio gas plant are provided and **40% of renewable** energy to total annual energy consumption.	16
IRM Credit 6	Off- site Green Power	12	Off- site energy production is not provided	-

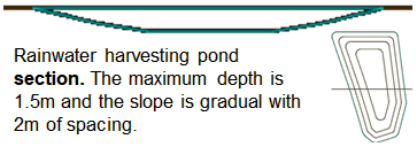
IRM Credit 7			Construction Waste Reduction (Civil Works)	6	**75%** of the construction wastes are not sent to landfills and the recyclable wastes are redirected to appropriates sites.	6
IRM Credit 8			Recycled Content (Civil Works)	8	**30%** of the construction materials are recycled	8
IRM Credit 9			Measurement & Verification Plan	2	Metering not required since the energy load is less	-
MAXIMUM POINTS FOR IRM				**70**	**POINTS ACHIEVED IN THIS CREDIT**	**56**

ECO-VILLAGE RUN OFF CALCULATION

S.No.	Zone	Area (sq.m.)	Run-off Coefficient	Impervious Area (sq. m.)
1	Cemented Roof	3128.10	0.95	2971.7
2	Sloped clay roof	4013.60	0.95	3812.9
3	Vegetation area	25029.30	0.20	5005.9
4	Sand	14720.70	0.10	1472.1
5	Hardscape (Pathways/Driveways)	14286.20	0.95	13571.9
			Net Impervious Area	**26834.4**
			Rainfall Intensity (m/day) considering 50% (Mandatory) of average peak rainfall (2 point)	0.011
			Rainfall Intensity (m/day) considering 75% of average peak rainfall (4 point)	0.017
			Rainfall Intensity (m/day) considering 95% of average peak rainfall (4 point)	0.021
			Total Run-off Volume (Cu.m.) for 50% average peak rain fall	**298.11 (300 Cu.m)**
			Total Run-off Volume (Cu.m.) for 75% average peak rain fall	447.17 (450 Cu.m)
			Total Run-off Volume (Cu.m.) for 95% average peak rain fall	**566.41 (566 Cu.m)**

Year	Peak Month Rainfall	Peak Rainfall (mm)
2016	September	275
2017	November	584
2018	August	198
2019	October	278
2020	April	332
Last 5 years average rainfall		22

Rainwater harvesting pond provided at site = Area of the pond x average depth
Average depth = 0.4 x maximum depth
= 0.4 x 1.5 m = 0.60m
Volume = 959 m² x 0.60m = **575.4 Cu.m**



Rainwater harvesting pond **section.** The maximum depth is 1.5m and the slope is gradual with 2m of spacing.

YEAR	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEPT		OCT		NOV		DEC	
	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP	R/F	%DEP
2016	0.5	-98	0.0	-100	0.0	-100	0.0	-100	198.1	355	109.3	70	59.6	-45	51.7	-65	275.3	132	28.8	-89	66.1	-82	247.2	59
2017	4.5	-80	0.0	-100	0.0	-100	0.0	-100	1.8	-96	58.5	-9	86.6	-20	233.4	58	71.2	-40	269.8	1	583.8	59	84.2	-46
2018	2.2	-90	0.9	-94	2.9	-3	0.0	-100	0.0	-100	39.2	-39	95.9	-12	197.7	34	62.5	-47	149.9	-44	171.9	-53	31.8	-80
2019	0.1	-99	1.5	-90	0.0	-100	0.0	-100	0.0	-100	56.0	-15	191.5	74	142.9	-1	197.5	66	277.6	5	145.4	-56	214.7	30
2020	40.7	85	0.1	-99	0.0	-100	52.2	332	1.0	-97	26.0	-63	188.4	65	92.1	-37	158.1	22	241.1	-12	570.4	65	229.3	41

SOURCE : https://extension.psu.edu/pond-measurements-area-volume-and-residence-time ; https://hydro.imd.gov.in/hydrometweb/(S(yv1wwo554telhp55a45jxgbv))/DistrictRaifall.aspx

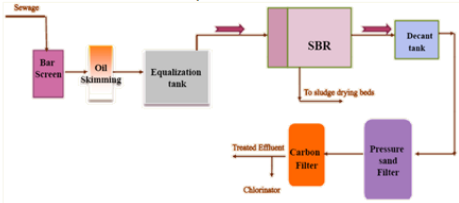
Fig 5.4.1: Rain water run-off calculation

DOMESTIC WATER CONSUMPTION FOR THE ECO-VILLAGE

S.no	Fixture type	Duration(Minutes)	Daily use per FTE	No . Of Occupants	Baseline		Proposed case	
					Flow rate	Total daily Water	Flow rate	Total daily Water
1	Water closets (High flush)	1	1	350	6	2100	4	1400
2	Water closets (Low flush)	1	4	350	3	4200	2	2800
3	Faucets	0.25	8	350	8	5600	6	4200
4	Health faucets LPM	0.25	1	350	8	700	4	350
6	Kitchen sink	0.25	6	350	8	4200	4	2100
7	Shower head LPM	8	1	321	10	25680	6	15408
				Baseline consumption		**42480**	**Proposed Consumption**	**26258**
				Percentage savings				**38.19%**

STP CALCULATION

Total domestic water demand (TWD) = 26,258 l/d or 26.25 KLD
Estimated sewage = 100% of the TWD
Estimated sewerage = 26.25 KLD
Estimated sewerage = 37.5 KLD (70% extra)
STP Space requirement for 37.5 cu.m ; Depth is 2.3m
(0.3m considered for free board) **STP size : 4.5 x 4.5 x 2 = 40.5Cu.m**



Schematic of Sequential Batch reactor

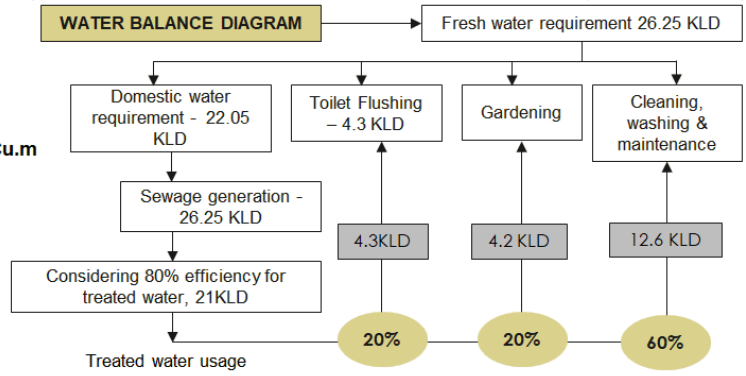


Fig 5.4.2: Daily domestic water demand calculation

Table 5.4.2: Energy calculation

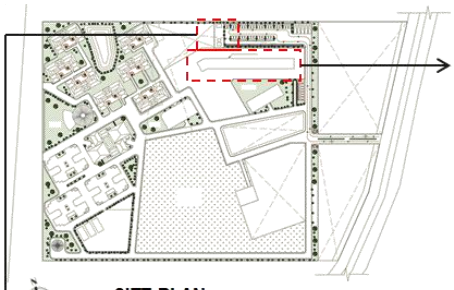
Fixtures	Watts	Nos	Total watts	Operation hours	Total energy consumption
Family co-living : Homeless accomodation - 3 Blocks					
Wall light	4	258	1032	6	2260.08
Ceiling light	16	366	5856	4	6839.808
Ceiling fan	54	180	9720	12	29801.52
Lamp	40	120	4800	8	14016
Exhaust fan	150	120	18000	1	5256
Tv	60	6	360	8	1051.2
Water heater	2000	18	36000	2.5	10800
Mixer	500	54	27000	0.2	1971
Refridgerator	350	54	18900	24	99338.4
Children dormitory					
Wall light	4	46	184	8	537.28
Ceiling light	16	120	1920	4	2242.56
Ceiling fan	54	30	1620	12	4966.92
Lamp	40	10	400	8	1168
Exhaust fan	150	12	1800	1	525.6
Tv	60	20	1200	8	3504

Fixtures	Watts	Nos	Total watts	Operation hours	Total energy consumption
Tourist Accommodation - 7 Blocks					
Wall light	4	126	504	6	1103.76
Ceiling light	16	490	7840	4	9157.12
Ceiling fan	54	98	5292	12	16225.272
Lamp	40	84	3360	8	9811.2
Exhaust fan	150	42	6300	1	1839.6
Tv	60	42	2520	8	7358.4
Water heater	2000	42	84000	2.5	25200
Mini Fridge	350	28	9800	24	51508.8

Fixtures	Watts	Nos	Total watts	Operation hours	Total energy consumption
Common house					
Wall light	4	35	140	4	204.4
Ceiling fan	54	110	5940	6	9106.02
Lamp	40	5	200	8	584
Exhaust fan	150	8	1200	1	350.4
Tv	60	6	360	5	657
Total energy Consumption for all the four buildings					**317384.34**

For providing 40% of the total energy consumed energy, **₹ 43,47,731** is required and 870 Sqm area is needed which is distributed on the roof of each blocks.

Percentage of On-site Renewable Energy Generated to the Total Annual Energy Consumption of the Building	Energy Consumption (Kwh)	Annual Energy Produced by 1Kw Solar Panel per Year (KWH)	Solar requirement (KW)	Approx. Investment in RS (Considering Rs.50,000 /KW)	Approx. Space Requirement in Sq.m (Considering Space Requirement 10 Sq.m/KW)
10% (4 Points)	31738	1460	22	₹ 10,86,933	217
20% (8 Points)	63477		43	₹ 21,73,865	435
30% (12 Points)	95215		65	₹ 32,60,798	652
40% (16 Points)	**126954**		**87**	**₹ 43,47,731**	**870**



SITE PLAN

Space for solar panel, A flat roof with a width of **10m** for about an area of **900Sqm** provided, this space can also provide shade to the workshops and other spaces below

Transformer yard, STP and the Biogas plant are located near the parking zone. It will be provided with a buffer on either side to avoid direct visibility.

Other energy alternative techniques provided is the bio gas plant

BIO GAS PLANT SIZE CALCULATION:
According to the IGBC, Organic waste per person is **0.25kgs** since there is **organic farming (3.5 Acres) and goshala**, the waste generated per person per day is around 0.5kgs ; Total users : 350 people (Approx.)
Waste generation is **350 x 0.5 = 175kgs /day**
So, **Large scale plant can be used** .

Availability from the site	VNS ENVIRO BIOGAS PLANTS is situated 50km from the site.
Cost of the bio gas plant	2.5 Lakhs / piece prefabricated
Usage **Size of 50 – 200 kg = 1.2x0.81x1.2**	Input : Food waste, Cow dung, vegetation & staw; Output : Cooking gas & Used for electricity alternatives ; yield : 6kWh/m².

SOURCE : https://www.indiamart.com/proddetail/bio-gas-plant-for-home-municipal-use-20598508288.html

Fig 5.4.3: Bio gas plant study

Table 5.4.3: IGBC Township rating feasibility report – Innovation and total points achieved

INNOVATION IN DESIGN & TECHNOLOGY				
IDT Credit 1.1	Innovation in design & technology	3	**Only 24%** of the site is built and **38%** of the site is designed with **landscape** and **38% is open**. Site area : 61177.9 Sqm ; Landscape area: 23010.7Sqm	3
IDT Credit 1.2	Innovation in design & technology	3	There are **no turf area** and all the landscape species are **native and draught tolerant**.	3
IDT Credit 1.4	Innovation in design & technology	3	The **water consumption is 38%** less than the baseline criteria.	3
IDT Credit 1.4	Innovation in design & technology	3	**More than 95%** of the **treated water** is used for **landscaping and flushing.**	3
IDT Credit 2	IGBC Accredited Professional	4	-	-
MAXIMUM POINTS FOR IDT		**16**	**POINTS ACHIEVED IN THIS CREDIT**	**12**
	TOTAL POINTS	**200**	**TOTAL POINTS**	**158**

CERTIFICATION LEVELS	TOWNSHIP POINTS ACHIEVED	ACHIEVED RECOGNITION
GOLD	**140 – 159 (158 Points achieved)**	**National Excellence**

DETAILS FOR COST ANALYSIS				
Buildings	**Area (Sqft)**	**cost per sq.ft in INR**	**Total cost in INR Cr**	**Nos**
Admin	4,520.8	2500	1.13	1
Admin - Furniture			0.03	
Community kitchen	4,951.4	2500	1.24	1
CK-Furn & Equipment's			0.10	
Tourist accomodation - GF	28,481.3	3500	9.97	7
TA - First floor	8,288.2	3500	2.90	
TA-Furniture			0.56	
Common house - GF	2,438.0	2500	0.61	1
Common house - FF	2,438.0	2500	0.61	
CH - Furniture			0.03	
Homeless stay - GF	21,861.5	2500	5.47	3
Homeless stay - FF	21,861.5	2500	5.47	
HS - Furniture			0.24	
Children dorm - GF	9,434.6	2500	2.36	1
Children dorm - FF	1,001.0	2500	0.25	
CD - Furniture			0.10	
Highway hotel	5,000.0	2500	1.25	1
HH-Furn & Equipment			0.10	
Cultural workshop	25,000.0	2000	5.00	1
Approval cost	1,35,276.3	75	1.01	1
Road	1,30,680.0	50	0.65	1
Landscape area	2,03,771.0	10	0.20	1
Compound wall	4,376.6	1500	0.66	1
3 bus, 5 buggy & 50 Cycle			0.88	
Energy cost			0.44	
STP	218.0	1500	0.13	
RO Plant			0.10	
Total			**41.48 Cr.**	

ORGANIC FARMING

Good income can be generated through **100% Organic farming**, The vegetable cultivation in the eco-village are the native crops produced in the kancipuram district, Paddy is the major crop cultivated in this district. Groundnuts, Sugarcane, Cereals & Millets and Pulses are the other major crops cultivated. For **0.25 Acres**, the total yield is ₹93,000 approx. (Inclusive of expense ₹6,000) So, for 3.5 Acres the yield is **₹1,40,000/year.**

REVENUE GENERATION					
Spaces	**Days**	**INR**		**Total revenue per Yr.**	**Expenses per Yr.**
Tourist stay	255	4000	per day per room	2.86	0.29
Highway hotel	365	50000	per day	1.83	0.91
Cultural workshop	255	20000	per day	0.51	0.03
Community kitchen	255	21000	per day	0.54	1.64
Organic farming	365		Per year	1.40	0.024
Total				7.13	2.87
Net revenue per annum				4.26 Crore	
Revenue % on Net operating income				10.3%	

SOURCE : Civil engineer (Mr.Kutralingham from the ultimate engineering, Mylapore, Chennai ; https://vikaspedia.in/agriculture/best-practices/sustainable-agriculture/organic-farming/excellent-income-through-100-organic-farming

COST ANALYSIS : Initially area of each space are multiplied by cost per Sqft, the furniture and equipment's are calculated thereafter, site development cost such as the internal roads, landscape, energy and STP are calculated and the revenue generated in the site are recorded along with the related expenses then repayment & payback is calculated.

REPAYMENT		
Repayment to	**Sharing ratio**	**INR in Cr**
Profit share to Tourism board	10%	0.43
Development cost repayment	55%	2.34
Community welfare	5%	0.21
Residents benefit	30%	1.28
Return on Investment in Years		**17.7**
Share for each resident in INR per month		**₹5,547**

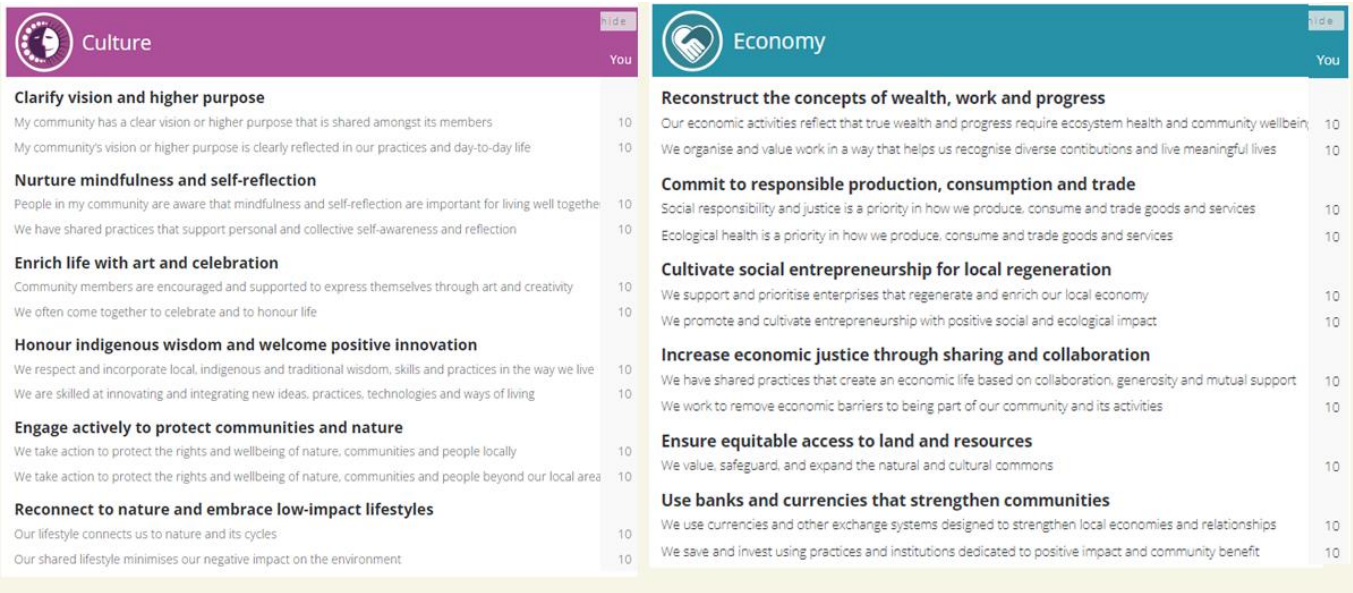
AFTER REPAYMENT OF DEVELOPMENT COST		
	Sharing ratio	INR in Cr
Profit share to Tourism board	30%	1.28
Community welfare	5%	0.21
Residents benefit	65%	2.77
Share for each resident in INR per month		**₹12,019**

Fig 5.4.4: Cost and payback study

Fig 5.4.5: Overall site plan

CHAPTER 6
CONCLUSION: SUSTAINABLE DEVELOPMENT GOALS

6.1. SUSTAINABLE DEVELOPMENT GOALS



Culture

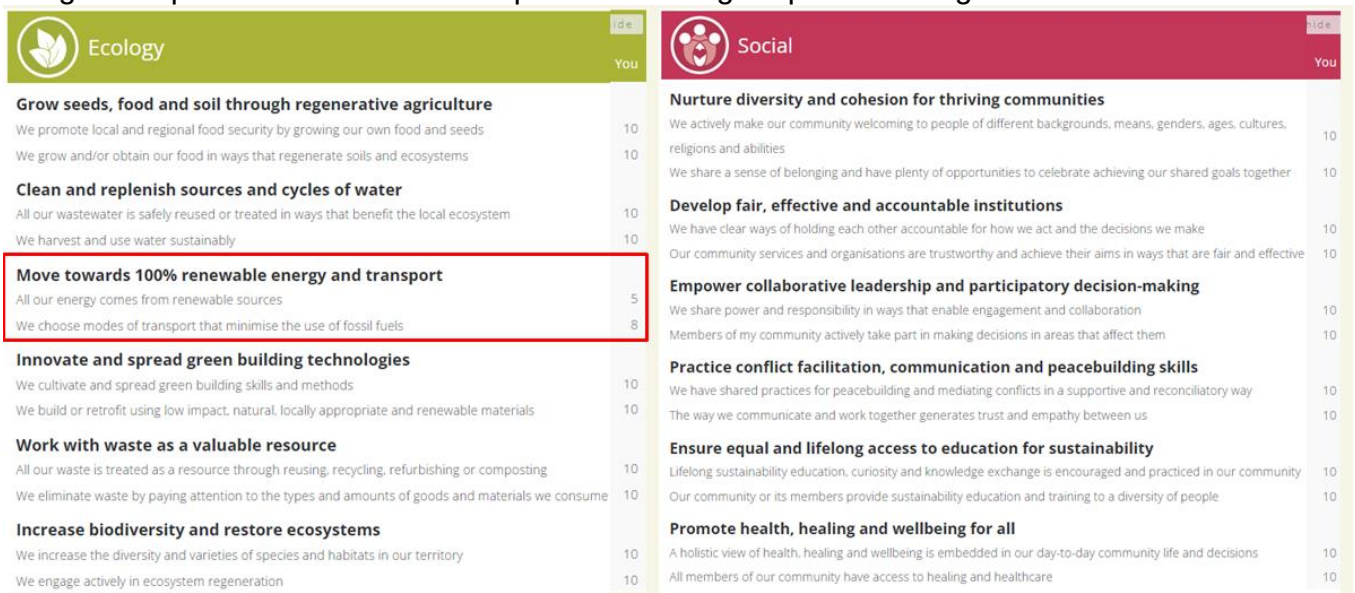
	You
Clarify vision and higher purpose	
My community has a clear vision or higher purpose that is shared amongst its members	10
My community's vision or higher purpose is clearly reflected in our practices and day-to-day life	10
Nurture mindfulness and self-reflection	
People in my community are aware that mindfulness and self-reflection are important for living well togethe	10
We have shared practices that support personal and collective self-awareness and reflection	10
Enrich life with art and celebration	
Community members are encouraged and supported to express themselves through art and creativity	10
We often come together to celebrate and to honour life	10
Honour indigenous wisdom and welcome positive innovation	
We respect and incorporate local, indigenous and traditional wisdom, skills and practices in the way we live	10
We are skilled at innovating and integrating new ideas, practices, technologies and ways of living	10
Engage actively to protect communities and nature	
We take action to protect the rights and wellbeing of nature, communities and people locally	10
We take action to protect the rights and wellbeing of nature, communities and people beyond our local area	10
Reconnect to nature and embrace low-impact lifestyles	
Our lifestyle connects us to nature and its cycles	10
Our shared lifestyle minimises our negative impact on the environment	10

Economy

	You
Reconstruct the concepts of wealth, work and progress	
Our economic activities reflect that true wealth and progress require ecosystem health and community wellbein	10
We organise and value work in a way that helps us recognise diverse contibutions and live meaningful lives	10
Commit to responsible production, consumption and trade	
Social responsibility and justice is a priority in how we produce, consume and trade goods and services	10
Ecological health is a priority in how we produce, consume and trade goods and services	10
Cultivate social entrepreneurship for local regeneration	
We support and prioritise enterprises that regenerate and enrich our local economy	10
We promote and cultivate entrepreneurship with positive social and ecological impact	10
Increase economic justice through sharing and collaboration	
We have shared practices that create an economic life based on collaboration, generosity and mutual support	10
We work to remove economic barriers to being part of our community and its activities	10
Ensure equitable access to land and resources	
We value, safeguard, and expand the natural and cultural commons	10
Use banks and currencies that strengthen communities	
We use currencies and other exchange systems designed to strengthen local economies and relationships	10
We save and invest using practices and institutions dedicated to positive impact and community benefit	10

Fig 6.1.1: SDG's – Culture and economy

INFERENCE: According to the 6 aspects respective to the Culture and Economy, the eco-village Complies with the created aspects achieving 10 points throughout.



Ecology

	You
Grow seeds, food and soil through regenerative agriculture	
We promote local and regional food security by growing our own food and seeds	10
We grow and/or obtain our food in ways that regenerate soils and ecosystems	10
Clean and replenish sources and cycles of water	
All our wastewater is safely reused or treated in ways that benefit the local ecosystem	10
We harvest and use water sustainably	10
Move towards 100% renewable energy and transport	
All our energy comes from renewable sources	5
We choose modes of transport that minimise the use of fossil fuels	8
Innovate and spread green building technologies	
We cultivate and spread green building skills and methods	10
We build or retrofit using low impact, natural, locally appropriate and renewable materials	10
Work with waste as a valuable resource	
All our waste is treated as a resource through reusing, recycling, refurbishing or composting	10
We eliminate waste by paying attention to the types and amounts of goods and materials we consume	10
Increase biodiversity and restore ecosystems	
We increase the diversity and varieties of species and habitats in our territory	10
We engage actively in ecosystem regeneration	10

Social

	You
Nurture diversity and cohesion for thriving communities	
We actively make our community welcoming to people of different backgrounds, means, genders, ages, cultures, religions and abilities	10
We share a sense of belonging and have plenty of opportunities to celebrate achieving our shared goals together	10
Develop fair, effective and accountable institutions	
We have clear ways of holding each other accountable for how we act and the decisions we make	10
Our community services and organisations are trustworthy and achieve their aims in ways that are fair and effective	10
Empower collaborative leadership and participatory decision-making	
We share power and responsibility in ways that enable engagement and collaboration	10
Members of my community actively take part in making decisions in areas that affect them	10
Practice conflict facilitation, communication and peacebuilding skills	
We have shared practices for peacebuilding and mediating conflicts in a supportive and reconciliatory way	10
The way we communicate and work together generates trust and empathy between us	10
Ensure equal and lifelong access to education for sustainability	
Lifelong sustainability education, curiosity and knowledge exchange is encouraged and practiced in our community	10
Our community or its members provide sustainability education and training to a diversity of people	10
Promote health, healing and wellbeing for all	
A holistic view of health, healing and wellbeing is embedded in our day-to-day community life and decisions	10
All members of our community have access to healing and healthcare	10

Fig 6.1.2: SDG's – Ecology and Social

INFERENCE : According to the **6 aspects** respective to **social**, the eco-village complies with all the aspects and respective to ecology, only **40% renewable energy** is achieved according **to IGBC** and **only few transportation** are **renewable** (Solar & electrical vehicle) and in the integrated category average point **9.4**, the eco-village complies with all the aspects achieving 10 points

Fig 6.1.3: SDG's – Result

Table 6.1.1: Tabulated result from the wheel of SDG's

Wheel showing the points achieved regarding the SDG's

CATEGORY	ACHIEVED	CATEGORY	ACHIEVED
01	10	**10**	10
02	10	**11**	9.06
03	10	**12**	10
04	10	**13**	9.68
05	10	**14**	10
06	10	**15**	10
07	6.5	**16**	10
08	10	**17**	10
09	10		

6.2. CONCLUSION

Table 6.2.1: Objective and research questions answered

OBJECTIVES & RESEARCH QUESTIONS	ACHIEVED
Designed to reduce the ecological footprint	76% open, reduce, reuse and recycle is practiced .
Co-living & Co-housing strategies	Co-living for Homeless families & Co-housing for tourists.
Energy alternatives & Passive strategies	Renewable energy & Passive strategies building & site level.
Different User experience	Completely different from the urban set up.
Appropriate rating system for eco-village ?	IGBC township rating calculated as per analysis .
Long term sustainable solutions ?	Renewable energy alternatives, eco-friendly construction.
Revenue generation aspects ?	Workshops & Cultural enhancements & Hotel developments.

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APPENDICES

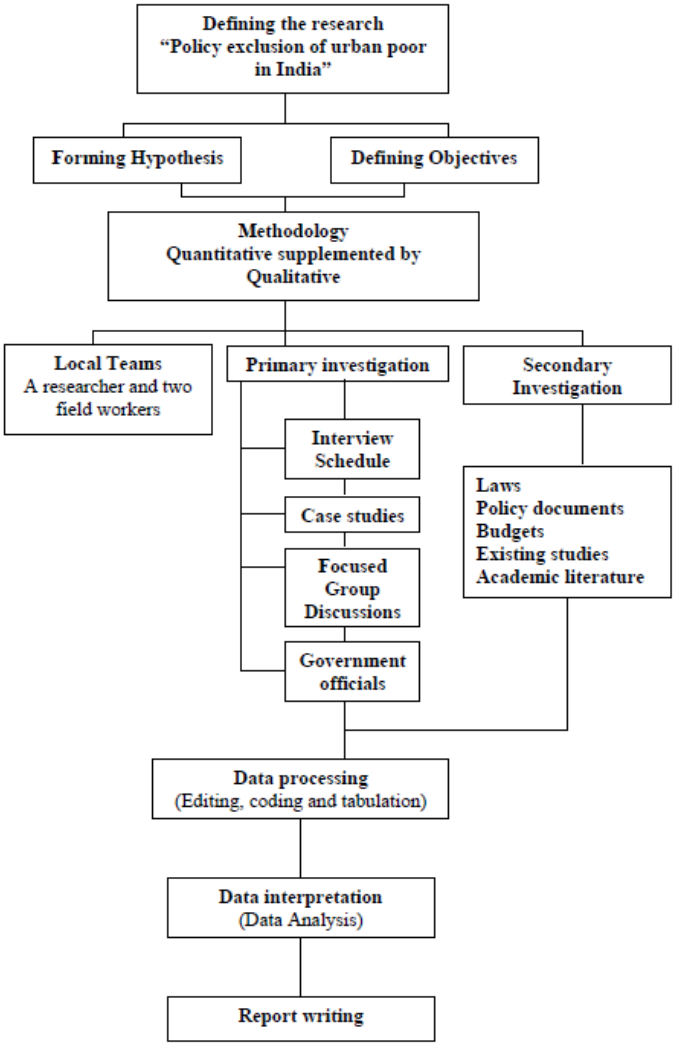
APPENDIX – I Socio economic demographics of the homeless

To understand the socio-economic demographics of the homeless, a research report is analyzed, “Living rough: Surviving the city streets, a study of homeless population of Delhi, Chennai, Patna & Madurai”. As the area of study is in Chennai, the information’s related to Chennai is only concentrated. The author of the study is harsh mander and the report is created by the year 2008.

Aim of the report

This paper records the finding of a small investigation into a fragment of this lived experience and into the social, economic, nutritional of urban homeless.

The methodology of the study is shown below,



Reason to select this report

To understand the social & cultural demographics of the homeless in Chennai, the problems faced by them and the policies which would eventually help them recover from this issue and provide them a better life.

Areas concentrated: Parry's terminal, Rattan bazar, NSC Bose road & Egmore (All from south Chennai, as they more urbanized & large share in homeless population).

Responders:

1. Randomly chosen, mainly the ones living on pavements, roadside of shops & on the railway stations.
2. Responders of all types were chosen.
3. 80 responders were interviewed.(20 sample (responders) in each area).

The results from the survey questions are tabulated and shown below,

S.No	Homeless Population	India	Tamilnadu	
			Total Population	% in National level
1	Urban	7,78,599	57,128 (66%)	7.3%
2	Rural	11,64,877	29,344 (34%)	2.5%
3	Total	19,43,476	86,472 (100%)	4.4%

Source: Census 2001

Age and Gender Profile of

Age/Sex		Chennai
Male	Below 16 years	9 (11.2%)
	16 – 60 years	7 (8.8%)
	Above 60 years	-
Female	Below 16 years	19 (23.8%)
	16 – 60 years	41 (51.3%)
	Above 60 years	3 (3.8%)
Eunuch	16- 60 years	1 (1.2%)
	Total	80 (100%)

Years of Homelessness

S.No	Years of Homelessness	Chennai
1	Less than one year	5 (6.25%)
2	1 to 5 years	7 (8.75%)
3	5 to 10 years	-
4	More than 10 Years	68 (85.0%)
5	No response	-
	Total	80 100%

Daily Income

S. No	Daily Income	Chennai
1	< 50	19 (23.75%)
2	50-100	29 (36.25%)
3	> 100	12 (15.0%)
4	NA/No income	20 (25.0%)
5	No response	-
	Total	80 (100%)

Educational status

S.No	Literacy	Chennai
1	Illiterate	34 (42.5%)
2	Primary	15 (18.8%)
3	Secondary	7 (8.8%)
4	Above 10th	-
5	NA (Students)	24 (30.0%)
6	No response	-
	Total	80 (100%)

Paying service charge

S.No	Paying service charge	Chennai
1	Drinking water	8 (10.0%)
2	Defecation	58 (72.5%)
3	Bathing	32 (40.0%)
4	Sleeping space	2 (2.5%)
5	Bedding	-
6	Others	-

Reasons for Homelessness

S.No	Reasons for Homelessness	Chennai
1	Extreme poverty	59 (73.75%)
2	Need to send money home	1 (1.25%)
3	Mental illness	-
4	Substance Abuse	-
5	Abandonment by family	2 (2.5%)
6	Absence of family	2 (2.5%)
7	Family abuse	-
8	Social persecution	-
9	Mentally challenged	-
10	Attraction to glamour of city	-
11	Cannot afford to rent house	11 (13.75%)
12	Stigmatizing illness	-
13	Natural calamity	-
14	Unemployment	2 (2.5%)
15	No demand for traditional skills	-
16	Any other	3 (3.75%)
17	No response	-
	Total	**80 (100%)**

Place of sleep

S.No	Place of Sleep	Chennai
1	Under staircase	2 (2.5%)
2	Under ledge of shops or homes	31 (38.75%)
3	In Market Corridors	1 (1.25%)
4	Railways Platform	-
5	Bus Stand	3 (3.75%)
6	Courtyard or places of worship	-
7	Drainage Pipes	-
8	Government night shelters	-
9	Deserted / Abandoned buildings	-
10	NGO Night shelters	-
11	Pavement /road –sides	42 (52.5%)
12	Road dividers (centre of the road)	-
13	Parks	-
14	On bridges	-
15	On flyovers	-
16	Under bridges	-
17	Under Flyovers	-
18	At your workplace	1 (1.25%)
19	Any Other	-
18	Not reported	-
	Total	**80 (100%)**

Primary Occupation

S. No	Primary Occupation	Chennai
1	Street vendor	20 (25.0%)
2	Casual daily wage labor	4 (5.0%)
3	Construction worker	10 (12.5%)
4	Passenger rickshaw puller	-
5	Rickshaw load puller	-
6	Handcart puller	-
7	Hammal	-
8	Commercial sex worker	-
9	Live by alms/receive charity	1 (1.25%)
10	Rag picking	-
11	Shoe Polisher	-
12	Street Performers	-
13	Professional blood donor	-
14	Domestic Worker	8 (10.0%)
15	Garage worker or cycle repair mechanic	-
16	Home maker	5 (6.25%)
17	Student	24 (30.0%)
18	Any Other	2 (2.5%)
19	No Response/No work	6 (7.5%)
	Total	**80 100%**

The urban poor suffer from certain social problems that the rural poor do not face. Some of these are:

a) Urban migrants from the countryside have been cut off from their community. They are new to the urban environment, and are therefore not adjusted to it. They feel alienated and lonely in this new system. However, they are rarely completely atomized, because of the prevalence mostly of a rural-urban continuum, in which they usually retain strong links with their families and communities in the village that they have left behind;

b) The social security systems, both formal and informal, which survive in the rural areas, are not nearly so developed in the urban areas. In the villages, the neighboring family is a family which has been one's neighbor for generations, and one can always fall back upon it in times of need, but this is not usually the case in urban areas;

c) The cost of living in urban areas is higher than in the rural areas;

d) The rural economy is still not fully monetized, while in urban areas, one has to pay for everything in money; for instance fuel is not available by foraging but has to be purchased. Moreover the natural environment usually provides even if minimally in most times of scarcity in the countryside, but this kind of purchased support from nature is unavailable in cities;

e) The physical environment in which the majority of the urban poor are forced to live is usually far more degraded, and mostly illegal, in comparison to that available to the rural poor; and

f) Most rural poor people have some land and cattle or other animals, which is their insurance against bad times. The urban poor have no such asset security, only their labor power.

Recommendations on housing

1. Reserve at least 30% of all new housing space for the poor.
2. Make it compulsory by law for all housing schemes in which more than 20 dwelling units are being constructed, whether for higher or middle income groups, to construct a certain% age (say 30% of the total number) of affordable houses of 25-30 sq. m for the poor as part of the scheme
3. Make it compulsory by law for all advertisements on housing, whether from builders or government
   Organizations, to specifically mention in what manner the poor would benefit from the housing scheme.
4. A law should be passed making it incumbent for the contractors to pay for space for the laborers in the night shelter before their tenders are considered.
5. Interest subsidy on bank loans for the poor should be introduced. It is ironical that the rich get income tax.
6. Rebate on housing loans, but the poor get no such benefit from government.
7. The poorest such as beggars and daily wage earners cannot afford even houses on a rental scheme. For them the scheme of night shelters should be revived as a centrally sponsored scheme.

Inference from the report

1. Demographic profile of the homeless people & street children were identified.
2. The reason for being in the streets was identified.
3. Livelihood options, income & household economics were identified.
4. Expenditure on food & consumption pattern was identified.
5. Issues relating to the access to food were identified.
6. There should be a change in law & policies to fulfill their basic needs.
7. Problems faced by the urban poor who are not faced by the rural poor are examined.

Certain housing recommendations for the homeless is listed which would provide them a greater benefit if followed.