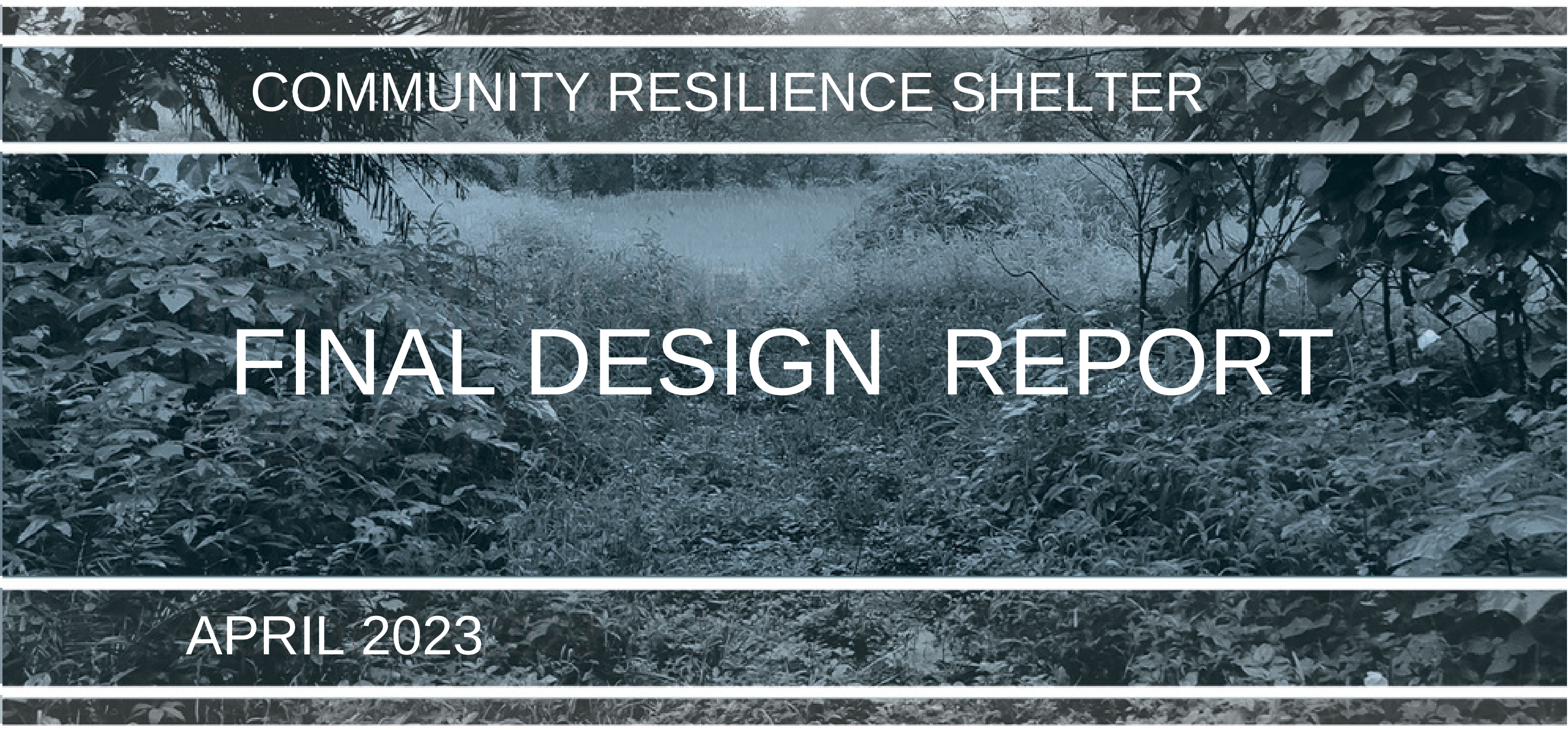
Solar™ Decathlon India

TEAM NISHTHA



COMMUNITY RESILIENCE SHELTER

FINAL DESIGN REPORT

APRIL 2023

Veermata Jijabai Technological Institute
Mumbai

Rachana Sansad's Academy of Architecture
Mumbai

Centre for Environment Planning & Technology
Ahmedabad

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EXECUTIVE SUMMARY

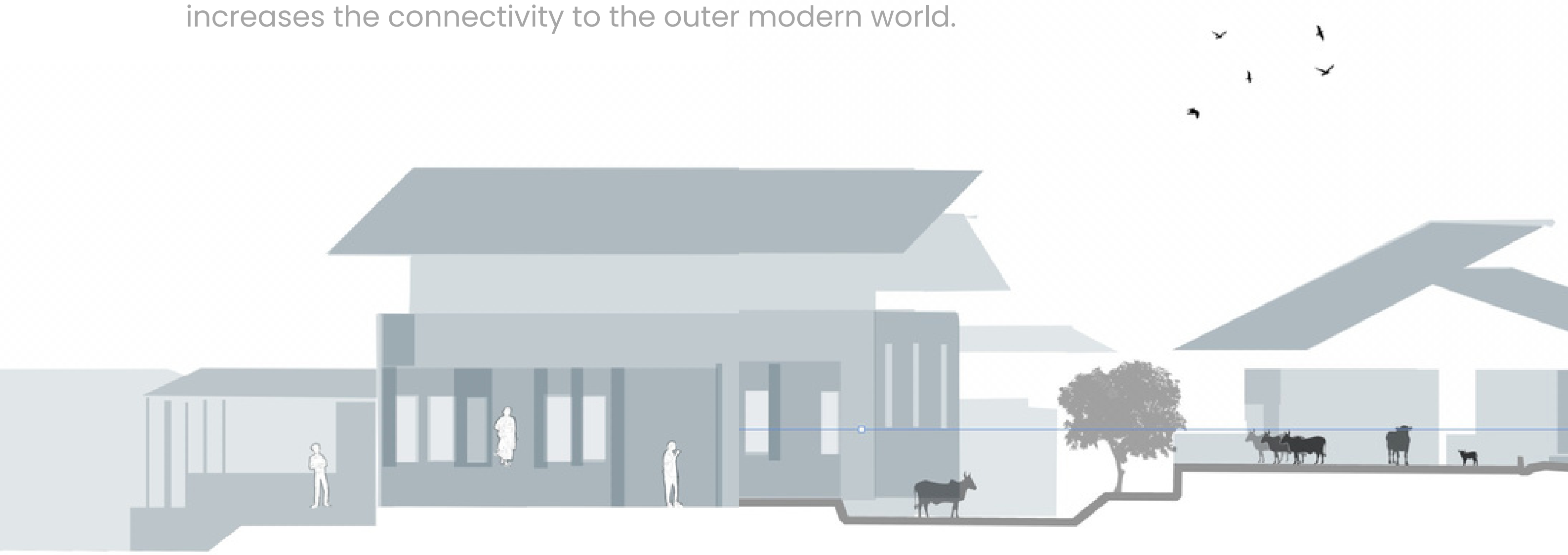
Team Nishtha, with 14 passionate students from architecture and engineering backgrounds, has been divided into groups based on their skill sets. Each student with their unique skills completes the team thus, utilizing the team's potential to it's full extent. Brainstorming and group discussions pave the path to creating an amalgamation of innovative ideas. Our project partner, an NGO, works to improve the lifestyle of people living in the Palghar district of Maharashtra.

With various collaborative discussions with the Project Partner, we ventured into Khomarpada as our site for our community resilience shelter. The first steps to the design were several site visits with direct interaction with the end users. Following this, there were a few brainstorming sessions within the team which were further discussed with faculty advisors. With the principle of making the resilience shelter to be a waited community space with various attributes like resilience, water, and energy sufficiency.

With the goal of running the center without any HVAC systems, the design focuses on passive cooling techniques. These techniques govern the zoning and form of structure. The design encourages the use of locally sourced materials with an introduction to using these vernacular materials efficiently for the local labor and villagers. This will redefine their vernacular ways giving the village its own identity. Our Industry partner helped us to ideate on different ways of construction technologies and gave us comprehensive knowledge.

This has helped us in achieving the EPI of **21.285** kWh/m^2/year with the help of the **100.07 KWh/day** energy by solar panels**,** a **41.1%** Overall reduction in Carbon emission, reduction in water demand by **55.25%.**

Our structure helps in providing electricity which is generated by solar panels on site, water which is rain water harvested, fuel generated from biogas plant, crops, grown on site and most importantly a proper shelter. This makes our Community resilience shelter, a self-sufficient and helps in strengthening the village. This also increases the connectivity to the outer modern world.



RESPONSE TO REVIEWER

	Review 1		
	Evaluation	Comment	Response
Energry Performance	Good	There seems to be a fair amount of thought that went into the massing and layout of masterplan with respect to wind, rain and solar irradiation. However this has not been elaborated and the analysis based data driven process to arrive at design decisions hasn't been explained. please provide more detail in this section especially because this development is naturally ventilated. Your analysis based approach for passive design integration would be very important to assess the performance. hence in this regard please provide more detail about the natural ventilation strategies, daylight integration strategies, glare control strategies, shading strategies for solar control, external comfort and internal comfort strategies, rain control strategies etc., backed up by detailed calculations and simulations. EPI calculations have to be derived from the energy model. The model has to be detailed out with various usage profiles for various types and times of usage. As daylight is being used to reduce artificial light usage, it as to be backed up by detailed daylight and glare analysis. The thermal comfort graphs mention mechanical ventilation, infiltration, and natural ventilation. Energy model input mentions OA value. if mechanical ventilation has been provided, explain the system being used and clarify if this has been included in the energy model. If mechanical ventilation has not been provided, then it cannot be considered in thermal comfort calculations. Infiltration also cannot be considered in naturally ventilated spaces. The energy simulation input shows the U-Value of walls as 0.3 using Adobe bricks. Please provide more details regarding these bricks and how you are able to achieve this. Please provide details on fenestrations sizes, and locations for NV and daylight. If Adobe bricks are used only on the South façade, please clarify the U-Value of the walls on the other facades. The LPD considered seems very low hence this requires justification and checking whether it meets the NBC requirements for artificial lighting. The solar PV array calculations seem right but the spacing shown in the image shows potential for a lot of shading. This needs to be corrected. If biogas is being used for electricity generation, please provide details of the system.	We have given energy simulations and simplified the calculations on pg no 12. Passive design strategies in ventilation have been justified in the health and well-being section pg. no. 31.
Water Performance	Good	Water calculations are very detailed out however there are a few discrepancies that need to be corrected. **The water use calculation should be done separately for the period of resilience and for the period of standard use separately**. This is applicable both for the **base case as well as the design case**. The 135 litres per day baseline is applicable only for the resilience use. Please **clarify as to how much savings is being achieved through efficient fixtures, how much grey water is available after treatment and how much of that treated grey water is being used in the buildings, for the landscaping and how much of it is being recharged**. Clarify how **WC water is being reduced using aerators and why bathing water has been considered to be only 12 litres**. Also **clarify how savings are being achieved in the kitchens and the toilet**. Detail out how rainwater is being collected, **how big the tanks are, what kind of treatment is being done to use the harvested rain water** for drinking and cooking. **How has irrigation water requirement been reduced to one litre per square metre**. Water calculations have to be done in a stepwise manner. Do clarify if the 55.25% savings is fresh water savings or water demand reduction. Explain **how the black water sewege treatment system works**, especially during monsoons.	Separate calculations for water use for standard use and during resilience are given on page no. 17. Grey water treatment, black water during monsoon seasons, fixtures and aerators are briefly explained on pg. no. 16 and 17.
Embodied Carbon	Good	The calculations for embodied energy are very detailed. However, it is not clear how these reductions have been achieved. Please **detail out the alternative materials** being proposed and how they have resulted in the **reduction of embodied carbon**.	We have addressed the selection of materials selected with respect to carbon emissions on page no. 20 . Reductions in embodied carbon by the use of native materials which do not require any harsh processing has also been addresed here.
Resilient Design	Very Good	The issues related to heavy rains is very well captured and detailed out. there is good understanding of all the related issues during this time. Do elaborate on all the other climate change related risks, their applicability and how the design responds to them.	We have elaborated other climate change risks and explained their applicability in the structure through design intervention. pg no. 22 and 23
Engineering and Operations	Good	It is very good to see the use of bamboo and wood. Engineering details of the buildings are very well explained. Explain how you plan to improve the life of these building materials in such climatic conditions.	Strategies used to improve the life of building materials are discussed on pg no.25.
Architectural Design	Fair	Please elaborate on the integrated data-driven approach to architecture design to achieve thermal and visual comfort, and external comfort, reduce solar heat gains, improve ventilation and ensure natural ventilation design is effective in all spaces.	Thermal comfort analysis is covered on page no. 33 (health and well-being). Various ventilation strategies have been covered through graphics on page no. 8.
Affordability	Good	While costing is fairly detailed out, justification and notes have to be better. Most of the cost differences between baseline and proposed case have not been explained properly.	The needed reasonings are tried to be justified in the excel itself as well as in the report pg no. 27.
Innovation	Fair	Interesting ideas that need greater thought on constructability and integration. Toilet innovation is not clear. how do bioswales help with decomposition? What happens during the rainy season? how is the wall with angular bricks actually constructed? Are there any examples of bamboo reinforcement for water tanks?	Toilet details are given in-water performance pg no 16. The details of angular bricks is covered on pg no 30. in innovation. The construction detail of bamboo reinforcement for water tanks is given on page no.29.
Health and Wellbeing	Good	Several studies seem to have been undertaken. however, they have to be analyzed and presented better. Comfort has to be measured against a chosen comfort standard such as IMAC. It should also be checked at hourly time steps and not monthly averages Daylight analysis shows a lot of glare and potential thermal and visual discomfort in several spaces. It should be studied in more detail. Natural ventilation has to be tested in the energy model. what is the basis for taking 30% and how does it help with NV? Please define the indoor and outdoor comfort standards that you wish to meet and show using simulations how you are able to meet them.	Represented graphically the strategies used to reduce the glare or thermal discomfort by achieving a wall window ratio of 1:20 and 1:15 is given on page no. 31. A separate analysis of comfort levels is provided on an hourly basis on page no. 32. The process of reducing visual discomfort due to daylight is given on page no. 33.
Value Proposition	Good	Very clear communication, Please support the statements with numbers. The statements presently are more qualitative and do not showcase the work done quantitatively.	The qualitative analysi of the work is tried to be justified by depicting community benefits pg no 35.

RESPONSE TO REVIEWER

	Review 2		
	Evaluation	Comment	Response
Energy Performance	Excellent	The epi looks good and is quite low.	We have provided detailed breakdown of EPI on page no. 12.
Water Performance	Excellent	The water reports look very good, good use of graphics.	Additionally we have provided a comparison of baseline and propsed case after usage of aerators pg no.17
Embodied Carbon	Excellent	Looks good. Please space out the graphs a little so that they are more legible.	We have addressed the selection of materials selected with respect to carbon emissions on page no. 20 . Reductions in embodied carbon by the use of native materials which do not require any harsh processing has also been addresed here.
Resilient Design	Very Good	Looks good. Please elaborate on resilience strategies that are more design specific.	Design specific resilient strategies have been elaborated responding to other potential risks on site refer pg no. 22 and 23
Engineering and Operations	Very Good	Please provide layouts for electricity, water and waste management, and structural planning.	Layout for electricity on pg no. 14. Layout for water and waste management on pg no. 15.
Architectural Design	Excellent	The design looks good and is well presented.	Various ventilation strategies have been covered through graphics on page no. 8.
Affordabilty	Very Good	Looks good. you can add some graphics for the affordability points you have covered.	A graphic summarizing affordability of the design on pg no. 31
Innovation	Very Good	The ideas explored look good.	We have explored new ideas in terms of materiality and their construction and techiques like aquaponics pg no. 29 and 30.
Health and Wellbeing	Excellent	The report looks good. Please add the compliance of comfort hours according to standards.	A separate analysis of comfort levels is provided on an hourly basis on page no. 32.
Value Proposition	Excellent	The proposition looks good. you can add a summarizing note which captures the idea germ and USP of your project.	The USP's are mentioned on pg no. 35.

TEAM INTRODUCTION

Team name - NISHTHA
Institution(s) name- Lead Institution- Rachana Sansad's Academy of Architecture
Division- Community Resilience Shelter
Team members:


Hetika Vani
3rd Year B.Arch
AOA
Adaptive Reuse


Sandesh Jadhav
3rd Year B.Arch
AOA
Value Proposition


Praniti Bhoir
3rd Year B.Arch
AOA
Innovation and Affordability


Isha Padte
3rd Year B.Arch
AOA
Health and well-being


Nikita Jagzap
3rd Year B.Arch
AOA
Arch. Design and Visualization


Isha Keni
3rd Year B.Arch
AOA
Arch. Design and Certification


Aarohan Dutta
2nd Year MLA
CEPT
Environmental Solutions

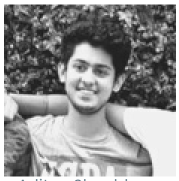

Shrutika Mahajan
3rd Year B.Arch
AOA
Health and wellbeing


Anushree Harmalkar
3rd Year B.Arch
AOA
Research and Documentation


Pranay Kutal
3rd Year B.Arch
AOA
Water Performance


Tejas Shinde
3rd Year B.Arch
AOA
Resilience


Rahul Bhoye
3rd Year B.Arch
AOA
Energy Performance


Aditya Shanbhag
3rd Year B.Arc
AOA
Embodied Carbon


Yuvraj Panchal
3rd Year B.Tech
VJTI
Structure and Timeline

Fig 01: Photos of team members

INSTITUTION

LEAD Institution - Rachana Sansad's Academy of Architecture, Mumbai

Rachana Sansad's Academy of Architecture provides B.Arch, B.Voc degree programmes. The students develop the understanding of the importance of developing a multidisciplinary approach while designing any built intervention. This encourages the students to inculcate various allied principles like user health and well-being, affordability as well as maintaining the carbon footprint and adds scope into their design process.

FACULTY TEAM

Ar. Shekoba Sanap (Faculty Lead) :
Architect, academician, and Alumni of AOA, with a master's degree in Urban Design from SPA Delhi. He is also the founder and CEO of studio UD+AC.

Ar. Rohit Shinkre (Faculty Advisor) :
Prof. Rohit Shinkre, DPLG Paris, France, is an award-winning architect, urbanist, and educator. 30+ years of professional global experience in Europe, India, and Africa. He is currently a doctoral candidate at the faculty at Rachana Sansad's Academy of Architecture, ULB, Belgium.

Ar. Amey Ghosalkar (Faculty Advisor) :
Expertise in Architectural design, interiors, and urban projects. Alumni of AOA and SPA Delhi. Previously worked at architects' combine, ARH, and Bentel Associates International and is faculty at Rachana Sansad.

Ar.Minal Gajjar (Faculty Advisor) :
Inspired by the living elements of nature, Landscape Planner Ar. Minal Gajjar, Alumni of L.S. Raheja School of Architecture and is currently a faculty at Rachana Sansad's Academy of Architecture.

Fig 02: Photos of faculty members

INDUSTRY PARTNERS

Ar. Mangesh Jadhav

Founder, Principal Architect, Nirmittee Consultants

Talented and result-oriented project architect who's practices vernacular architecture. Collaboration with him has helped the team to explore various innovative construction techniques and better usage of locally sourced materials.

Agnigarbha Pvt. Ltd.

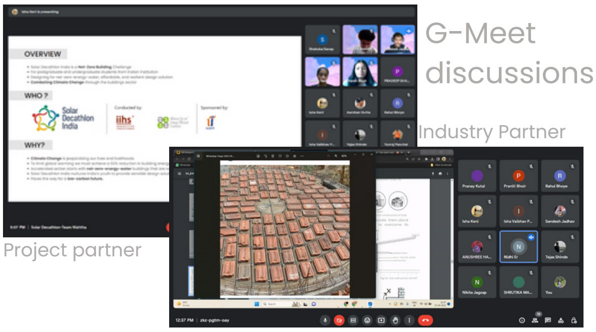
Agnigarbha Pvt. Ltd. is a Solar Power EPC and is SP 4E-certified MNRE channel partner. Agnigarbha Pvt. Ltd is incorporated under the companies act and is one of the innovative companies in the responsible business category .Designs, buildS and implements solar power generation systems

DESIGN MANAGEMENT PROCESS

SOFTWARES USED

AUTOCAD | DESIGN BUILDER | RHINOCEROS | REVIT | CLIMATE CONSULTANT | SKETCHUP

Hands on paper discussions

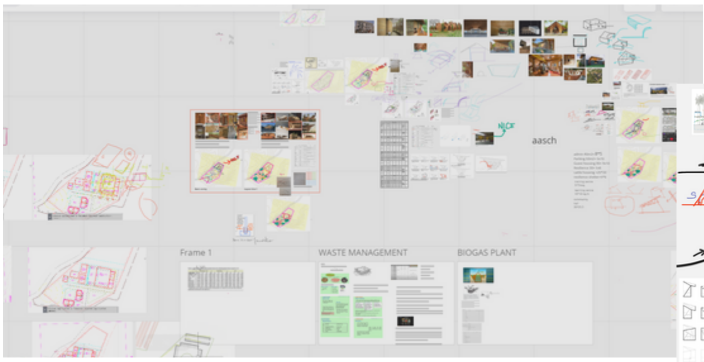


G-Meet discussions

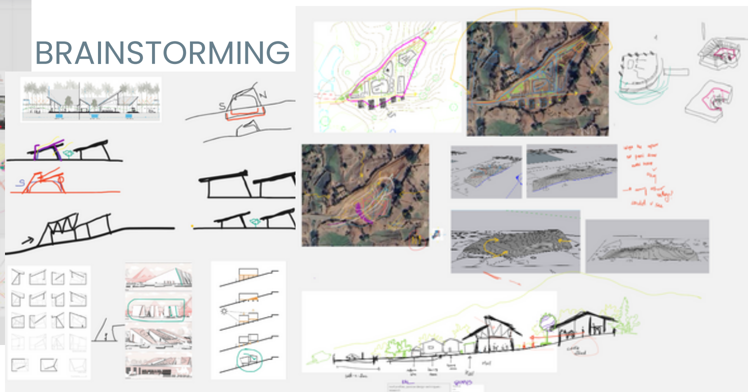
Industry Partner

Project partner

INSTAGRAM



BRAINSTORMING



SITE VISITS

Team photo

Discussions with the villagers

Fig 03: Design management process

PROJECT BACKGROUND

PROJECT NAME: JEEVIKA

PROJECT PARTNER: Akshar Dhara Foundation

Akshar Dhara Foundation is an NGO that helps to solve socio-economic issues faced by the people of scheduled tribes by promoting and providing education and making them self–sufficient and to develop self–worth.
Despite being in the vicinity of a megacity like Mumbai, places like Dahanu, Palghar, and Vikramgad are still drowning in malnutrition, starvation, illiteracy, etc. Unemployment, poverty, and education are some of the significant issues faced by many localities of Scheduled Tribes. Akshar Dhara Foundation was created to give back to society to serve the less fortunate and bridge the social and economic gaps faced by people in rural settings.

KEY INDIVIDUALS:

Deepak Chauhan | Pradeep Sharma | Rakesh Shah | Vaibhav Srivastav | Nikul Dave

Fig 04: Photos of project partners

PROJECT DESCRIPTION

Akshar Dhara Foundation aims to improve the lifestyle of the community of Khomarpada village. The village is located in a remote area of Palghar, which leads to disconnectivity mostly during heavy rainfall. The project focuses on solving the problems related to this disconnection, likely poor income sources, sanitation, and education. It will be forming a network within the village where the community would come together and help each other to enhance their standard of living.

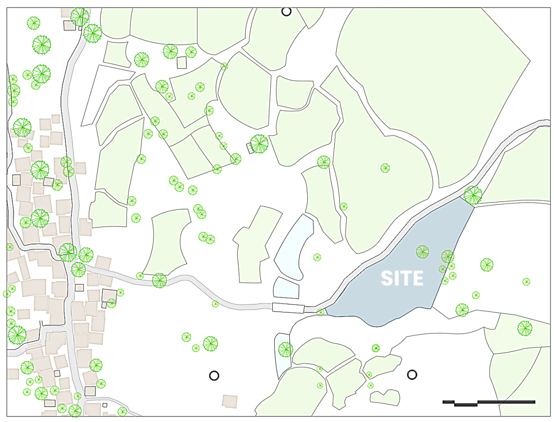


Fig 05: Context Map.

Climate zone - Warm and humid (ECBC)
Site area - 6109 sq.m
Estimated ground coverage -2554 sq.m
Proposed built-up area- 1716 sq.m
Stage of Project : Design development and construction documentation stage
Profile of Occupants: Villagers of Khomarpada, Medical Professionals, Trainers ,Guests
Hours of operation : During resilence 24 hrs otherwise 9pm -5pm
Purpose of project : Built-own-operate for the community

PROJECT BACKGROUND

SPECIAL REQUIREMENT FROM PROJECT PARTNER

- The intervention should blend with the vernacular context which is handled in a contemporary way.
- The intervention should accommodate both, humans and cattle and protect them from the harsh weather of the region.

Target Capex Cost : 39.7 Million
Utility Cost: 0.25 Million
Opex cost : 0.7 Million per year
Involvement of Project Partner post-completion of construction: Total handover to the village of Khomarpada

Detailed Building Area Programme:

FUNCTION	NO. OF USERS	SIZE OF UNIT (m^2)	NO. OF UNITS	TOTAL AREA (m^2)	REMARKS	CONDITIONING	FUNCTION DURING DISASTER
AO Common Room	6	35	1	30	Keeps account of all the actvities in the stucture.Conducting village and gram panchanayt meet.	Unconditioned	Used to manage the center and keep a track of the basic needs of rescued people
Training Centre Wing (TC)							
TC Laboratory	13+2	31	1	31	Centre providing training for various small businesses, menstrual hygiene, waste disposal	Unconditioned	Also used as a sleeping space during resilience at night
TC Equipment Storage	2-3	5	1	5			
Toilet block	40	40	1	40			
Learning Center Wing (LC)							
LC Library	20	43	1	43	Promoting education by providing exposure internet and technology	Unconditioned	-
LC E-Library	6	27	1	27			
Public spaces							
Community hall with mezzanine	300	600	1	600	used as a community hall for activities like health drives,weddings,death rituals.	Unconditioned	Can be used as Active during resilience as an accommodation
PS Toilet Block	40	46	2	92			
Guest based							
Guest house spaces	10	46	4	184	Used as a accomdation for guests visiting the village	Unconditioned	Can be used as Active during resilience as an accommodation
Bathroom Block	8	8	4	32			
Heath and services							
First-Aid Room	3	23	1	23	Provide health check ups on regular basis inside the community .The kitchen serves food for activities like health drives,weddings,death rituals.	Unconditioned	caters as an emergency health check room while loss of connectivity with the rest of the city and also provides emergency food storage
Common Kitchen	8	45	1	45			
Pantry Storage	2	10	1	10			
Waste adaptive reuse							
VermiComposting Pit	2	7	2	14	Promoting native practices, and thereby also providing an income making the structure is self suficient . Helps for making fuel used for cooking .	Unconditioned	The biogas produced during the time of resilence is stored is used to generate electicity.
Sewage Treatment plant	2		-				
Nadep	2	7	3	21			
Biogas Plant block	2	4+4+28	1	36			
Resilience based							
Seedbank	2	11	1	11	Active during resilience	Unconditioned	Can be used as Active during resilience as an accommodation
Cattle housing							
Health Centre	3	22	1	22	Providing regular health check-up for animals .	Unconditioned	Active during resilience as a shelter for the cattle providing food and comfort.
Cow Shed	85	124	2	248			
Goat Shed	150	141	1	141			
Common Hen Unit	500	41	2	82			
Cattle Food Storage	2	10	2	10			
Fodder Machinery	2	5	1	5			
Miscellaneous services							
circulation spaces				757			
Overhead tank		45		45			
Landscape and road areas							
Courtyards (b/w admin & lib)		22		22			
courtyards (guest house)		110		110			
bamboo plantations		240		240			
landscape		896		896			
roads + pedestrian		1140		1140			
Water collection tank		55		55			
backside area				1092			
Cumulative Calculation							
BUILT UP AREA				1716			
GROUND COVERAGE				2554			
LANDSCAPE				3555			
TOTAL				**6109**			

Table 02. Building Area Programme

TOTAL BUILT- UP AREA = 2554 SQ.M

GOALS AND STRATEGIES

	GOALS	STRATEGY
 **Resilience**	To make structure resilient and self-sufficient for 60 hours and overcome the loss of connectivity.	Providing on-site generated electricity, proper water management system, and emergency food storage with health care.
 **Energy Performance**	To achieve a net zero energy building with an EPI of 21.285 kWh/ m2.	The solar panels generate 100 KWh/day by mono crystalline solar panel grid and stores the required energy on-site in a hybrid mode.
 **Water performance**	To reduce, reuse and recharge water by recycling 60% water on site for various activities and strategically planning the usage of harvested water.	To reduce, reuse and recharge water by recycling 60% water on site for drinking, flushing, landscaping and strategically planning the usage of harvested water.
 **Architectural Design**	Familiarity in Design to encourage more participation in communal activities and cater to the needs of various user groups.	Providing learning, health services and gathering spaces. Providing a comfortable shelter to tackle natural calamity.
 **Health and Well Being**	No use of HVAC and minimize the indoor temperature.	Structure oriented at 170° which initiates natural ventilation that aids in maximizing thermal comfort with the numerous courtyards and various other passive design strategies.
 **Engineering & operations**	To make locals sensitive towards the local materials and make them aware about the correct way of using them	Introduced the new construction techniques with locally sourced material. Procuring the material for nearby areas and processing them on site.
 **Affordability**	To manage efficiently and introduce economical and native solutions.	Use of passive design strategies and local labor, material, and construction methods to reduce the operational cost.
 **Innovation**	To use natural materials with vernacular and modern techniques.	Completing the life cycle of the material and recycling it after the deterioration of the structure.
 **Value Proposition**	To provide cost-effective structure by using innovative technologies	To design a self-sustaining structure using existing resources.
 **Landscape & Ecology**	To facilitate the villagers with a new way of handling waste generated.	Waste treatment plant such as vermicompost and Nadeep are installed. Use of biodigeter, provides fuel for cooking.
 **Embodied Carbon**	To achieve a minimum reduction of 41% carbon emissions in comparison to a localized baseline structural study.	Restricting PCC involvement in construction. Utilizing Adobe bricks reduces the U value.

Fig 06: Goals

DESIGN DOCUMENTATION

ARCHITECTURAL DESIGN

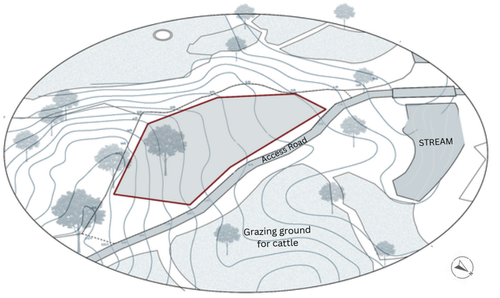


Fig 07: SITE CONTEXT

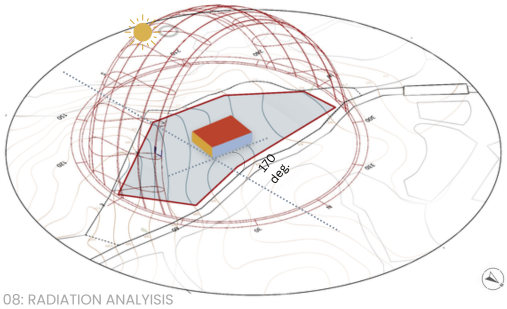
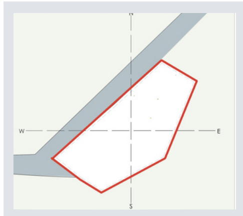


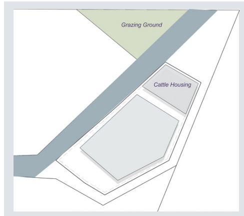
Fig 08: RADIATION ANALYISIS

The site, located in the village of Vikramgad, is accessible through a bridge with a road running along the northwest periphery.

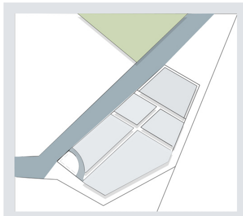
The structure is oriented at 170° from the east with a radiation gain of 1180.35 kWh/m2.



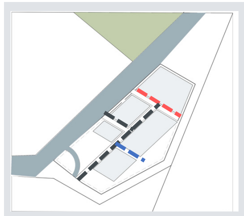
Site orientation- NE-SW



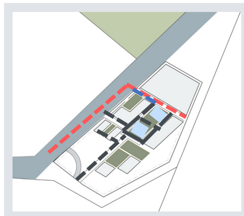
Cattle housing block placed adjacent to grazing ground



Linear access road similar to village typology with cattle and service entry separately



Division of masses according to accessibility



Addition of courtyards and waterscapes for better ventilation

PRELIMINARY DESIGN GRID

- AnimalCorridor
- Service access
- Pedestrian access

Fig 09: Form Evolution

DESIGN CONCEPT

Hall Exposed to direct air flow for better ventilation

Air congregating towards courtyards

Air following the venturi effect

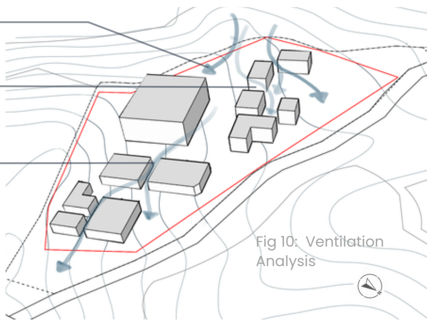


Fig 10: Ventilation Analysis

entry decorated with Champa trees

neem trees to provide shade and for air purification

boundary demarcated with edge plants

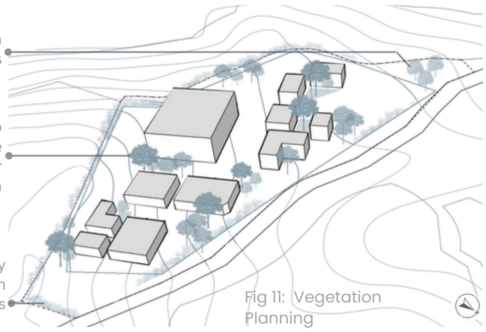


Fig 11: Vegetation Planning

Planning of close and open spaces to control the airflow for better ventilation

Vegetation planted strategically to block the harsh sunlight from entering and maintain the internal room temperature.

CATTLE SHED

Located at the highest point of site to provide a visible permeability from every corner of the Resilience shelter

COMMUNITY HALL

Is centrally placed with a separate service road access

The courtyard offers a reading area and buffer zone to the community hall

GUEST HOUSE

Offers accommodation for tourists & guests to live amidst the calm nature

- Library
- Community Hall
- Guest House
- Training Center
- Cattle shed

Fig 12: Zoning Diagram

VENTILATION

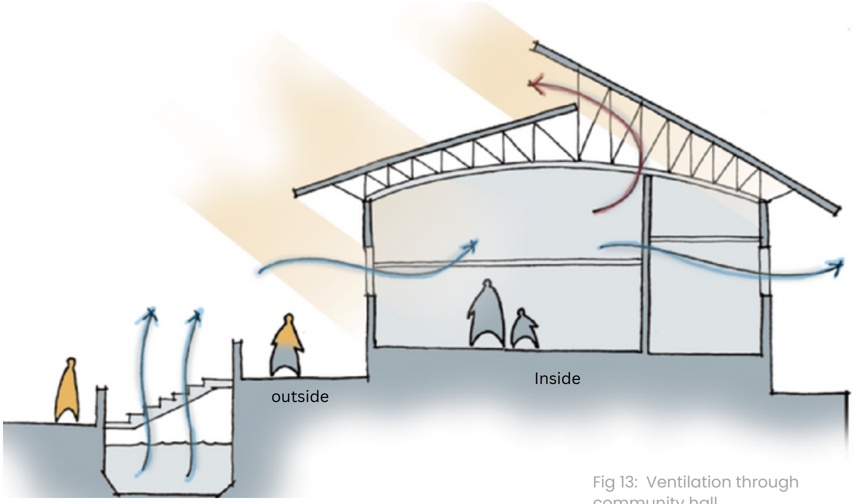


Fig 13: Ventilation through community hall

People pass through the bridge over the pond to reduce thermal stress as they transition between indoors and outdoors. Aquaponics is used to provide cool air by means of evaporative cooling technique.

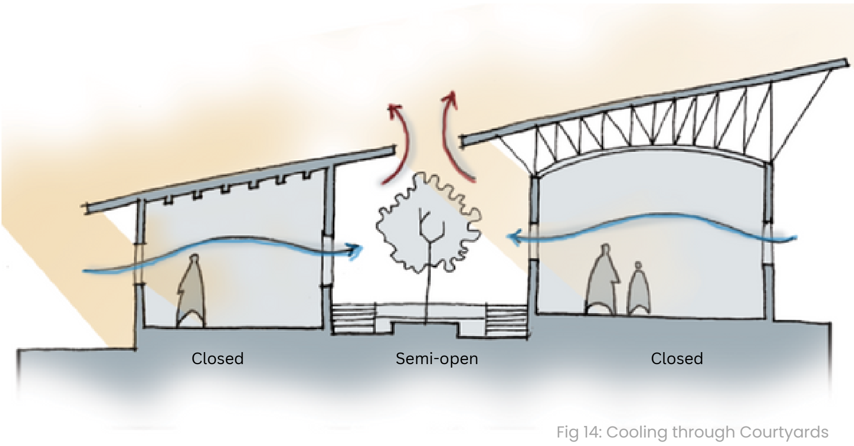


Fig 14: Cooling through Courtyards

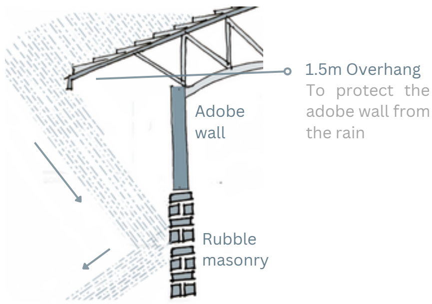


Fig 15: Designing for the rains

DURING RESILIENCE

The structure is designed to shelter the villagers during natural calamity with every block acting to combat them.

Comm-unity hall Acts as the main gathering space and place to sleep at night with a proper division of the genders through the opposite elevated platforms to maintain the social conditions.


Fig 16: Bedding layout for night

Training center Becomes an extension to the first aid accommodating the sicks and injured individuals

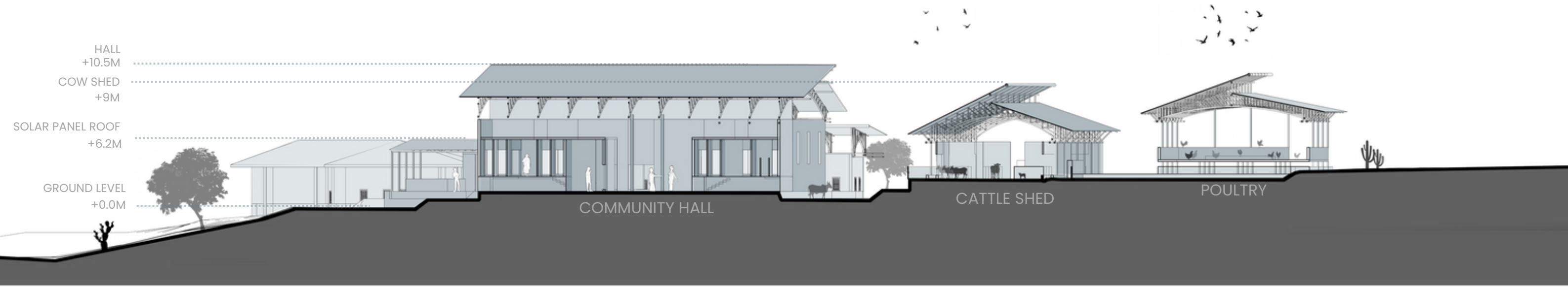
Guest house Acts as an isolation wards for severely affected people during any epidemic.

Library A relaxation place to overcome a stress and pass the time.

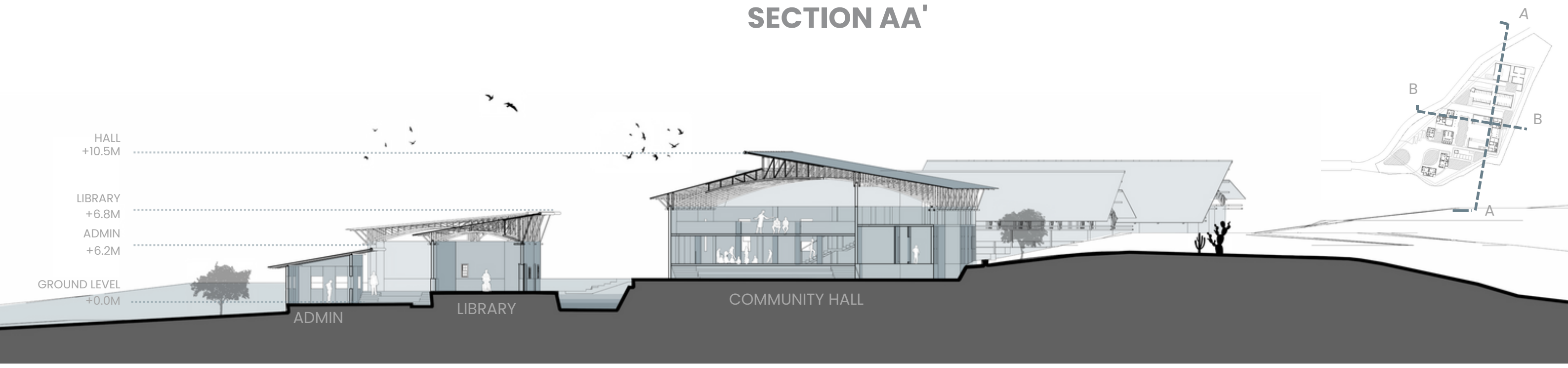
Fig 17: Master Plan.

LEGEND:

1. ENTRANCE
2. PARKING
3. ADMIN
4. LIBRARY & E-LIBRARY
5. TRAINING CENTER
6. FIRST AID
7. AQUAPONICS POND
8. GUEST HOUSE
9. BACKYARD WITH OPEN KITCHEN
10. COMMUNITY HALL
11. NADEP
12. TOILETS
13. ANIMAL CORRIDOR
14. COW SHED
15. GOAT SHED
16. POULTRY
17. HEALTH CARE FOR ANIMALS
18. BIOGAS PLANT
19. OHT
20. KITCHEN
21. FARMLANDS



SECTION AA'



SECTION BB'

Fig 18: Section

ACTIVITY MAPPING

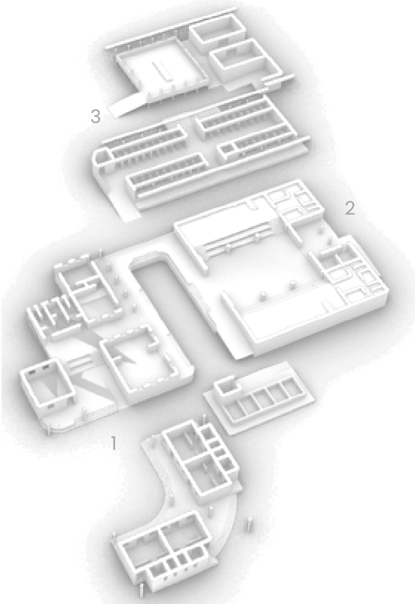


Fig 19: Axonometric view of structure

1 LIBRARY

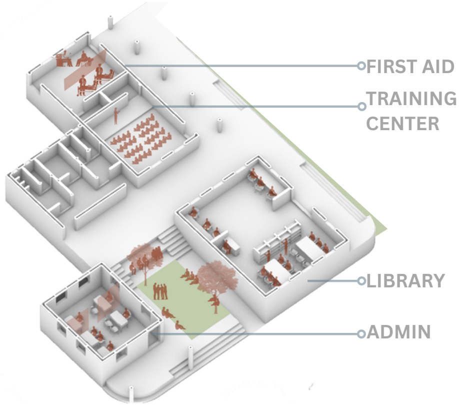
An area for which provides study materials or used as just a place for relaxation to read.

ADMIN

A working place accompanied by a reception area with a courtyard acting as a waiting space.

TRAINING CENTER

A place to conduct workshops or small lectures to expose the villagers to the urban world. This place can also be converted to accommodate small businesses during weekly market days



GUEST HOUSE

The guest house offers a place to accommodate tourists.
It has an attic place and also a small dining area at the back

Fig 20: View from the entrance

2 CATTLE SHED

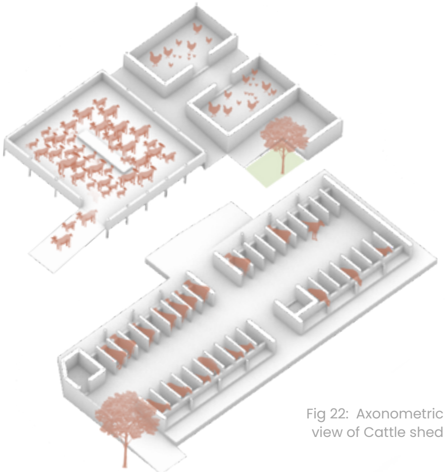


Fig 22: Axonometric view of Cattle shed

Fig 21: View of Cattle shed and goat pen

- Accommodates the cattle with a proper segregation of cows, goats and hens and has a provision of a health care.
- It also has a health care service for the cattle.

3 COMMUNITY HALL

- Hall provides a space for large social gatherings like village meetings, Marriages, festivals and conducts workshops, health camps.
- It is divided into three parts serving a proper segregation during the events.

Fig 23: View of Community hall (Interior)

Fig 24: View of Community hall (exterior)

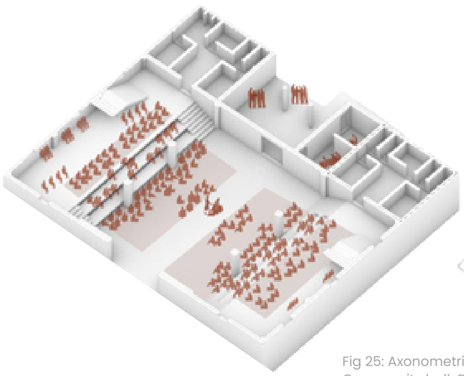


Fig 25: Axonometric view of Community hall-During Marriages

DURING MARRIAGE

During the marriage, the central part serves as a stage area with the radially guests gathering around and the courtyard becomes a spill-out.

Fig 26: Axonometric view of Community hall -During Health Camp

HEALTH CAMPS

The elevated platforms are converted to a private booth for check-ups and the central part serves as a public orientation space.

FEATURES OF MULTIPURPOSE HALL

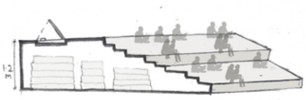
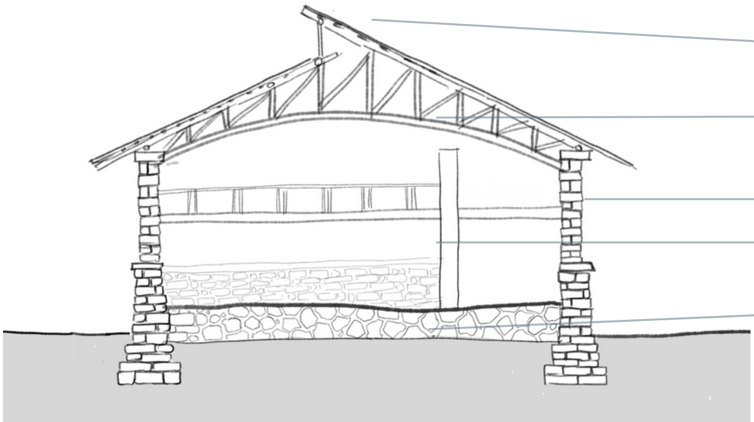


Fig 27: Community hall-Storage

The space below the seating stage is utilized for storing emergency items like bedding that will help the community to stay in hall during resilience.

MATERIALS

The architecture being native, the materials are procured and processed from nearbv areas or done on-site.



ROOFING MATERIAL: Shingled Bamboo resting on bamboo truss

MEZZANINE MATERIAL: Timber planking supported by bamboo rafters with bamboo railing

COLUMN MATERIAL: Rubble columns

WALL MATERIAL: Rubble masonry with adobe bricks from sill level

PLINTH MATERIAL: Rubble plinth with stone foundation

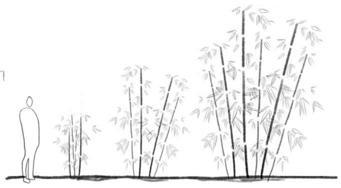
Fig 28: Section showing materials

Process

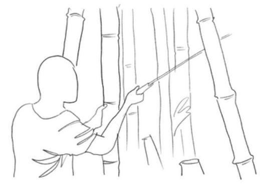
Bamboo

Bamboo seedling raised on nursery bed

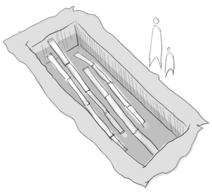
On site planting in grid



6-8 weeks of growing time

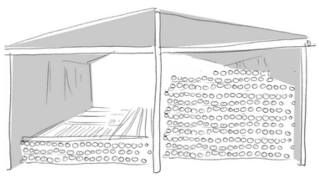


Harvesting- dry season



Construction of tank- dug into ground- Tarpaulins sheets

Treatment -Cold soak method where the bamboo is dipped in sol. of boric acid for 7-14 days



stacking-temporary storage

The site chosen won't hinder the construction and the bamboo will grow throughout the construction process as per the need.

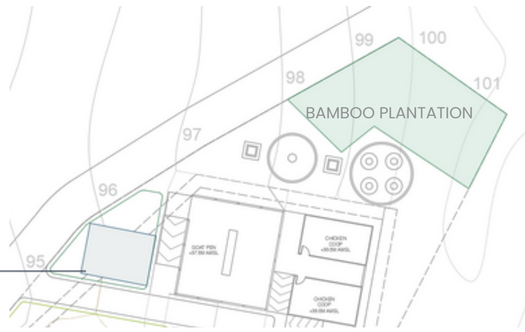


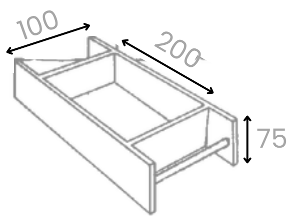
Fig 29: Process of bamboo and site allocation

ADOBE

- To reduce the embodied carbon during manufacturing process.
- it provides better thermal insulation during summers

Composition in adobe

Slaked lime : M sand : Surukhi in a proportion 2 : 1 : 7



Size of adobe brick

200 X 100 X 75

Fig 30: Process of adobe bricks

ENERGY PERFORMANCE

Building Program Based Data		Appliances in Use								
Block	Total Area (m^2)	Lights	Fans	Pump	Cooling	Heating	Computer	Fridge	TV	Projector
Admin Office Block (AO)	40	9	6	0	0	0	3	0	1	0
Training Centre Wing (TC)	35	8	6	0	0	0	0	0	1	0
Learning Center Wing (LC)	100	13	10	0	0	0	7	0	0	0
Public spaces	745	18	18	0	0	0	0	0	0	1
Guest based	130	32	8	0	0	0	0	0	4	0
Health and services	95	43	4	2	0	0	0	2	0	0
Waste adaptive reuse	80	2	0	0	0	0	0	0	0	0
Resilience based	30	97	0	0	0	0	0	0	0	0
Cattle housing	985	66	2	0	0	0	0	0	0	0
Cumulative Calculation	2240	288	54	2	0	0	10	2	6	1

Table 03 : Programme based list of appliances

An EPI of **21.285 kWh/m²/year** is achieved for the Community Resilience Center with an average yearly energy requirement of **36524.528 kWh/year**. Such a low EPI was achieved by elimination of HVAC system which is a major contributor to increased energy demands. This decision was taken based on the context of the site which being rural, and the lack of knowledge and ability to operate and maintain the system proved inefficient which in future considerations could disturb the net-zero system. Additionally, use of LEDs for lighting reduced the energy demand further.

Total Energy Consumption						
Appliances	Rating (kWh)	Usage Hours in a day (h)	Energy Usage in a Day (kWh/day)	Energy Usage in a Year (kWh/y)	Total Appliances	Total Energy Consumption
Fan	0.06	14	0.84	306.6	54	16556.4
Pump	0.75	2	1.5	547.5	2	1095
Computer	0.25	4	1	365	10	3650
Fridge	0.0264	24	0.6336	231.264	2	462.528
TV	0.05	3	0.15	54.75	6	328.5
Projector	0.3	3	0.9	328.5	1	328.5
LED Bulb	0.012	6	0.072	26.28	245	6438.6
LED Battens	0.02	6	0.12	43.8	25	1095
Street Light	0.075	12	0.9	328.5	20	6570
Cummulative			6.1156	2232.194	365	36524.528

Energy Required/Day	100.0672	kWh/day
Energy Required/Year	36524.528	kWh/year
Total BuiltUp Proposed	1716	m²
EPI	21.285	kWh/m²/year

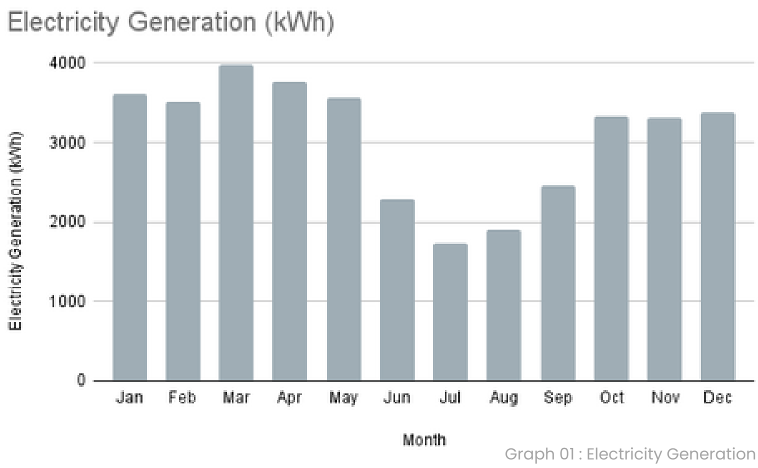
Table 04 : Total Energy Consumption

As an alternative to HVAC system, use of passive cooling systems are used like use of Stone and Adobe brick walls, clerestory openings for natural air ventilation, clay tiles for roofing.

ENERGY PERFORMANCE

Month	Solar Radiation (kWh/m²)	Electricity Generation (kWh)
Jan	195.3	3609.9
Feb	193.8	3505.8
Mar	224.5	3987.9
Apr	211.4	3766.2
May	197.9	3562.9
Jun	123.6	2280.8
Jul	93.1	1738.5
Aug	101.8	1907
Sep	131.9	2453.5
Oct	182.6	3335.1
Nov	180.3	3307.2
Dec	182.3	3383.6
Yearly	2018.5	36838.4

Table 05: Solar Potential



Graph 01 : Electricity Generation

PV Module Specifications	
Manufacturer	Trinasolar
Module Name	Vertex
Peak Output	645 W
Size	2384 x 1303 x 33 mm
Area	3.106 m²
Efficiency	20.80%
No. of Panels	50
Total Area	153.3176 m²
Yearly Average PV Output	36838.6 kWh
Azimuth	190º
Tilt	24º

Table 06: PV Module Specifications

The Solar Array is placed over the Nadep pits which serves the function of adaptive waste reuse. The panels are oriented **190⁰ from North** with a **tilt of 24⁰** providing maximum solar irradiance.

Ground based fix-mounted PV configuration was selected as rooftop based system were not able to provide the required azimuth angle for maximum efficiency.

The PV Modules which are **50** in numbers are arranged in **4 rows** of **12 panels** placed adjacent to each other with additional 2 on either sides. Panels are placed in a tilted manner such that they form a large continuous surface. The Solar Array is connected to batteries for storage and a inverter for conversion of DC to AC.

Fig 31: PV Module layout- view

Target energy requirement of **36524 kWh/year**, the solar array on average generates **36838 kWh/year**, making the structure net-zero in terms of energy.

LIGHTING LAYOUT

Fig 32: Electrical Layout

ENERGY SIMULATION INPUTS

Input Parameters	Proposed Design Values
General	
Building Area	1716 sq m
Conditioned Area	0 sqm
Electricity Rate	7 INR/kWh
Natural Gas Rate	0 INR/GJ (BIOGAS USED)
Building Occupancy Hours	8HRS (from 9am -5pm)
Average Occupant Density	0.17 person/m²
Internal Loads	
Interior Average Lighting Power Density	2.62 W/m²
List of Lighting Controls	Switch board
Minimum OA (outside air) Ventilation (Building Average)	17 l/sec.m²

Input Parameters	Proposed Design Values
Envelope	
Roof Assembly U value	1.4
Roof Assembly SRI	0.32
Average Wall Assembly U value	0.293 W/m².K
Window to Wall Area Ratio (WWR)	20%
Windows U value	5.894
Windows SHGC	0.861
Windows VLT	0.898
Infiltration Rate	0.5 ach
Describe Exterior Shading Devices	The adobe bricks are used for walls with angular facades on the south side. To prevent rainwater from destroying the bricks, the lower part (Height: 1m from the plinth) is made of rubble.

Table 07: Input simulations

WATER PERFORMANCE

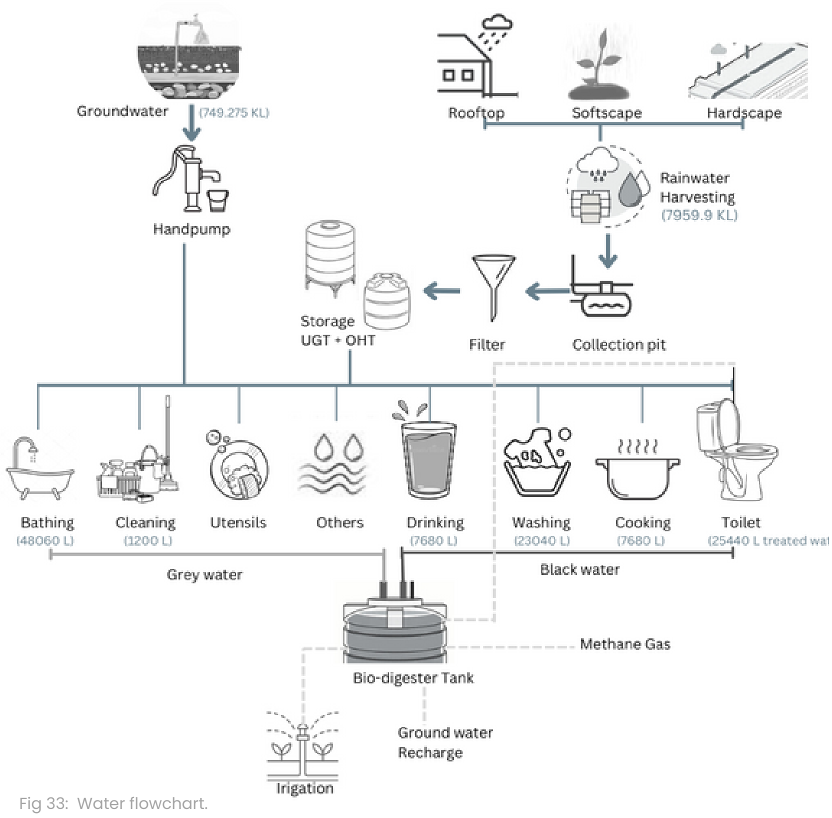


Fig 33: Water flowchart.

The net-positive water cycle is achieved with a demand of **55 liters per person per day**. The water demand is therefore **reduced by 55.25%** using the principle of Reduce, reuse, and recharge. The effective methods for storage, treatment, collection, and optimization are achieved by the usage of bioswales, bio digesters, and aerators.

Water use	Quantity	Quantity
Domestic Use (LPD/ Head)	300	55
Irrigation (max) : {m2 x l/m2}	1000	1.7
Cooling tower (max) : {Ton x l/Ton}	0	0
Other	-	-

Table 08. Water Usage

Rainwater harvesting surfaces	Area(m2)	Running co-efficient	Effective Catchment area(m2)
Roof Surfaces	3200	0.85	2720
Hardscape Area	1140	0.7	798
Softscape Area	2415	0.3	724.5
Others	-	-	-
Total Effective Catchment Area			4242.5

Table 09. Water catchment

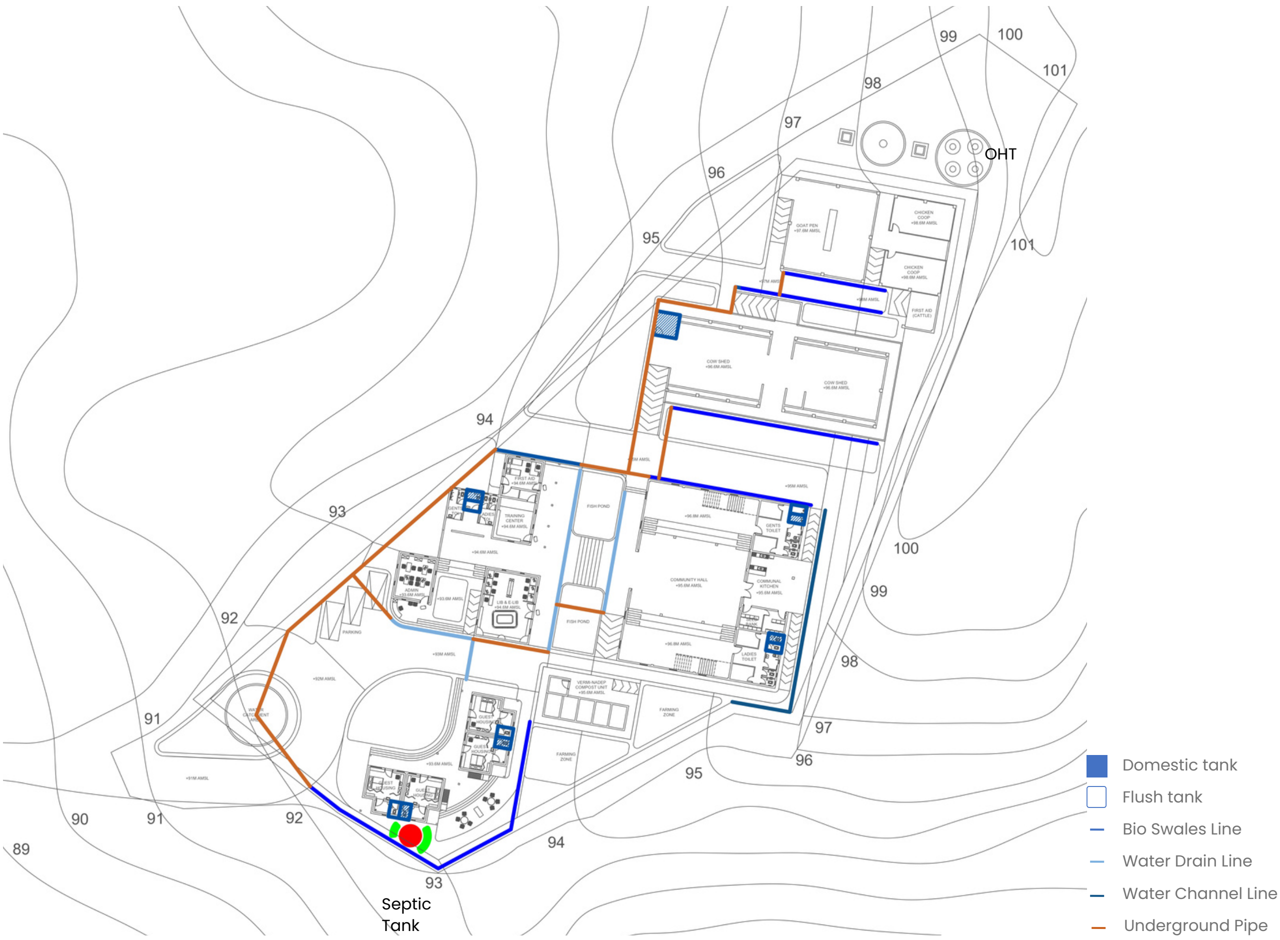


Fig 34: Water and waste management plan.

WATER PERFORMANCE

Reuse - Greywater treated to reuse

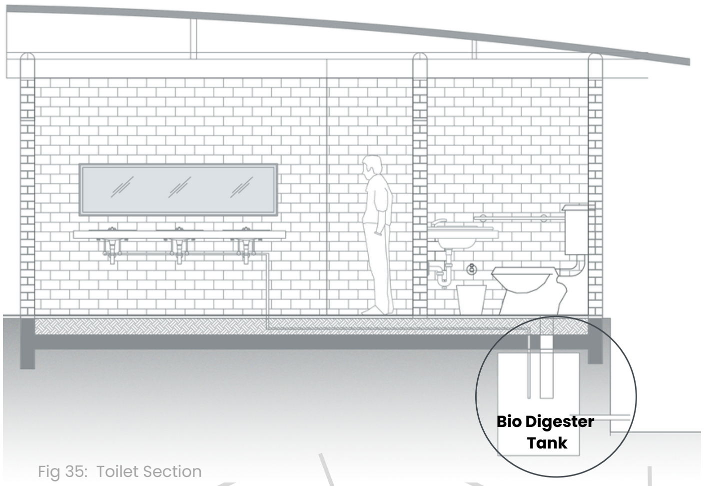


Fig 35: Toilet Section

A biodigester tank is a **closed, controlled environment** in which microorganisms are able to break down organic matter into **biogas** and **liquid fertilizer** through a process called anaerobic digestion. The organic matter can include a variety of waste products, such as agricultural waste, **animal manure**, or even **human waste.**
Biodigester tanks are particularly **useful in rural areas,** where access to **centralized sewage treatment facilities is limited**. They are also increasingly being used in urban areas, such as **schools, hospitals, and apartment buildings**, as a sustainable solution for waste management and energy production.

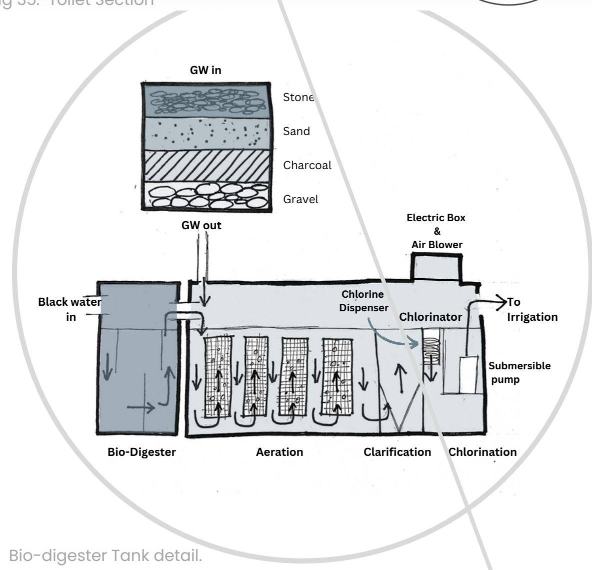


Fig 36: Bio-digester Tank detail.

Recharge -

Bioswales are a type of green infrastructure used for **stormwater management.** They are **shallow channels** that are designed to capture, filter, and treat stormwater runoff. The channels are typically **filled with vegetation and soil**, and sometimes contain engineered components like **permeable layers or filters** to enhance their stormwater treatment capabilities.In addition, bioswales offer numerous ancillary benefits such as **enhancing air quality, reducing urban heat island effects**, and enhancing the aesthetic appeal of the surrounding environment.

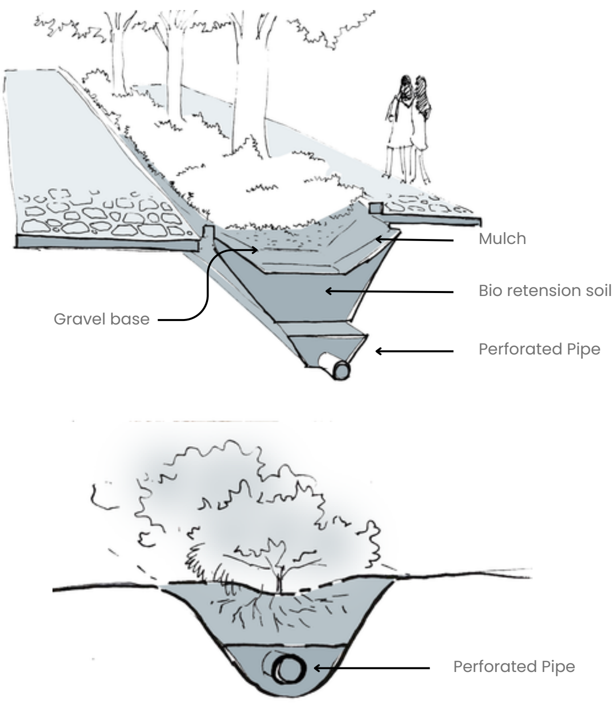


Fig 37: Bio-swales.

WATER PERFORMANCE

Recharge -

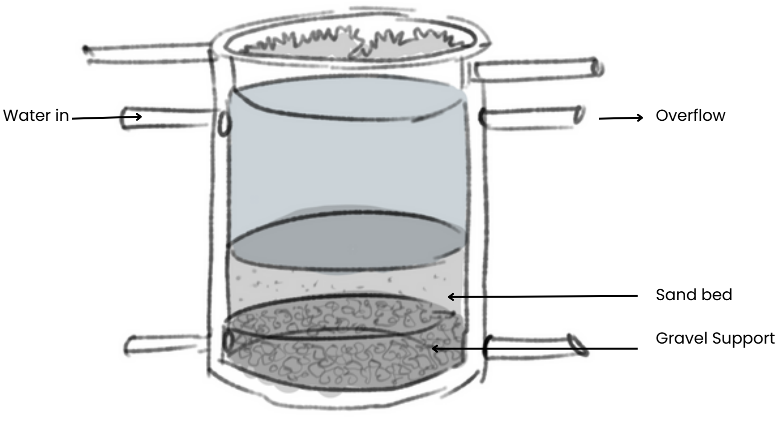


Fig 38: Surface runoff collection tank.

Sediment filtration is a process of removing suspended solids and other large particles from water. Sediment filters are typically made of a **bed of sand, gravel,** or other media that has various sizes of pore spaces. When water flows through the filter, the larger particles and sediment get trapped in the filter media, allowing the filtered water to pass through. The effectiveness of the filter depends on **the size of the filter media, the water flow rate, and the level of contamination.**

Reduce - Flushing water reduced by 50% to from 6 lpf to 3 lpf using an aerator

- By using **Cistern flush tank**(wall mounted) the water get used is reduce to 3LPM from 6LPM.
- Also, 12LPM used from taps in kitchen, bathroom is reduced to 6LPM by means of using **Aerators** in them

Pr im ar y	Secondary	Tertiary
Filtration	Removal of nutrients and contaminants	Final cleaning process
	Biological/ physiochemical methods	Removes remaining inorganic compounds , bacteria, microorganisms, parasites
Removes solids that might clog up the other treatments	Use microbes, sunlight,oxygen	Alum might be used
	Aerobic process require more energy	Water polishing - usage of UV rays
	Anerobic process require less energy	

Table 14. Greywater treatment

	Vol.	Area	Height	Capacity days
OHT				
	75000	50	1.5	4.5
Storage Tanks (Community Hall, Toilet Block ,Guest Housing)				
Domestic	3750	2.5	1.5	3
Flushing	3750	2.5	1.5	3
Water Collection pit				
	1,00,000	50	2	3
Septic Tank				
	14140	7.07	2	3

Table 12. Water Tanks capacity

Per Capita Consumption per day			
Activities	Domestic (lts) Period of Standard Use	Domestic (lts) Period of Resilience	
Wash basin	4L (10%)	2L (6.667%)	40 Litres of water for standard use and reduce to 30 litres in time of resililence
Drinking	12L (30%)	10L (33.33%)	
Cooking	2L (5%)	2L (6.667%)	
Cleaning	4L (10%)	1L (3.334%)	
Activities	Flushing (lts)		
WC flushing	12L(30%)	10L(33.33%)	
Urinal Flushing	6L (15%)	5L (16.667%)	

Table 10. Baseline case

Per Capita Consumption per day			
Activities	Domestic (lts) Period of Standard Use	Domestic (lts) Period of Resilience	
Wash basin	1.5L (8.5%)	1L (6.667%)	Aided by using aerators and reuse of greywater, water consumed is reduced to 17.5 Lts and 15 Lts during Resilience time
Drinking	12L (68.5%)	10L (66.667%)	
Cooking	2L (11.4%)	2L (13.334%)	
Cleaning	2L (11.4%)	2L (13.334%)	
Activities	Flushing (lts)		
WC flushing	0	0	
Urinal Flushing	0	0	

Table 11. Proposed case

Occupant's Activity	Percent Usage %	Quantity litres	Grey Water litres	Black water litres
Drinking	9.09	2	0	2
Cooking	9.09	2	0	2
Flushing	27.27	6	0	6
Bathing	54.54	12	12	0

Table 13. Percentage calculation of activities

Months	Occupancy	No. of days	Rainfall (mm)	Effective rain (mm)	Harvested rainwater (l)	Whitewater Drinking (per person 2l)	Cooking	Cleaning (per person 2l)	Bathing (per person 12l)	Washing	Animal drinking	Greywater Reuse Flushing 3 lpf	Irrigation	Total grey water consumed per month	Total Water Consumption per month	Total Black Water Generated per month	Reduced blackwater per month
January	Daily - 30	26				60	60		360	180	8 Cows + 8 Goats+ 20 Hens 250	180			9497	9497	75
	Events - 300	5	0	0	0	600	600	100	3600	1800		2000		3380			2238
February	Daily - 30	25				60	60		360	180		180			9497	9497	75
	Events - 300	3	0	0	0	600	600	100	3600	1800		2000		3380			2238
March	Daily - 30	26				60	60		360	180		180			9497	9497	75
	Events - 300	5	0	0	0	600	600	100	3600	1800		2000		3380			2238
April	Daily - 30	25				60	60		360	180		180			9497	9497	75
	Events - 300	5	0	0	0	600	600	100	3600	1800		2000		3380			2238
May	Daily - 30	26				60	60		360	180		180			9497	9497	75
	Events - 300	5	0	0	0	600	600	100	3600	1800		2000		3380			2238
June	Events - 300										8 Cows + 8 Goats+ 20 Hens 3450	2000	600 sq.m x 1 litre = 600 litres	2600	430500	430500	2238
	Resilience	30	585	580	1566000	600	600	100	3600	1800							
July	Events - 300											2000		2600	444850	444850	2238
	Resilience	31	1162	1157	3123900	600	600	100	3600	1800							
August	Events - 300											2000		2600	444850	444850	2238
	Resilience	31	710	705	1903500	600	600	100	3600	1800							
September	Events - 300											2000		2600	430500	430500	2238
	Resilience	30	370	365	985500	600	600	100	3600	1800							
October	Daily - 30	26				60	60		360	180	8 Cows + 8 Goats + 20 Hens 250	180			9497	9497	75
	Events - 300	5	105	100	270000	600	600	100	3600	1800		2000		3380			2238
November	Daily - 30	25				60	60		360	180		180			9497	9497	75
	Events - 300	5	45	40	108000	600	600	100	3600	1800		2000		3380			2238
December	Daily - 30	26				60	60		360	180		180			9497	9497	75
	Events - 300	5	0	0	0	600	600	100	3600	1800		2000		3380			2238
TOTAL		365	7956900			7680	7680	1200	46080	23040	biogas	25440		37440	1826676	1826676	27456

Table 15. Water calculation

ADAPTIVE REUSE

DEALING WITH CATTLE WASTE:

COMPOSTING:

The process of making compost starts after the monsoons when the level of moisture decreases.
The units are constructed with lime crete and bamboo as reinforcement.

Vermicomposting:

- Duration: 60-90 days
- Red worms are used to achieve faster result, pits and kept in shaded area to protect worms form direct sunlight.

Nadep:

- Duration: 90-120 days
- The process is more simple for the villagers to use. The layers are arranged and left to decompose.

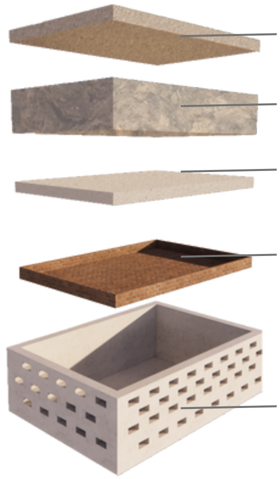


Fig 39: Vermi-nadep exploded isometric view

BIO GAS PLANT:

Biogas treats cattle waste to generate fuel which is supplied to kitchen and stored when not in use.

- Total waste generated per day (dung of 40 cows & 75 goats)(B): 40x10kg dung+75x1kg dung= 475kg dung
- Gas consumed by 1 person/day= 300L
- Gas requirement= 300(no. of people)x 300=90,000L

Calculating vol. of digester(Vd)= Retention time(Rt)x Substrate input quantity(Sd)

- Sd=Bx water= 237.5+475=712.5kg
- Vd=712.5x3=2137.5 m^3
- Daily gas production= G= Bx Specific gas yield (Gy)
- Gy for cow dung and urine= 220m^3xdxkg
- **G= 475x220= 1,04,500L**
- Daily gas generation rate per m^3 digester volume= Gp= G/Vd=104500/2137.5= 48.88 (m^3/d)m^3

Calculating gas holder volume (Vg):

- Vg= G x tx max (max. zero consumption time)
- = 104500x 19= 198550 m^3
- **40% of Vg for storage= 794200 m^3**

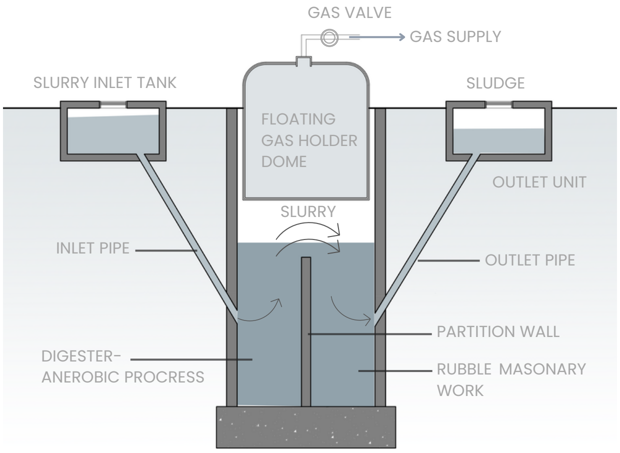


Fig 40: Biogas Section

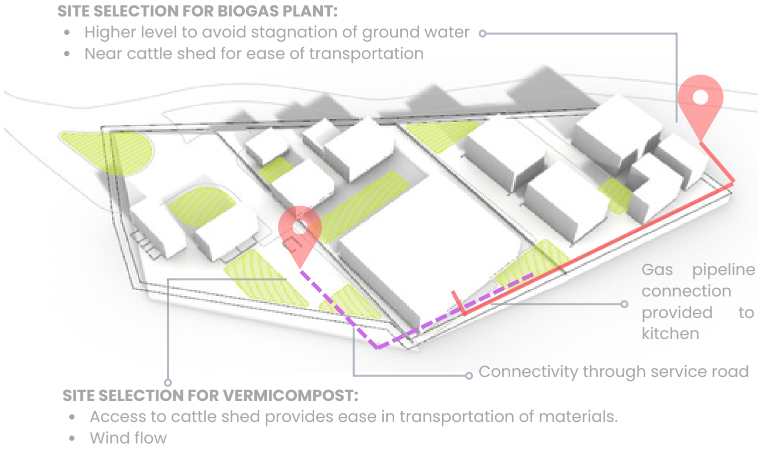


Fig 41: Site placement for biogas and vermi/nadep

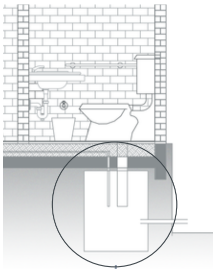
WASTE MANAGEMENT CYCLE:

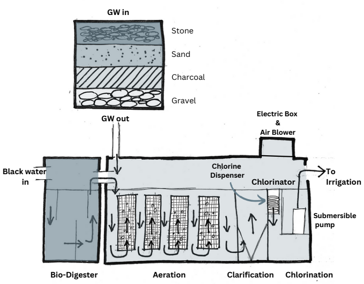
WASTE PRODUCED ON SITE

HUMAN GENERATED WASTE

- Solid & liquid waste

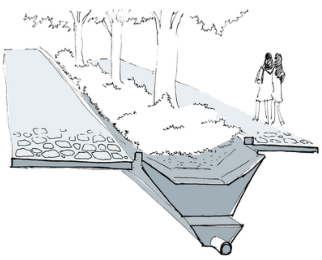
Bio toilets





GREY WATER

- Cleaning water
- Bathing
- Cooking
- Washing



Bio swales: Treated water used for irrigation

Using water for irrigation purpose

VEGETABLE/ ORGANIC WASTE

Vermi-composting & Nadep

Waste is put in unit layer by layer

Used as fertilizers in farming

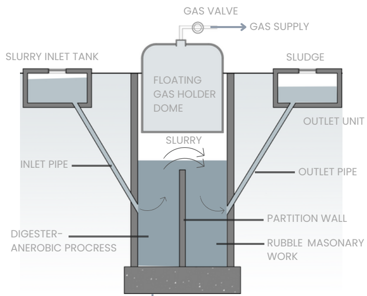
CATTLE GENERATED WASTE

- Cow dung & urine

Bio-gas plant

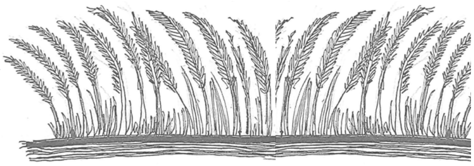
Input- Cattle waste

Anerobic process



By product: Sludge, used as fertilizers

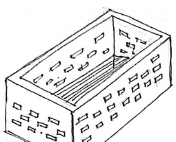
Product: Biogas, used as fuel



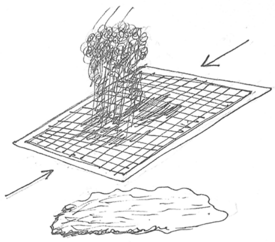
Farming

Kitchen

REFINING AND USAGE PROCESS:



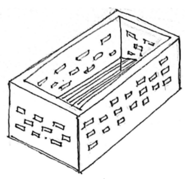
Composting pit



Refining

Fine particles used as fertilizers

Soil and larger granules left



Reusing composting material

Fig 42: Waste management cycle

EMBODIED CARBON

With due consideration to the context, the site is located at a fair distance from the Industrial Centres and urban material markets. This could pose a strain on the transportation based emissions materials.
Further, 3 main guidelines were incorporated in regards to material selection and subsequent carbon emission based study. They are as follows,

- **Whole building program:** Caters to establishing efficient layouts so as to minimise the built extents of the site. The building area program is strictly adhered to so as to achieve this.
- **Material Substitution:** Adobe blocks serve as the primary building block in the design. These are a very green building element. Overall, it becomes imperative to adopt localised admixtures and mortar bases into the finer aspects of design.
- **System Assembly Substitution:** Catering to the issues of transportation again, the project aimed at minimising all possible Concrete based systems. Also, Bamboo acts as a truss building element and substitutes for steel. For cultivating bamboo, necessary on site interventions are put into place.

	Materials	Units	Quantity	Emissions Factor	Material Emissions	Type of vehicle	No. of trips	Total distance	Total fuel consumed	Transport Emission	Type of vehicle	No. of trips	Total distance	Total fuel consumed	Transport Emission
DESIGN STANDARDS															
WALL	Adobe	kg	1860	0.01	18.6	Lorry	1.0	59.6	24.0	144.2	Lorry	1	2	0.8	4.8
	Local Mortar	kg	500	0.11	55	-	0.0	0.0	0.0	0.0	-	0	0	0	0
	Stone	kg	200	0.01	2	Lorry	1.0	2.0	0.8	4.8	-	0	0	0	0
	Plaster	kg	8500	0.27	2295	-	0.0	0.0	0.0	0.0	-	0	0	0	0
	Water	l		0	0	-	0.0	0.0	0.0	0.0	-	0	0	0	0
			Total Material Emissions		118.53	Total Transport 1 Emission per functional unit				7.5	Total Transport 2 Emission per functional unit				0.2419
ROOF	Bamboo	kg	1450	1.5	2175	-	-	0	0.0	0.0	-	0	0	0	0
	Joinery bolting	kg	7	2.2	15.4	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.81	16.13
	Purlins	kg	87	1.5	130.5	-	-	0	0.0	0.0	-	0	0	0.00	0.00
	Half Cut Bamboo	kg	1450	1.5	2175	-	-	0	0.0	0.0	-	0	0	0.00	0.00
	Polycarbonate sheet	kg	6	3	18	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.81	16.13
			Total Material Emissions		225.695	Total Transport 1 Emission per functional unit				48.1	Total Transport 2 Emission per functional unit				1.6
FLOOR	Stone	kg	2500	0.01	25	Lorry	1	2	0.81	4.84	Lorry	1	2	0.81	4.84
	Soil Fill	kg	3000	0	0	-	0	0	0	0	-	0	0	0	0
	Plastic Bottles	kg	1500	0	0	-	0	0	0	0	-	0	0	0	0
	Lime plaster	kg	1430	0.43	614.9	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
			Total Material Emissions		31.995	Total Transport 1 Emission per functional unit				7.451612903	Total Transport 2 Emission per functional unit				0.4838709677
FENESTRATION	Wooden frame	kg	20	2.4	48	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Bamboo Jali	kg	20	-0.43	-8.6	-	0	0	0.00	0.00	-	0	0	0.00	0.00
	Shutters	kg	45	2.4	108	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
			Total Material Emissions		7.37	Total Transport 1 Emission per functional unit				14.41935484	Total Transport 2 Emission per functional unit				0.48
STRUCTURE	Stone Column	kg	2500	0.01	25	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Rubble Rubble footing	kg	1000	0.01	10	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Coarsed Quoin Stone	kg	997	0.056	55.832	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Coarsed Basalt Stone	kg	900	0.056	50.4	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Hard Stone Foundation	kg	3750	0.27	1012.5	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
			Total Material Emissions		57.6866	Total Transport 1 Emission per functional unit				8.177419355	Total Transport 2 Emission per functional unit				0.24

Table 16: Tabular Analysis of Baseline considerarions

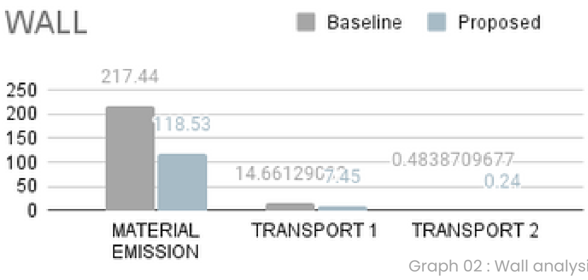
	Materials	Units	Quantity	Emissions Factor	Material Emissions	Type of vehicle	No. of trips	Total distance	Total fuel consumed	Transport Emission	Type of vehicle	No. of trips	Total distance	Total fuel consumed	Transport Emission
BASELINE STANDARDS															
WALL	Brick	kg	7260	0.39	2831.4	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Cement	kg	1460	0.91	1328.6	-	0	0	0.00	0.00	-	0	0	0.00	0.00
	Steel reinforcement	kg	20	2.6	52	Lorry	1	2	0.81	4.84	-	0	0	0.00	0.00
	Lime Plaster	kg	500	0.27	135	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Stone	kg	200	0.009	1.8	-	0	0	0.00	0.00	-	0	0	0	0
			Total Material Emissions		217.44	Total Transport 1 Emission per functional unit				14.66129032	Total Transport 2 Emission per functional unit				0.4838709677
ROOF	Steel	kg	1450	2.5	3625	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Joinery Wireframe	kg	8	2.2	17.6	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.8	16.1
	Steel Purlins	kg	120	3.5	420	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.8	16.1
	Mangalore tiles	kg	3300	0.51	1683	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Glazed Glass	kg	100	1.2	120	Mini truck	1	59.6	24.0	480.6	Mini truck	1	59.6	24.0	480.6
			Total Material Emissions		293.28	Total Transport 1 Emission per functional unit				86.51612903	Total Transport 2 Emission per functional unit				26.12903226
FLOOR	Stone	kg	2500	0.01	25	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Soil Fill	kg	3000	0	0	-	0	0	0	0	-	0	0	0	0
	PCC bedding	kg	0	0	0	-	0	0	0	0	-	0	0	0	0
	RCC	kg	1500	0.26	390	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Tile	kg	2300	0.47	1081	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
			Total Material Emissions		74.8	Total Transport 1 Emission per functional unit				14.66129032	Total Transport 2 Emission per functional unit				0.48
FENESTRATION	Timber frame	kg	20	2.4	48	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.8	16.1
	Glazed Glass	kg	20	0.8	16	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.8	16.1
	Shutters	kg	45	2.4	108	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.8	16.1
			Total Material Emissions		8.6	Total Transport 1 Emission per functional unit				72.09677419	Total Transport 2 Emission per functional unit				2.419354839
STRUCTURE	RCC	kg	2500	0.26	650	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	RCC Step footing	kg	1000	0.26	260	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Coarsed Quoin Stone	kg	180	0.056	10.08	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Coarsed Basalt Stone	kg	1650	0.056	92.4	Lorry	1	2	0.81	4.84	-	0	0	0	0
	PCC Bed	kg	3750	0.27	1012.5	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
			Total Material Emissions		101.249	Total Transport 1 Emission per functional unit				22.11290323	Total Transport 2 Emission per functional unit				0.7258064516

Table 16: Tabular Analysis of Proposed Considerations

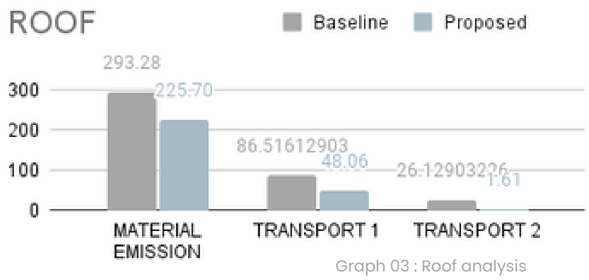
EMBODIED CARBON

SUMMARY CALCULATION									
	BASELINE					PROPOSED			
SYSTEM TYPE	MATERIAL EMISSION (kg-CO2 e)	TRANSPORT 1 (kg-CO2 e)	TRANSPORT 2 (kg-CO2 e)	TOTAL (kg-CO2 e)		MATERIAL EMISSION (kg-CO2 e)	TRANSPORT 1 (kg-CO2 e)	TRANSPORT 2 (kg-CO2 e)	TOTAL (kg-CO2 e)
WALL	217.44	14.66	0.48	232.59		118.53	7.45	0.24	126.22
ROOF	293.28	86.52	26.13	405.93		225.70	48.06	1.61	275.37
FLOOR	74.8	14.66	0.48	89.95		32.00	7.45	0.48	39.93
FENESTRATION	8.6	72.10	2.42	83.12		7.37	14.42	0.48	22.27
STRUCTURE	96.125	22.11	0.73	118.96		57.69	8.18	0.24	66.11
	GRAND TOTAL emissions per functonal unit (kg-CO2 e)			930.54		GRAND TOTAL emissions per functonal unit (kg-CO2 e)			529.9

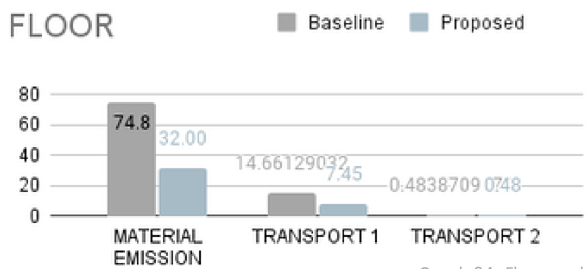
Table 17: Tabular Analysis of Carbon emission



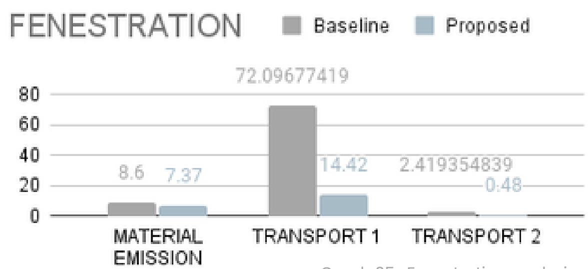
Graph 02 : Wall analysis



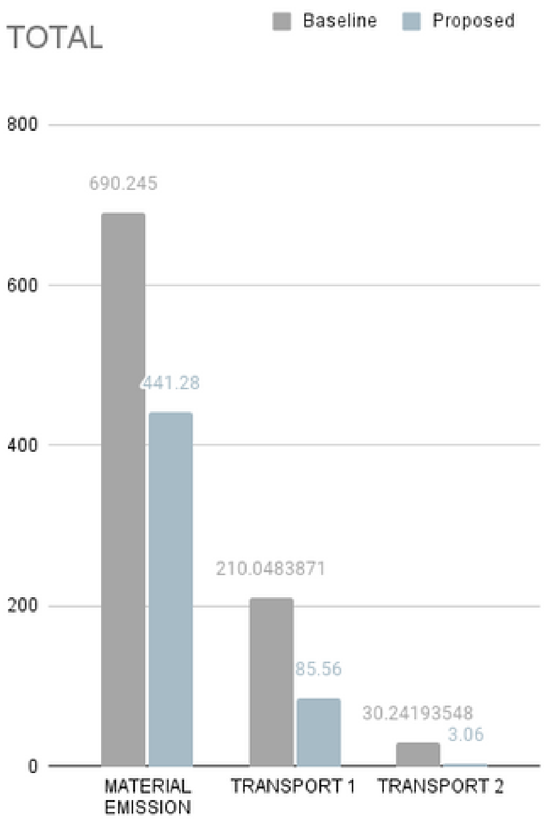
Graph 03 : Roof analysis

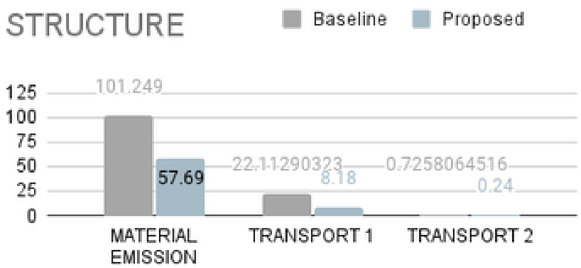


Graph 04 : Floor analysis



Graph 05 : Fenestration analysis





Graph 06 : Structural analysis

Thus as observed, in comparison to baseline cases an overall **40.1% reduction** in all carbon emissions is observed. The Architectural design and engineering work together to devise various means of lowering emissions at all scales of design.

Graph 07: Overall analysis

RESILIENCE

ASSESSMENT OF POTENTIAL RISKS ON SITE:

Flooding:
The village, situated above sea level, is often not prone to flooding despite the region's prevailing high rainfall.

Heat gains:
The built structure is subjected to intense heat during summers which increases the external heat gains, thus rendering the structure to be unfit for accomodation.

Cold temperatures:
The village experience intense winters with the temperature decreasing to as low as 17ºC. Absence of thermal insulation in the built structure makes the situation more concerning.

High winds:
The built structure is exposed to high winds from South-West, thus incerasing the wind load on the structure and making it susceptable to damage.

Disjuncture:
The village is disconnected from the outside due to a lack of well-facilitated infrastructure. Also, frequent blackouts are prevalent during rain storms and cyclone situations.

Lack of medical facilities & public awareness:
Due to the unavailability of immediate medical facilities, health issues posed by rodents (infested sites) put human life at imminent risk.
Most of the masses lack awareness about waste disposal mainly plastic. Facilities like toilets are being made available by the government but water availability is lacking. Menstrual hygiene is at stake with no exposure to sanitary napkins.

STRATEGIES TO OVERCOME THE RISKS / EXISTING SOLUTIONS:

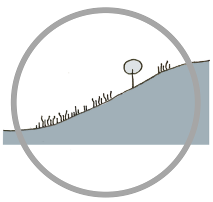


Fig 43: Site topography

Topographical advantage:
The sloping topography of the site situated on a ridge terminates the risk of water logging on the site.

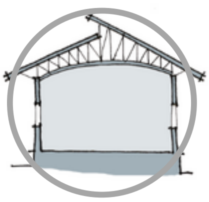


Fig 44: Roof structure

Clerestory roofing:
Clerestory opening enables well-ventilated spaces reducing cumulative wind load on the structure.

Extended plinth:
The extended portion of the plinth prevents rodents from infiltrating important spaces.


Fig 45:Extended plinth

First Aid & Training Center:
Medical treatment for the injured/ diseased and creating public awareness through campaigns/ lectures provide a better opportunity for community dynamism.

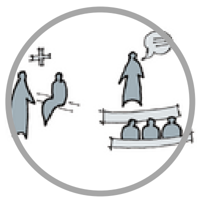


Fig 46: Improving community dynamism

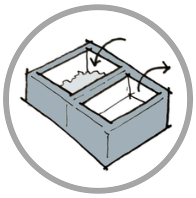


Fig 47: Vermi-NADEP compost

Waste disposal:
Vermi-NADEP composting pits produce manure for the crops effectively reusing the produced waste.

Angular bricks on South facade:
It reduces the overall heat gains in summers and heat loss in winters by a marginally satisfying value.

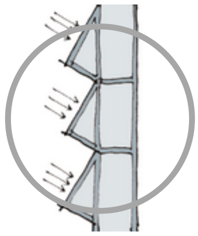


Fig 48: South façade wall

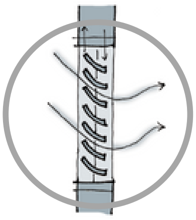


Fig 49: Window typology

Operable bamboo louvers:
Windows with operable mechanism enables controlled air intake during any specific time of the day.

On site farming activities:
This makes the resilence shelter self sustainable in terms of food shortages and keeping a ecomony check during disjuncture.

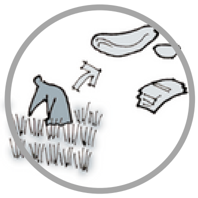


Fig 50:Farming activities

AUTONOMY OF CRITICAL FUNCTIONS:

Vermi-NADEP produce:
90,000 L of gas is consumed per day when the community center works at full capacity. 475kg of waste (dung) which is sourced from the cattle shed when in full capacity generates 1,04,500 L of gas fulfilling the needs and giving a sufficient backup.

Water facility:
Water storage: 75000 l, Water consumption per day: 56 LPD. During the disaster period, 300 people occupy the shelter, giving 4.5 days of autonomy. During regular times 30 people occupy the shelter giving 45 days of autonomy.

Energy efficiency:
Energy consumption per year is 36542.528 kWh which includes lighting, fans(ventilation) computer, television, and projector equipment.
The energy required is generated using Solar PV which is 36838.6 kWh/year from the 50-panel PV grid array on an average. During power outage, the shelter gives 3 days of autonomy.

RESILIENCE ACTION PLAN:

1. Relocate villagers and cattle folk to the resilience center.
2. Cater to the injured and look after the well-being of villagers and cattle.
3. Provide villagers with a safe space in the center for temporary/ long periods of stay before the resilience time period settles down.
4. Provide villagers with sufficient food and water supply.
5. Conduct communal activities to engage villagers during distress.
6. Educate/ train villagers for basic self-care during extended distress periods.

ENGINEERING AND OPERATIONS

WINDOW JOINERY DETAIL:

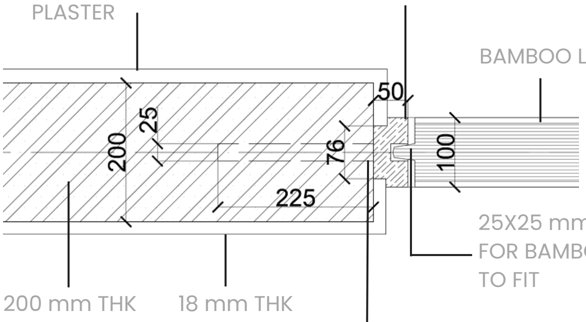


Fig 51: Plan showing frame connection with adobe wall

PLAN SHOWING FRAME CONNECTION WITH ADOBE WALL

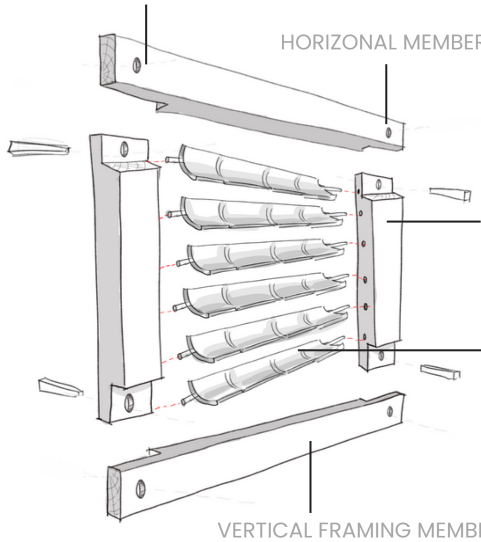


Fig 52: Isometric view of window

ISOMETRIC VIEW

RUBBLE MASONARY DETAILS:

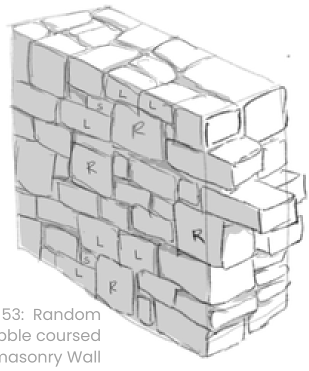


Fig 53: Random rubble coursed masonry Wall

RANDOM RUBBLE COURSED MASONRY WALL TILL SILL LEVEL

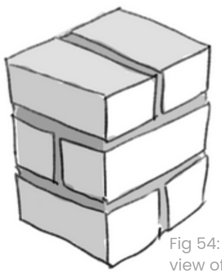


Fig 54: Isometric view of column

400x200x100 mm DRESSED STONES PLACED IN ALTERNATE COURCES

ISOMETRIC VIEW OF COLUMN

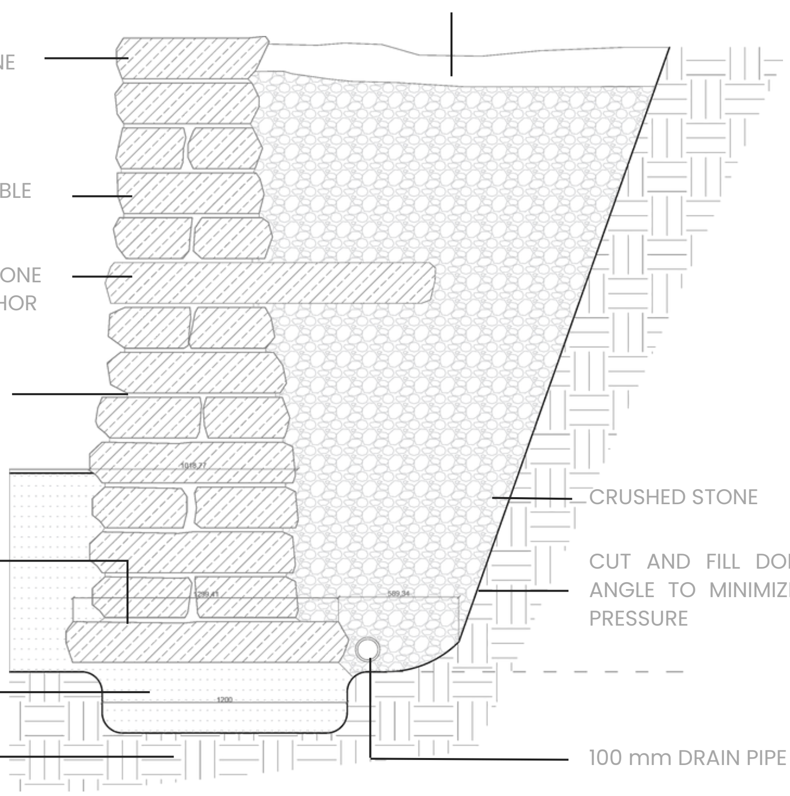
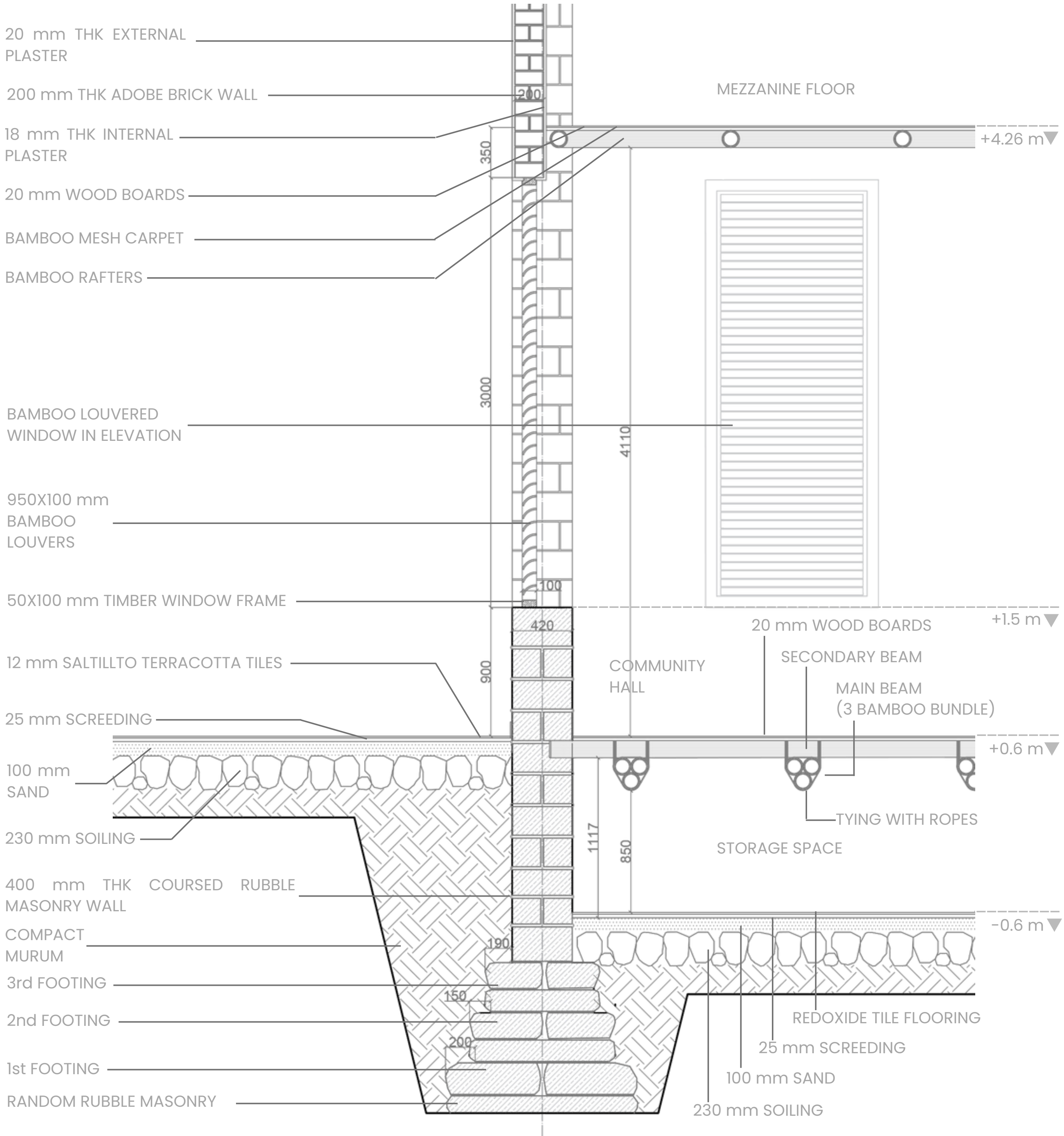


Fig 55: Retaining wall section

RETAINING WALL SECTION

ENGINEERING AND OPERATIONS



END WALL SECTION

Fig 56: End wall Section

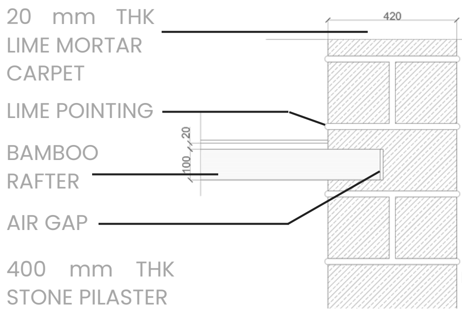
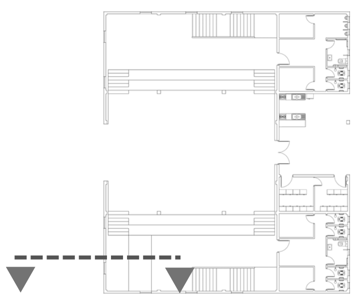


Fig 57: Floor Slab detail

FLOOR SLAB DETAIL



KEY PLAN

ENGINEERING AND OPERATIONS

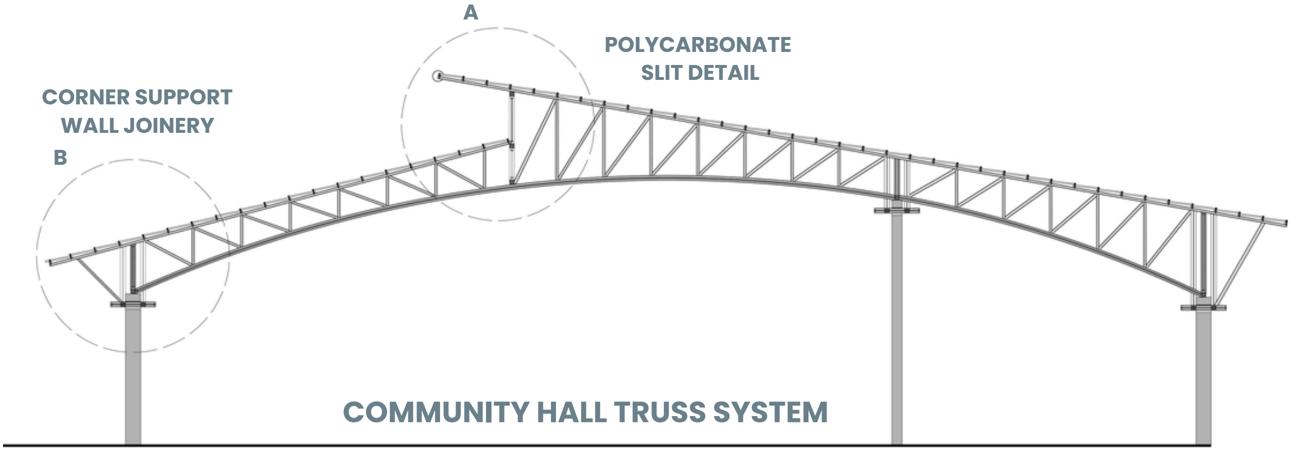


Fig 58: Community Hall truss System

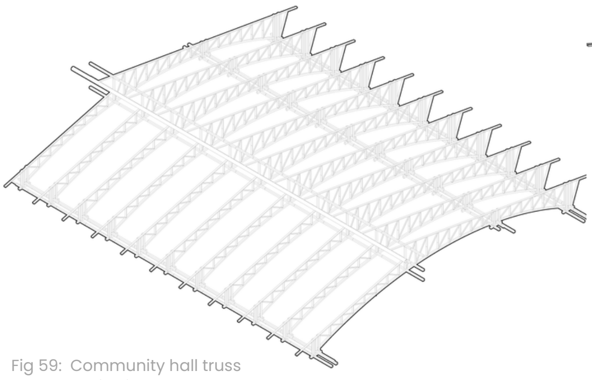


Fig 59: Community hall truss axonometric view

COMMUNITY HALL TRUSS AXOMETRIC VIEW

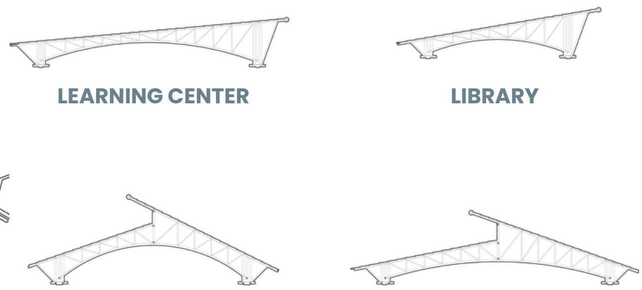


Fig 60: All site based roof truss profile

ALL SITE BASED ROOF TRUSS PROFILES

The entire assembly is derived from an explorative process of using Bamboo for the structural requirements. To attain structural strengths, a Bamboo Member is curated wherein one structural member consists of interlocked Bamboo rods all of **5 MM thick** diameter. As such members in various permutations like **2x1** and **2x2** are incorporated through the design.

These members are internally connected by **Bamboo dowels** and member to member connections are achieved by **Nut and Bolts**.

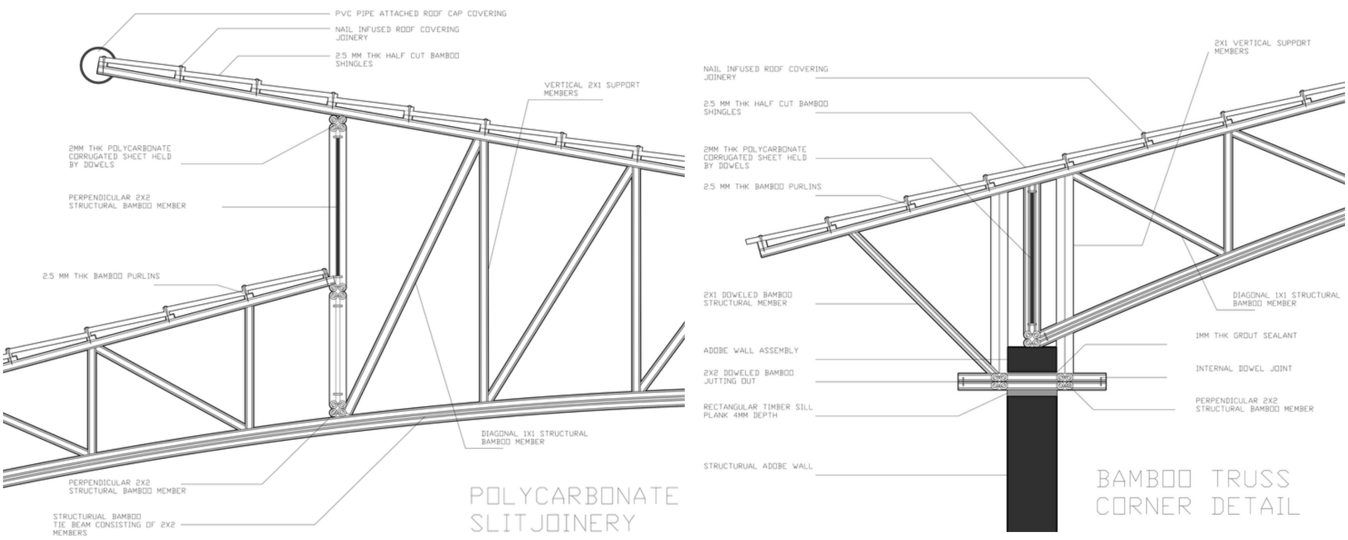


Fig 61: DETAIL A

STRUCTURAL DETAILS AT TRUSS JUNCTIONS

AFFORDABILITY

Comparison of total project cost :
BASE CASE vs PROPOSED CASE

S.No.	Particulars	Definition	Baseline Estimate (Project Partner / SOR basis) Amount (Million INR)	%	Amount (INR per sqm)	Proposed Design Estimate Amount (Million INR)	%	Amount (INR per sqm)
1	Land	Cost of land purchased or leased by the Project Partner	100	53.60%	43,478	100	72.00%	43,478
2	Civil Works	Refer Item A, Civil works in Cost of construction worksheet	2.2	1.20%	957	2.6	1.90%	1,130
3	Internal Works	Refer Item B, Civil works in Cost of construction worksheet	1.44	0.80%	626	1.43	1.00%	622
4	MEP Services	Refer Item C, Civil works in Cost of construction worksheet	40.17	21.50%	17,466	0	0.00%	-
5	Equipment & Furnishing	Refer Item D, Civil works in Cost of construction worksheet	0.01	0.00%	4	0.01	0.00%	4
6	Landscape & Site Development	Refer Item E, Civil works in Cost of construction worksheet	0.2	0.10%	88	0	0.00%	1
7	Contingency	Amount added to the total estimate for incidental and miscellaneous expenses.	2.2	1.20%	957	3.21	2.30%	1,395
	TOTAL HARD COST		**146.2**	**78%**	**63,576**	**107.3**	**77%**	**46,631**
8	Pre Operative Expenses	Cost of Permits, Licenses, Market research, Advertising etc	10	5.40%	4,348	10	5.40%	4,348
9	Consultants	Consultant fees on a typical Project	10	5.40%	4,348	10	5.40%	4,348
10	Interest During Construction	Interest paid on loans related to the project during construction	20.25	10.90%	8,806	11.72	6.30%	5,097
	TOTAL SOFT COST		**40.3**	**22%**	**17,502**	**31.7**	**17%**	**13,792**
	TOTAL PROJECT COST		**186.5**	**100%**	**81,078**	**139**	**100%**	**60,423**

Table 18: Comparison of Total project cost.

Justifications

1. The cost of landscaping is reduced significantly by the usage of native species which require no cost for plantation.
2. Built-in furniture reduces the capital cost of furnishing and increases durability reducing maintenance costs.
3. Contingency cost is estimated to be greater because of the usage of materials like bamboo which require appropriate sizing and material handling.
4. Charges for MEP services are significantly reduced by the use of passive and native techniques in architecture.

Design strategies

- The proposed cost estimate is substantially decreased due to use of local materials **reducing the transportation cost.**
- Right-sizing of materials to **reduce material wastage** and any opex costs for refurbishing the materials ISHRAE standards.
- labor cost is reduced as the **community itself is employed** in the construction.
- The landscape is such planned that only native trees are planted which **don't require special maintenance** and also **aid in reusing water** several times with biological treatments.
- Passive systems of ventilation, and shading, are devices that increase the capex cost but **reduce the recurring opex cost**.
- The community hall modifies itself to create an **economy-generating marketplace.**

AFFORDABILITY

Energy Interventions

• Independent Grid - Solar PV Panels save opex costs of electricity bills with a **payback period of 7.5 year**s

• Optimized fenestrations inducing daylight **reduces the need for electrical lighting** along the operational hours

• LED Lighting -Compared to incandescent bulbs and CFLs, LEDs are energy efficient, have lesser carbon footprints, and also **reduce our energy demand** which reduces the electricity bills.

•Natural ventilation provides no room for discomfort and thus reduces **the load on HVAC systems to zero.**

Water management

• The structure can sustain the harvested rainwater all throughout the year rainwater contributes to the **reduction of reliance on groundwater** and has the potential to save a significant amount of water per year.

• Water- Use of efficient techniques, to **reduce water demand**; **reducing overhead tank sizes** by reusing grey water.

• Tank is placed at a higher level to use the contour and gravity to bring water to the desired function and thereby **reduce the energy demand**.

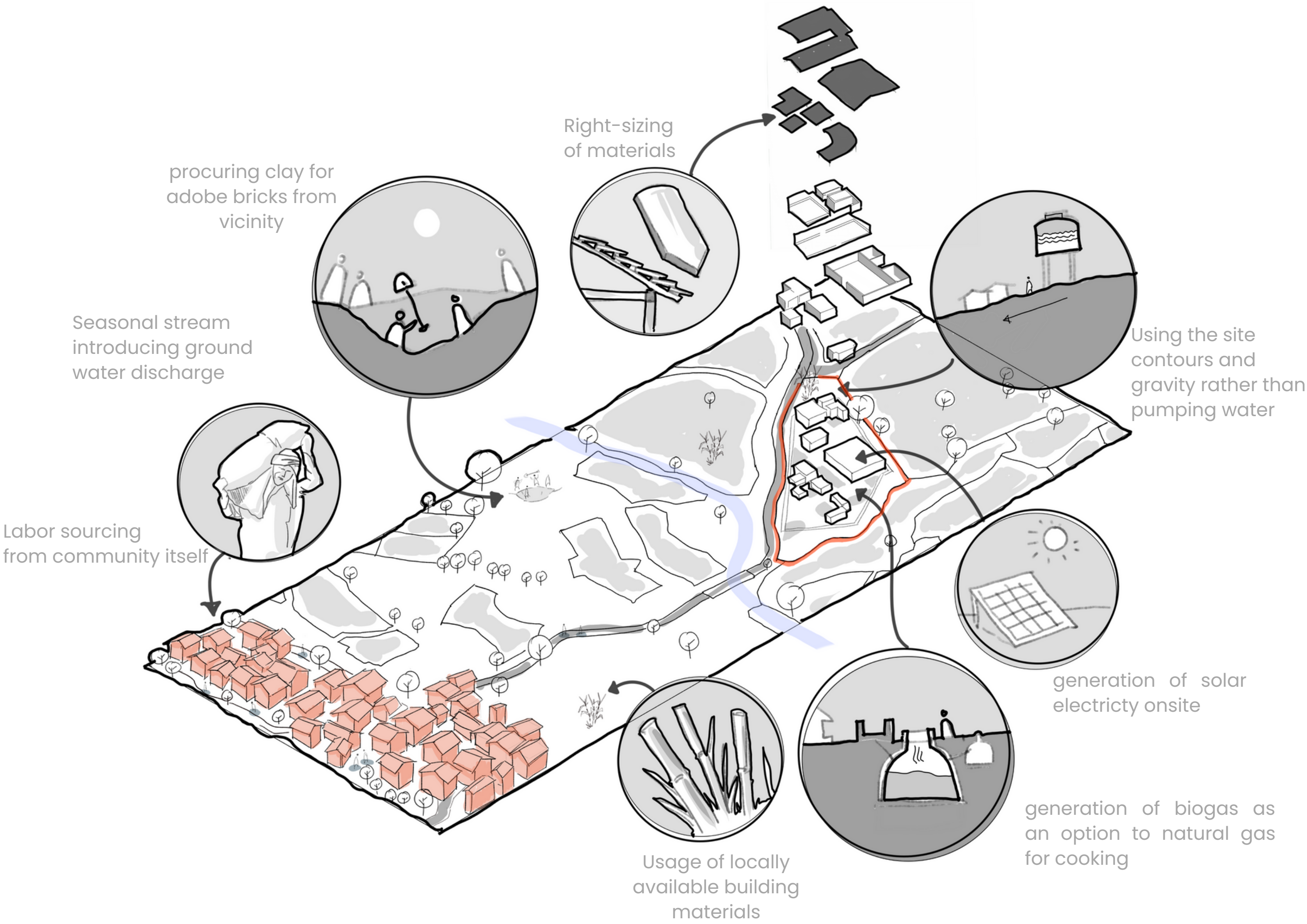


Fig 62: Measures to reduce cost

INNOVATION

Closed Cycle of materials

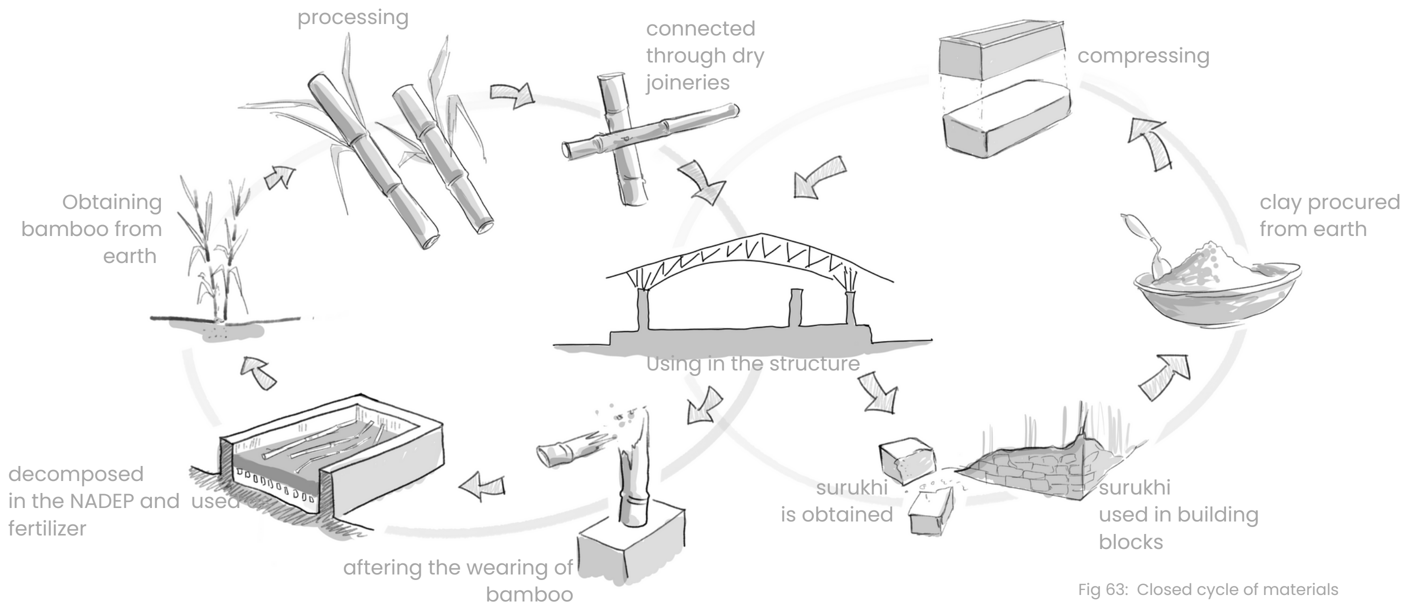


Fig 63: Closed cycle of materials

The materials obey a closed cycle. The basic principle here is to give back what we take from mother earth or re-usage of material on the disintegration of the structure.

Achieving TRIVIAL STEEL NO CONCRETE

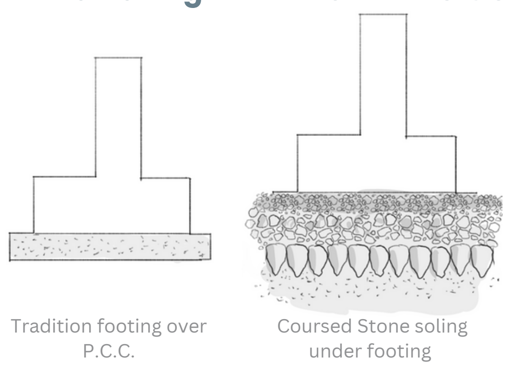


Fig 64: Comparison of footings

Stone as an alternative to P.C.C

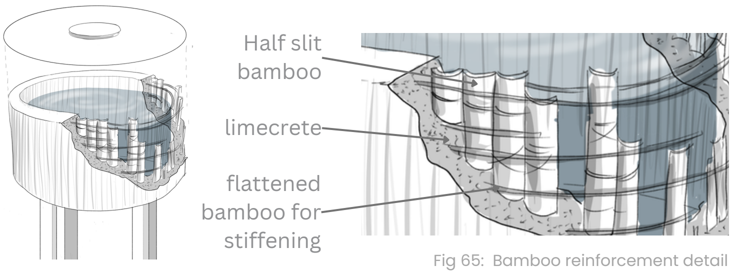


Fig 65: Bamboo reinforcement detail

Bamboo as a reinforcement in limecrete

Filler slab for OHT tanks

- Slab of the OHT will be subjected to forces exerted by water. Hence filler slab is used to strengthen the slab and reduce its dead load.
- Mangalore tiles are used as fillers.

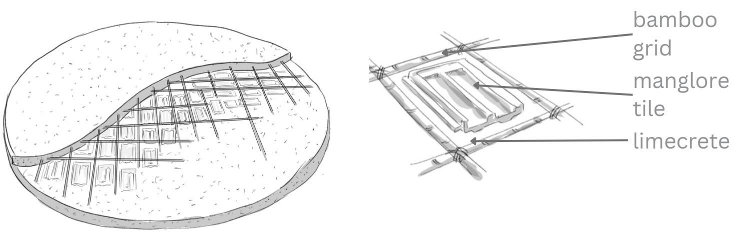


Fig 66: Filler slab detail

Providing strength to Adobe bricks

- Slaked lime : M sand : Surukhi in a proportion 2 : 1 : 7
- Slaked lime provides waterproofing and binding
- M Sand reduces voids and bleeding
- Surukhi provides hydraulicity and strength

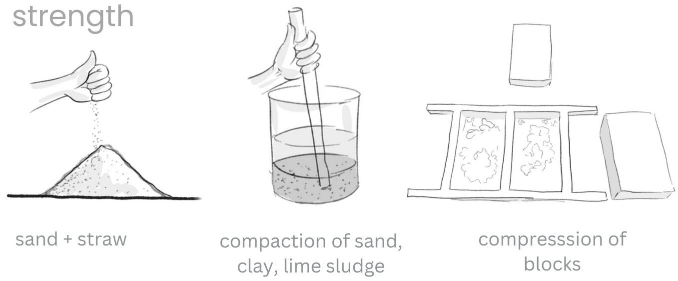


Fig 67: Strengthening Adobe bricks

INNOVATION

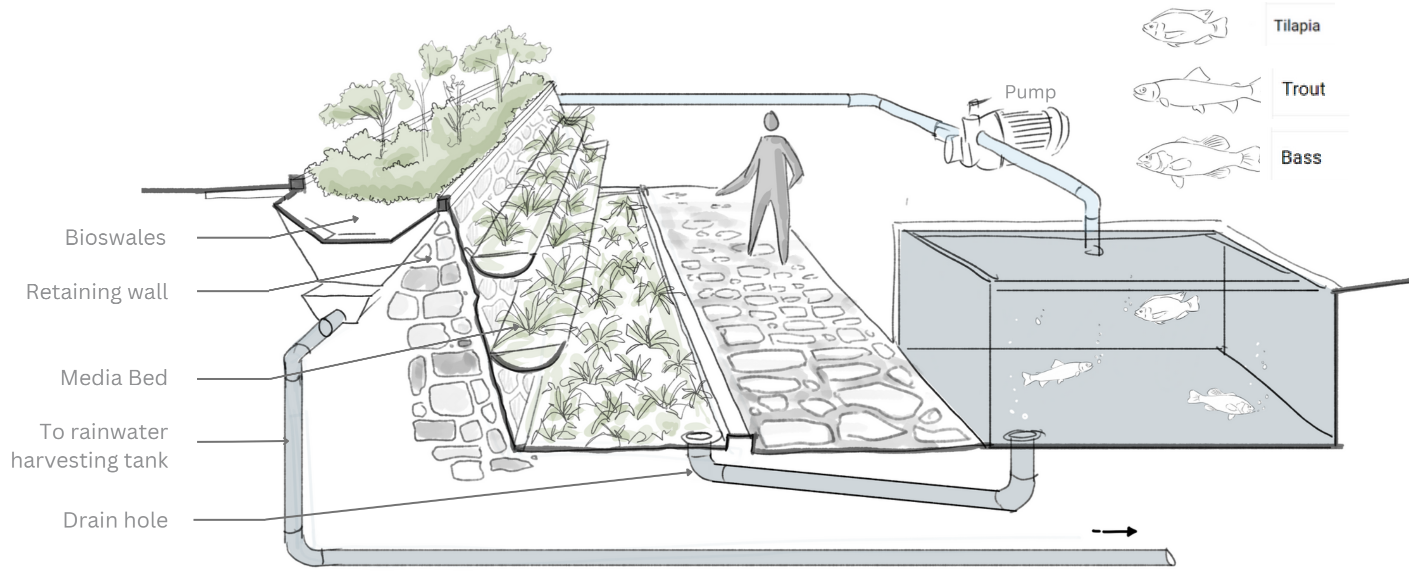


Fig 68: Aquaponics

Aquaponics

An indigenous system in of aquaculture in which the nitrogenous waste produced by farm fishes like Tilapia, Trout, Bass supply nutrients to plants grown hydroponically, which in turn purify the water.

- automatic recirculating system
- does not require much monitoring or measuring
- Economy generation through vegetation like tomatoes, lettuce, spinach

INBUILT FURNITURE

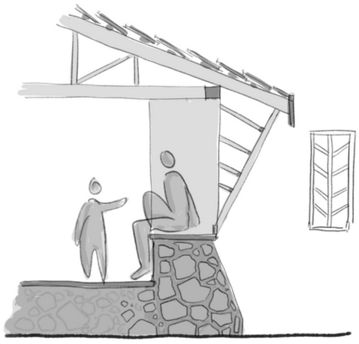


Fig 69: Inbuilt seating

The structure is such designed that the built itself carves out spaces like furniture.

REDESIGNING THE PLINTH

The plinth is designed with a protruding nosing to prevent rodents from entering inside .

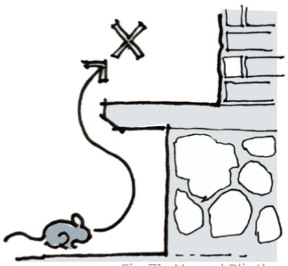


Fig 71: Nosed Plinths

THERMAL HEAT REDUCTION

The south facade is shaded by angular bricks decreasing the surface area exposed to sun, reducing heat transfer.

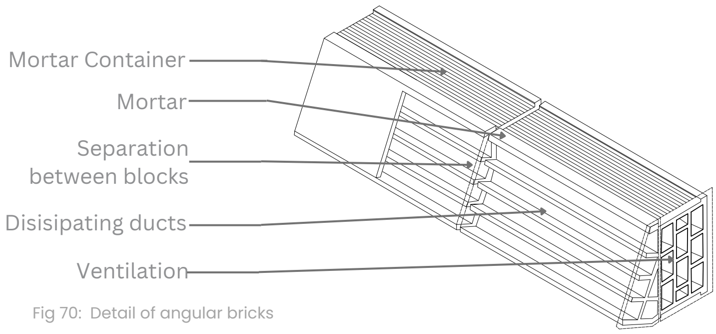


Fig 70: Detail of angular bricks

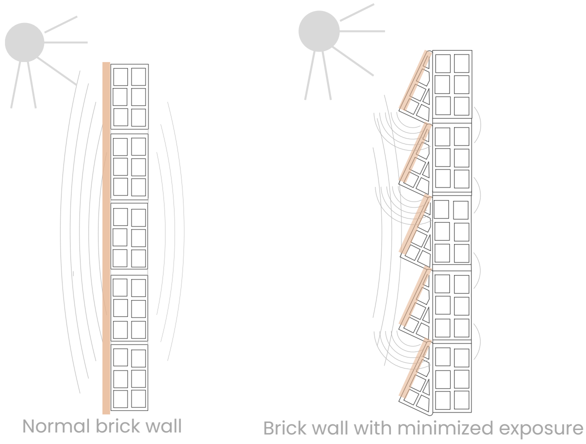


Fig 72: Comparison between brick types

HEALTH AND WELL - BEING

Khomarpada is located in Palghar which lies in the warm and humid climatic zone. We tried to provide maximum thermal comfort by passive means and reduce the load on mechanical equipment.

THERMAL COMFORT AND HEAT GAIN

The entire complex is placed at an axis of 170 ° to minimize the heat gain and maximize thermal comfort. The windows for areas which will be used for maximum time throughout the day are placed in the North and North - East direction. The courtyard shared by each space provides cross ventilation.

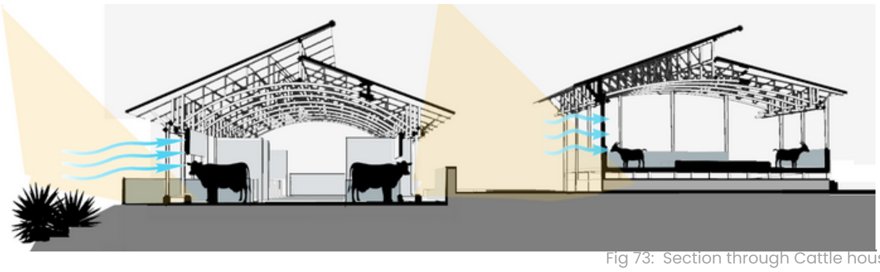


Fig 73: Section through Cattle housing.

The cattle housing is designed and placed in a way to allow maximum natural light and minimize heat gain due to surrounding trees.

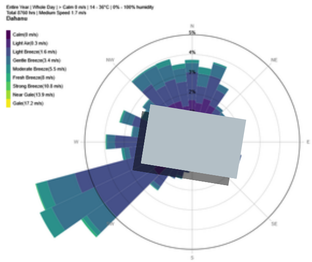


Fig 74: Windrose diagram.

From the Windrose Analysis, it is observed that 170° from east is the most appropriate orientation , about 20.92 % wind flows from that direction

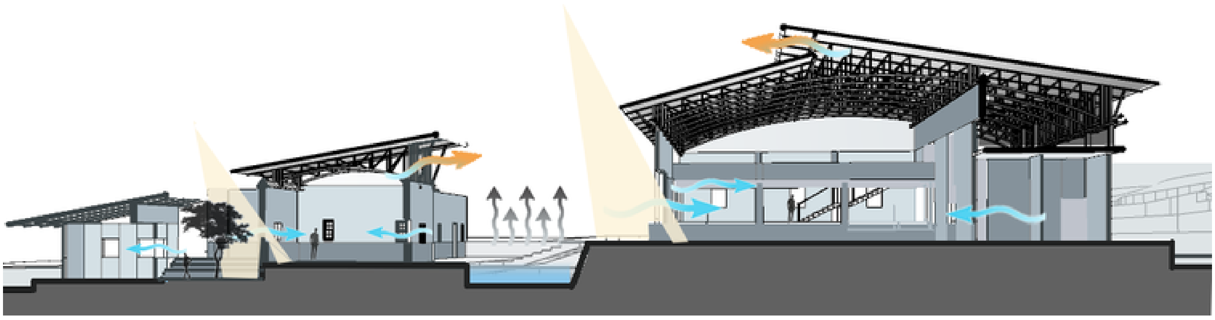


Fig 75: Section through Community Hall.

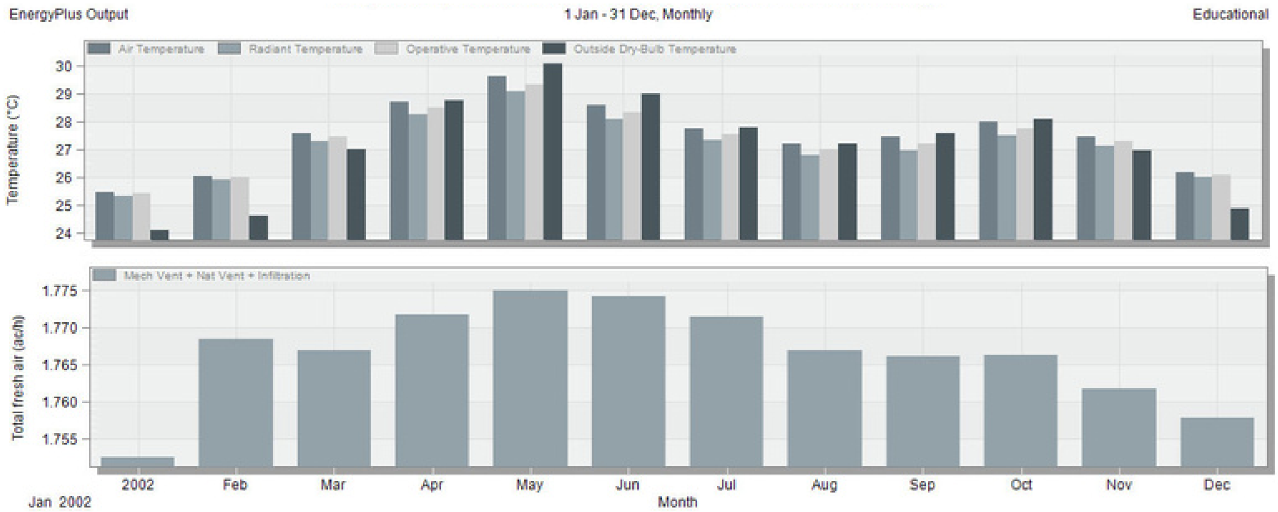
VENTILATION RATE

The wall window ratio has been taken as 1:20 to bring down the internal temperature. We have provided a terraced landscape which cools the incoming wind, and further, bamboo blinds which reduce the heat coming in. the southern façade is insulated to heat by reducing the WWR to 1:15 or with no openings in some blocks .The window placed on opposite walls facilitates natural ventilation, which is aided by fans and this brings the further indoor temperature further down. Clerestory openings are provided for Cross ventilation. According to the number of occupants in respective areas, the ventilation rate is calculated following the standards from NBC and ASHRAE.

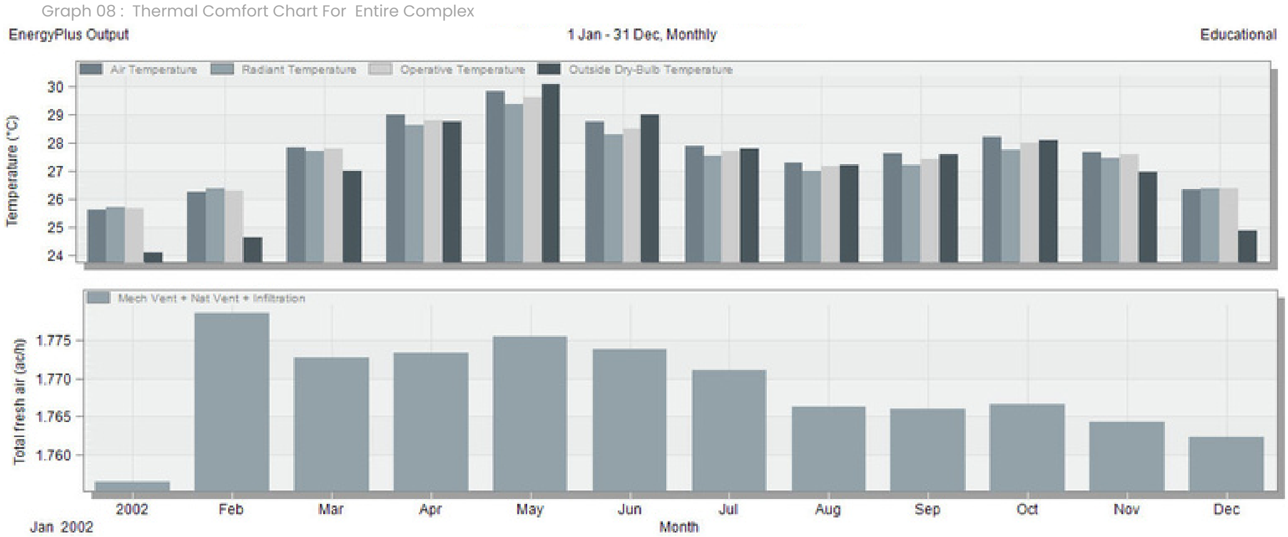
Space type	No. of occupant	Rp (l/s.person)	Floor Area (m2)	Ra (l/s.m2)	Ventilation rate (l/s)
ADMIN	6	3.8	30	0.3	31.8
LEARNING CENTER, LIBRARY	20	5	70	0.6	142
GUEST HOUSING	10	2.5	216	0.3	89.8
TRAINING CENTER	18	3.8	35	0.3	78.9
COMMUNITY HALL	300	3.8	692	0.6	1555.2
HEALTHCARE HUMANS	3	2.5	23	0.3	14.4
HEALTHCARE ANIMALS	7	3.8	30	0.9	53.6
ANIMAL SHELTER	735	3.8	500	0.9	3243

Table 19. Ventilation rate chart

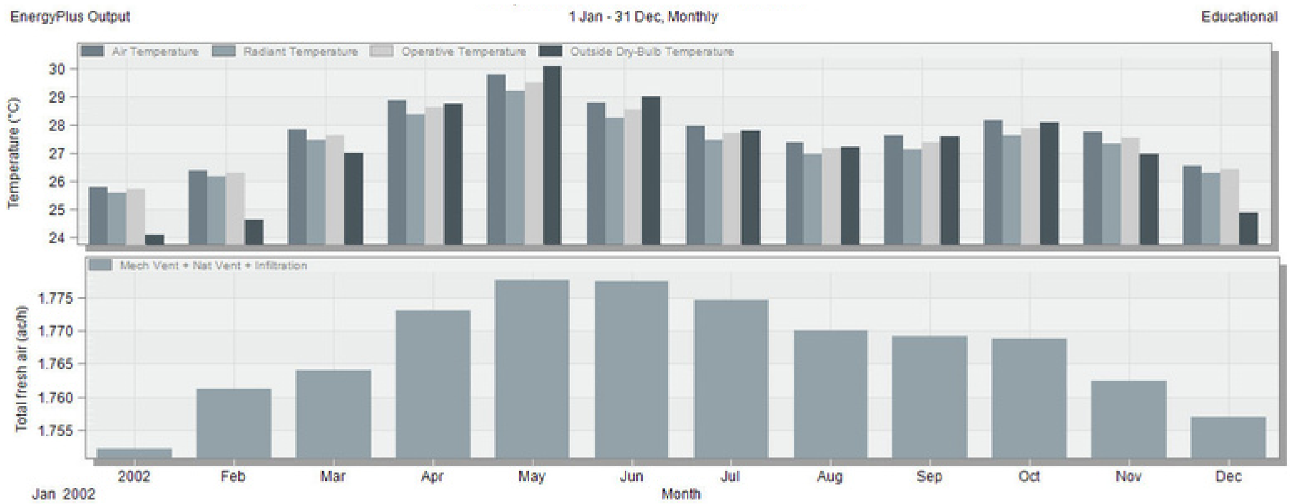
HEALTH AND WELL - BEING



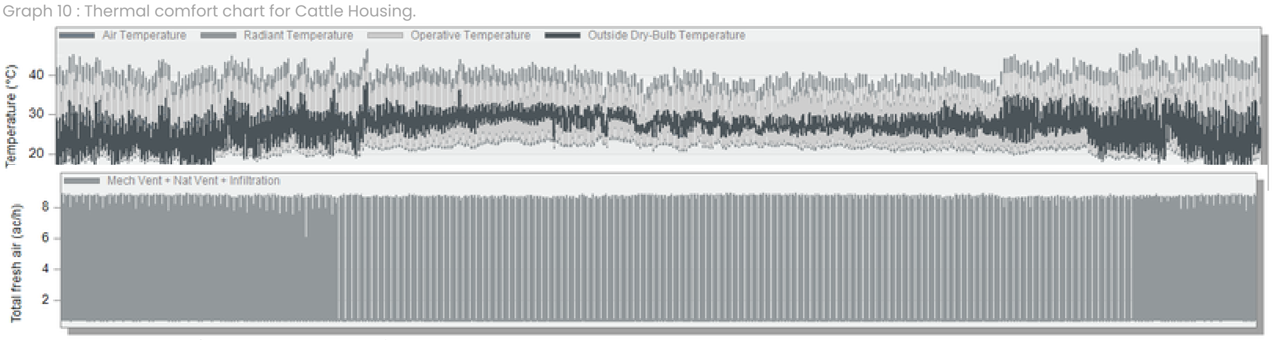
Graph 08 : Thermal Comfort Chart For Entire Complex



Graph 09 : Thermal comfort chart for Community Hall.



Graph 10 : Thermal comfort chart for Cattle Housing.



Graph 11 : Thermal comfort chart on hourly basis

Time/Date

HEALTH AND WELL - BEING

The wall is made with stone till the sill level and the rest of the wall is made of adobe which help in maintain a temperature difference of 5-10 ° between outdoor(35°) and indoors (30°)using only natural ventilation , it can be further reduced to indoors (25 ° - comfortable indoor temperature) using mechanical ventilation (fans).

DAYLIGHT FACTOR

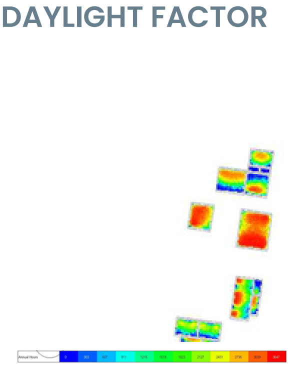


Fig 76: Day lighting factor

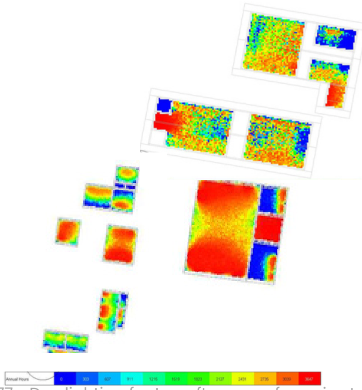
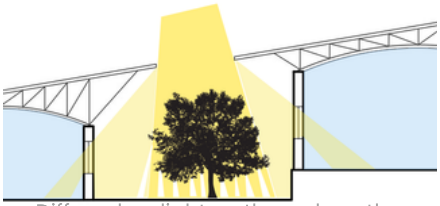


Fig 77: Day lighting factor after use of passive techniques

STRATEGIES FOR VISUAL THERMAL COMFORT :

Intensity of light reduced due to plant cover , making the air around more cooler due to evaporative cooling



Diffused light through the courtyard reduces the glare and keeps the structure overall cool.

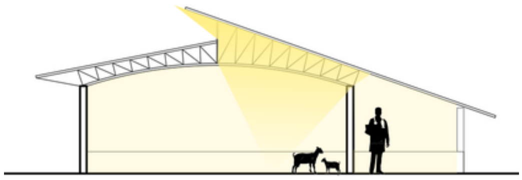
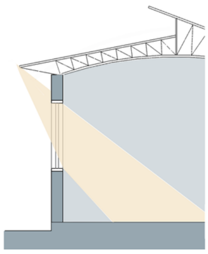


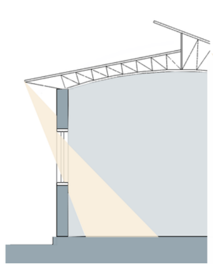
Fig 78: Strategies for visual Thermal comfort

The clerestory openings brings in required light and takes away the hot air in the structure

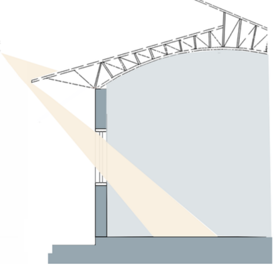
STRATEGIES TO REDUCE THE GLARE THROUGH OPENINGS:



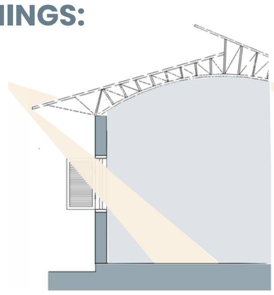
without passive strategies



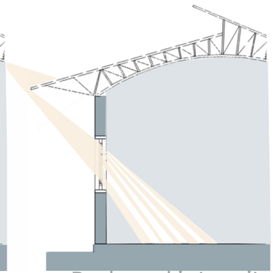
Reduction in amount of light due to 1:20 WWR



Reduction in light intensity due to increased overhang



Intensity of light with open window



Reduced intensity of light due to louvered window

Fig 78: Strategies to reduce glare through openings

WIND SIMULATION

The wind simulation demonstrates how the windows, as well as their size and placement, contribute to increased ventilation within the modules. Thus, using passive technologies and orienting the building maximum wind flows through the clusters. The design and planning strategies increase the number of thermal comfort hours via the use of strategies falling under various categories:

TABLE 1 DESIRABLE WIND SPEEDS (m/s) FOR THERMAL COMFORT CONDITIONS
(*Clause* 4.2)

DRY BULB TEMPERATURE, °C	RELATIVE HUMIDITY (PERCENTAGE)						
	30	40	50	60	70	80	90
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.

Reference from NBC

TABLE 5 INFLUENCE OF LOUVERS ON INDOOR AIR MOTION
[*Clause* A-4.2 (f)]

TYPE OF LOUVER	CHANGE IN V (PERCENT OF V)	
	0°	45°
(1)	(2)	(3)
Chhajja	−20	−20
Horizontal and vertical	+5	+10
Box type :		
Contraction ratio 1 : 1	0	−25
Contraction ratio 2 : 1	0	0
Multiple horizontal	−10	−13
Multiple vertical	−15	−25

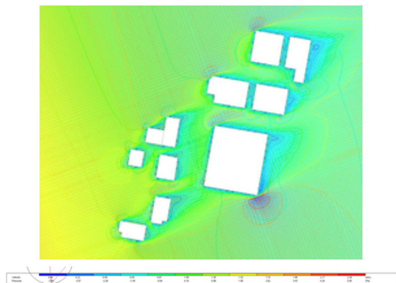


Fig 80: Wind simulation diagram

VALUE PROPOSITION

Fig 81: Self sustaining center

Design:

- Redefining resilience
- Water , energy, and biogas cycle - net positive
- Increasing connectivity
- Flexible community space
- Resilience for 300 people with efficient water availability of 4-5 days
- Natural invaders we overcome them by raising the plinth of structure
- **Self-sustaining community resilience shelter that caters to the need of community and cattle.**
- The design stands as a tourism for outsiders to visit as well as homely to villagers and animals

Built:

- Vernacular material stabilizes using modern technique
- Trusses timber + manglore tiles
- Natural mud using with rice husk forming abobe bricks which stabilizes the structure where rice husk does the role of reinforcement.

Operate:

- High Capex, but low Opex
- Few operation things to be carried out after structure being build including cleaning, basic treatment and landscape.

Pricing:

- The base cost is 81,078 INR per. sq.m and the estimated comes out to 60,423 INR per. sq.m

  aspects that we applied to reduce our pricing,
- Use of local material
- Use of local labor
- Integration of solar panels in design has increased the Capex cost
- Reduced the use of pumps by placing the oht at high position on site.

VALUE PROPOSITION

Community Benefits:

Fig 82: View of the resilience center

- The community is involved in the building process thus providing them with **employment facilities** and **exposure to new techniques** using their native materials.
- The community gets **ownership of the center** as they can manage the centre build for them ,by them.
- With functions which cater pre-disaster drills, during resilience shelter, and post resilience assistance, and various other lifestyle functions which makes the operation of the community centre reliable.

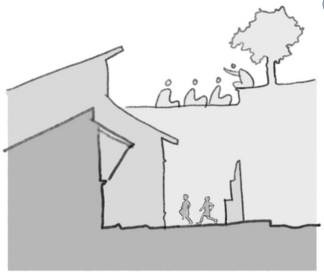


Fig 83: Facilities for children

Children & Youth:

1. new apertures and exposure to education and technologies
2. safe area for play and rest

Fig 84: Facilities for women

Women:

1. female hygiene awareness
2. small business job openings

Fig 85: Facilities for animals

Animal:

1. safe space for shelter
2. health checkups

Fig 86: Facilities for senior citizens

Senior citizens:

1. safe place for recreation
2. access to medical camp

USP's:

- Built by the community for the community using the techniques of native.
- Caters to the well-being of the community makes the village feel like an extended family as well as opens new opportunities for employment.
- During a disaster, a backup of 60 hours of food, water, energy, and security maximizes the comfort of the community and its cattle.
- Overall it is also on updradation in lifestyle for the community.

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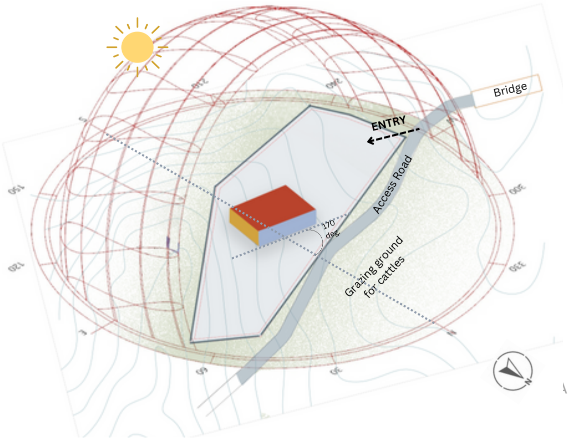
- https://energypedia.info/wiki/Cooking_with_Biogas

DETAILED BUILDING AREA PROGRAM

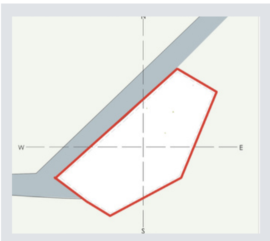
FUNCTION	NO. OF USERS	SIZE OF UNIT (m^2)	NO. OF UNITS	TOTAL AREA (m^2)	REMARKS	CONDITIONING	FUNCTION DURING DISASTER
AO Common Room	6	35	1	30	Keeps account of all the actvities in the stucture.Conducting village and gram panchanayt meet.	Unconditioned	Used to manage the center and keep a track of the basic needs of rescued people
Training Centre Wing (TC)							
TC Laboratory	13+2	31	1	31	Centre providing training for various small businesses, menstrual hygiene, waste disposal	Unconditioned	Also used as a sleeping space during resilience at night
TC Equipment Storage	2-3	5	1	5			
Toilet block	40	40	1	40			
Learning Center Wing (LC)							
LC Library	20	43	1	43	Promoting education by providing exposure internet and technology	Unconditioned	-
LC E-Library	6	27	1	27			
Public spaces							
Community hall with mezzanine	300	600	1	600	used as a community hall for activities like health drives,weddings,death rituals.	Unconditioned	Can be used as Active during resilience as an accommodation
PS Toilet Block	40	46	2	92			
Guest based							
Guest house spaces	10	46	4	184	Used as a accomdation for guests visiting the village	Unconditioned	Can be used as Active during resilience as an accommodation
Bathroom Block	8	8	4	32			
Heath and services							
First-Aid Room	3	23	1	23	Provide health check ups on regular basis inside the community .The kitchen serves food for activities like health drives,weddings,death rituals.	Unconditioned	caters as an emergency health check room while loss of connectivity with the rest of the city and also provides emergency food storage
Common Kitchen	8	45	1	45			
Pantry Storage	2	10	1	10			
Waste adaptive reuse							
VermiComposting Pit	2	7	2	14	Promoting native practices, and thereby also providing an income making the structure is self suficient . Helps for making fuel used for cooking .	Unconditioned	The biogas produced during the time of resilence is stored is used to generate electicity.
Sewage Treatment plant	2		-				
Nadep	2	7	3	21			
Biogas Plant block	2	4+4+28	1	36			
Resilience based							
Seedbank	2	11	1	11	Active during resilience	Unconditioned	Can be used as Active during resilience as an accommodation
Cattle housing							
Health Centre	3	22	1	22	Providing regular health check-up for animals .	Unconditioned	Active during resilience as a shelter for the cattle providing food and comfort.
Cow Shed	85	124	2	248			
Goat Shed	150	141	1	141			
Common Hen Unit	500	41	2	82			
Cattle Food Storage	2	10	2	10			
Fodder Machinery	2	5	1	5			
Miscellaneous services							
circulation spaces				757			
Overhead tank		45		45			
Landscape and road areas							
Courtyards (b/w admin & lib)		22		22			
courtyards (guest house)		110		110			
bamboo plantations		240		240			
landscape		896		896			
roads + pedestrian		1140		1140			
Water collection tank		55		55			
backside area				1092			
Cumulative Calculation							
BUILT UP AREA				1716			
GROUND COVERAGE				2554			
LANDSCAPE				3555			
TOTAL				**6109**			

Climate zone - Warm and humid (ECBC)
Site area - 6109 sq.m
Estimated ground coverage -2554 sq.m
Proposed built-up area- 1716 sq.m

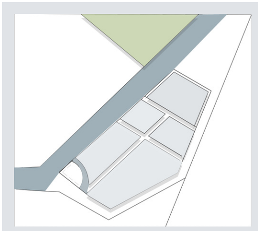
ARCHITECTURAL DRAWINGS



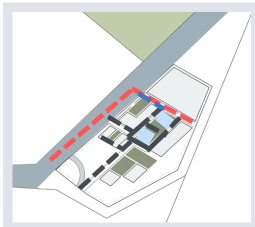
The site, located in the village of Vikramgad. The structure is oriented at 170° from the east with a radiation gain of 1180.35 kWh/m2.



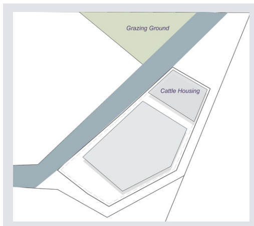
Site orientation- NE-SW



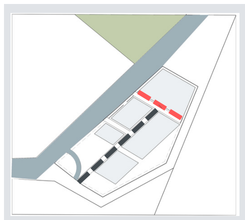
Linear access road similar to village typology with cattle and service entry separately



Addition of courtyards and waterscapes for better ventilation

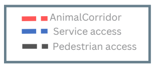


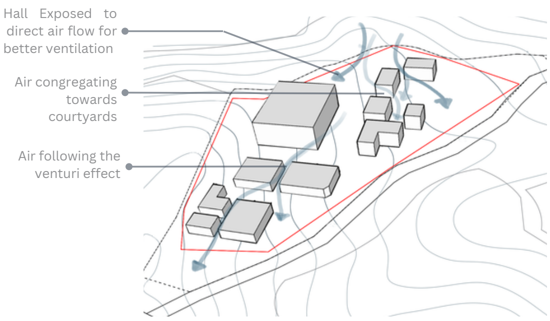
Cattle housing block placed adjacent to grazing ground



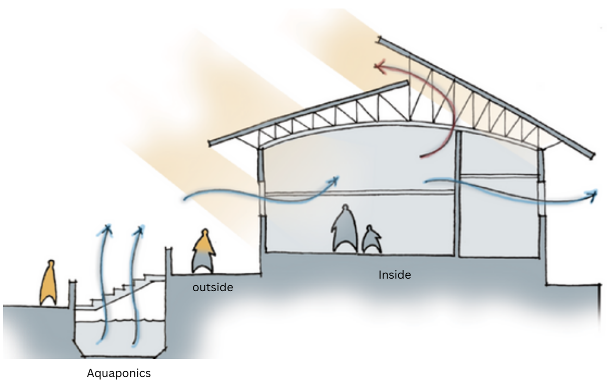
Division of masses according to accessibility

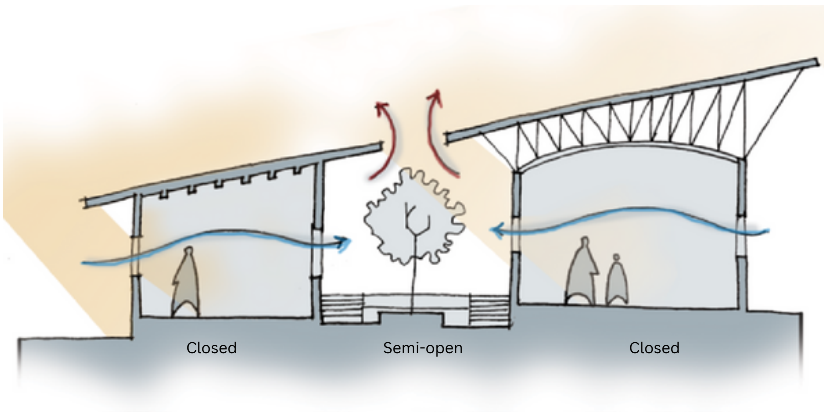
PRELIMINARY DESIGN GRID





Passive cooling techniques are used to keep the center well-ventilated and maintain the standard comfort level temperature.



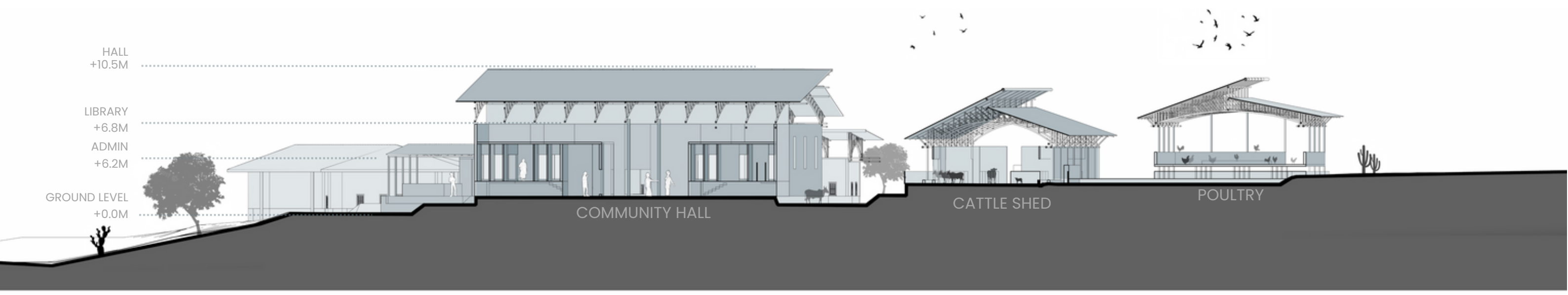


For passive cooling, the truss design allows the hot air to pass through it, cooling the internal spaces.
Evaporative cooling, courtyards are other ways of passive cooling techniques used.

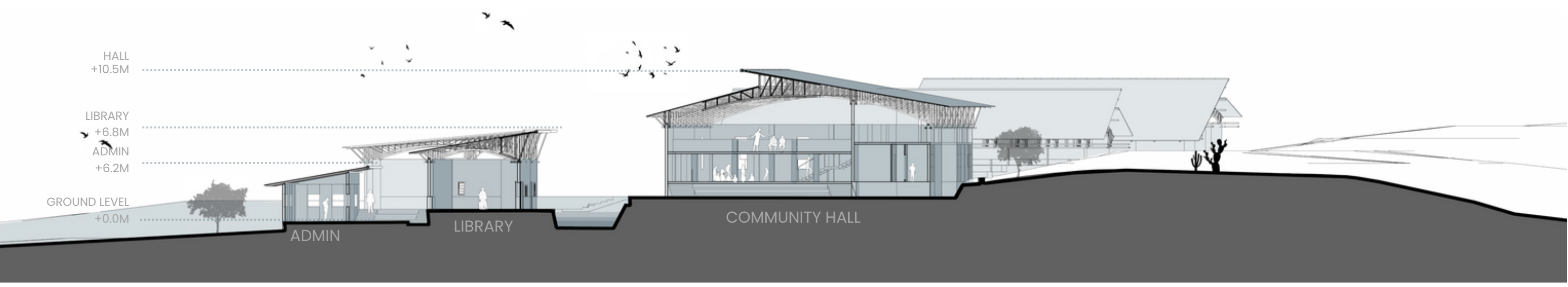
Fig 10: Master Plan.

LEGEND:

1. ENTRANCE
2. PARKING
3. ADMIN
4. LIBRARY & E-LIBRARY
5. TRAINING CENTER
6. FIRST AID
7. AQUPONICS POND
8. GUEST HOUSE
9. BACKYARD WITH OPEN KITCHEN
10. COMMUNITY HALL
11. NADEP
12. TOILETS
13. ANIMAL CORRIDOR
14. COW SHED
15. GOAT SHED
16. POULTRY
17. HEALTH CARE FOR ANIMALS
18. BIOGAS PLANT
19. OHT
20. KITCHEN



SECTION AA'

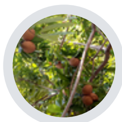
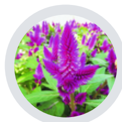


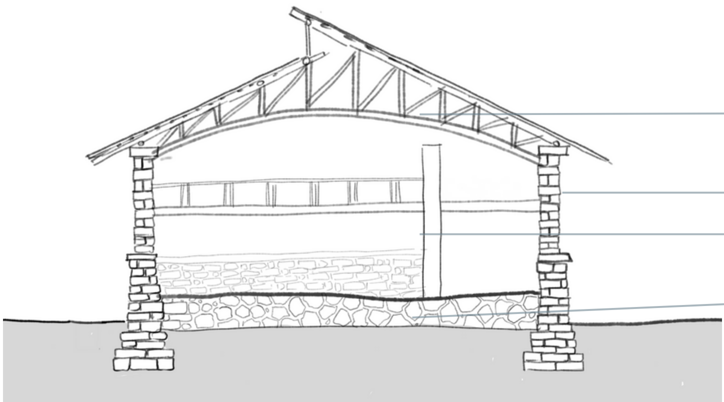
SECTION BB'

Fig 19: Section

VEGETATION PLAN

Fig 21: Vegetation plan

TYPE OF TREE	 NEEM	 CHAMPA	 CHICKOO	 LEMON	 TURMERIC	 KURDU
REASON	Shading and air purification	Light shading and fragrant tree	Shading	Medicinal plant and kitchen plant	Medicinal plant and kitchen plant	Flowering shrub
SPACE	Community hall , animal shelter , entrance and near opening	Library, near Guest housing,	Community hall , animal shelter , entrance and near opening	Kitchen garden	Kitchen garden	Open spill out spaces -library



MATERIALS

MEZZANINE MATERIAL: Timber planking supported by bamboo rafters with bamboo railing

COLUMN MATERIAL: Rubble columns

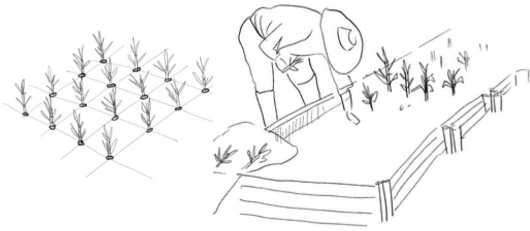
WALL MATERIAL: Rubble masonry with adobe bricks from sill level

PLINTH MATERIAL: Rubble plinth with stone foundation

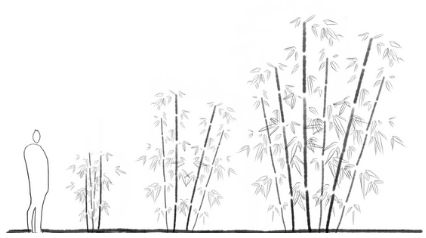
Process

Bamboo

Bamboo seedling
raised on nursery bed

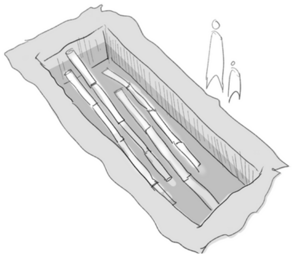


On site planting in grid



6-8 weeks of growing time

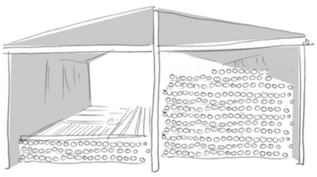
Harvesting- dry season

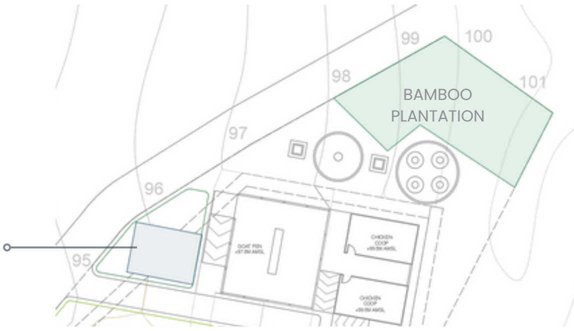


Construction of tank- dug into
ground- Tarpaulins sheets

Treatment -Cold soak method where the
bamboo is dipped in sol. of boric acid for
7-14 days

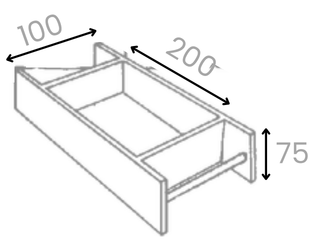
stacking-
temporary
storage





ADOBE

Adobe bricks are used to reduce the embodied carbon and better thermal insulation



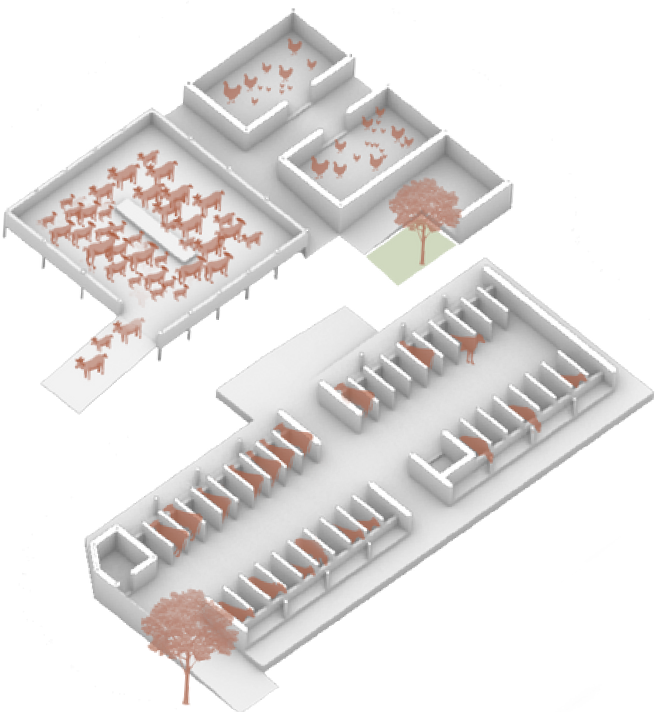
Size of adobe brick
200 X 100 X 75

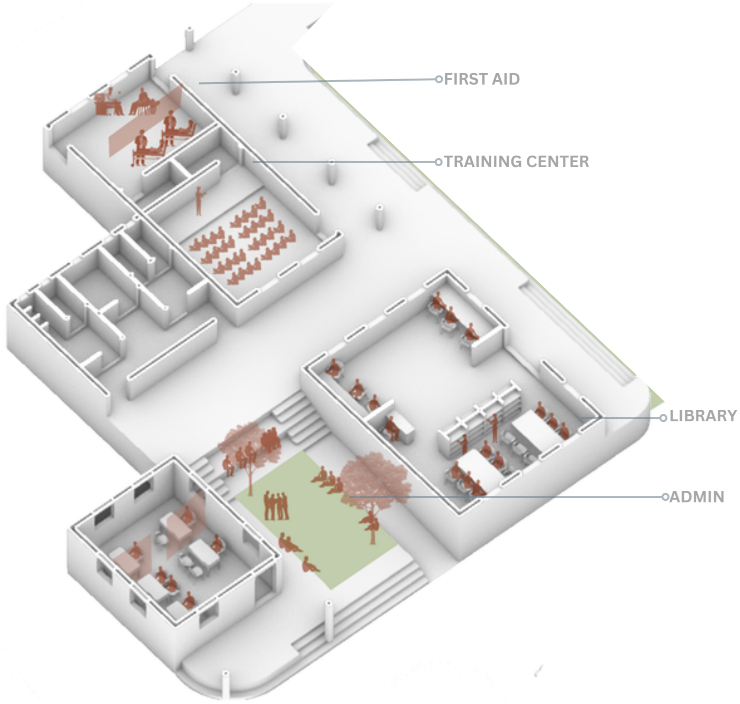
Composition in adobe

Slaked lime : M sand : *Surukhi*
in a proportion 2 : 1 : 7

- Slaked lime provides waterproofing and binding
- M Sand reduces voids and bleeding
- *Surukhi* provides hydraulicity and strength

ACTIVITY MAPPING





CATTLE SHED

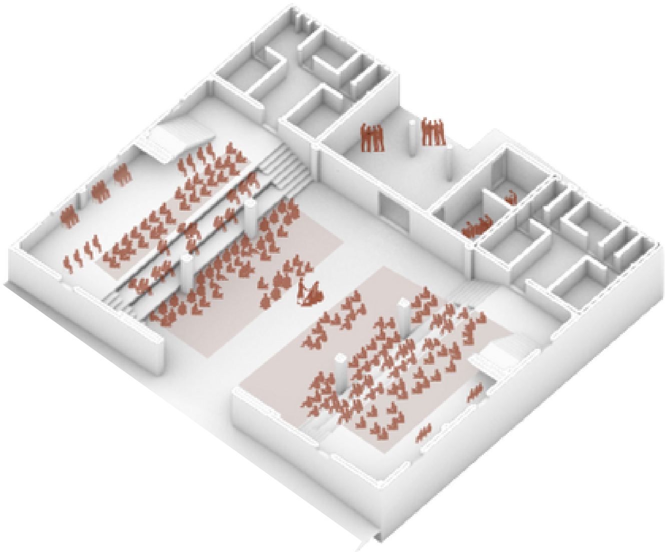
Accommodates the cattle, Goats, and Hen with proper segregation and health care.

TRAINING CENTER

A place to conduct workshops or small lectures to expose the villagers to the urban worlds

COMMUNITY HALL

Hall provides a space for large social gatherings like village meetings, Marriages, festivals, workshops etc.

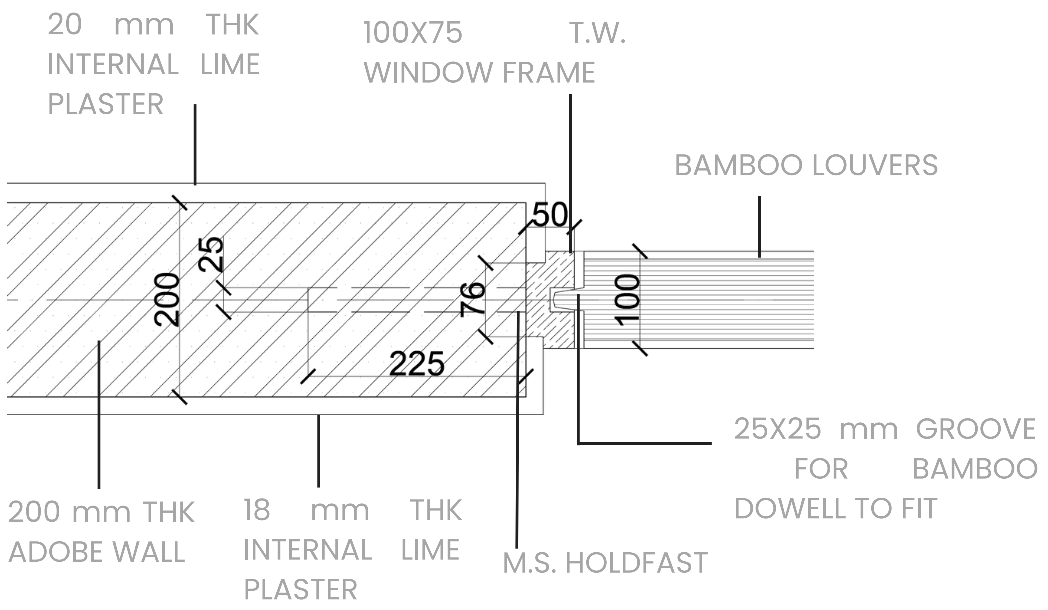


DURING MARRIAGE
The central part serves as a stage area with the radially guests gathering around it

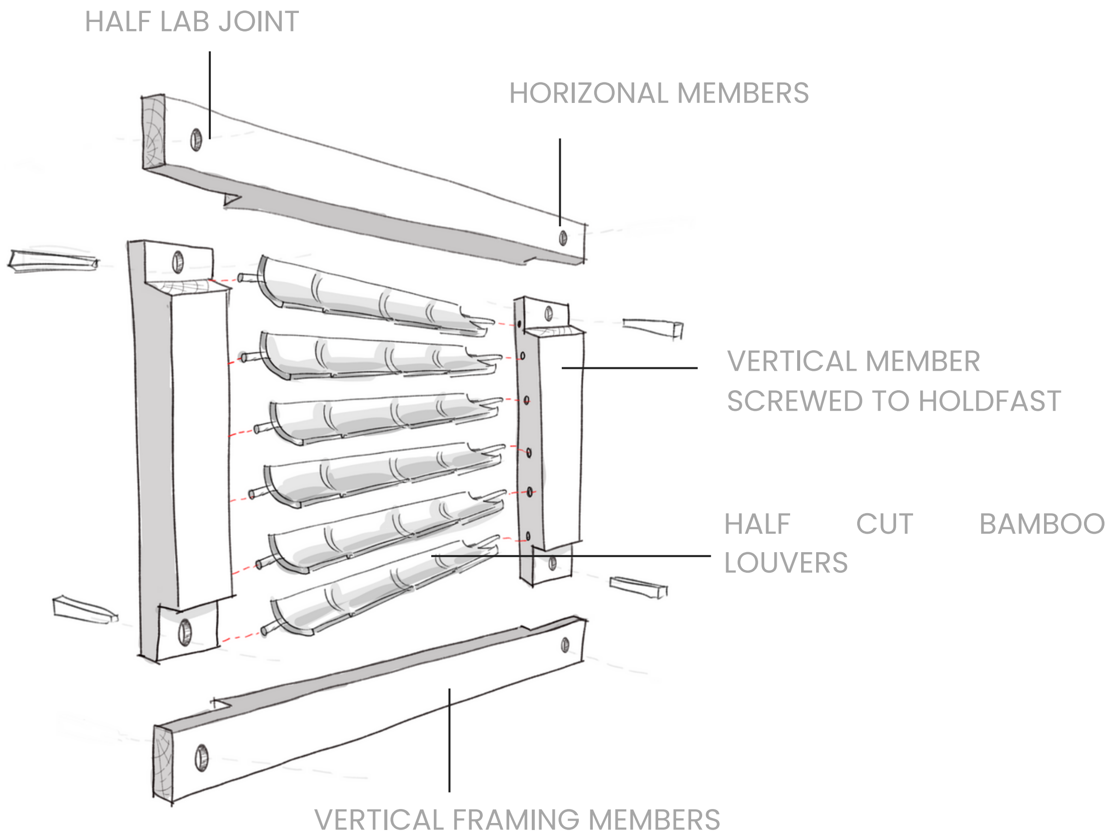
DURING HEALTH CAMPS
, The elevated platforms are converted to become a private booth for check-ups and the central part serves as a public orientation space.

ENGINEERING AND OPERATIONS

WINDOW JOINERY DETAIL:



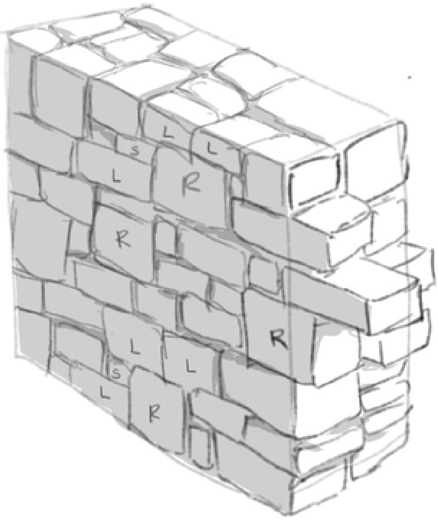
PLAN SHOWING FRAME CONNECTION WITH ADOBE WALL



ISOMETRIC VIEW

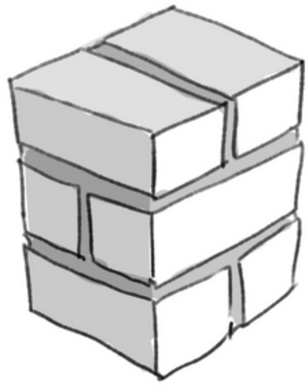
ENGINEERING AND OPERATIONS

RUBBLE MASONARY DETAILS:



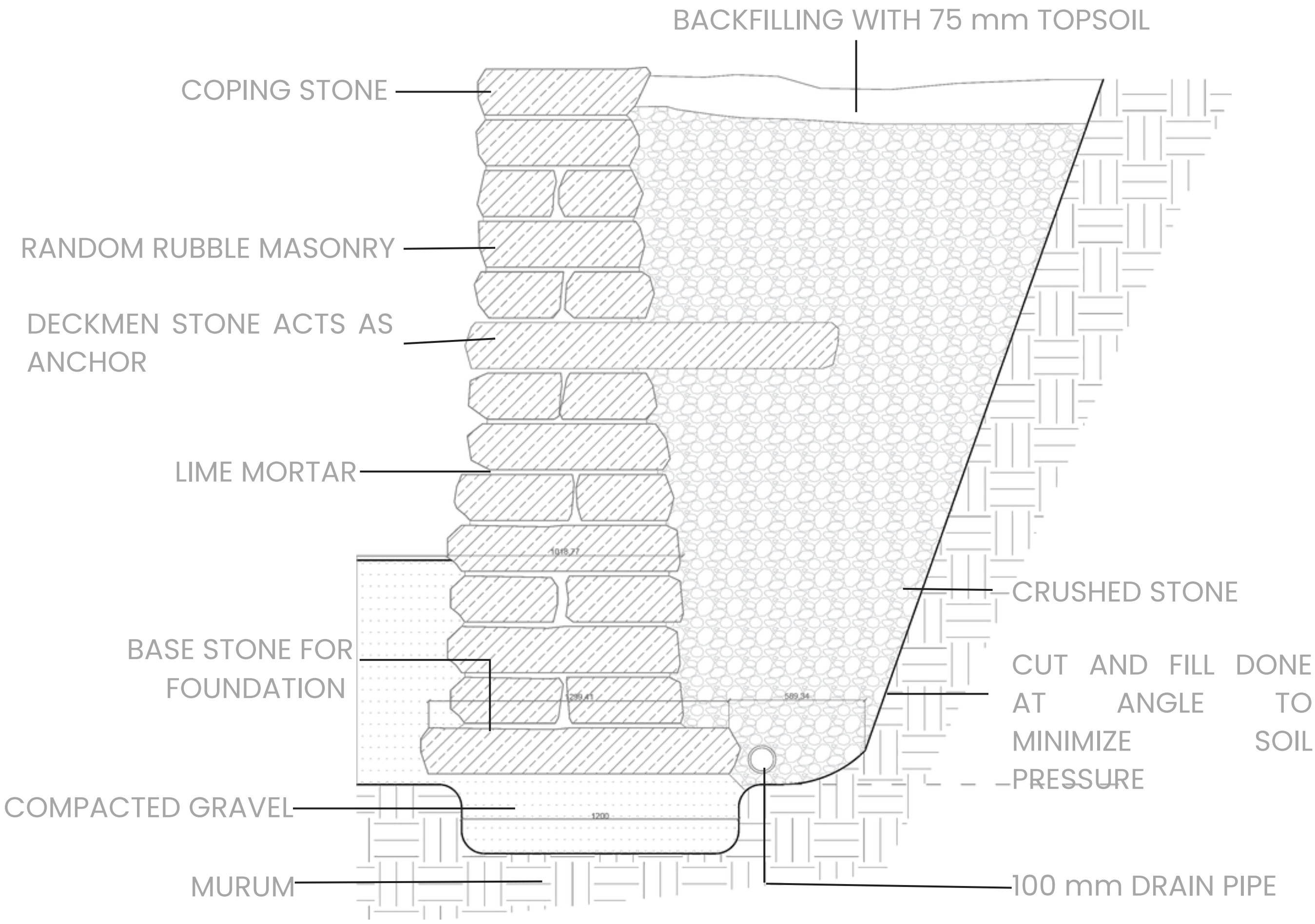
RANDOM RUBBLE
COURSED MASONRY

STONE MASONRY TILL SILL LEVEL

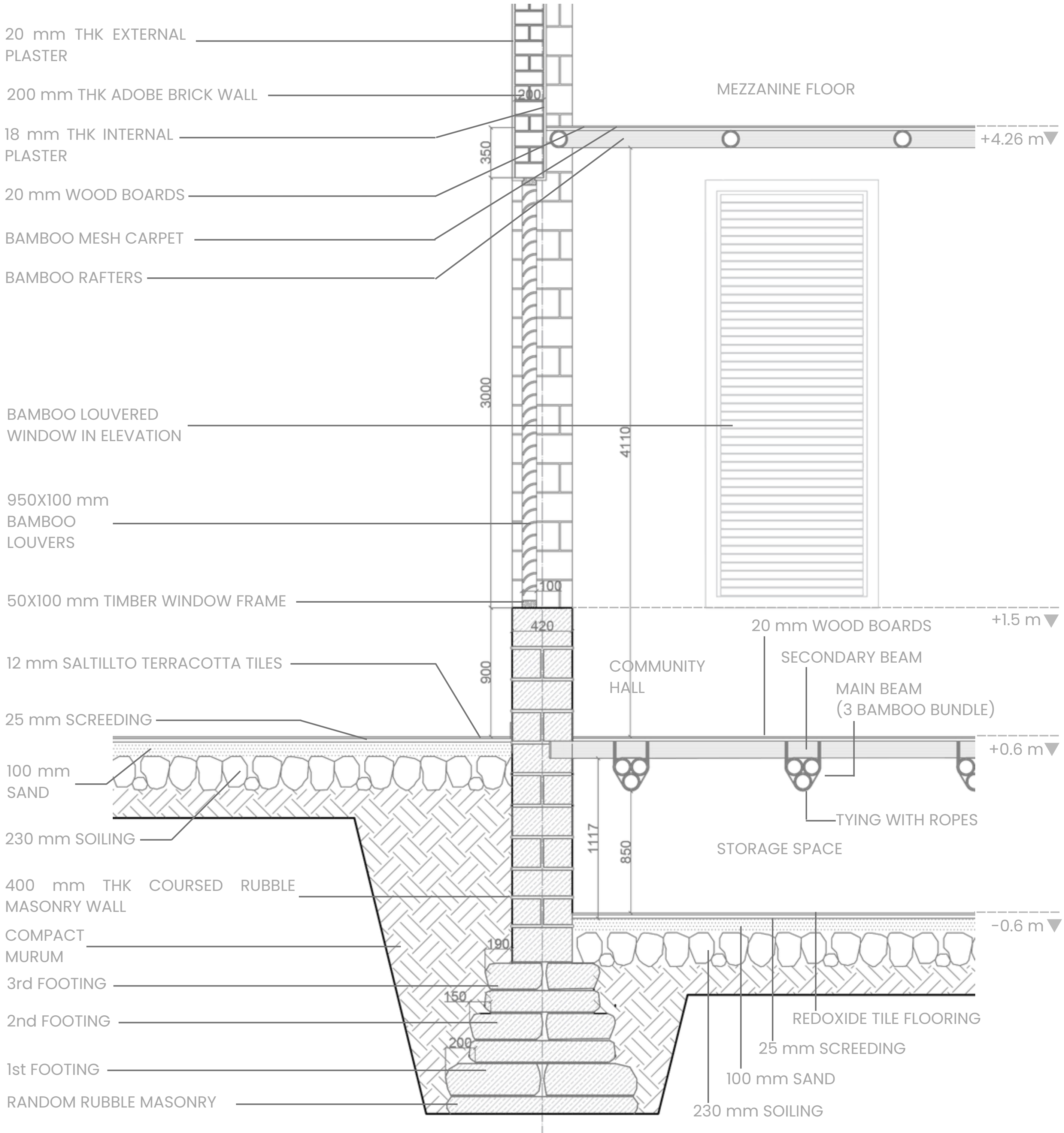


400x200x100 mm
DRESSED STONES
PLACED IN ALTERNATE
COURCES

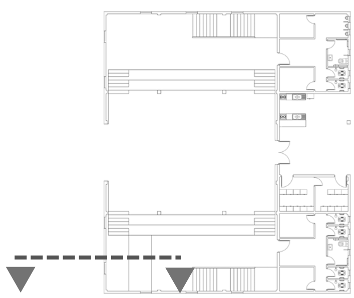
RUBBLE MASONRY PILASTER



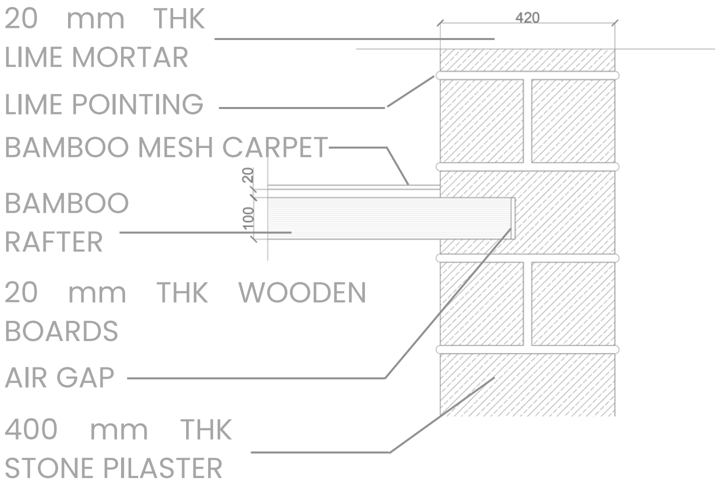
RETAINING WALL SECTION



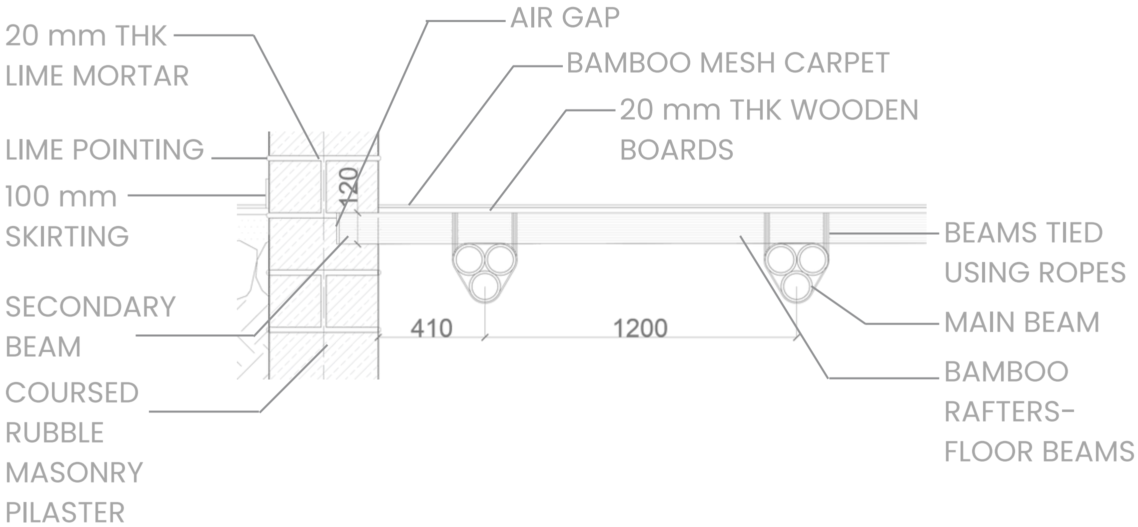
END WALL SECTION



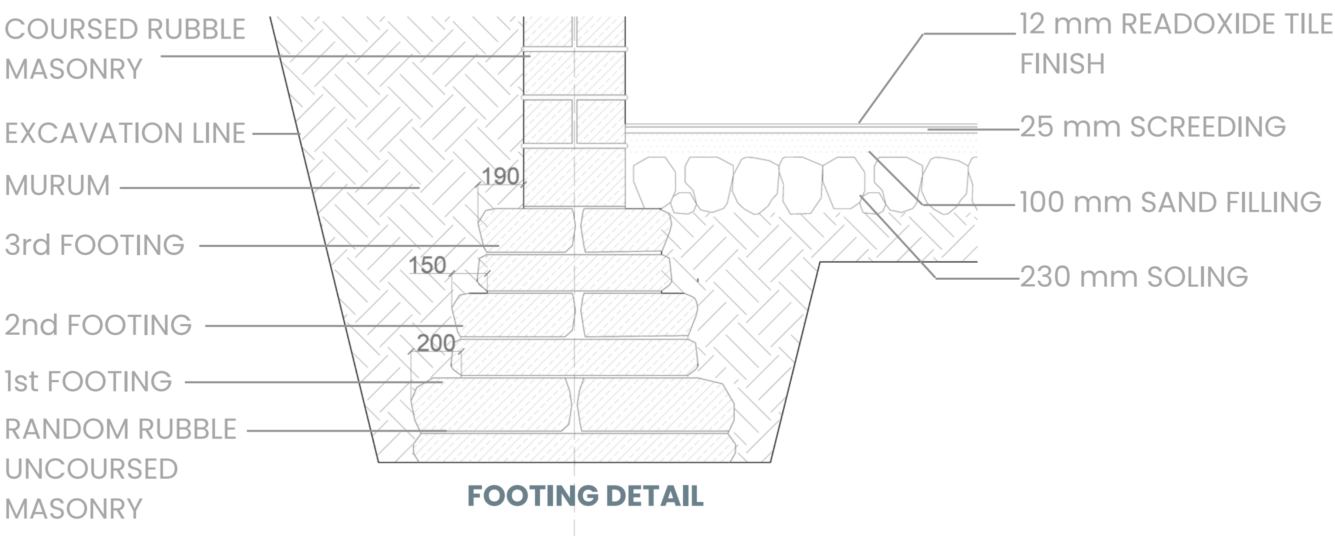
KEY PLAN



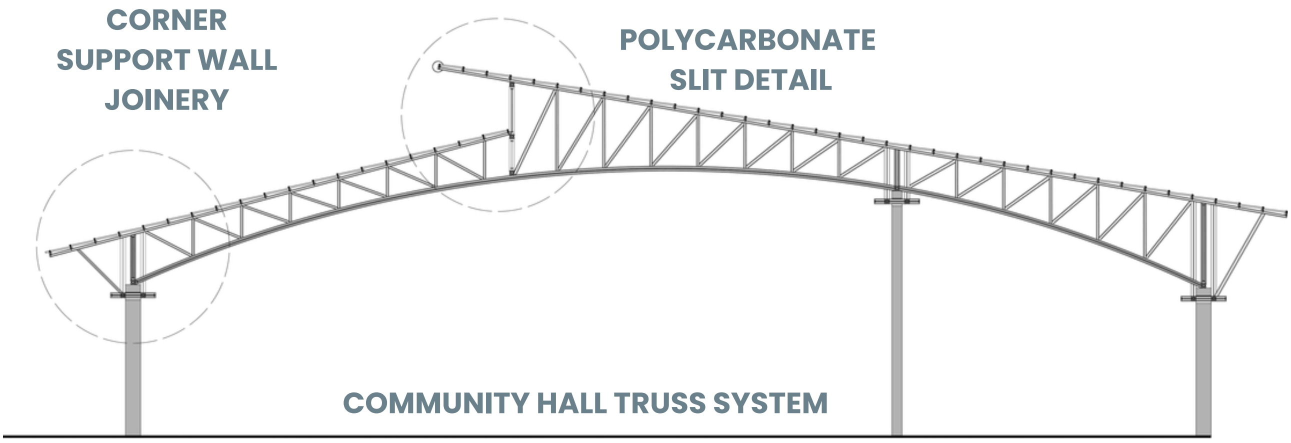
FLOOR SLAB DETAIL



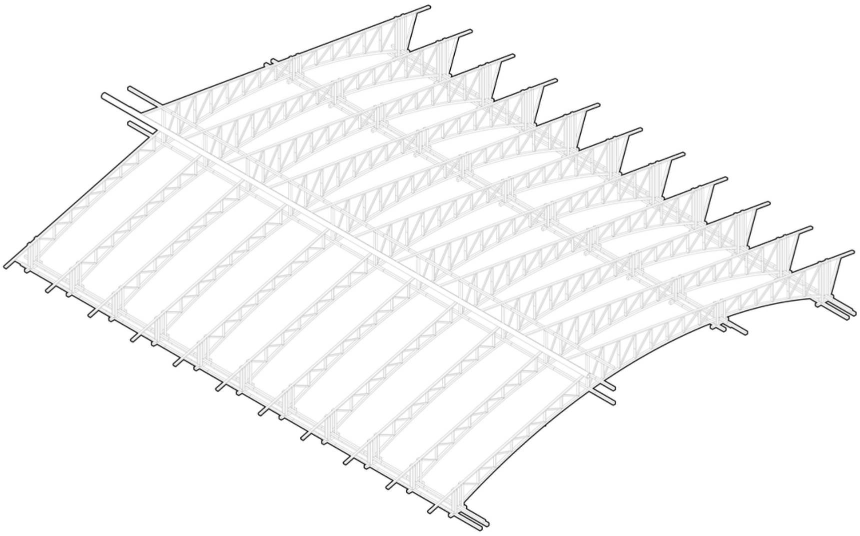
STORAGE FLOOR SLAB DETAIL



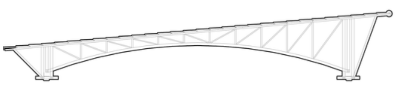
FOOTING DETAIL



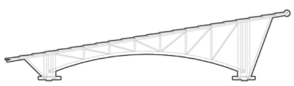
COMMUNITY HALL TRUSS SYSTEM



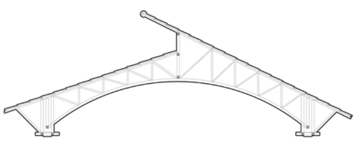
COMMUNITY HALL TRUSS AXOMETRIC VIEW



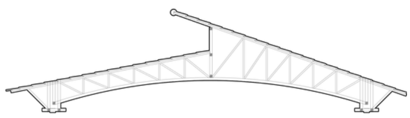
LEARNING CENTER



LIBRARY

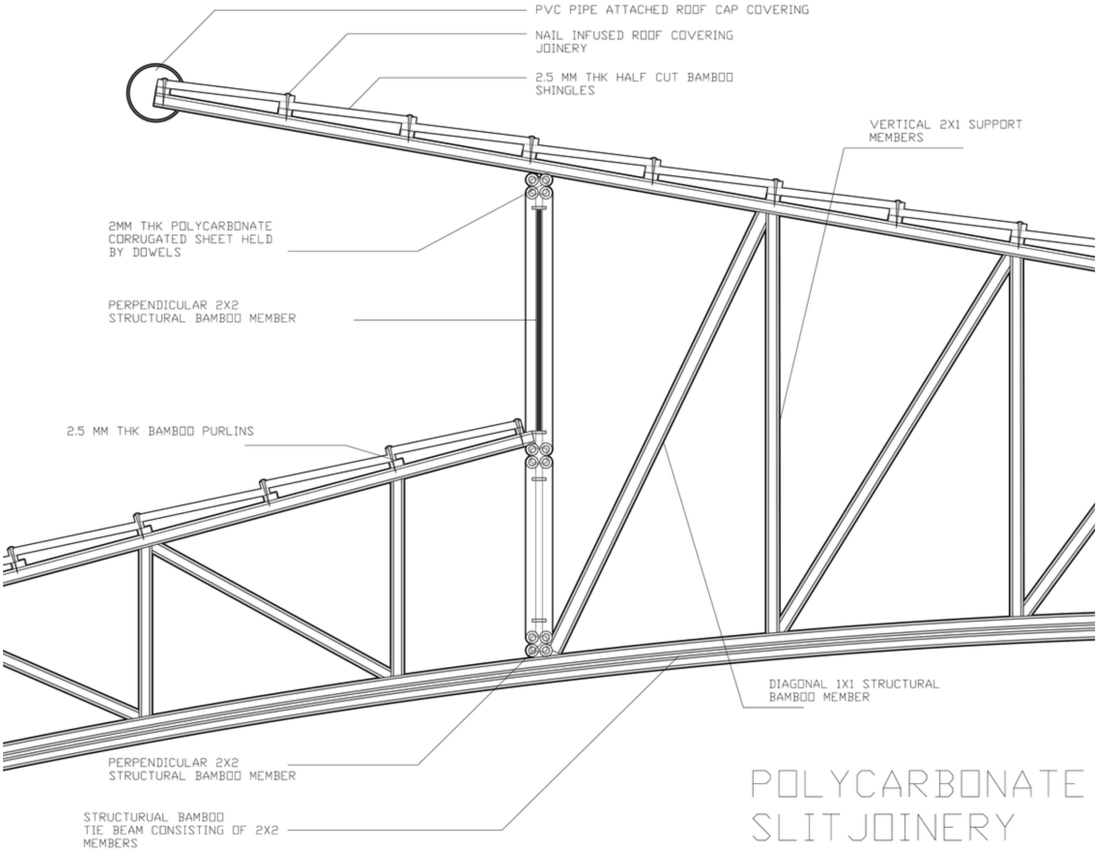


CATTLE SHED

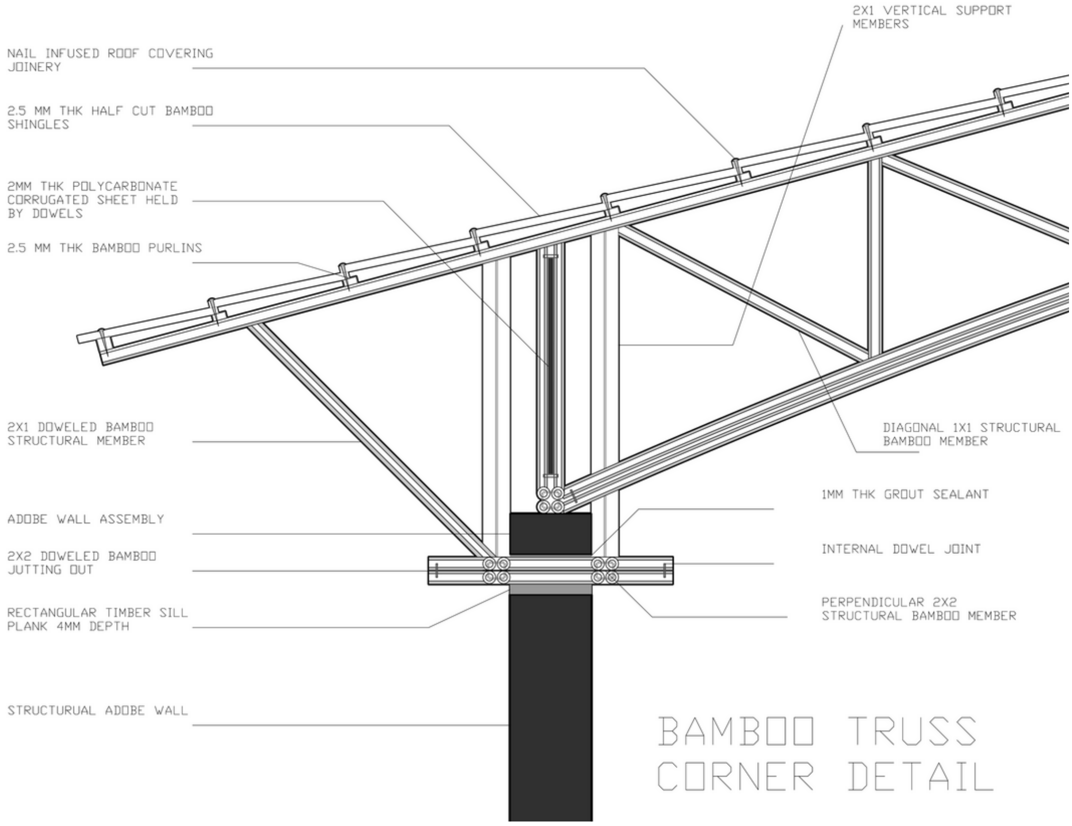


HEN COUP

ALL SITE BASED ROOF TRUSS PROFILES



STRUCTURAL DETAILS AT TRUSS JUNCTIONS



OUTLINE SPECIFICATIONS

Out line of Building Systems	Solar panels	Biogas Plant	Ventilation		Rainwater harvesting System
Summary of building system installed	Solar panels consist of a hybrid system.	The fuel required for cooking is generated using the biogas plant.	Natural Ventilation in the building provides a cooling effect by natural air flow by cross ventilation from SW and SE, evaporative cooling, courtyard effect, and thermally driven buoyancy.	Mechanical ventilation of the bulding includes fans.	Harvested rainwater is collected through a hybrid system of bioswales, water channels, drains, and from roof run-off.
Description of automated operations, if applicable	Automation of power switch.	-	-	Automation of power switch.	Automation of power supply to pump.
Instruction for operating the building system	-	-	-	-	-
Description of manual operations, if applicable	When the power is not supplied from all three phases, that is not sufficient enough for all the appliances to work. During these conditions, occupants can switch on the battery-stored solar power.	Dump cow dung manually not more than 475kg. Checking of gas valves to avoid explosion or fire. Clearing the slurry produced as by product and using it as manure for farming.	Occupants can operate the windows to maintain there comfort level, depending upon health and environmental conditions. The windows can be opened full or half shutter during summers and winters to achieve thermal During heavy rains and high speed winds as well as to maintian privacy, occupants can adjust shutter louvers according to there comfort.	When occupants feel increase in humidity levels of the room, they can utilize the mechanical ventilation system by switching on the fan.	Pumping water to OHT in rainy seasons daily.
Instruction for regular inspection and maintenance	Cleaning the solar panels using water and mops bi-weekly bases during summer and winter season	The slurry canals & inlet outlet tanks should be cleaned to avoid blocage daily before use. Gate valve and gas pipe line be tested for leakage and rectification.	Check the windows for smooth operation and leaks before and after the monsoon season every year.	Check all components and tighten anything that may have come loose with a screwdriver. Lubricate Ceiling Fan Bearings	Bi-weeklycleaning of accumulated sediments,leaves and debris, to avoid breakage in water flow in water Checking and repairing the damage cause by weather,humans,
	Lead acid batteries used, required refilling of distilled water yearly.	Gas holder and dome are checked for leakage in 6 months. Worn out accessories are to be repaired or replaced yearly Gas taps/gas cock may need lubrication monthly.	Clean the dust accumalated on lovers for clean air to pass through.	Use a vacuum wand attachment or feather duster to remove all dust Check and clean the motor every 14 days.	Controlling vegetation growth in and around water channels by remoing plants weekly. Replacing the dead or damaged vegetation in bio swales monthly.
Operations of the system in critical mode	During extreme events, when the grid power supply is restricted, solar power is switched. This would provide electrical supply to the community hall, aminal shelter & first aid. Restricting the supply to certain blocks can reduce the load on battery storage and increase the supply time.	During extreme events when gas production is low due to a shortage of cow dung, the gas can always be produced by collecting cow dung produced from the cattle in the village.	-	During events when mechanical ventilation stops working due to technical issues, window shutters can be opened to allow natural airflow.	During a shortage of water supply a backup of 48 hours is provided.

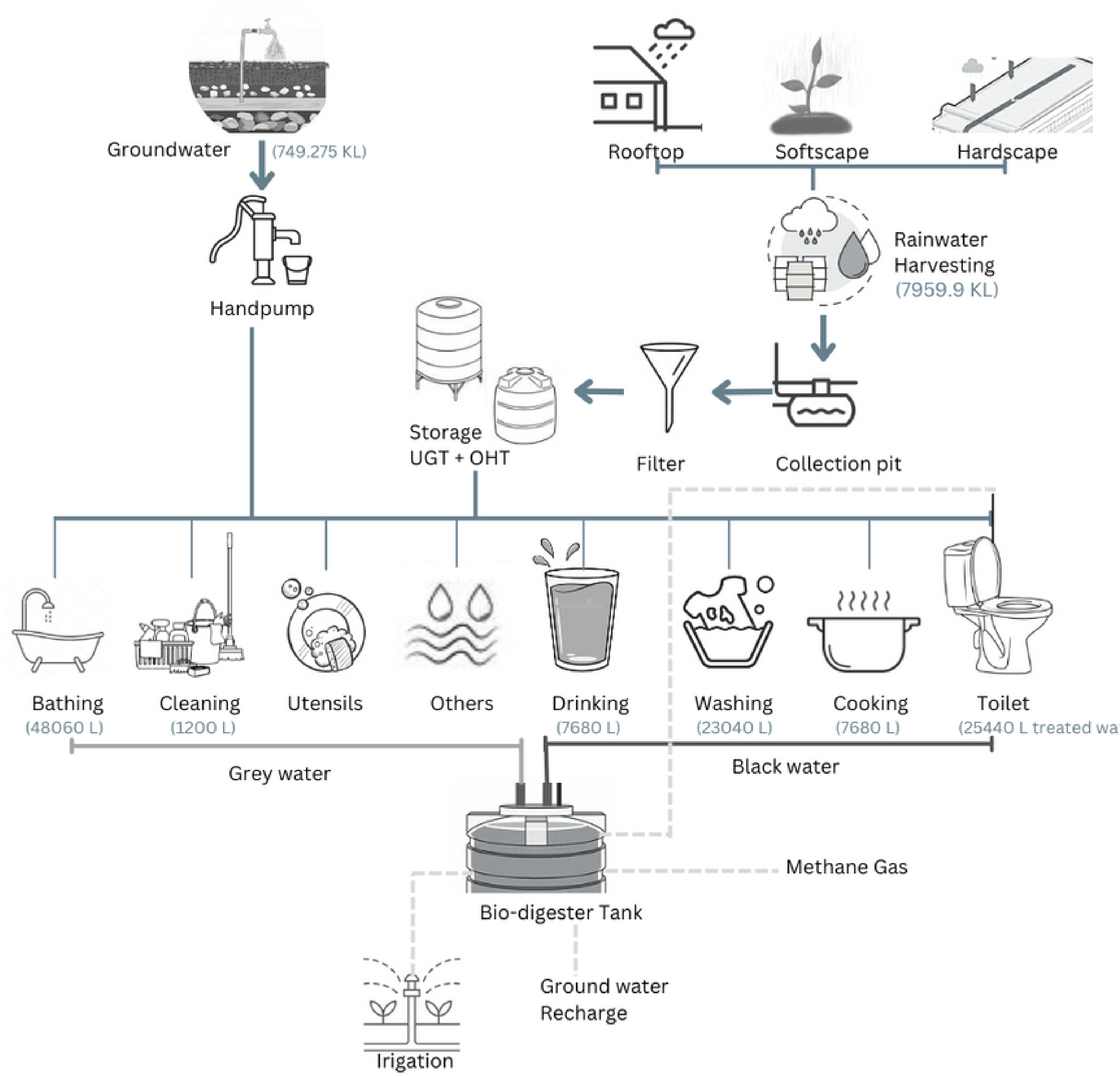
ENERGY SIMULATION INPUTS

Input Parameters	Proposed Design Values
General	
Building Area	1716 sq m
Conditioned Area	0 sqm
Electricity Rate	7 INR/kWh
Natural Gas Rate	0 INR/GJ (BIOGAS USED)
Building Occupancy Hours	8HRS (from 9am -5pm)
Average Occupant Density	0.17 person/m²
Internal Loads	
Interior Average Lighting Power Density	2.62 W/m²
List of Lighting Controls	Switch board
Minimum OA (outside air) Ventilation (Building Average)	17 l/sec.m²
Envelope	
Roof Assembly U value	1.4
Roof Assembly SRI	0.32
Average Wall Assembly U value	0.293 W/m².K
Window to Wall Area Ratio (WWR)	20%
Windows U value	5.894
Windows SHGC	0.861
Windows VLT	0.898
Infiltration Rate	0.5 ach
Describe Exterior Shading Devices	The adobe bricks are used for walls with angular facades on the south side. To prevent rainwater from destroying the bricks, the lower part (Height: 1m from the plinth) is made of rubble.

Input simulations

NET- ZERO WATER CALCULATIONS

SUMMARY OF WATER CYCLE:



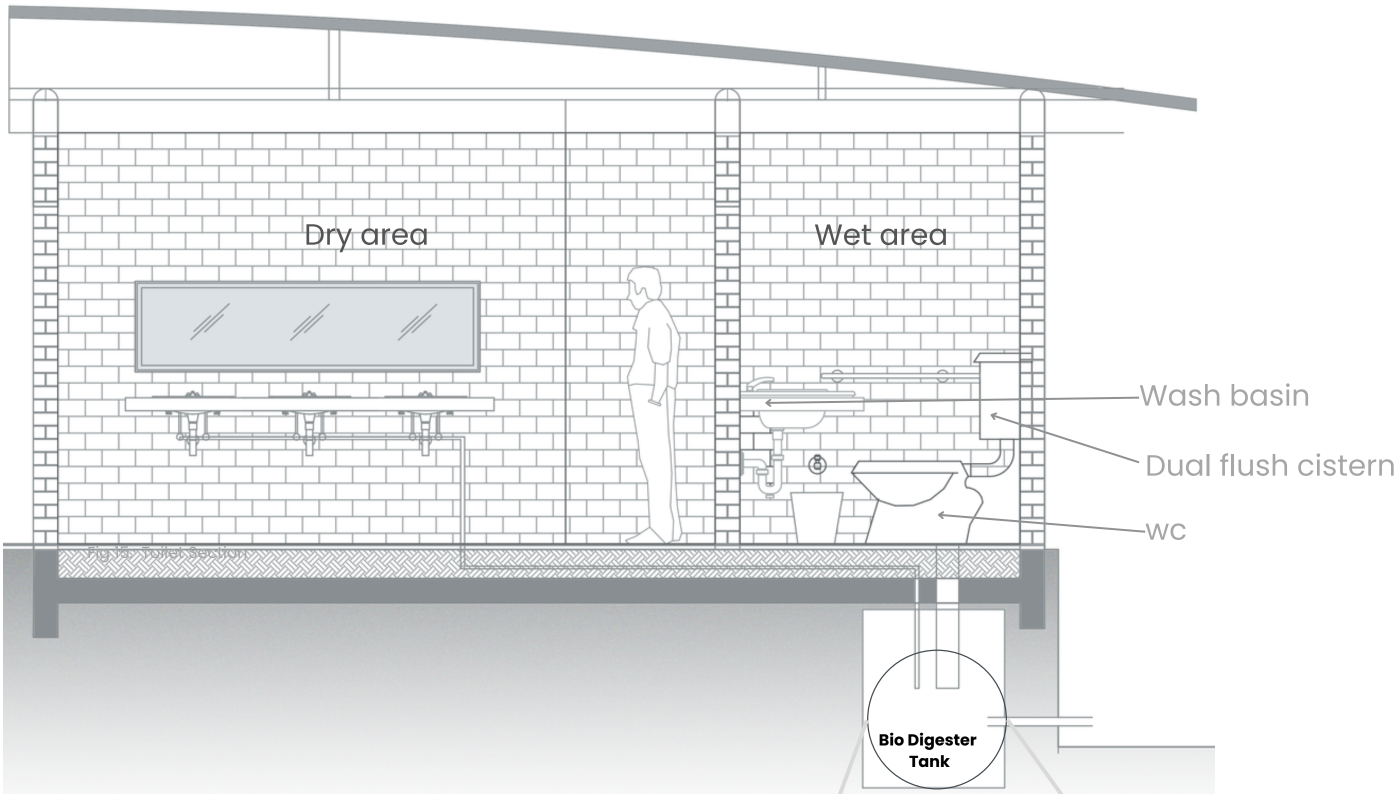
The net-positive water cycle is achieved with a demand of **55 liters per person per day**. The water demand is therefore **reduced by 55.25%** using the principle of Reduce, reuse, and recharge. The effective methods for storage, treatment, collection, and optimization are achieved by the usage of bioswales, bio digesters, and aerators.

Water use	Quantity	Quantity
Domestic Use (LPD/ Head)	300	55
Irrigation (max) : {m2 x l/m2}	1000	1.7
Cooling tower (max) : {Ton x l/Ton}	0	0
Other	-	-

Table 08: Water Usage

Rainwater harvesting surfaces	Area(m2)	Running co-efficient	Effective Catchment area(m2)
Roof Surfaces	3200	0.85	2720
Hardscape Area	1140	0.7	798
Softscape Area	2415	0.3	724.5
Others	-	-	-
Total Effective Catchment Area			4242.5

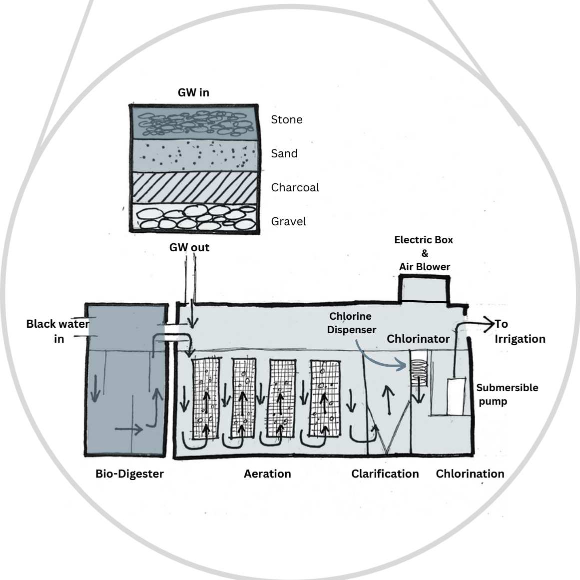
REUSAGE OF WATER THROUGH BIO-TIOLETS:



SECTION THROUGH TOILET

FILTRATION PROCESS

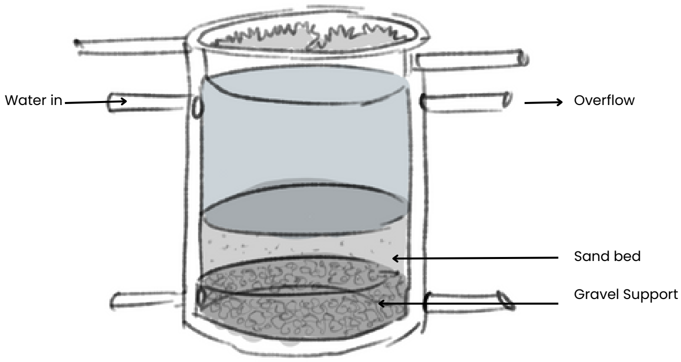
Pr im ar y	Secondary	Tertiary
Filtration	Removal of nutrients and contaminants	Final cleaning process
	Biological/ physiochemical methods	Removes remaining inorganic compounds , bacteria, microorganisms, parasites
Removes solids that might clog up the other treatments	Use microbes, sunlight,oxygen	Alum might be used
	Aerobic process require more energy	Water polishing - usage of UV rays
	Anerobic process require less energy	



BIO-TOILETS

A biodigester tank is an in which microorganisms are able to break down organic matter into **biogas** and **liquid fertilizer** through a process called anaerobic digestion. Organic matter can include a variety of waste products, such as agricultural waste, **animal manure**, or even **human waste.**

WATER CALCULATIONS AND SYSTEMS:
WATER SEDIMENTATION



Sediment filtration is a process of removing suspended solids and other large particles from water. Sediment filters are typically made of a **bed of sand, gravel,** or other media that has various sizes of pore spaces.

WATER CALCULATIONS:

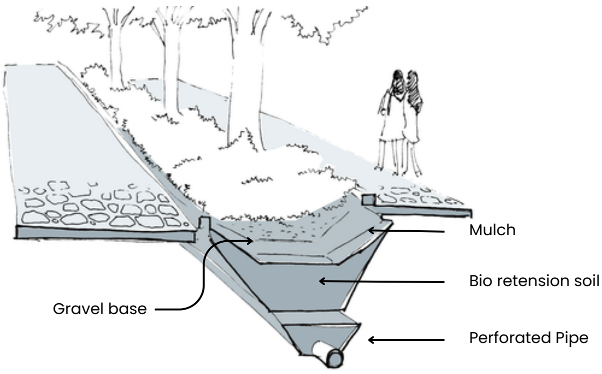
Per Capita Consumption per day			
Activities	Domestic (lts)		
	Period of Standard Use	Period of Resilience	
Wash basin	4L (10%)	2L (6.667%)	40 Litres of water for standard use and reduce to 30 litres in time of resililence
Drinking	12L (30%)	10L (33.33%)	
Cooking	2L (5%)	2L (6.667%)	
Cleaning	4L (10%)	1L (3.334%)	
Activities	Flushing (lts)		
WC flushing	12L(30%)	10L(33.33%)	
Urinal Flushing	6L (15%)	5L (16.667%)	

Per Capita Consumption per day			
Activities	Domestic (lts)		
	Period of Standard Use	Period of Resilience	
Wash basin	1.5L (8.5%)	1L (6.667%)	Aided by using aerators and reuse of greywater, water consumed is reduced to 17.5 Lts and 15 Lts during Resilience time
Drinking	12L (68.5%)	10L (66.667%)	
Cooking	2L (11.4%)	2L (13.334%)	
Cleaning	2L (11.4%)	2L (13.334%)	
Activities	Flushing (lts)		
WC flushing	0	0	
Urinal Flushing	0	0	

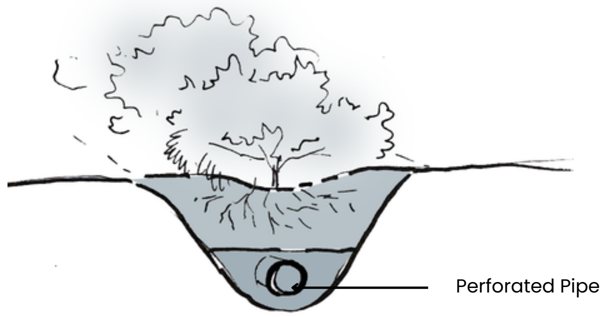
Occupant's Activity	Percent Usage	Quantity	Grey Water	Black water
	%	litres	litres	litres
Drinking	9.09	2	0	2
Cooking	9.09	2	0	2
Flushing	27.27	6	0	6
Bathing	54.54	12	12	0

Vol.		Area	Height	Capacity days
OHT				
75000		50	1.5	4.5
Storage Tanks (Community Hall, Toilet Block ,Guest Housing)				
Domesti	375	2.5	1.5	3
c	0	2.5	1.5	3
Flushing	375 Water Collection pit			
1,00,000	0	50	2	3
Septic Tank				
14140		7.07	2	3

BIOSWALES



Bioswales are a type of green infrastructure used for stormwater management. They are shallow channels that are designed to capture, filter, and treat stormwater runoff.



WATER LAYOUT PLAN:

NET ZERO WATER CALCULATIONS:

Months	Occupancy	No. of days	Rainfall (mm)	Effective rain (mm)	Harvested rainwater (l)	Whitewater: Drinking (per person 2l)	Cooking	Cleaning (per person 2l)	Bathing (per person 12l)	Washing	Animal drinking	Greywater Reuse: Flushing 3 lpf	Irrigation	Total grey water consumed per month	Total Water Consumption per month	Total Black Water Generated per month	Reduced blackwater per month
January	Daily - 30	26				60	60		360	180	8 Cows + 8 Goats+ 20 Hens 250	180	600 sq.m x 1 litre = 600 litres		9497	9497	75
	Events - 300	5	0	0	0	600	600	100	3600	1800		2000		3380			2238
February	Daily - 30	25				60	60		360	180		180			9497	9497	75
	Events - 300	3	0	0	0	600	600	100	3600	1800		2000		3380			2238
March	Daily - 30	26				60	60		360	180		180			9497	9497	75
	Events - 300	5	0	0	0	600	600	100	3600	1800		2000		3380			2238
April	Daily - 30	25				60	60		360	180		180			9497	9497	75
	Events - 300	5	0	0	0	600	600	100	3600	1800		2000		3380			2238
May	Daily - 30	26				60	60		360	180		180			9497	9497	75
	Events - 300	5	0	0	0	600	600	100	3600	1800		2000		3380			2238
June	Events - 300										8 Cows + 8 Goats+ 20 Hens 3450	2000		2600	430500	430500	2238
	Resilience	30	585	580	1566000	600	600	100	3600	1800							
July	Events - 300											2000		2600	444850	444850	2238
	Resilience	31	1162	1157	3123900	600	600	100	3600	1800							
August	Events - 300											2000		2600	444850	444850	2238
	Resilience	31	710	705	1903500	600	600	100	3600	1800							
September	Events - 300											2000		2600	430500	430500	2238
	Resilience	30	370	365	985500	600	600	100	3600	1800							
October	Daily - 30	26				60	60		360	180	8 Cows + 8 Goats + 20 Hens 250	180			9497	9497	75
	Events - 300	5	105	100	270000	600	600	100	3600	1800		2000		3380			2238
November	Daily - 30	25				60	60		360	180		180			9497	9497	75
	Events - 300	5	45	40	108000	600	600	100	3600	1800		2000		3380			2238
December	Daily - 30	26				60	60		360	180		180			9497	9497	75
	Events - 300	5	0	0	0	600	600	100	3600	1800		2000		3380			2238
TOTAL		365		7956900		7680	7680	1200	46080	23040	biogas	25440		37440	1826676	1826676	27456

Summary of Cost Estimation

Project Summary									
Project Informa	Project Information								
	Team:	Nishtha							
	Division:	Community Resilience Shelter		Land Cost:	100	Million INR			
		Site Area (sqm)	6,234		City:	Palghar			
		Built-up Area (E	1,752		State:	Maharashtra			
		Ground Coveraį	2,185						
Project Summary									
			aseline Estimate (Project Partner / SOR basis			Proposed Design Estimate			
S.No.	Particulars	Definition	ount in Million	%	(INR per sqm)	ount in Million	%	(INR per sqm)	
1	Land	Cost of land pu	100	63.70%	57,078	100	63.70%	57,078	
2	Civil Works	Refer Item A, C	39.94	25.50%	22,797	38.77	24.70%	22,130	
3	Internal Works	Refer Item B, C	2.25	1.40%	1,282	1.72	1.10%	983	
4	MEP Services	Refer Item C, C	0.69	0.40%	397	0.7	0.40%	399	
5	Equipment & F	Refer Item D, C	0	0.00%	-	0	0.00%	-	
6	Landscape & S	Refer Item E, C	0.19	0.10%	110	0.12	0.10%	70	
7	Contingency	Amount added	2.15	5.00%	1,229	2.07	5.00%	1,179	
	TOTAL HARD COST		145.23	96.20%	82,893	143.38	95.10%	81,840	
8	Pre Operative E	Cost of Permits	0.02	0.00%	11	0.02	0.00%	11	
9	Consultants	Consultant fees	0.06	0.00%	34	0.06	0.00%	34	
10	Interest During	Interest paid on	11.62	7.40%	6,632	6.4	4.10%	3,653	
	TOTAL SOFT COST		11.7	7.50%	6,677	6.48	4.10%	3,699	
	TOTAL PROJECT COST		156.93	100.00%	89,570	149.86	95.50%	85,538	

Summary

1. The cost of landscaping is reduced significantly by the usage of native species which require no cost for plantation.
2. Built-in furniture reduces the capital cost of furnishing and increases durability reducing maintenance costs.
3. Contingency cost is estimated to be greater because of the usage of materials like bamboo which require appropriate sizing and material handling.
4. Charges for MEP services are significantly reduced by the use of passive and native techniques in architecture.

Strategies

- The proposed cost estimate is substantially decreased due to use of local materials **reducing the transportation cost.**
- Right-sizing of materials to **reduce material wastage** and any opex costs for refurbishing the materials ISHRAE standards.
- labor cost is reduced as the **community itself is employed** in the construction.
- The landscape is such planned that only native trees are planted which **don't require special maintenance** and also **aid in reusing water** several times with biological treatments.
- Passive systems of ventilation, and shading, are devices that increase the capex cost but **reduce the recurring opex cost**.
- The community hall modifies itself to create an **economy-generating marketplace.**

EMBODIED CARBON CALCULATIONS

	Materials	Units	Quantity	Emissions Factor	Material Emissions	Type of vehicle	No. of trips	Total distance	Total fuel consumed	Transport Emission	Type of vehicle	No. of trips	Total distance	Total fuel consumed	Transport Emission
DESIGN STANDARDS															
WALL	Adobe	kg	1860	0.01	18.6	Lorry	1.0	59.6	24.0	144.2	Lorry	1	2	0.8	4.8
	Local Mortar	kg	500	0.11	55	-	0.0	0.0	0.0	0.0	-	0	0	0	0
	Stone	kg	200	0.01	2	Lorry	1.0	2.0	0.8	4.8	-	0	0	0	0
	Plaster	kg	8500	0.27	2295	-	0.0	0.0	0.0	0.0	-	0	0	0	0
	Water	l		0	0	-	0.0	0.0	0.0	0.0	-	0	0	0	0
			Total Material Emissions		118.53	Total Transport 1 Emission per functional unit				7.5	Total Transport 2 Emission per functional unit				0.2419
ROOF	Bamboo	kg	1450	1.5	2175	-	-	0	0.0	0.0	-	0	0	0	0
	Joinery bolting	kg	7	2.2	15.4	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.81	16.13
	Purlins	kg	87	1.5	130.5	-	-	0	0.0	0.0	-	0	0	0.00	0.00
	Half Cut Bamboo	kg	1450	1.5	2175	-	-	0	0.0	0.0	-	0	0	0.00	0.00
	Polycarbonate sheet	kg	6	3	18	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.81	16.13
			Total Material Emissions		225.695	Total Transport 1 Emission per functional unit				48.1	Total Transport 2 Emission per functional unit				1.6
FLOOR	Stone	kg	2500	0.01	25	Lorry	1	2	0.81	4.84	Lorry	1	2	0.81	4.84
	Soil Fill	kg	3000	0	0	-	0	0	0	0	-	0	0	0	0
	Plastic Bottles	kg	1500	0	0	-	0	0	0	0	-	0	0	0	0
	Lime plaster	kg	1430	0.43	614.9	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
			Total Material Emissions		31.995	Total Transport 1 Emission per functional unit				7.451612903	Total Transport 2 Emission per functional unit				0.4838709677
FENESTRATION	Wooden frame	kg	20	2.4	48	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Bamboo Jali	kg	20	-0.43	-8.6	-	0	0	0.00	0.00	-	0	0	0.00	0.00
	Shutters	kg	45	2.4	108	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
			Total Material Emissions		7.37	Total Transport 1 Emission per functional unit				14.41935484	Total Transport 2 Emission per functional unit				0.48
STRUCTURE	Stone Column	kg	2500	0.01	25	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Rubble Rubble footing	kg	1000	0.01	10	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Coarsed Quoin Stone	kg	997	0.056	55.832	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Coarsed Basalt Stone	kg	900	0.056	50.4	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Hard Stone Foundation	kg	3750	0.27	1012.5	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
			Total Material Emissions		57.6866	Total Transport 1 Emission per functional unit				8.177419355	Total Transport 2 Emission per functional unit				0.24

TABULAR ANALYSIS OF BASELINE CONSIDERATIONS

	Materials	Units	Quantity	Emissions Factor	Material Emissions	Type of vehicle	No. of trips	Total distance	Total fuel consumed	Transport Emission	Type of vehicle	No. of trips	Total distance	Total fuel consumed	Transport Emission
BASELINE STANDARDS															
WALL	Brick	kg	7260	0.39	2831.4	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Cement	kg	1460	0.91	1328.6	-	0	0	0.00	0.00	-	0	0	0.00	0.00
	Steel reinforcement	kg	20	2.6	52	Lorry	1	2	0.81	4.84	-	0	0	0.00	0.00
	Lime Plaster	kg	500	0.27	135	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Stone	kg	200	0.009	1.8	-	0	0	0.00	0.00	-	0	0	0	0
			Total Material Emissions		217.44	Total Transport 1 Emission per functional unit				14.66129032	Total Transport 2 Emission per functional unit				0.4838709677
ROOF	Steel	kg	1450	2.5	3625	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Joinery Wireframe	kg	8	2.2	17.6	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.8	16.1
	Steel Purlins	kg	120	3.5	420	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.8	16.1
	Mangalore tiles	kg	3300	0.51	1683	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Glazed Glass	kg	100	1.2	120	Mini truck	1	59.6	24.0	480.6	Mini truck	1	59.6	24.0	480.6
			Total Material Emissions		293.28	Total Transport 1 Emission per functional unit				86.51612903	Total Transport 2 Emission per functional unit				26.12903226
FLOOR	Stone	kg	2500	0.01	25	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Soil Fill	kg	3000	0	0	-	0	0	0	0	-	0	0	0	0
	PCC bedding	kg	0	0	0	-	0	0	0	0	-	0	0	0	0
	RCC	kg	1500	0.26	390	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Tile	kg	2300	0.47	1081	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
			Total Material Emissions		74.8	Total Transport 1 Emission per functional unit				14.66129032	Total Transport 2 Emission per functional unit				0.48
FENESTRATION	Timber frame	kg	20	2.4	48	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.8	16.1
	Glazed Glass	kg	20	0.8	16	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.8	16.1
	Shutters	kg	45	2.4	108	Mini truck	1	59.6	24.0	480.6	Mini truck	1	2	0.8	16.1
			Total Material Emissions		8.6	Total Transport 1 Emission per functional unit				72.09677419	Total Transport 2 Emission per functional unit				2.419354839
STRUCTURE	RCC	kg	2500	0.26	650	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	RCC Step footing	kg	1000	0.26	260	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
	Coarsed Quoin Stone	kg	180	0.056	10.08	Lorry	1	2	0.81	4.84	-	0	0	0	0
	Coarsed Basalt Stone	kg	1650	0.056	92.4	Lorry	1	2	0.81	4.84	-	0	0	0	0
	PCC Bed	kg	3750	0.27	1012.5	Lorry	1	59.6	24.03	144.19	Lorry	1	2	0.81	4.84
			Total Material Emissions		101.249	Total Transport 1 Emission per functional unit				22.11290323	Total Transport 2 Emission per functional unit				0.7258064516

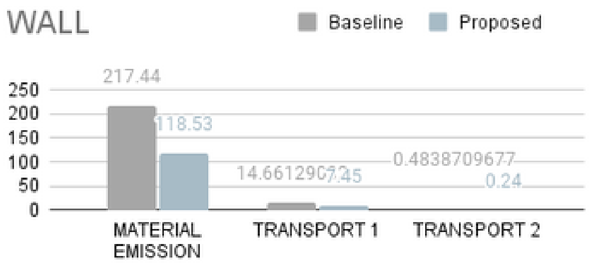
TABULAR ANALYSIS OF PROPOSED CONSIDERATIONS

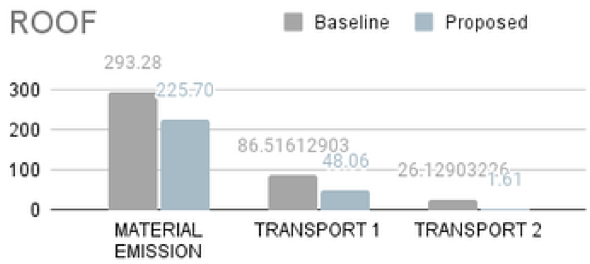
SUMMARY CALCULATION								
	BASELINE				PROPOSED			
SYSTEM TYPE	MATERIAL EMISSION (kg-CO2 e)	TRANSPORT 1 (kg-CO2 e)	TRANSPORT 2 (kg-CO2 e)	TOTAL (kg-CO2 e)	MATERIAL EMISSION (kg-CO2 e)	TRANSPORT 1 (kg-CO2 e)	TRANSPORT 2 (kg-CO2 e)	TOTAL (kg-CO2 e)
WALL	217.44	14.66	0.48	232.59	118.53	7.45	0.24	126.22
ROOF	293.28	86.52	26.13	405.93	225.70	48.06	1.61	275.37
FLOOR	74.8	14.66	0.48	89.95	32.00	7.45	0.48	39.93
FENESTRATION	8.6	72.10	2.42	83.12	7.37	14.42	0.48	22.27
STRUCTURE	96.125	22.11	0.73	118.96	57.69	8.18	0.24	66.11
	GRAND TOTAL emissions per functonal unit (kg-CO2 e)			930.54	GRAND TOTAL emissions per functonal unit (kg-CO2 e)			529.9

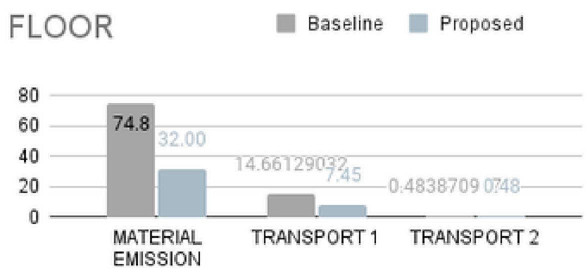
SUMMARY ANALYSIS OF CARBON EMISSIONS

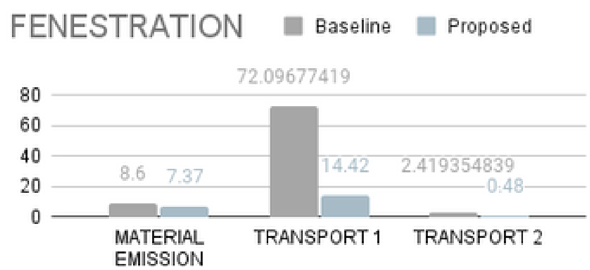
EMBODIED CARBON CALCULATIONS

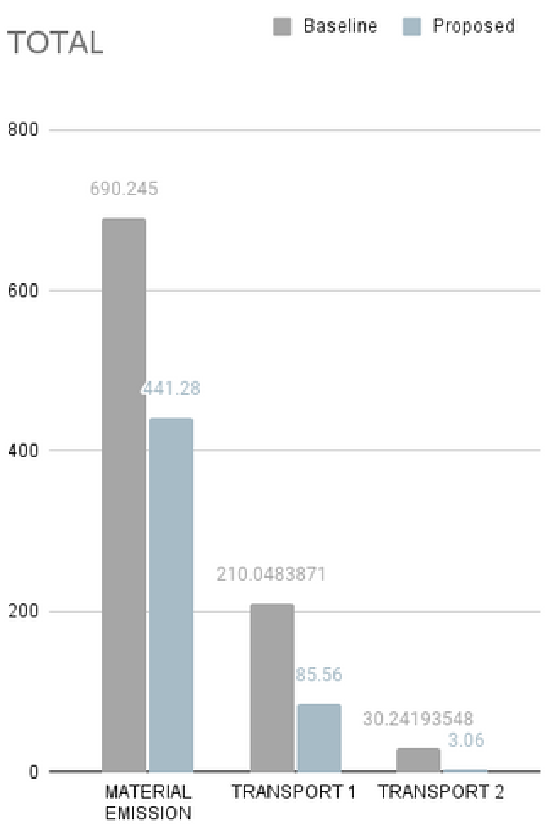
GRAPHICAL ANALYSIS OF CARBON EMISSIONS WRT BUILDING SYSTEMS

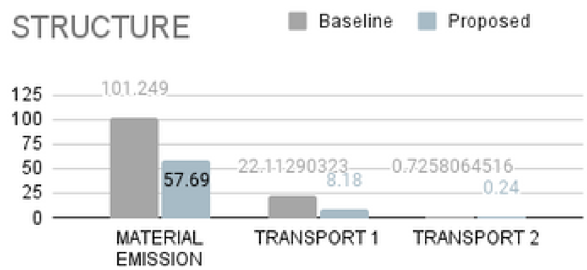












OVERALL ANALYSIS OF CARBON EMISSIONS

SUMMARY:
Thus as observed, in comparison to baseline cases an overall 40.1% reduction in all carbon emissions is observed. The Architectural design and engineering work together to devise various means of lowering emissions at all scales of design.

BUILDING OPERATIONAL NARRATIVE

Exterior lighting:

- LED Street light provides lighting solution during evenings and nights
- Operated by the village staff.
- To navigate the villagers during the night, the LED street lights which are along the roadside should be lit. And at the time of the resilience or whenever the center is occupied at night, the streetlights should be lit to ensure security.
- Make sure to switch off the lights soon after sunrise.

Interior Lighting:

- Toilet lights need to be on all the time whenever the community center is in use.
- The use of natural light is encouraged to save energy usage.
- Village staff should check all the switches before leaving and make sure to switch them off. This is to be done to not only save energy but also to avoid fires and short circuits.
- Important spaces like a community hall, first aid, and cattle shed should be lit brightly during the resilience period.

Thermal comfort and ventilation system, including operable windows:

- Opening of windows - half shutter, full shutter to maintain the thermal comfort level
- To maintain the privacy or to restrain the rainfall from entering, one can adjust the shutter louvers to permit the entering wind.
- If the humidity level of the room increases, one must switch on the fans.
- Partially opened windows and doors, partially opened windows and doors can still provide adequate ventilation especially when the weather is colder.
- Village staff shall open windows and doors fully to air spaces before and after occupancy open windows fully at the start and end of the day to ventilate the room fully.
- Opening windows and doors opposite each other, will facilitate a quick exchange of room air for fresh air.

Renewable energy and on-site energy storage system:

Solar:

- Main circuit board to be operated by the village staff in times of resilience, maintenance or whenever required.
- Cleaning of solar panels to be done by the village staff during the summer and winter season on bi-weekly basis to prevent accumulation of dirt or dust which reduces the efficiency of the panels.
- Cleaning to be done with clean water and mop to remove the stuck on dirt or dust on the panels.
- Don't cover the panels with anything, tall trees should not be allowed to grow near the panels to ensure maximum exposure to sunlight.
- Ensure battery storage area to remain free from moisture at all times.
- Maintenance of the lead acid batteries to be done on yearly basis to ensure proper functioning and prolonged life of the batteries.
- Don't touch the battery terminals, cleaning of the batteries should be done by a proper technician.
- Use of hybrid system for power supply grid to maximize the use of solar power during the time of need.
- Auto switching between main power grid and solar power when electricity gets shut off from main power grid, no manual switching required by the village staff.
- Don't manually switch between main power grid and solar power unless required.
- Manual switching to be done by the village staff if needed during unavailability of one or two of the three phases from the main power grid.

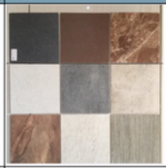
Biogas plant:

- Remove, straw pieces of sticks, etc. from the slurry (mixture of dung and water) before feeding.
- Village staff shall remove, straw pieces of sticks, etc. from the slurry (mixture of dung and water) before feeding.
- Village staff shall break the scum formed on the surface of the slurry in the digester by rotating the gas holder daily after feeding.
- Close the main gas cock by the end of operational hours of the structure after the use of gas is over.
- Use soap solution for testing leakage of gas in the dome/gas holder.
- Don't inhale biogas since it may be hazardous.
- Don't make the air shutter tight or too loose. In both the cases, there would be incomplete combustion and thus wastage of gas.
- Don't add either more water or less water to make a homogeneous mixture with cattle dung for feeding.
- Don't allow soil or sand particles to entire the digester along with the slurry.
- Feed biogas plant with cattle dung and water in 1:1 proportion, making it a homogeneous mixture after thorough mixing.
- End users or villagers using the biogas as fuel should not inhale it and lit the gas properly using a lighter.

Water supply and wastewater processing system

- The water system will be a partially automated system as at a few junctures we rely on the natural forces of plants and the groundwater.
- Maximum rainwater will be harvested during the months of June - October through surface and roof runoff. One should ensure that these surfaces are maintained well by at least cleaning the ground surfaces daily and roof surfaces once in 3 days and are free of any hazardous chemicals that may pollute the water.
- The drains which are assisted by bioswales should be maintained weekly by trimming the plants and vegetation above them.
- All the storage tanks - overhead as well as underground to be cleaned at least twice a year.
- While cleaning first, drain the tank. Through the exit valve, drain the water. Make sure there won't be any localized flooding due to the water. With a bucket, collect any remaining water. The tank must first be cleaned and emptied from the outside.
- After that, sprinkle liquid detergent and baking soda on the tank walls after preparing the mixture. Scrub the interior of the tank with an abrasive sponge or bristle brush.
- Sediment, algae, rust, and biofilm can be ridden out with a pole-mounted brush or a power washer.
- All hoses, pumps, and pipes used to fill and empty the tank should be cleaned and rinsed.
- To obliterate the detergent and any other cleaning ingredient, use a water jet. Allow it to air dry.
- Clean your faucets with a mild cleaner and damp cloth to remove dirt particles and grease.
- Aerators get worn out and accumulate dirt over time. Ensure that you clean aerators at least annually.

PARAMETERS TO MEASURE THE PERFORMANCE OF BUILDING

Sanitary Fixtures	Cistern flush & flush tank(wall mounted)	Aerator	Taps	Wash basin	Kitchen sink	Tiles
Image of the Sanitary fixture						
Baseline water usage LPM (1 BAR Pressure)	6 lts					
Benchmark water usage LPM (1 BAR Pressure)	3 lts					
Cost (INR)	1,150	199	378	2,799	1,695	₹ 55/ ft²
Company	Hindware	Acetap	Alligator	REMANENCE	ATC Jindal	Kajaria

Electric Fixtures	LED Bulb	Batten Light	Switch Board	Street Light
Image of the Electric fixture				
Power Usage (kWh)	0.012	0.02	-	0.075
Cost (INR)	70	200	845	2,180
Company	Syska	Syska	Anchor	75W LED Street Light - Galaxy
Electric Fixtures	**Stand Fan**	**Ceiling Fan**	**Computer**	**Pump**
Image of the Electric fixture				
Power Usage (kWh)	0.06	0.06	0.25	0.75
Cost (INR)	3,300	1,800	30,000	11,500
Company	Crompton Pedestal Fan	Crompton Ceiling Fan - 1200 mm	HP, Intel	Crompton MBK1.52C - 1.5 HP Centrifugal Water Pump

BONAFIDES FROM EDUCATIONAL INSTITUTIONS

रचना संसद
RACHANA SANSAD'S
ACADEMY OF ARCHITECTURE
MUMBAI
FOUNDED IN 1955, AFFILIATED TO UNIVERSITY OF MUMBAI, RECOGNISED BY COUNCIL OF ARCHITECTURE AND GOVERNMENT OF MAHARASHTRA.

Ref. No. 06/stu/337/2302

Date : 07/02/2023

TO WHOMSOEVER IT MAY CONCERN

You are aware that Academy of Architecture, an Architecture Institution in Mumbai, imparts Five Year (full time) Bachelor's Degree Course in Architecture, affiliated to the University of Mumbai.

The undermentioned students of Third Year B. Arch studying during session 2022-2023 are participating in the design challenge of Solar Decathlon India. We acknowledge them as Bonafide Students from our esteemed College.

(Suresh M. Singh)
Principal
Academy of Architecture

ACADEMY OF ARCHITECTURE रचना संसद MUMBAI-25.

Name of the Students:-

1. Hetika Vani
2. Praniti Bhoir
3. Sandesh Jadhav
4. Pranay Kutal
5. Tejas Shinde
6. Shrutika Mahajan
7. Anushree Harmalkar
8. Isha Padte
9. Isha Keni
10. Nikita Jagzap
11. Rahul Bhoye

278, Shankar Ghanekar Marg, Prabhadevi, Mumbai - 400 025. Tel. : 2430 1024 / 2431 0807 Fax : 2430 1724
Email: contact@aoamumbai.in website : www.aoamumbai.in

BONAFIDES FROM EDUCATIONAL INSTITUTIONS

रचना संसद

RACHANA SANSAD'S
ACADEMY OF ARCHITECTURE

MUMBAI FOUNDED IN 1955, AFFILIATED TO UNIVERSITY OF MUMBAI, RECOGNISED BY COUNCIL OF ARCHITECTURE AND GOVERNMENT OF MAHARASHTRA.

Ref. No. AOAUA / STU / 367 / 2023

22nd February, 2023

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **SHRI ADITYA PARAG SHANBHAG** is a bonafide student of the Academy of Architecture (unaided) studying in the **Third Year** Architecture during session 2022-2023 of the Five Year (Full-time) Bachelor's Degree Course in Architecture affiliated to the University of Mumbai.

This certificate is issued for the purpose of **Solar Decathlon, India**.

Thanking you

For Academy of Architecture (unaided)

Dr. Shilpa Sharma
HOD Incharge, Professor (Ad-hoc)

ACADEMY OF ARCHITECTURE (U.C.) रचना संसद MUMBAI-25

278, Shankar Ghanekar Marg, Prabhadevi, Mumbai - 400 025. Tel. : 2430 1024 / 2431 0807 Fax : 2430 1724
Email: contact@aoamumbai.in website : www.aoamumbai.in

BONAFIDES FROM EDUCATIONAL INSTITUTIONS

VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE MUMBAI

H R Mahajani Marg, Matunga east, Mumbai, Maharashtra 400019

BONAFIDE CERTIFICATE

This is to certify that ***Mr. PANCHAL YUVRAJ ASHOKKUMAR***

is /was a bonafide student of this institute attending ***Fourth Year***

of the ***Four Year Degree*** *Course in* ***(B.TECH) Civil Engineering***

His Character and conduct have been good.

His Roll No. is /was ***201010909*** *Year* ***2022-23***

Date & Place of Birth ***06-June-2001***

Registrar

VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE MUMBAI
H R Mahajani Marg, Matunga east, Mumbai, Maharashtra 400019

Date : ***14/02/2023***

VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE MATUNGA MUMBAI-19

Note : This is computer generated certificate.

Printed Date :14/02/2023 11:14:42 am

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BONAFIDES FROM EDUCATIONAL INSTITUTIONS

CEPT UNIVERSITY

FACULTY OF ARCHITECTURE

No: CEPT/FA-PG2022-23/1080

TO WHOMSOEVER IT MAY CONCERN

20th Feb. 2023

This is to certify that **Mr. Aarohan Dutta (PLA21004)** is a bonafide student at CEPT University under the Master's in Landscape Architecture program at the Faculty of Architecture, registered in the Spring 2023 semester.

This certificate has been issued on the student's request to participate in the Solar Decathlon India competition (Design Challenge).

SJ.

Prepared by
Shivani Joshi

Ms. Anita Hiranandani
Registrar
CEPT University

CEPT UNIVERSITY PHONE 079-68310000 AHMEDABAD

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KASTURBHAI LALBHAI
CAMPUS, UNIVERSITY RD
NAVRANGPURA
AHMEDABAD 380 009
GUJARAT, INDIA

LETTER OF CONFIRMATION: PROJECT PARTNER

AKSHAR DHARA FOUNDATION Regn. No. 317803
805 / 806, Palm Project 'C' Co - op. HSG Society Limited
Link Road, Malad (West), Mumbai - 400 064 Tel. : +91 93725 81487
Email : enquiry@akshardhara.org Website : www.akshardhara.org

To,
The Director,
Solar Decathlon India

Date: 10-Oct-2022

Dear Sir,

This is to inform you that our organization, **Akshardhara Foundation**, has provided information about our **JEEVIKA** project to the participating team led by **Rachna Sansad's Academy of Architecture**, so that their team Nishtha may use this information for their **Solar Decathlon India 2022-23 Challenge** entry.

As a **Project Partner** to this team for the Solar Decathlon India 2022-23 competition, we are interested in seeing the Net-Zero-Energy, Net-Zero-Water, resilient and affordable solutions this student based team proposes and the innovation that results from this.

We intend to have a representative from our organization attend the Design Challenge Finals event in April, if this team is selected for the finals.

We would like our organization's **logo** to be displayed on the Solar Decathlon India website, recognizing us as one of the Project Partners for the 2022-23 Challenge.

With warm regards,

Name of Representative: PRADEEP SHARMA
Designation: DIRECTOR
Email: ARYASHARMA25@YAHOO.CO.IN
Phone: 9987014091

AKSHAR DHARA FOUNDATION MUMBAI 64.

LETTER OF CONFIRMATION: INDUSTRY PARTNER

Date: 23rd Feb

To,

The Director,

Solar Decathlon India

Subject: Confirmation letter from Industry partner

Dear Sir,

This is to inform you that our firm, 'Nirmittee Consultant', is collaborating with the participating team led by Rachana Sansad's Academy of Architecture. This team is working on a Community Resilience Shelter Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will cater to innovative design. We will aid the students to design in effective use of locally sourced materials and their construction techniques.

We would not be able to have a representative from our organization to attend the Design Challenge Finals event in April/May, if this team is selected for the Finals.

We do not want our organization's logo displayed on the Solar Decathlon India website, recognising us as one of the Industry Partners for the 2022-23 competition.

With warm regards,

Ar.Mangesh Jadhav,
Founder,
Nirmittee consultants,
mangesh10@gmail.com,
9869135153 .

LETTER OF CONFIRMATION: INDUSTRY PARTNER

Date: 23rd Feb

To,

The Director,

Solar Decathlon India

Subject: Confirmation letter from Industry partner

Dear Sir,

This is to inform you that our organization, 'Agnigarbha Pvt. Ltd.' is collaborating with the participating team led by Rachana Sansad's Academy of Architecture. This team is working on a Community Resilience Shelter Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will cater to innovative design. We will guide the team with creative use of solar panels and its optimization.

We would not be able to have a representative from our organization to attend the Design Challenge Finals event in April/May, if this team is selected for the Finals.

We do not want our organization's logo displayed on the Solar Decathlon India website, recognising us as one of the Industry Partners for the 2022-23 competition.

With warm regards,

Kiran Bhagat,
Director,
Agnigarbha Pvt. Ltd.,
Agnigarbha9@gmail.com
9819983570

TEAM NISHTHA