BMS College of Architecture

SELCO Foundation

COMMUNITY RESILIENCE SHELTER

FINAL DESIGN REPORT 2023
APRIL 2023

సురక్ష

TEAM BMSCA

Solar Decathlon India™

SECTION	REVIEWER'S COMMENT	OUR RESPONSE
REVIEWER 1		
Energy Performance	The EPI looks good and aligns with the design strategies used	No response.
Water Performance	The calculations look good and the graphics are well presented	No response.
Embodied Carbon	The reduction is significant and well presented, you can talk about the choice of material in more detail.	We have addressed this on Pg 17.
Resilient Design	Well presented and you have covered the important points. You can talk more about climatic/ ecological resilience.	We have addressed this on Pg 18.
Engineering and Operations	good work. Please include aspects of availability of materials and transportation graphically. also, please include waste management layouts	We have addressed this on Pg 29.
Architectural Design	Well presented and integrated	No response.
Affordability	The data looks good, please check the values to be added in the blanks for the cost and percentage reduction.	We have addressed this on Pg 32.
Innovation	The design explorations are creative and well presented	No response.
Health and wellbeing	Well done. Please add the compliance of comfort hours according to standards in your report. It is an important aspect for you as you are not incorporating hvac systems in your design.	We have addressed this on Pg 35.
Value Proposition	Well written and concise.	No response.
REVIEWER 2		
Energy Performance	Good use of passive strategies and solar PV	No response.
Water Performance	Well thought through design for rain water harvesting, reducing demand and also reuse of greywater.	No response.
Embodied Carbon	Significant reduction from the baseline	No response.
Resilient Design	Resilience from various aspects catered for.	No response.
Engineering and Operations	Engineering design seems to have been done, but more information on electrical system would be helpful	We have addressed this on Pg 29.
Architectural Design	Well designed after evaluating various design options	No response.
Affordability	Cost per sqm still on higher side and no significant reduction from the baseline	We have addressed this on Pg 32.
Innovation	Solar chimney to reduce the heat in the building is a good idea.	No response.
Health and wellbeing	Multiple strategies to improve health and well being	No response.
Value Proposition	Well articulated	No response.

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EXECUTIVE SUMMARY

Team BMSCA consists of diverse like-minded individuals, across different backgrounds of architecture and engineering, driven by passion and zeal to create a strong impact on social and environmental landscapes and address effects of natural calamities through thoughtful, resilient, architectural interventions while simultaneously providing an environment for knowledge exchange and mutual learning.
Under the able guidance of faculty lead and faculty advisor, the team conducted several discussions with the project partner on-board, understanding the project aspirations and the client requirements and the nature of goals and strategies that can be possibly looked at. As a result, the team clearly laid down their job roles, assigned and delegated the work amongst its members based on their skill-sets and interests. This was followed by approaching relevant industry partners, regular update meetings, brainstorming, timely feedbacks from the project partner and industry partners.
The chosen project is located in Kuruni thota, a low-income settlement in Jambagi village, Rural Jamkhandi Taluk, Bagalkot, Karnataka- with a warm and humid climate**.** The settlement comprises of 65 families in dispersed pockets, lying in close proximity to Krishna River.
On-site documentation and assessment of the current on-ground situation done revealed poor living conditions and the use of thatch, GI sheets and other highly inefficient materials used to make houses, resulting in high levels of indoor temperatures and compromised security.
Every monsoon, the settlement's proximity to the backwaters of the Krishna River, results in rising water levels and periodic flooding, thus displacing a large number of people and animals, forcing the community to the streets where they wait until waters recede.
It is during these times of distress that their houses are submerged, their livelihood is affected, and the community is forced to make ad hoc arrangements for the entire duration of flooding.

As the first step towards providing the community with a sense of economic security and livelihood, we devised a program that encourages and upscales economic activity- through the provision of facilities for: dairy processes of cooling, and packaging, allowing it to be sold to the closest town; for sewing, and running of the flour mill as additional methods of income generation.
As a response to the climatic severity, we incorporated strategies to bring about active, passive cooling and cross ventilation as part of the design process. Thermal efficiency has also been brought about through the conscious choice of materials- the use of Compressed Stabilised Earth Blocks (CSEB).

<u>Design strategies and problems addressed:</u>

- We explored configuration of the built form in a U shape, enclosing a North facing courtyard within, thus facilitating cross ventilation and maximizing admission of natural daylight within enclosed spaces, thereby reducing energy consumption.
- Our use of solar chimneys has been an innovative breakthrough to tackle the issues of high humidity arising during monsoon months despite lower indoor temperatures.
- Angular orientation of wall projections abutting windows to shade them on the south and west facades, as well as to draw in predominant south west winds into the built spaces, facilitated an ambient indoor environment achieved through cross ventilation of spaces.
- Usage of Stabilised Earth Blocks (SEB) that are produced in close proximity to the site as a strategy that increases the thermal lag between outdoor and indoor temperatures was employed
- Roof overhangs and *chajjas* to shade the vertical surfaces of the built mass were introduced thereby reducing solar heat gain.
- Elevation of the structure on concrete stilts as a means to adapt to rising water levels during monsoon months in addition to allowing transfer of heat from the building to the earth

<u>Through the aforementioned strategies, we have aimed to achieve</u>:

- **Cost effectiveness and embodied carbon** -through the use of locally available stabilized earth blocks, thereby reducing costs incurred and carbon emissions due to transportation of materials, and through the use of rattrap bonds thus reducing the material (brick and mortar) by approximately 30%
- **Resilience**- ensuring a reserve of energy, communications, first aid and relief material, food, water supply and sanitation to suffice days of autonomy.
- **Innovation**- through the various design strategies and construction methods.
- **Water performance-** through efficient strategies and reducing consumption demands, we achieved a net-positive water cycle
- **Energy performance -**through employing of active and passive design strategies as well as harnessing solar energy on-site, we achieved an EPI of 24.29 kWh/m2

Thus, our aim is to provide a community centre in the village as a measure that provides resilience to the community during a disaster event. In addition, the centre would provide a platform for generating livelihood activities and serve as a temporary home for the families in wake of a disaster.
We intend to carry forward this consistent work approach throughout the challenge, with the aim of providing our project partner with cost effective, thoughtful, sustainable and net zero solutions while meeting the proposed goals with utmost efficiency.

TEAM MEMBERS

1.1 Team Members

1.2 Team Name: BMSCA
1.3 Institution: BMS College of Architecture, BMS College of Engineering
1.4 Division: Community Resilience Shelter

1.5 Background of the Institution:

B. M. S. College of Architecture (BMSCA) is affiliated to the Visvesvaraya Technological University, Belagavi and recognized by the Council of Architecture, New Delhi. Conveniently located in the heart of the city, it has been a frontrunner in the field of architectural education for the past 40 years. The college is well equipped with state-of-the-art facilities and infrastructure and is strong academically with well qualified faculty who are specialized in diverse fields of architecture. BMSCA offers an environment ideal for stimulating discourse on art, architecture, technology, and sustainability. Hands on approach to the academic curriculum, research-oriented creative thinking and a multitude of areas that fall under the broad umbrella of architectural thinking, homes the BMSCA family into being better architects, designers, and ultimately better human beings.

B. M. S. College of Engineering (BMSCE) was founded in the year 1946 by Late Sri. B. M. Sreenivasaiah a great visionary and philanthropist and nurtured by his illustrious son Late Sri. B. S. Narayan. BMSCE is the first private sector initiative in engineering education in India. Over the past 74 years of its illustrious existence, the institution has produced innumerous engineers and leaders who have enriched the world through their immense contributions to mankind.

VISION: Foster Growth & Nurture Creativity

MISSION:

To be a landmark institution by imparting quality architectural education strengthened through innovation, research and consultancy to produce responsible architects for the society.

PROGRAMMES OFFERED BY BMSCA:

- Bachelors of Architecture
- Masters of Architecture (Habitat Design)
- Doctoral Program

PROGRAMMES OFFERED BY BMSCE:

- Bachelors of Engineering
- Masters of Technology
- Ph.D

SUPPORT SYSTEMS OFFERED BY BMS:

- Innovation and exploration is assisted through state-of-the-art computing facilities and supportive labs.
- Knowledge resources in the library support access to comprehensive and latest print and E-resources.
- Supportive labs include-Environmental lab, Acoustics and illumination lab, Survey lab, Carpentry and art workshop, material Museum etc.

1.6 FACULTY LEADS

CHANNABASAVARADHYA K B

Channabasavaradhya, an associate professor at BMSCA holds a B.Arch Degree and a Masters in Construction and Project Management.
He has 12 years of academic and industrial experience. His areas of interest include: building materials, methods of construction, building services, architectural design and construction management.

SAKSHI REDDY

Sakshi Reddy, an assistant professor at BMSCA holds a B.Arch degree from RVCA, a Masters in Urban Planning and Design from CEPT University. She is presently the mobility champion of Bengaluru for the year 2022.

1.7 INDUSTRY PARTNERS

Ekam Eco Solutions, founded in 2013, is a over five thousand man hours of research on Sanitation forms the backbone of this organization. They focus on developing sustainable technologies and solutions to conserves water and convert waste into resource using natural means.

Aureka, is an ISO 9001 certified engineering company, operating under the auspices of Auroville, focused on the design and production of equipment for sustainable construction and living. Specializing in Earth Block Presses and Mixers, we also produce Windmills, Shredders & Chippers, Accessories & Spare Parts and believe that reducing the impact on the environment , is the best way to make a responsible use of the planet's resources.

SOFTWARES USED:

Fig 01: Tools used throughout the challenge
[All the logos are sourced from the Internet]

1. Understanding the challenge and picking a project partner that resonates with our intent of bringing change under the vertical - **Community Resilience Shelter.**
2. Meeting our project partner **Selco Foundation**, Project selection and understanding of project brief
3. Picking the site based on our research and the **flood** levels in the area. We as a team then performed a **Pre design analysis** in the form of Case studies, Literature studies, Site analysis, Climate analysis, Context understanding etc.
4. Attending **webinars** and **Self Learning Modules**, working on the zoning and basic design ideas - came up with 4 different design iterations.
5. **Budget planning**, preliminary **estimation** and **costing**. **Water cycle planning**, research and comparison of equipment.
6. Comparing the values generated by **simulations** of the different **iterations** and selecting the one.
7. **Detailing the design** by integrating passive and active strategies that contributed in tackling the **challenges** faced by the people of the region.
8. Getting inputs from our project partner, faculty leads, Ar. Shashi Bhooshan (Architect of our case study Tungal Schools) and our industry partner **Ekam Eco** and **Aureka** gave us insights that guided us in the right direction.
9. Compiling all our research, content, simulations, learnings, inferences into our second last submission **D3**.
10. **Working together as a team for the Final Report 2023.**

Fig 02: Design Documentation

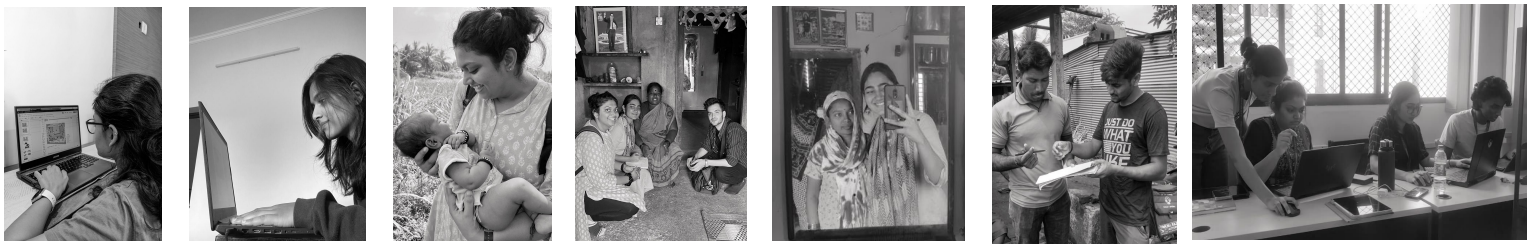


Fig 03: On site documentation and Group huddles

2.1 Project Name: SAMPADA
2.2 Project Partner: SELCO Foundation
2.3 About SELCO Foundation

SELCO Foundation is a not-for-profit, public charitable trust. It was founded in 2010 and is headquartered in Bangalore, Karnataka, India. SELCO Foundation seeks to inspire and implement solutions that alleviate poverty by improving access to sustainable energy to underserved communities across India in a manner that is socially, financially, and environmentally sustainable. The Programs under Built Environment are focused on the sectors of Housing, Workspaces, Health, Education and Livelihoods and the work streams they follow are passive cooling, productivity and well-being, and disaster resilience.

2.4 Key Individuals

MARIA MONICA S

- Project Manager
- Research and Evaluation
- Built Environment
- Selco Foundation

NIRMITA CHANDRASHEKHAR

- Program Manager
- Built Environment
- Selco Foundation

2.5 Brief Description of Project and Site:
Location: Kuruni thoota, Jamkhandi Rural, Bagalkote, Karnataka
Climate: Warm and Humid (According to ECBC)
Stage of the Project: proposed now, unconstructed, land with little vegetation.
Hours of operation: 8 hours during regular days and 24 hours during pandemic or disaster times.
Purpose: Build-Own-Operate

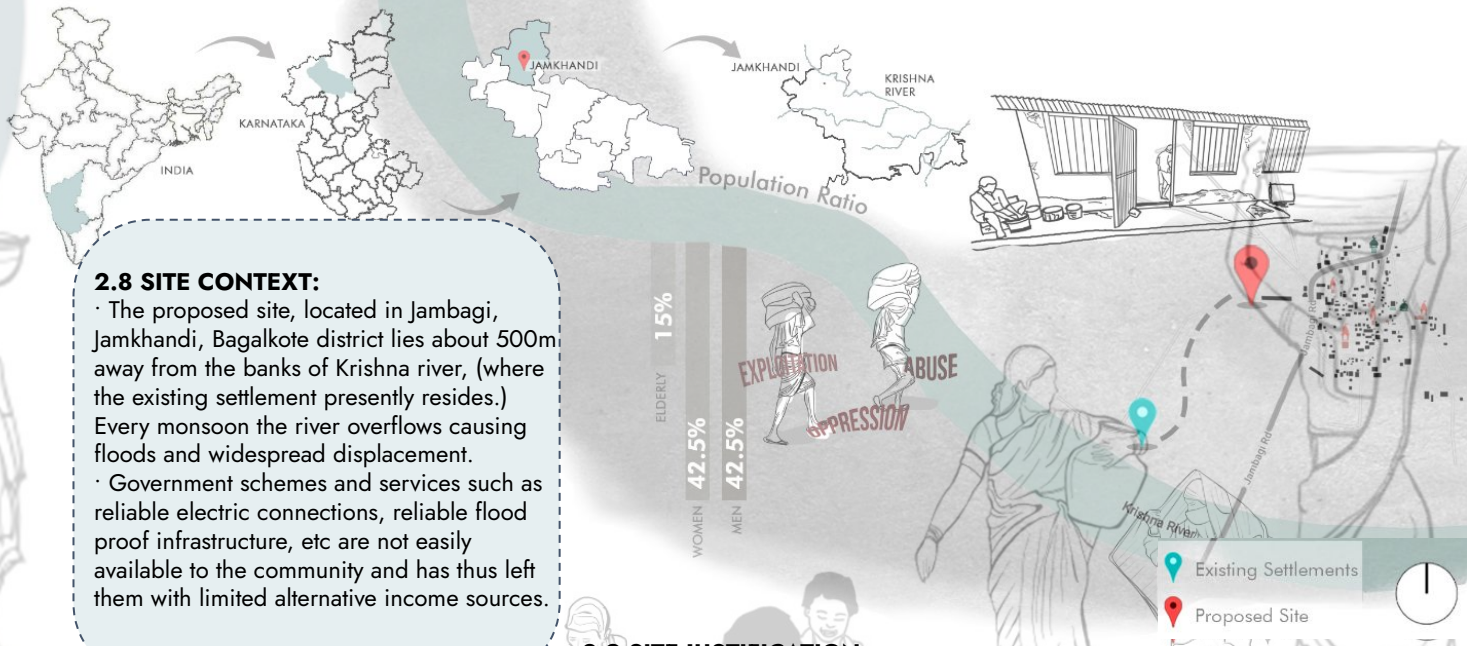
Kuruni thoota is a low-income settlement in Jambagi village located 10 kilometres from Rural Jamkhandi Taluk, in Bagalkote, Karnataka. Every monsoon, owing to the settlement's proximity to the backwaters of the Krishna River, the families run the risk of being prone to rising water and periodic flooding. The flooding occurs as a result of its closeness to the Koyna / Almatti Dam; every July waters flow from Maharashtra and the river partially submerges the settlement. This phenomenon has forced the community to move and set up tents by the roadside for a period of 3 months (July-August and September). The last move was as recent as in July of 2022 upto September 15th 2022.

Thus, Jamkhandi is characterized by disaster events like man-made floods,heat waves resulting in substantial loss of infrastructures, properties and compromise on well-being.

2.6 Profile of occupants:
The settlement comprises of 65 families(260 people) in dispersed pockets, who have ancestral links to the Devdasi community. As for their livelihood practice, most men and women work in the surrounding agricultural fields, offering labour work in the sugarcane fields and are involved in other agricultural activities during the cultivation period from December to May. The population consists of men and women in a similar ratio, with 15% comprising the elderly.Literacy rate of Jambagi village is 51.34% out of which 61.02% males and 40.91% females are literate.
The aim is to provide a community disaster centre in the village, as an adaptation and resilience measure in the community. The centre aims to provide respite for the community during a disaster event, as well as help provide a platform for generating livelihood activities as well as serve as a temporary home for the families in crisis.

2.7 Site Data:

Proposed Site Area:	2000 sq.m		
Permissible Built up Area (FAR 1.5):	3000 sq.m	Proposed/ Estimated Built up Area:	~2085 sq.m
Permissible Ground Coverage (45%):	900 sq.m	Proposed Ground Coverage	: ~ 725 sq.m



2.8 SITE CONTEXT:

· The proposed site, located in Jambagi, Jamkhandi, Bagalkote district lies about 500m away from the banks of Krishna river, (where the existing settlement presently resides.) Every monsoon the river overflows causing floods and widespread displacement.

· Government schemes and services such as reliable electric connections, reliable flood proof infrastructure, etc are not easily available to the community and has thus left them with limited alternative income sources.

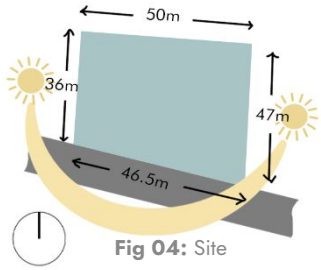


Fig 04: Site

2.9 SITE JUSTIFICATION:

The river's depth ranges from 518m MSL - 524m MSL, based on the current scenario and in the event of a flood.

The settlement currently abuts the river belt- at 523m MSL.

The flood level ranges between 524 - 526m MSL (as seen in the video documentation, where the houses were inundated upto 3m), we have proposed the site at MSL - 528m, decreasing the risk of flooding.

The site's proximity to the existing settlement, makes it easy for the people to move their belongings during the disaster. Further, it is connected to the road network, thus making the logistics convenient.

SITE ANALYSIS

BIOPHYSICAL CONTEXT

The region has rich deposits of black clay soil, suitable for agricultural activities. Sugarcane, coconut plantations are seen in maximum. The water table remains 12-14 m below ground during non-monsoon period and about 2m below the ground in monsoon months.

This analysis helped us in employing foundation type, landscaping strategies etc.

LIVING CONDITIONS

The compromised standard of living is due to a dearth of power supply and clean water, with only a few houses powered by electricity. Water accessed directly from the Krishna river is stored in containers and barrels for domestic use. Drinking water is made available through filtered water and is also procured from the city market. Hygiene and sanitation is poor due to lack of proper ventilation and waste management hence open defecation is adopted.

INFRASTRUCTURE AND FACILITIES

People walk 1km from the backwater area until they reach a source of public transportation (Bus). The post office is the only amenity in the vicinity.

MATERIALITY AND CONSTRUCTION- MARKET ANALYSIS

Locally manufactured clay bricks, red granite stone, coconut coir , wood, tarpaulin. Trabeated construction is used widely in buildings that are mostly G+2 structures.Under land use, 70% of Jhamkhandi is residential as per data, of which one of the government owned land is handed to the community.Facilities like hospitals, bus stops , schools, retail markets etc are few and dispersed across.They are deprived of electricity from the main grid.

In the surrounding context there are multiple brick manufacturing units and sugarcane farms and industries.

There is a need for kids learning space, women tailoring workspace and so on among the community after the survey was conducted.

Thus the market analysis showed that the project that we are proposing has immense demand and potential in the documented region, and thus would help in empowering the community and provide standards of living

2.10 Special Requirements of Project Partner:

· Use of locally available building materials and construction techniques in the building design.

· Strategic use of building materials, techniques for thermal insulation for indoor thermal comfort

· Community gathering spaces for gatherings, livelihood activities, etc. to be considered.

· Living areas for the population of the village, with required access to basic facilities like energy, water, sanitation.

3.1 PRIMARY GOALS

RESILIENCE

Objective:

- To make the structure resilient to withstand different disasters (flood and hazards like heat waves) and function efficiently and independently during days of autonomy.
- To provide physical and psychological resilience to the occupants as well as to the cattle

Strategies:

- Adoption of disaster mitigation strategies, and flood resistant design, through measures like stilted structural design,decks, waterproofing and relevant materiality.
- Employing efficient water treatment and storage facility.
- Employing on-site energy generation for meeting all the building energy requirements.
- Provision of proper healthcare facilities and support for building occupants.

ENERGY PERFORMANCE

Objective:

- To achieve the target EPI of 31 KWh/m2 per year and maximise the energy efficiency of the structure, aiming towards net-zero energy.
- To achieve efficient thermal comfort within the building catering to the needs of the occupants.

Strategies:

- Employing on-site renewable energy generation through usage of solar energy.
- Minimal usage of mechanical (active) ventilation and lighting.
- Employing climate responsive design with a combination of active and passive design strategies, thereby reducing energy demands and hence the consumption by ~60%.

WATER PERFORMANCE

Objective:

- To reduce water consumption by at least 30% with an aim towards net-zero water efficiency.

Strategies:

- Employing rain water harvesting systems.
- Recycling all the used water (zero waste water discharge) and engage in systems that reduce unnecessary wastage of water.
- Provision of sufficient water storage capacity during/for the days of autonomy.

ARCHITECTURAL DESIGN

Objective:

- To ensure efficient building design, minimizing dependency on mechanical and active design strategies.
- To ensure community building – we feeling, amongst the occupants.

Strategies:

- Response to climate, sun and wind orientation, through relevant design strategies.
- Maximizing natural day lit spaces by 80%.
- Ensuring natural and passive ventilation and cooling(solar chimney) up to 70%.
- Use of sustainable, locally available, cost-effective materials.
- Ensure visual connection with the outdoors, and building community interaction through spatial design.

3.2 SECONDARY GOALS

ENGINEERING AND OPERATION

Objective:

- To ensure efficiency of various equipments and reduce wastage of energy, materials etc. during construction and operational periods.

Strategies:

- Use of automation systems, smart technologies (sensor-based lighting etc.)
- Use of low-energy consuming systems, powered by solar or wind, saving up to 50% of energy.

AFFORDABILITY

Objective:

- To achieve cost effective building design and considerable optimization/reduction in operational and capital cost of the building.

Strategies:

- Employing low-cost construction techniques and locally sourced materials.
- Minimum capital investment in excavation and building design, yet meeting the net-zero building requirements.

INNOVATION

Objective:

- To enhance overall design efficiency by introducing relevant innovative technologies.

Strategies:

- Probable Use of sensor system (rising water levels), kinetic systems, partition walls, multi-use furniture, retractable decks.
- Exploring solar chimney for passive cooling and innovative temporary decks.

HEALTH AND WELLBEING

Objective:

- To achieve a design with adequate physical, emotional, intellectual and social well being.

Strategies:

- Spatial design encouraging socialization, interaction and creating a sense of safety, dignity, pride, and belongingness for their community.
- Good indoor air quality, water quality, privacy, security, comfort and healthcare provisions.

EMBODIED CARBON

Objective:

- To reduce carbon emissions from walls, fenestrations and partitions, by overall~20 %

Strategies:

- By employing combination of carbon negative materials like thatch, bamboo, timber, CSEB and RCC structural framework
- By using local materials available in close proximities,reducing down transportation and thereby reducing off-site carbon generation due to energy utilisation

VALUE PROPOSITION- SELF-SUFFICIENT AND ERGONOMIC DESIGN:

Objective:

- To achieve self-sufficiency in design for occupants through unique building program development.

Strategies:

- Creating opportunities for occupants to become self-sufficient by acquiring new skills.
- Designing dynamic, adaptable and efficient multipurpose shelter that provides livelihood activities to the occupants through acquisition of new skills.
- Innovating ways to incorporate by-products/waste generated through various means for meeting energy and other relevant demands.

4.1 ENERGY PERFORMANCE

Graph showing the temperature, heat gain and energy consumption

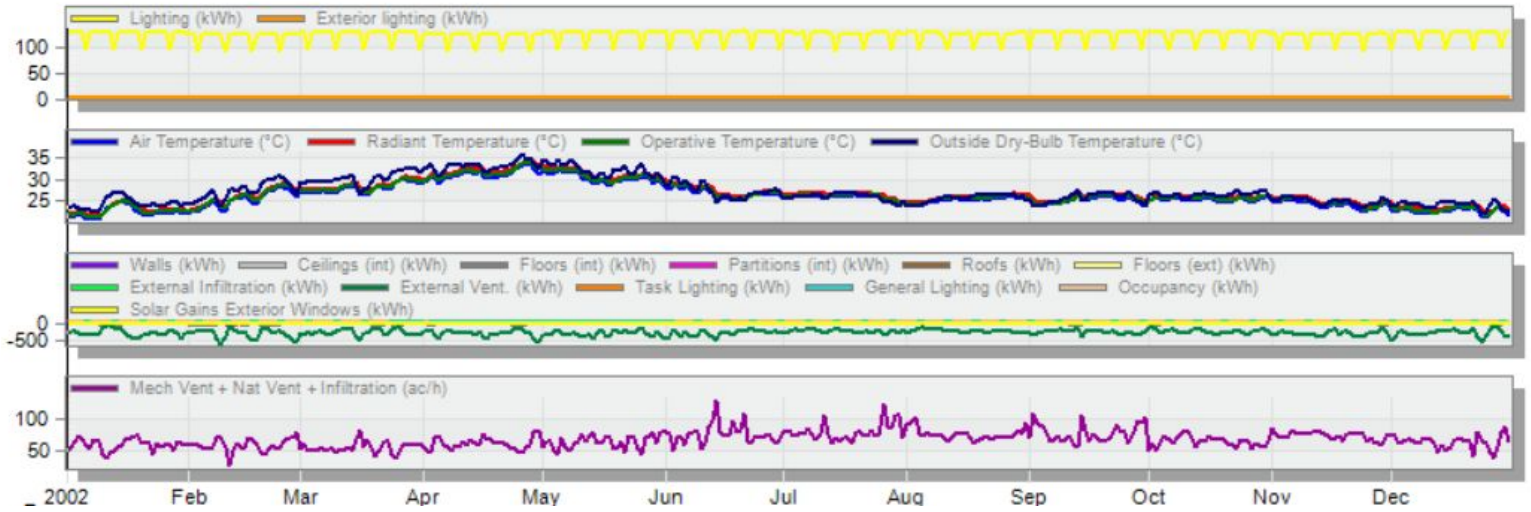


Fig 05: Temperature, heat gains and energy consumption

ACTIVE AND PASSIVE STRATEGIES

The primary step to designing a net zero building is to use passive strategies. The sun, wind, light and the micro-climatic conditions need to be taken into account from the climate study. Building form, orientation, and the shading decisions made early in the design process have the most impact on the building's energy consumption. Our project Sampada is located in a hot and humid climate zone in which air conditioning will always be required. But our goal is to reduced the use of air conditioning by minimizing the overheating using **passive strategies.**

Active		
1	**Solar Panels**	Solar Panels are the main renewable and clean source of electricity for all the appliances used by the community. It has a low maintenance cost and also scalable (Lighting, Exhaust fans, Machineries)
2	**Lighting**	Replacing current Fluorescent and incandecent lightings to LED lighting as it consumes significantly less energy and have a longer lifespan.
3	**Fan and Exhaust fans**	BLDC Brushless Direct Current Motor (energy saving fan) - its a type of ceiling fan which consumes lower electricity compare to normal induction fan.
4	**Pumps**	Electric water pump is being replaced by solar water pump as it is an application of **photovoltaic technology** which converts solar energy into electricity to run the pumping system.
5	**Solar chimney**	During the monsoons, due to the reduction in incident solar radiation, sufficient pressure difference is not created between the inlet and the outlet which is mechanically assisted by a centrifugal fan.

Passive		
5	**Rat trap bond**	Bricks are placed in a vertical position which creates a cavity in the wall.The spaces in between the bricks act as thermal insulators, helping the inside of the structure maintain cool temperatures in summer and warmth in winter. Therefore decreases the usage of **fans** throughout the building.
6	**Large openings**	Large building openings provide ample amount of natural light, ventilation and climate control for rooms which eliminates 90% of artificial lighting in the daytime.
7	**Overhangs**	overhangs shades the windows in different seasons and thereby prevents the shelter from overheating.This helps the building in maintaining an ambient temperature
8	**Solar chimney**	It works on the principle of a temperature gradient created due to the uneven heating in the vertical shaft this creates a pressure difference between the inlet and outlet and then goes on to create a continuous convection current in the building.
9	**Angular wall**	They help direct predominant south western wind into the built spaces in addition to shading the windows.

Table 01: Active and Passive strategies

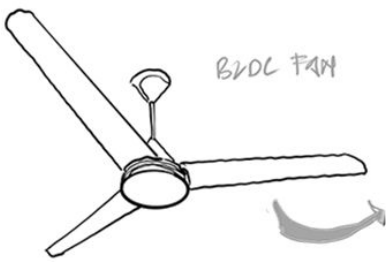


Fig 06: Active strategies: BLDC Fans

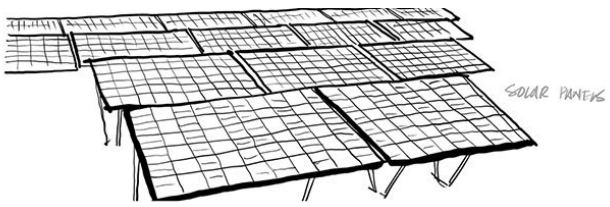


Fig 07: Solar Panels

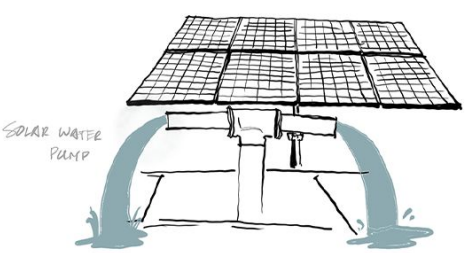


Fig 08: Solar pumps

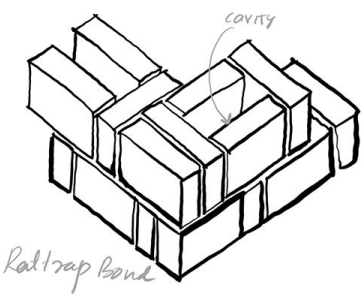


Fig 09: Rat trap CSEB bond

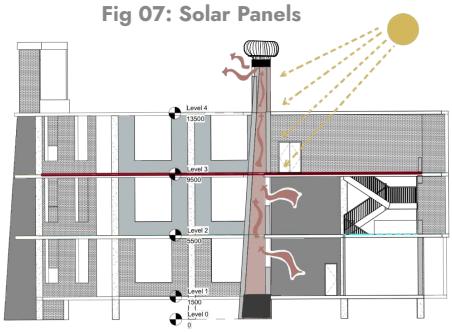


Fig 10: Solar chimney

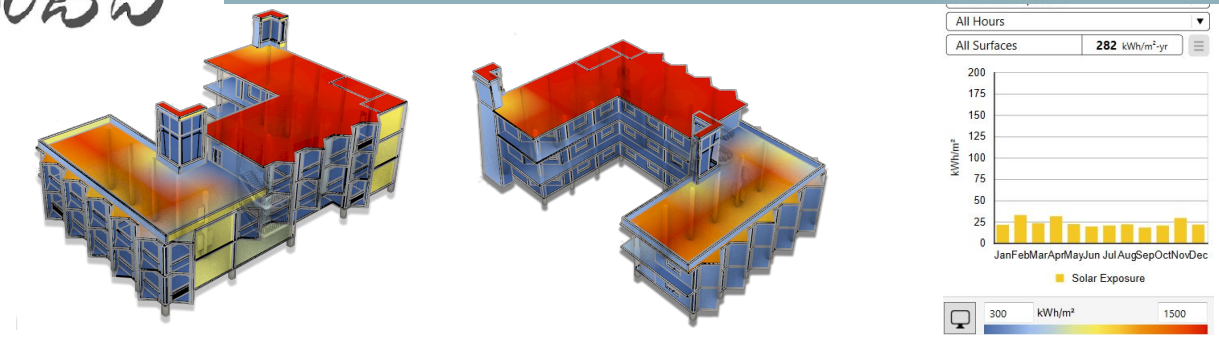


Fig 11: Radiation Analysis

RADIATION ANALYSIS:

Inclined windows facilitate the **movement of fresh air from the south west** into the building while allowing stale air to escape, **shading the windows** and creating **less solar gain on the southern facade** and hence a more comfortable indoor environment with **improved natural ventilation.**

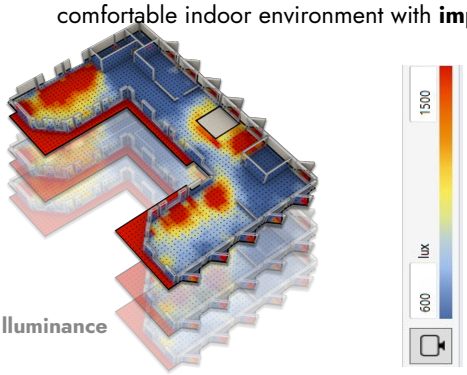


Fig 12: Illuminance

ILLUMINANCE:

All **frequently used spaces** in the building program that require **ambient lighting** throughout the day receive higher **diffused north light in comparison** to less frequently used spaces like storage and restrooms.

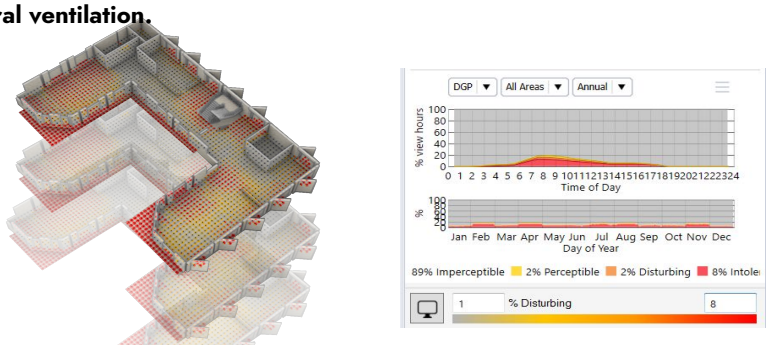


Fig 13: Glare Analysis

GLARE:

The **floor plate** has been designed in a way that the majority of the **habitable zones** are glare-free. Presence of **Inclined windows** in the south and west facade cuts the glare and allows ambient lighting.

MATERIAL SPECIFICATIONS

	Wall	Window	Roofing	Flooring
Baseline design	230mm Brick wall 10mm plaster both the sides	Single glazed glass Window	150mm cast concrete + plaster with 10mm + XPS insulation	Concrete flooring with ceramic tiles
	U-value = 2.0 W/m2 .K	U-value = 5 W/m2 .K	U-value = 0.6 W/m2 .K	U-value = 2.676 W/m2 .K
Proposed design	Compressed Stabilised Earth Block masonry with 100mm insulation Rat Trap Bond	Nahar wood frame with single glazed glass + bamboo grills	Concrete RCC slab with thermal paint coating(117mm thk).	Reinforced concrete flooring with red oxide
	U-value = 0.305 W/m2 .K	U-value = 3.7 W/m2 .K	U-value = 0.523 W/m2 .K	U-value = 0.1260 W/m2 .K
	120mm Bison Board	Clay jali		
	U-value = 1.279 W/m2 .K	U-value = 0.9 W/m2 .K		

Table 02: Material Specification

Fig 14: Section through wall, floor and roof respectively.

THE DETAILED SPECIFICATION FOR ENERGY WILL BE IN APPENDIX A-1

ENERGY PERFORMANCE INDEX (EPI)

Target EPI	28.24	kWh/m2 /year
Energy demands of the building:		
Energy consumed by a sq.m of the building in a year.	28.24	kWh/m2 /year
Energy consumed by the total building area in a year.	58660.61	kWh
Energy consumed by the total building area in a day	184	kWh
On-site energy generation for the building:		
Solar PV system is designed to cater to 100% of the energy demand of the building during disaster as well as non-disaster time. (i.e 35 kWh/m2 / year of energy from photovoltaic cells)		
Selco Solar Power company solar panel details :		
Power rating of the solar panel:	300	W
No. of hours functional in a day (average):	8	hours
Energy generated during the day:	2.41	kWh
No. of solar panels employed:	115	
Total energy produced in a day:	277.15	kWh
Total energy produced during a year:	69287.5	kWh
Efficiency of the panel:	22.60%	
Size of the panel:	1.2 x 1.05	m
	1.26	sq.m
Area taken up by 120 panels:	144.9	sq.m

Table 04: On site energy generation

BATTERY REQUIREMENT CALCULATION

Energy consumed by the total building area in a year.	66,386.40	kWh
Energy consumed by the total building area in a day	184	kWh
No. of Solar battery employed:	57	
Battery capacity to store energy from 300 W solar panels	100	ah
Energy drawn from one 300W 100ap battery for 1 hour	1000	W
Energy drawn by 115 solar panels for 1 hour in a day	57000	Wh
Total Energy drawn by batteries in a year	20805	kWh
Amt of energy stored produced by the panels in the batteries	30	%
Total number of days energy imparted from the batteries	100	days

Table 05: Battery Requirement Calculation

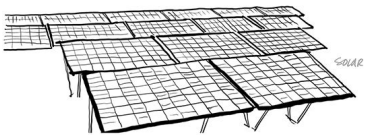


Fig 16: 300 Watt solar panel

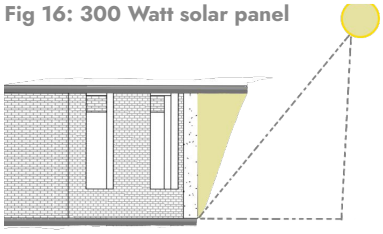


Fig 18: Chajja Orientation

CHAJJA ORIENTATION:

Chajja with a longer length has been provided on S,SW,W for the optimum shading performance. Chajja with shorter length has been provided in the N, E to prevent the gush of water through rain.

Fig 17: 100ah Luminous battery

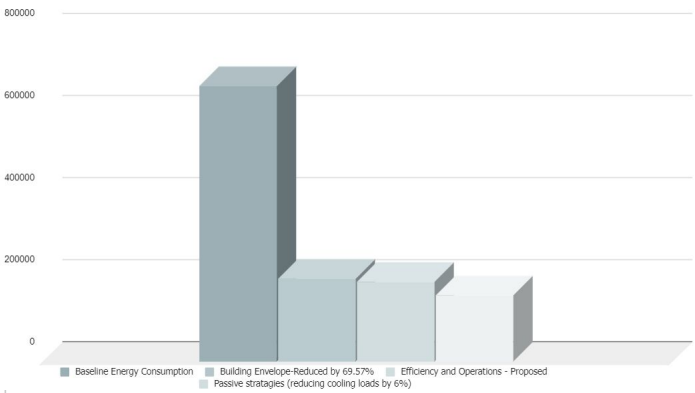


Fig 15: Energy Performance graph

Baseline Energy Consumption		669645
Building envelope - 69.57% - reduced by	Solar Chimney (reducing cooling loads by 41%)	200893.5
	Rat Trap bonds (reducing cooling loads by 12%)	
	Red Oxide - (reducing cooling loads by 7%)	
	Stabilized Earth Blocks (reducing cooling loads by 9.57%)	
Efficiency and Operations - Proposed		193850
Passive design Strategies- Reduced by 8%	Massing and Block orientation (reducing cooling loads ny 3%)	160714.8
	Angular wall shading the window- (reducing cooling loads by 3%)	

Table 03: EPI Generation

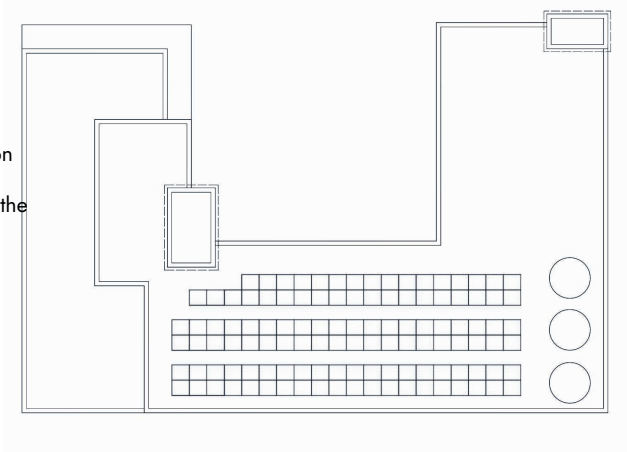


Fig 19: Strategic Positioning of panels and tank on terrace

4.2 WATER PERFORMANCE

Water Consumption Demand And Reduction- Baseline Vs Proposed

- As per Ministry of Housing and Urban Affairs and NBC considerations, a minimum service delivery of 80 lpcd of water has been fixed, for rural areas.
- We intend to reduce the water consumption demand by 30% through thoughtful implementation of strategies.
- The subsequent tables show the calculation, as same for both flood and non-flood periods, as the target population of 260 people remains the same(refer table_____ for details)

1A- DAILY WATER CONSUMPTION- BASELINE AND PROPOSED

WATER CONSUMPTION OF PEOPLE (DOMESTIC USE)			
Total population in the community	**260**		
FUNCTIONS	**CONSUMPTION WITHOUT STRATEGIES (BASELINE)-LPD/person**	**STRATEGIES AND REDUCTION**	**CONSUMPTION WITH STRATEGIES (PROPOSED)-LPD/person**
Drinking	3	-	3
Bathing	18	Pressure regulators, efficient fixtures including aerators, nozzles - (~17% reduction)	15
Cooking	2	-	2
Washing clothes	15	Pressure regulators, efficient fixtures including aerators, nozzles (35% reduction)	11
Washing utensils	14	Pressure regulators, efficient fixtures including aerators, nozzles (~35% reduction)	9
Flushing	15	Dual flush toilets,Ekam waterless urinals (40% reduction)	9
Cleaning	7	Pressure regulators, efficient fixtures including aerators, nozzles (455% reduction)	4
Others	6	Pressure regulators, efficient fixtures including aerators, nozzles (65% reduction)	2
Total consumption of water per day/person	**80**		**55**
Total consumption of water per day/260 people.	**20800**		**14300**

WATER CONSUMPTION OF DAIRY UNIT			
FUNCTIONS	**BASELINE(L)**	**STRATEGIES AND REDUCTION**	**PROPOSED(L)**
Cleaning of Chilled Milk Storage Tanks(storing 1000 L of milk from 150 cows)	500	Pressure regulators (50% reduction)	250

WATER REQUIREMENTS FOR SOFTSCAPES/LANDSCAPES			
FUNCTIONS	**BASELINE(L/m2)**	**STRATEGIES AND REDUCTION**	**PROPOSED(L/m2)**
Water consumption for open landscape areas per day (1.5 litres/m2- Area of softscape: 775 m2)	1162	Use of sprinkler system (50% reduction), xeriscaping	600

Table 06 : Daily water consumption - baseline and proposed

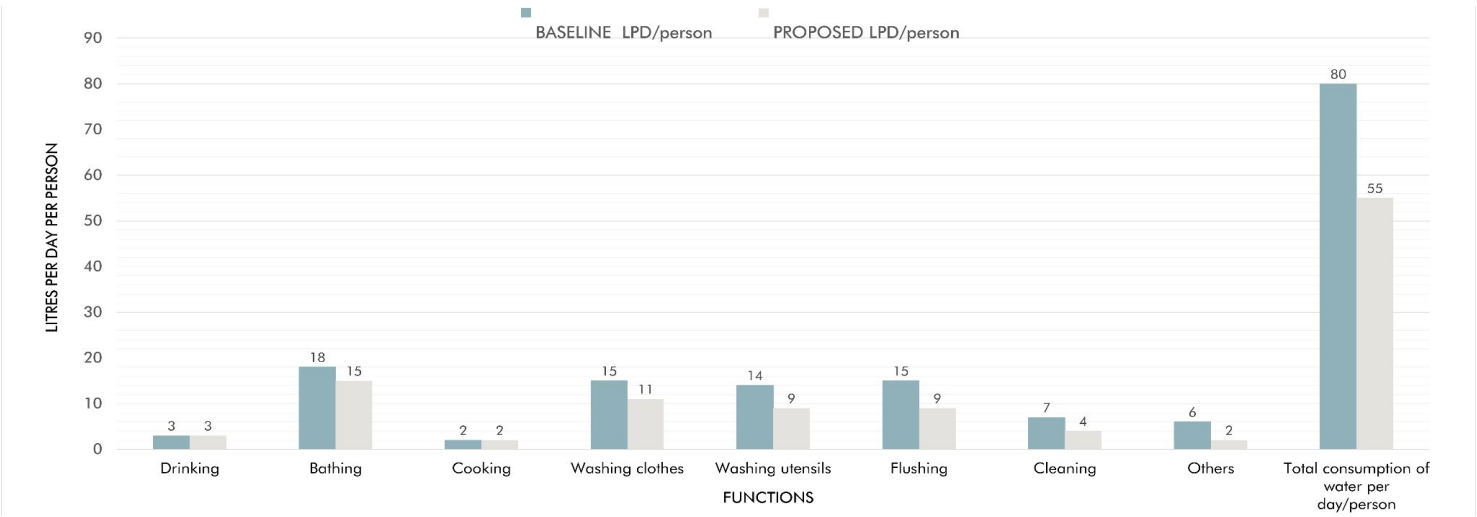


Fig 20: Daily water consumption

STRATEGIES FOR WATER DEMAND REDUCTION- "REDUCE"

REDUCING INDOOR WATER DEMAND:

The usage of various water efficient fixtures, including **Aerators, nozzles, water efficient taps, pressure regulators, water saving flush bank, vacuum suction, use of dual flush toilets, waterless urinals, and recycling of residual water for flushing and awareness**: programs in which inhabitants are sensitized towards water conservation measures and its importance, along with the incentivisation of such measures.**Low-cost** yet effective aerators and nozzles cut down the water flow to up to 500ml. In addition, reusing plastic bottles and reducing the flushing demand by 2L per flush, thereby increasing the efficiency and reduce water demands.

Fig 21: Fixtures

REDUCING OUTDOOR WATER DEMAND:

The outdoor water demand for landscape plantation and farming are reduced by 60A% or more by employing a combination of effective techniques like **Xeriscaping, sprinkler systems, drip irrigation. Xeriscaping** is the process of landscaping that reduces the need for irrigation thus reducing water usage and maintenance, improves biodiversity, lowers pollution, and mitigates heat.It involves choosing of plants such as Black Jamun, *gulmohar* etc that can be maintained with little supplemental watering.

Thus, the indoor demand of water has been reduced by ~30%, i.e., 80 LPD from the base case to 55 LPD

Fig 22: Xeriscaping

1.3 RAIN WATER AND WASTE WATER GENERATION POTENTIAL- "REUSE ,RECYCLE AND RECHARGE"

RAIN WATER HARVESTING:

All rainwater is collected through roof to a common collection point in an underground water tank. Prior to that, the filtration takes place by using the Rainy Dual-Intensity Rain Water Harvesting Filters FL-500 and cleaned by a desilting chamber which has rapid sand filtration system, after which it is stored in underground water tanks to be used for potable uses

All the rainwater collected on the ground is channeled through storm water drains , treated and led in to the underground tank.

In case of excess rainwater, it will be recharged as groundwater using affordable Micro Injection.

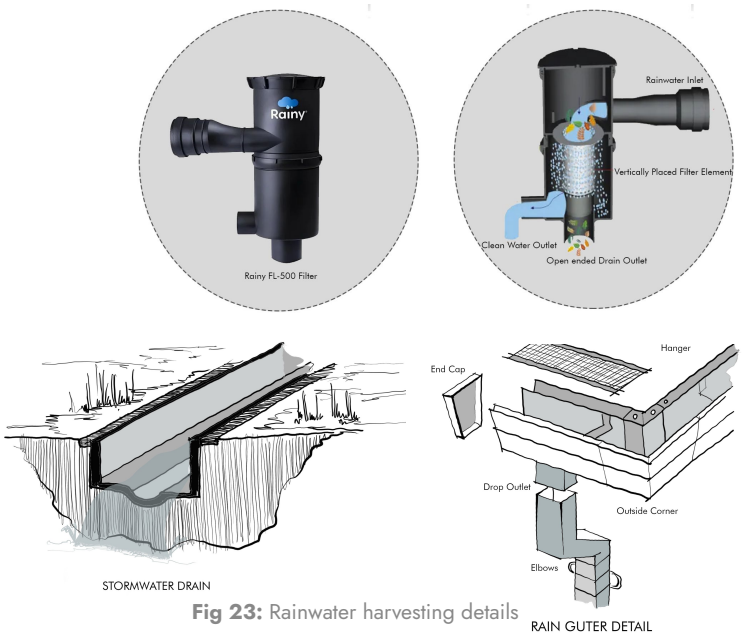


Fig 23: Rainwater harvesting details

EFFECTIVE AREA CALCULATION FOR RAINWATER HARVESTING			
Surfaces	**Area**	**Runoff Coefficient**	**Effective Area**
Roof	980	0.85	833
Hardscape	500	0.75	375
Softscape	775	0.35	271.25
Total	**2255**		**1479.25**
Total Area			**2255**
Total Effective Area			**~1480**
Average run-off coefficient			**0.65**

Table 07: Effective area calculation for rainwater harvesting

2C- ANNUAL RAINWATER HARVESTING POTENTIAL			
Months	**Average rainfall (mm)**	**Rainfall Caught (0.65 i.e 65%)**	**Collection (L)= (rainfall caught x total effective area)**
Jan	3.7	2.405	3559
Feb	0.8	0.52	770
Mar	2.2	1.43	2116
April	11.5	7.475	11063
May	54.9	35.68	52806
Jun	180.1	117.065	173256
July	143.5	93.275	138047
Aug	154.8	100.62	148918
Sep	189.8	123.37	182588
Oct	139.9	90.93	134576
Nov	38.3	24.895	36845
Dec	4.9	3.185	4714
Total	**924.4**	**600.85**	**889258**
Total annual rainfall received			**924.4**
Total annual rainfall caught as rainwater harvesting (in mm)			**600.85**
Total annual rainfall caught as rainwater harvesting (in litres)			**889258**

Table 08: Daily water consumption - baseline and proposed

2A-DAILY WASTE WATER GENERATION

FUNCTIONS/END USE	PER CENT USE	CONSUMPTION (L)- (TOTAL LPD x %)	GREY WATER GENERATED PER DAY(L)	TREATED GREY WATER GENERATED PER DAY(L)	BLACK WATER GENERATED PER DAY(L)	TREATED BLACK WATER GENERATED PER DAY(L)
Drinking	4%	572	-	Employing physical mesh filtration to remove the solid wastes and Ekam Eco Water Solutions-Johkasou-STP with chlorination treatment, is employed which has 85% efficiency. Therefore, treated gray water generated =85% x 6880	572	Black water generated is passed into the Johkasou-Packaged STP where it is biologically treated and discharged to ground. (85% overall eficiency)
Cooking	3%	429	-		429	
Flushing	17%	2431	-		2431	
Others	2%	286	143		143	
Bathing	30%	4290	4290		-	
Washing clothes	20%	2860	2860		-	
Washing utensils	16%	2288	2288		-	
Cleaning	8%	1144	1144		-	
Cleaning of Chilled Milk Storage Tanks	-	250	250		-	
TOTAL GREY AND BLACK WATER GENERATION PER DAY			**10975**	**9329**	**3575**	**3039**
TOTAL WASTE WATER GENERATION PER DAY						**14550**
TOTAL TREATED WASTE WATER GENERATION PER DAY (85% efficiency)						**12368**

Table 09: Daily waste water generation

2B-TOTAL ANNUAL WASTE WATER GENERATION

MONTH	DAYS IN MONTH	GREY WATER (L)	BLACK WATER (L)
January	31	289199	94209
February	28	261212	85092
March	31	289199	94209
April	30	279870	91170
May	31	289199	94209
June	30	279870	91170
July	31	289199	94209
August	31	289199	94209
September	30	279870	91170
October	31	289199	94209
November	30	279870	91170
December	31	289199	94209
ANNUAL GENERATION		**3405085**	**1109235**

Table 10: Annual waste water generation

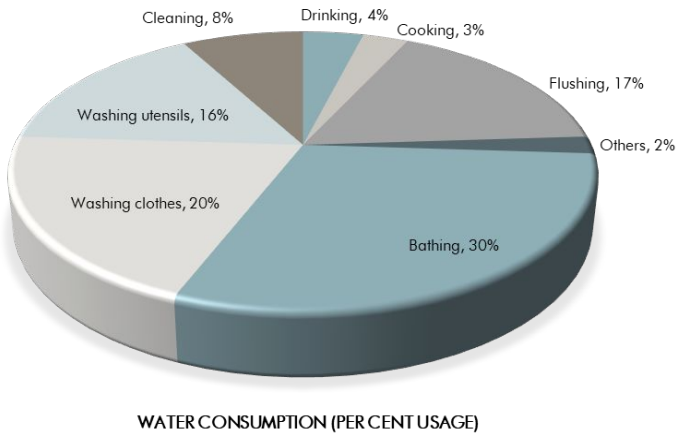


Fig 24: Pie chart showing water consumption usage

The CRS shelter generates 34,05,085 L of grey water and 11,09,235 L of black water annually. Wastewater is **recycled, filtered and reused** for various purposes and a part of it is recharged back to ground.

- Treated grey water is used for flushing, cleaning, irrigation, landscaping, other non potable uses.
- Treated black water used for sludge as manure, discharge to ground,municipal sewerage system.
- Treated rainwater and municipal water source is used for potable uses: drinking,bathing,washing utensils, cooking, dairy etc.

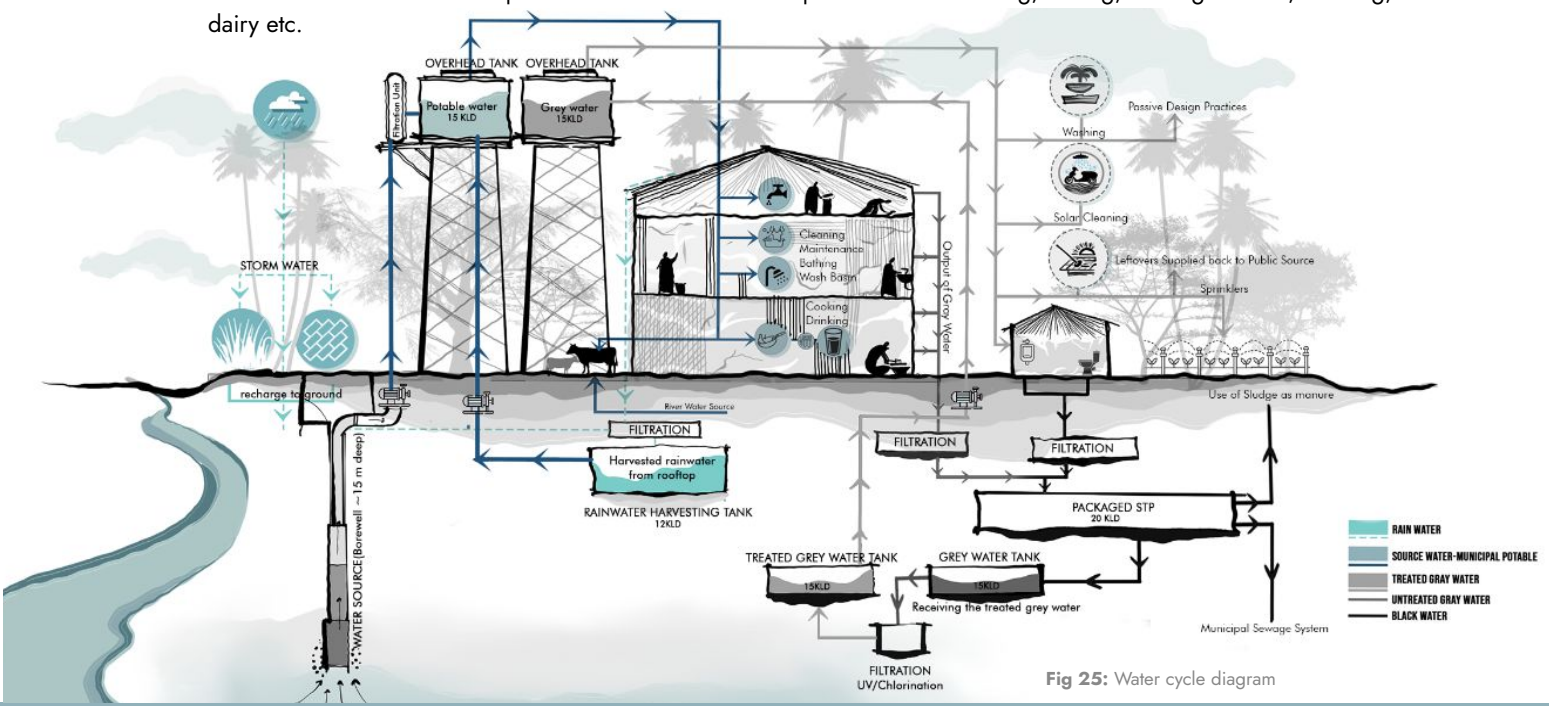


Fig 25: Water cycle diagram

3A- SUMMARY WATER BALANCE TABLE															
WATER CONSUMPTION										WATER SOURCES					
MONTH	DAYS IN MONTH	DOMESTIC USE(L)	COOLING USE %	COOLING USE (L)	DAIRY USE %	DAIRY USE (L)	IRRIGATION USE %	IRRIGATION USE (L)	TOTAL CONSUMPTION (L)	EXTERNAL SOURCE (L)	RAIN WATER (L)	GREY WATER (L)	BLACK WATER (L)	TOTAL SOURCED (L)	TOTAL STORED (L)
Jul	31	443300	-	-	100 %	7750	5%	930	451980	200000	138047	289199	94209	721455	175266
Aug	31	443300	-	-	100 %	7750	5%	930	451980	200000	148918	289199	94209	732326	361403
Sep	30	429000	-	-	100 %	7500	5%	900	437400	150000	182588	279870	91170	703628	536461
Oct	31	443300	-	-	100 %	7750	20%	3720	454770	200000	134576	289199	94209	717984	705466
Nov	30	429000	-	-	100 %	7500	30%	5400	441900	300000	36845	279870	91170	707885	880281
Dec	31	443300	-	-	100 %	7750	50%	9300	460350	320000	4714	289199	94209	708122	1033844
Jan	31	443300	-	-	100 %	7750	90%	16740	467790	320000	3559	289199	94209	706967	1178812
Feb	28	400400	-	-	100 %	7000	90%	15120	422520	300000	770	261212	85092	647074	1318274
Mar	31	443300	-	-	100 %	7750	90%	16740	467790	320000	2116	289199	94209	705524	1461799
AprIL	30	429000	-	-	100 %	7500	50%	9000	445500	300000	11063	279870	91170	682103	1607232
May	31	443300	-	-	100 %	7750	30%	5580	456630	300000	52806	289199	94209	736214	1792607
June	30	429000	-	-	100 %	7500	5%	900	437400	150000	173256	279870	91170	694296	1958333
TOTAL		**5219500**				**91250**		**85260**	**5396010**	**3060000**	**889258**	**3405085**	**1109235**	**8463578**	**13009778**

Table 11: Water Balance Table

WATER BALANCE SYSTEM AND ACHIEVING NET-POSITIVE WATER PERFORMANCE

The site has no access to the municipal water supply. There is an existing water source of Krishna river in proximity to the site. However, it is deemed unfit for use in case of prevalent floods. Since the groundwater table is high in the region, we intend to capitalize on underground water through installation of borewell water system, which ensures perennial water supply. This along with rainwater harvesting system comfortably meets the potable water demands of the shelter.

3B- SUMMARY TABLE		
CONSUMPTION	**All sources (L)**	**Only Domestic use(per day per capita) (L)**
Total annual potable water consumption demand	3887250	3796000
Total annual water demand that can be met by treated gray water	1508760	1423500
Total Annual Water Demand	**5396010**	**5219500**

Table 12: Annual water consumption

GENERATION	**All sources (L)**	**Only through Domestic use(per day per capita) (L)**
Total annual rain water harvested	889258	889258
Total annual treated gray water generated	3405085	3327431
Total annual treated black water generated	1109235	1109235
Total Annual Water Generation	**5403578**	**5325924**

Table 13: Annual water generation

GRAY AND BLACK WATER	**All sources (L)**	**Domestic(per day per capita) (L)**
Total annual treated gray and black water generated	4514320	4436666
Gray water utilised for functions(flushing, washing, landscaping etc.) annually	1508760	1423500
Remaining waste water (greywater and black water) not utilised and recharged as ground water and given to public source annually	3005560	3013166

Table 14: Annual gray and black water

POTABLE WATER	**All sources (L)**	**Only Domestic use(per day per capita) (L)**
Total annual potable water demand	3887250	3796000
Annual Potable water demand met by rainwater	889258	889258

3D-NET ZERO WATER CYCLE- ALL SOURCES			
ANNUAL WATER CONSUMPTION	**HARVESTED RAIN WATER**	**RECYCLED WATER**	**TREATED WASTEWATER TO SOURCE**
5396010	889258	1508760	3005560
5396010	**5403578**		
The table above shows, a net positive water cycle is achieved (54,03,578 - 53,96,010 = 7,568 L)			

Table 15: Net Zero Water Cycle (All Sources)

3D-NET ZERO WATER CYCLE- ONLY DOMESTIC USE			
ANNUAL WATER CONSUMPTION	**HARVESTED RAIN WATER**	**RECYCLED WATER**	**TREATED WASTEWATER TO SOURCE**
5219500	889258	1423500	3013166
5219500	**5325924**		
The table above shows, a net positive water cycle is achieved (53,25,924 - 51,24,600= 1,06,424)			

Table 16: Net Zero Water Cycle (Domestic Use)

STRATEGIES FOR WATER FILTRATION AND TREATMENT

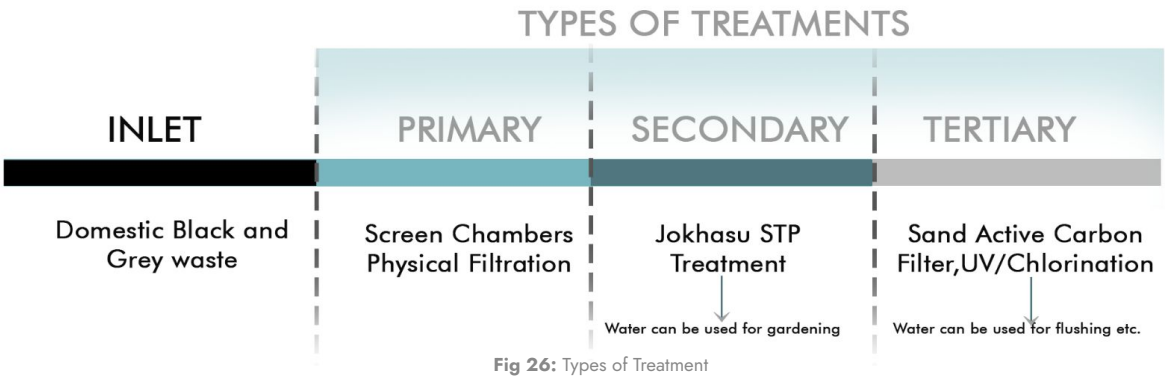


Fig 26: Types of Treatment

The greywater and blackwater is collected and guided to pre-filtration,sedimentation and led to the packaged STP on-site. It is further treated through Sand Active filters, UV processes etc to generate treated wastewater for use.

WATER TREATMENT- JOHKASOU PACKAGED SEWAGE TREATMENT PLANT
We discussed with our Industry Partner, *Ekam Eco Solutions,* the feasible methods that we could employ for secondary treatment of greywater and blackwater with maximum efficiency, and came up with the adoption of **Johkasou-Packaged Sewage Treatment Plant**, a technology provided by the Industry Partners.

It involves aerobic and anaerobic treatments with nitrification and denitrification processes.It features

- Low initial investment cost – Manufactured in large quantities, hence the price of Johkasou is lower than competitive technologies.
- Less vulnerable to natural disasters : in case of natural disasters like floods or earthquakes Johkasou can be reinstated quickly as it does not have complicated plumbing requirements or complex mechanical apparatus.
- Operational expenses are very less compared to conventional treatment systems
- Johkasou tanks life time is more than 50 years. 100% factory made
- Various guaranteed parameters as per model selection. It meets the requirement of MoEF & local PCB standards
- It is less noisy(less than 50dB)
- It has high mobility- 100% packaged unit. Thus easy to relocate

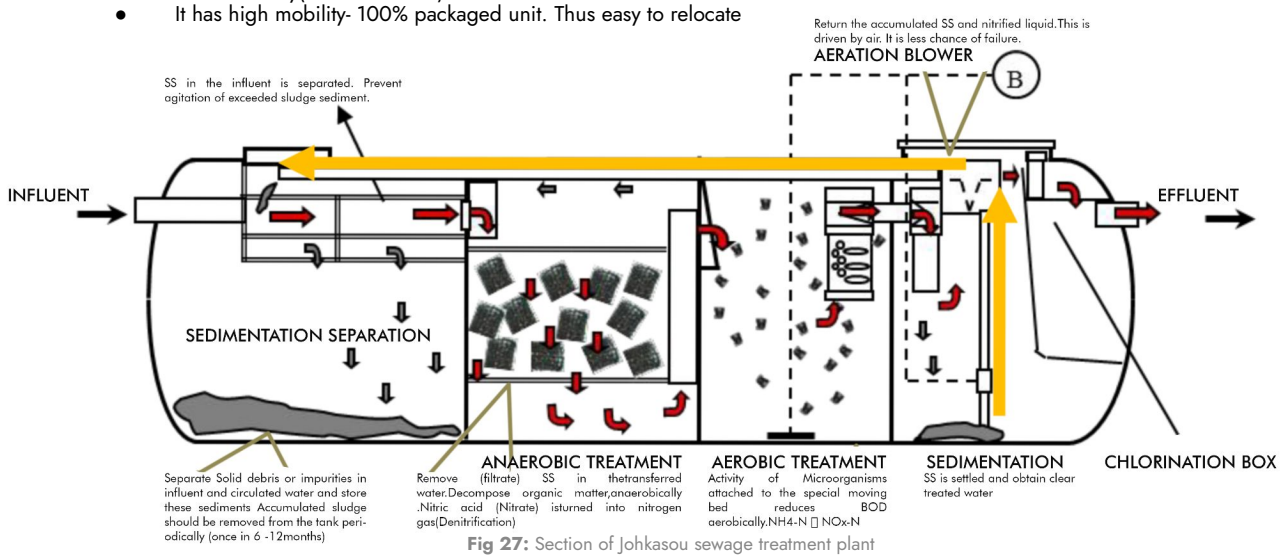


Fig 27: Section of Johkasou sewage treatment plant

OTHER FILTRATION PROCESSES:

SLOW SAND FILTER WITH MIX AGGREGATES: · Slow sand filters are used in water purification for treating raw water to produce a potable produce. · As they require little or no mechanical power, chemicals or replaceable parts, and they require minimal operator training and only periodic maintenance, they are often an appropriate technology for poor and isolated areas.

BAMBOO CHARCOAL FILTER: · Bamboo charcoal's chemical composition and physical structure both contribute heavily to its strength as a water filter. It is 85-98% carbon, the same substance used in most modern filtration methods. Its structure is very porous, so it can absorb and retain impurities easily. Apart from the use of bamboo, we also use gravel and pebbles in various stages to aid particle sedimentation for further filtering and purification process, and thus maintain the quality of treated water.

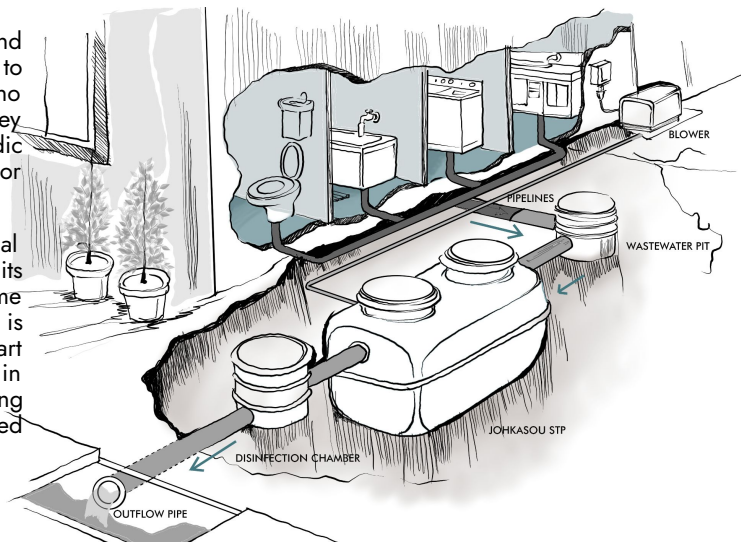


Fig 28: View of Johkasou sewage treatment plant

CONCLUSION- WATER RESILIENCE

- Fundamental 3 R's of water conservation – Reduce, Reuse, and Recycle are strategized along with the Recharge of groundwater and utilizing the rain water
- Use of water efficient fixtures, harvested rainwater, reuse of treated greywater and sufficient recharge of groundwater ensures a sustainable water usage system, leading to a net-positive water performance
- The net water cycle is always positive on a monthly scale. The surplus quantity of water recycled every month, can be either flushed out/recharged back to ground or stored as a provision in any kind of emergency/disaster/miscellaneous use.
- **WATER SOURCE:** Borewell system is installed which ensures water supply throughout the year. Surplus amount of water is recycled *(calculations shown in Water Balance table)* monthly which ensures steady groundwater recharge rate, thereby maintaining the optimum water table levels for usage.
- **WATER STORAGE:** Required number of water storage tanks have been employed, which provide easy availability of water for various functions of the centre, even during the times of distress.

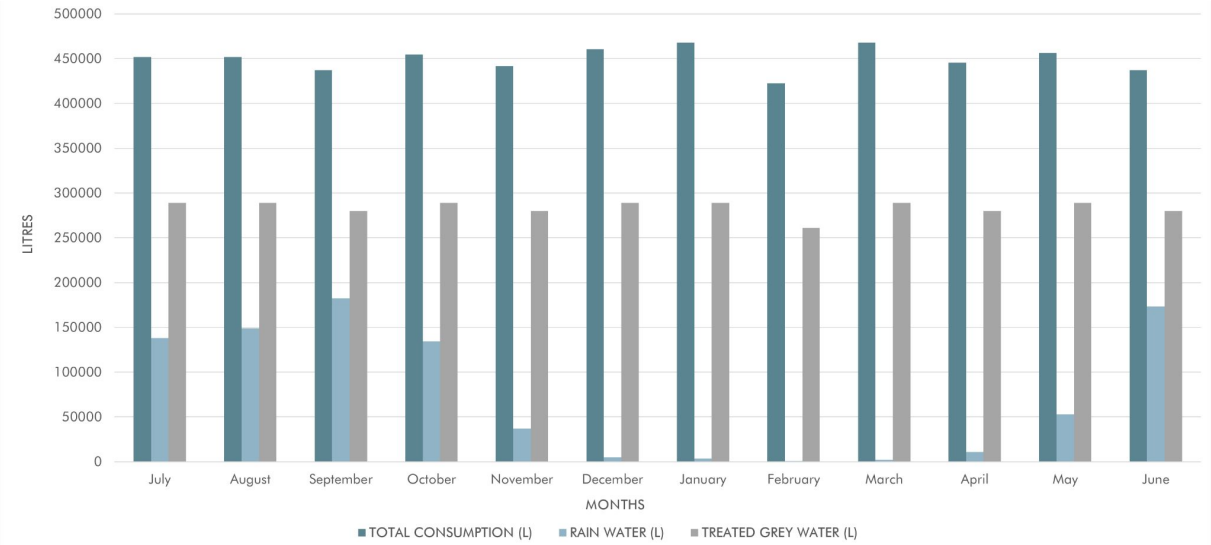


Fig 29: Graph showing the total consumption of water (treated grey water and rainwater) throughout the year

WATER TANK PROVISIONS AND CALCULATIONS

TYPE OF TANK	FUNCTION	WATER REQUIREMENT/GENERATION	CAPACITY (L)	DIMENSION (in metre)	NO.S
UNDERGROUND WATER TANKS	RAIN-WATER HARVESTING TANK	5500 L ~ 6000 L (For a provision of two days: 12000 L)	12000 L ~ 12 cubic. m	4 x 3 x 1	1
	GREY WATER TANK	9329 L ~ 15000 L (For a provision of one day treatment and filling)	15000 L ~ 15 cubic.m	3 x 5 x 1	2
	SEWAGE TREATMENT TANK	14550 L 20000 L	20000 L ~ 20 cubic.m	2 x 5 x 2	1
OVERHEAD WATER TANKS	POTABLE WATER TANK	10650 L ~ 15000 L (For a provision of one day usage and refill)	15000 L ~ 15 cubic.m	Radius= 1.4 Height=2.5	2
	GREY WATER TANK	9329 L ~ 15000 L (For a provision of one day usage and refill)	15000 L ~ 15 cubic.m	Radius= 1.4 Height=2.5	1

Table 17: Representing water tank provisions and calculations

ACCOUNTING THE DISASTER AND NON-DISASTER PERIODS

NON-FLOOD SCENARIO	FLOOD SCENARIO
• Under normal circumstances, the shelter serves as a community centre, catering to various needs of the target community, maintaining a daily population of around **260 people**(200 people from the community with 50-60 visitors**).** • **This water demand is met by the borewell system installed, which ensures regular supply throughout the year**	• Under the conditions of flooding, the shelter aims to provide resilience to the total population of the target community i.e. **260**. • ·In additions to the calculations already shown in the tables which serve to justify the requirements of the flood period too, the project aims to provide shelter to the community's cattle during prevalent disaster. • *·Total cattle population: 150* • *No. of days for shelter(Jun-Oct): 153* • *·Water Requirement/cow/day: 10 L* • *·Total water requirement: 2,29,500 L* • *·This additional water requirement can be easily met by the water source reserves as shown in the subsequent tables* • **This extra water demand is easily met by the borewell system installed, by drawing out required quantities of water through solar water pumps installed.**

Table 18: Comparing the disaster and non - disaster periods

4.3 EMBODIED CARBON

Materials:

- **CSEB**: SCEB is a building material made primarily from an appropriate mix of fairly dry inorganic subsoil, non-expansive clay, sand, and aggregate. If the blocks are stabilized with a chemical binder such as Portland cement they are called *compressed stabilized earth block* (CSEB).
- Assembling onto walls using simple slurry made of soil/ clay/cement mortar or shaped to be interlocking. Production of SCEB can be done with little to no carbon emissions and in situ with just a mechanical or hand press machine.
- **Bison Boards**: Bison Panel is a cement bonded particle board made out of 62% cement & 28% wood. Due to adoption of a special manufacturing process, the panel acquires the strength & durability of cement & the workability of wood. It is lightweight, excellent fire resistance and moisture resistance.
- **XPS sheets**: Extruded polystyrene (XPS) is a closed cell foam material. It is used for it floor insulation due to its compressive strength. XPS foams are sustainable building products. After only few months of use, it saves more energy, resources and emissions than used to produce them.
- **Filler slab**: Filler slab technology is an innovative and cost-effective technology where the dead load of the slab is reduced by replacing the concrete with filler material. The filler used in the our slabs are salvaged pots.

Fig 30: Materials

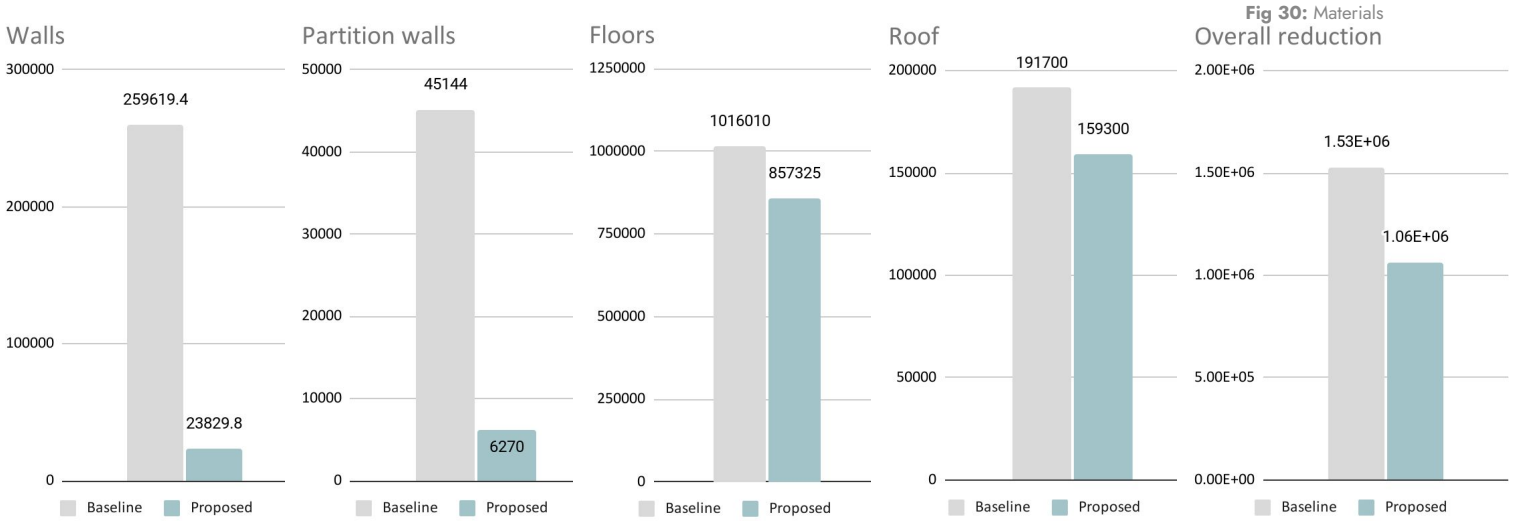
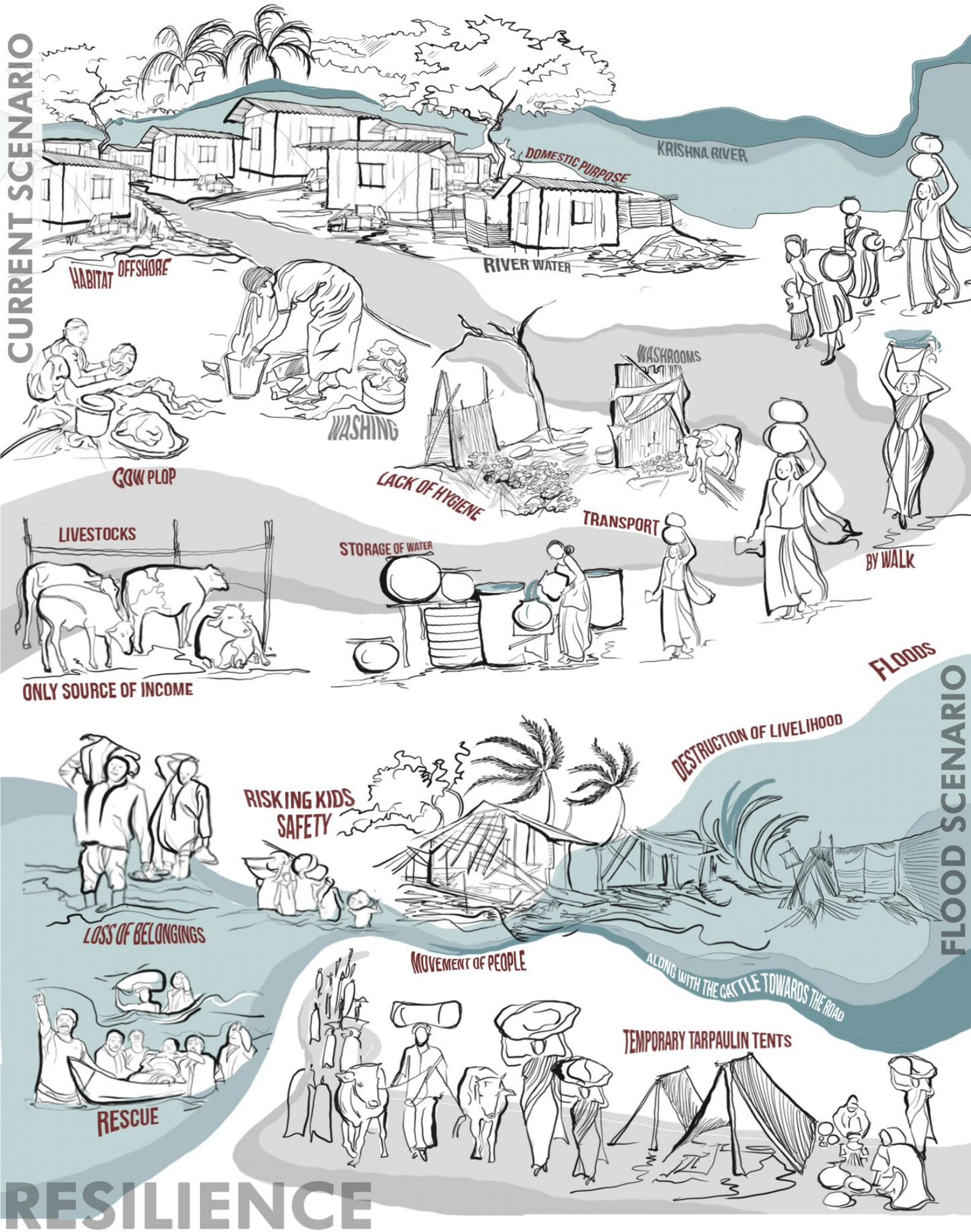


Fig 31: Baseline vs Proposed for Embodied Carbon

- The carbon emissions are reduced by 93.24% from baseline to proposed using **compressed stabilized earth blocks.**
- The carbon emissions are reduced by 116% from baseline to proposed by changing the material of the partition walls from brick to **bison board on timber frame.**
- The carbon emissions are reduced by 15.62% from baseline to proposed using **filler slabs for the floors.**
- The carbon emissions are reduced by 16.9% from baseline to proposed using **filler slabs and xps sheets for insulation for roof.**
- The carbon emission reduction per functional unit is 19%.
- The overall carbon emission is reduced by 30.44%.

	Baseline			Proposed		
System Type	**Material emission**	**Transport**	**Total**	**Material emission**	**Transport**	**Total**
Walls	207	3	210	19	1	20
Roof	423	6	429	431	11	442
Floor	426	6	432	426	6	432
Fenestration	43	6	49	8	3	11
Strutural	22	6	28	22	6	28
	Grand total emission per functional units(kg - CO2 e)		**1148**	**Grand total emission per functional units(kg - CO2 e)**		**933**

Table 19: Embodied carbon summary table


CURRENT SCENARIO
KRISHNA RIVER
DOMESTIC PURPOSE
RIVER WATER
HABITAT OFFSHORE
WASHING
COW PLOP
WASHROOMS
LACK OF HYGIENE
TRANSPORT
BY WALk
LIVESTOCKS
STORAGE OF WATER
ONLY SOURCE OF INCOME
FLOODS
FLOOD SCENARIO
DESTRUCTION OF LIVELIHOOD
RISKING KIDS SAFETY
LOSS OF BELONGINGS
MOVEMENT OF PEOPLE
ALONG WITH THE CATTLE TOWARDS THE ROAD
TEMPORARY TARPAULIN TENTS
RESCUE
RESILIENCE

RESILIENCE

POTENTIAL RISKS:

DISASTER AND CLIMATE CHANGE

Annual Floods: Owing to the settlement's proximity to the backwaters of the Krishna River, every monsoon, the community runs the risk of being prone to water rising and periodic flooding. The flooding occurs as a result of its closeness to the Koyna / Almatti Dam- every July waters flow from Maharashtra and the river partially submerges the settlement.

Heat Waves: In addition, during the months of summer, effects of heat waves can be felt in the region.

PUBLIC HEALTH HAZARDS:

Lack of basic amenities: The standard of living is compromised. There is a dearth of power supply, drinking water and sanitation facilities.

Lack of hygiene and sanitation: Hygiene and sanitation is poor due to lack of proper facilities. Improper waste management, open defecation, etc. makes the settlement prone to many diseases and subsequent health issues.

Stagnation of the collected water for domestic and other uses, can become breeding grounds for mosquitoes, leading to various diseases.

Lack of drinking water: Provision of potable drinking water is compromised and limited.

Lack of infrastructure and facilities: Infrastructure and facilities like hospitals are limited. Due to the lack of a well established transport system, people usually walk 1km from the backwater area to the nearest town establishments where a basic source of public transport (bus) is in effect.

OTHER RISKS:

Societal Construct: Exclusion and outcasting of the community due to their lineage has limited the scope of their growth and development.

Lack of Education and Skills: Limited access to these requisites could potentially lead to illiteracy, poverty and distress within the community.

STRESS AND DISRUPTION TO SERVICES:

LIVING CONDITIONS:

In wake of floods, people are forced to move from their existing settlements to the main road near Jamkhandi bridge (lying at a higher elevation), where they set up temporary sheds (jhopadi) until the floods subside.

This becomes a very cumbersome activity as people have to travel long distances along with their important belongings, while on foot. They lie in a distressed state along the road side with no proper shelter, food source or safety and security.

ENERGY AND EQUIPMENTS:

All the power/ electricity sources get disrupted, leaving the community with no electrical connectivity.

All lighting facilities are disrupted with no lighting arrangements for late evenings and nighttime.

Existing solar batteries, equipment and machinery like flour mill etc. are unusable and destroyed due to the flood.

WATER REQUIREMENTS:

As the community relies on the Krishna River for their domestic water usage, the flooding leaves the water unusable and deems it unfit for any type of consumption, leading to scarcity of water for other activities.

CATTLE AND LIVESTOCK:

Cattle are the backbone of economy as the milk produced is commercialised and sold within the city. The incoming floods disrupt this activity and pose a threat to the safety and accommodation of cattle and livestock.

FOOD SECURITY:

The stored food grains, ration etc is all lost in the wake of floods.

Fodder for cattle is also destroyed, leaving the community in complete agony.

WASTE DISPOSAL:

As per the current scenario, waste disposal occurs on-ground and is passed on to the river. As a result of water levels rising up due to floods, the exposed waste comes on-surface and thus poses a threat of various diseases.

CONCLUSION:

Though flooding is frequent, people hesitate to shift due to ownership of ancestral land and the attached sentimental value. Collective trauma is experienced as they are at loss for a few months which has a huge impact on their livelihood. The need for a resilient shelter arises- as one that caters to their requirements during most part of the year, and during floods - adapts in use to facilitate and support shelter to the affected communities, and to aide the sustenance of the community.

AIM: Our intervention focuses on elevating the lifestyle of the community in a way that ensures their independence and adaptation to a changing environment with quality living such that they are resilient to face future disasters without much concern.

RESILIENCE

4.4 RESILIENCE

Resilience has been addressed keeping in mind the following aspects:

WATER SUPPLY AND SANITATION

Installation of **running water** for sanitation, cooking, and daily use activities. In addition to the provision of **toilets and bathrooms** with **water efficient plumbing** facilities

COMMUNICATIONS

Through the provision of a **control and communication room**: equipped with hard-wired telephone, wireless internet components (cable modem, wireless router, etc.) and a satellite phone that can function during emergencies

FOOD SECURITY

Through the provision of a **food storage room**: to ensure food security by storing adequate food to provide for **days of autonomy**

ENERGY

Through the use of renewable energy source such as **solar panels, batteries** and through **energy efficient fixtures that are sufficient for 100 days of autonomy**

MEDICINES AND FIRST AID

Through the provision of a **medical facility**: An infirmary equipped with first aid, beds, and medicines

FIRE SAFETY

Through the provision of assembly points, fire extinguishers, smoke detectors, and smoke alarms installed at various points

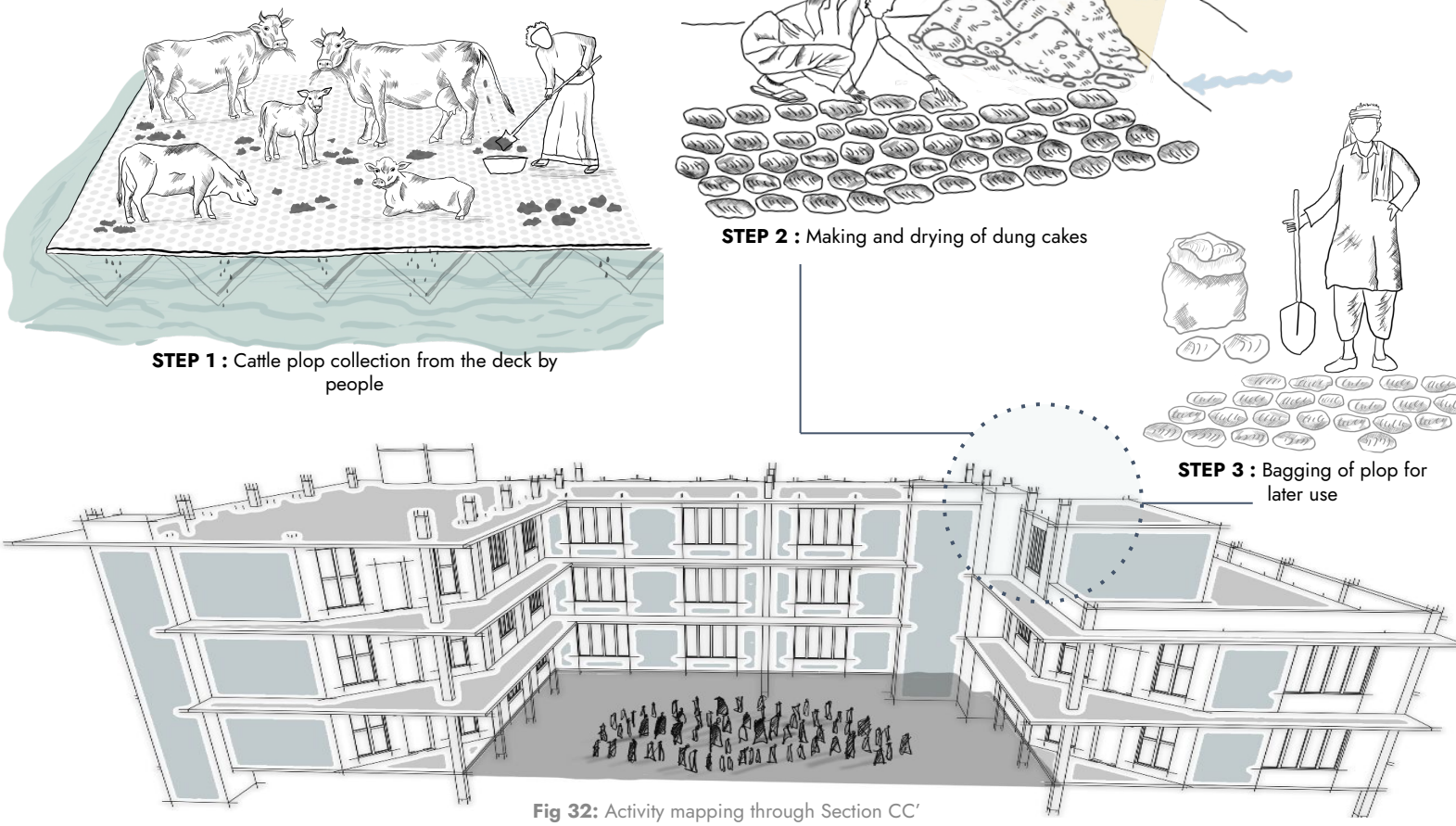
CLIMATE RESPONSE:

Apart from catering to the aforementioned principles, resilience has been worked on as a response to the prevalent climatic conditions.

Climate responsive strategies have been implemented through passive measures of various building components:

- **Orientation:** Orienting the building with longer axes facing North and South, thus reducing surface area of glare facing sides (East and West)
- **Open spaces:** The provision of a courtyard, allowing for cross ventilation of adjacent built spaces
- **Floors:** Through the use of a red oxide coating on floor surfaces, indoor temperatures have been reduced significantly
- **Walls:** the use of rattrap bonds made with Compressed Stabilised Earth Blocks (CSEB)
- **Roof:** Presence of solar panels on the roof surface provides additional shading and thus reduced heat gain
- **Windows:** The use of inclined walls that shade windows to reduce solar heat gain while maintaining unhindered cross ventilation

WASTE MANAGEMENT:



STEP 1 : Cattle plop collection from the deck by people

STEP 2 : Making and drying of dung cakes

STEP 3 : Bagging of plop for later use

Fig 32: Activity mapping through Section CC'

RISK MANAGEMENT AND RECOVERY:

Mitigation of the disaster is first addressed through selection of a site that is situated at an elevation of 528m above MSL, while the current flood levels measure up to around 524m-526m above MSL, thus minimising the risk of a waterlogged site during the period of flooding.

In addition, the entire built mass is raised on a stilted deck 1.5m above ground level, ensuring a safe interior environment even in the extreme case of flood levels rising by an additional 4.5m as compared to the present scenario.

Furthermore, vertical zoning of spaces allows for spaces for accommodation and storage of personal belongings on the G+1 and G+2 floors.

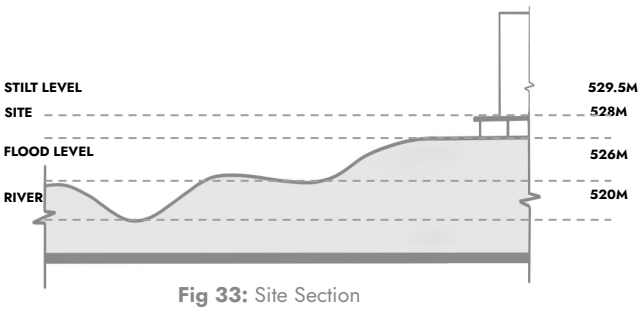


Fig 33: Site Section

Fig 34: Perspective View

DESIGN PROCESS

4.5 ARCHITECTURAL DESIGN

DESIGN PROCESS

The design process began with the understanding of the brief and the requirements of the project partner. Further on, understanding the site and choosing the right location for the community resilience structure.

STEP 1: SITE ANALYSIS

The site is about 500m from the current settlement and is located at +528 MSL which is 4m above the present level of the river.

The site's proximity to the existing settlement, makes it easy for the people to move their belongings during the disaster. Further, it is connected to the road network, thus making the logistics convenient.

The southern edge receives the maximum solar radiation. While wind direction is from south west to north east.
The western side of the site has coconut trees.

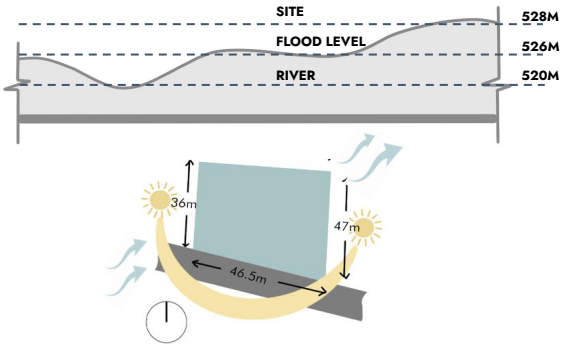


Fig 35: Site plan and Section

STEP 2: FORM DEVELOPMENT

Based on the thermal study, it is understood that the building should take advantage of the low solar radiation on the northern edge which is observed throughout the year. The southern and the western edge receives the maximum solar radiation throughout the year. These facades have to be well addressed.

The prevalent winds are from South-Western edge and North-eastern edge. Due to the warm and humid climate, elongated forms will favour more cross ventilation and increases the thermal comfort of the occupants.

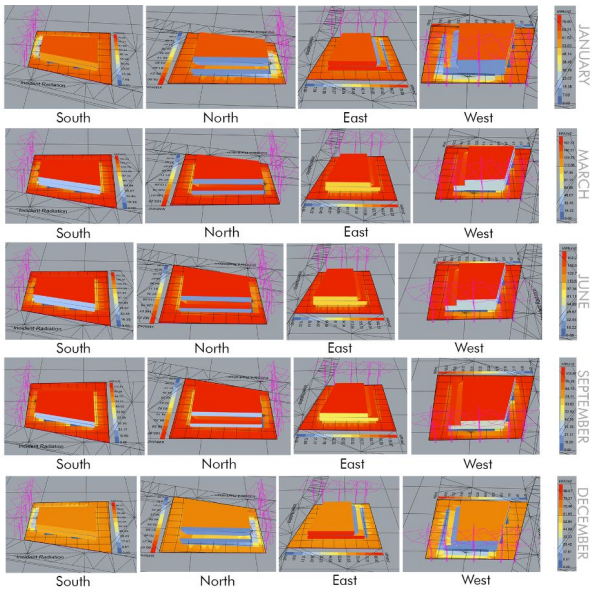


Fig 36: Thermal Analysis

STEP 3: ZONING

After analysing the different iterations, a programme was developed according to the requirement of the users as well as the project partners. .
The different spaces were analysed and zoning was done for the iterations by coming up with different combinations of spaces with respect to orientation of the builtform, circulation, proximity requirements and thermal comfort.

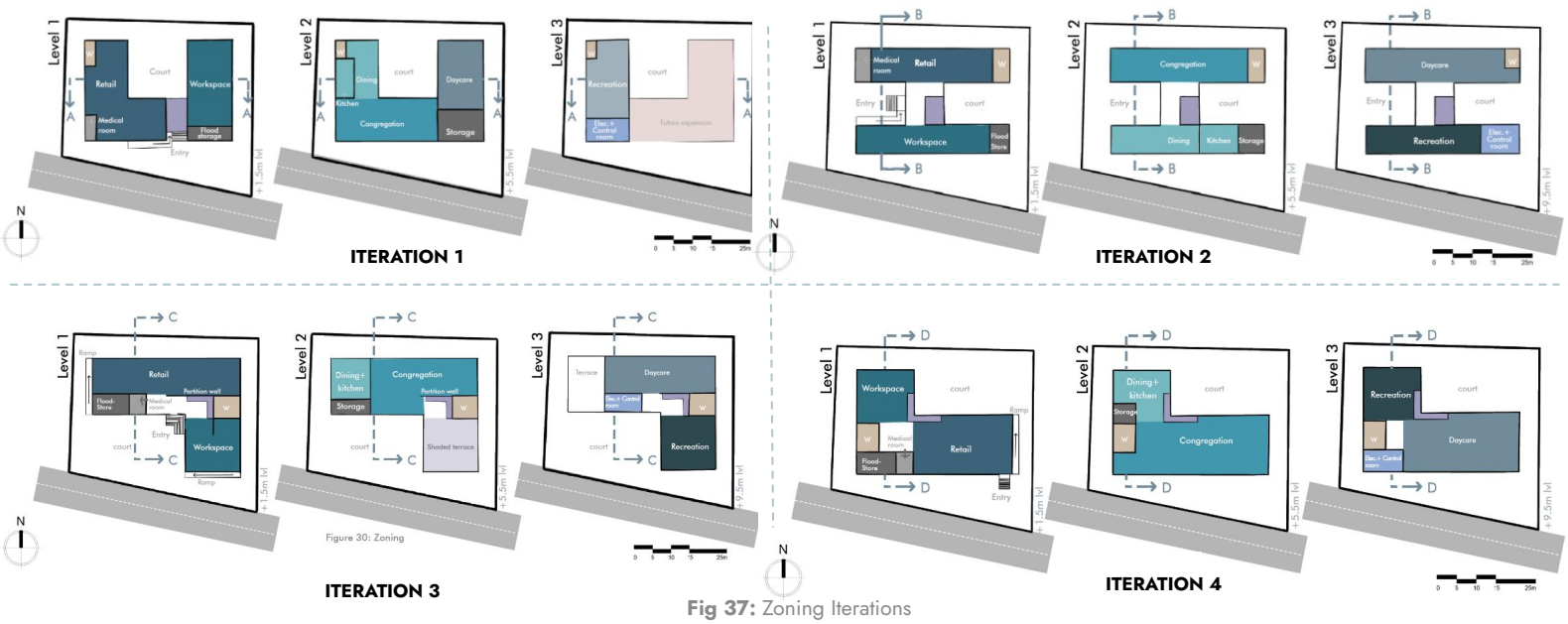
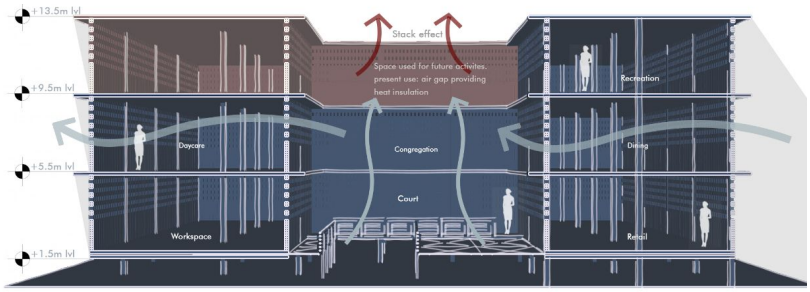
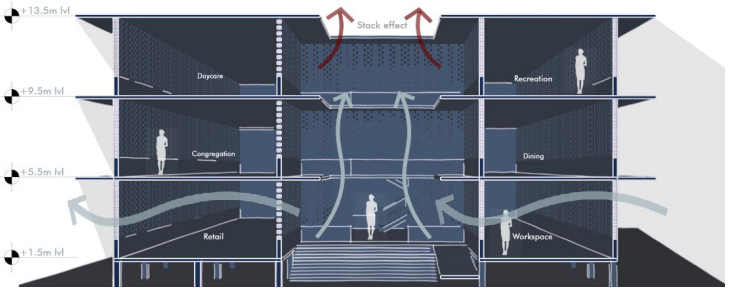


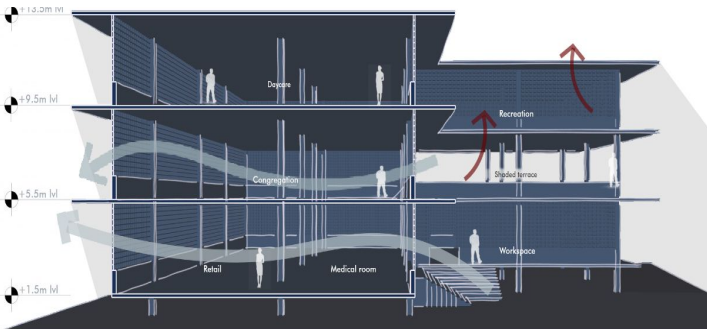
Fig 37: Zoning Iterations



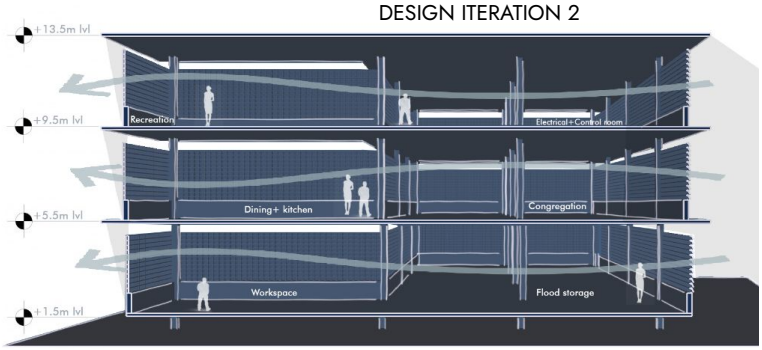
DESIGN ITERATION 1



DESIGN ITERATION 2

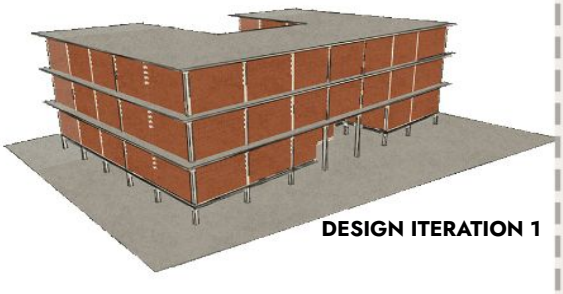


DESIGN ITERATION 3

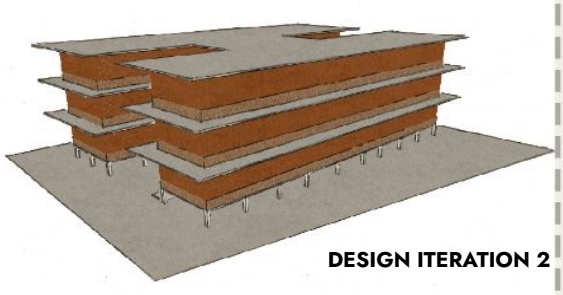


DESIGN ITERATION 4

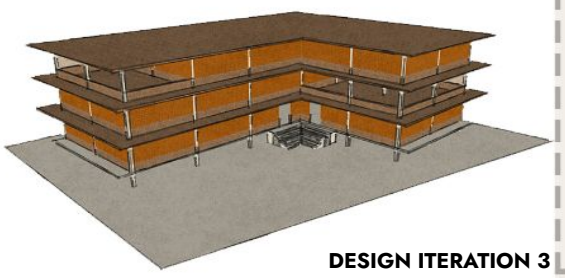
Fig 38: Sectional View of Design Iterations



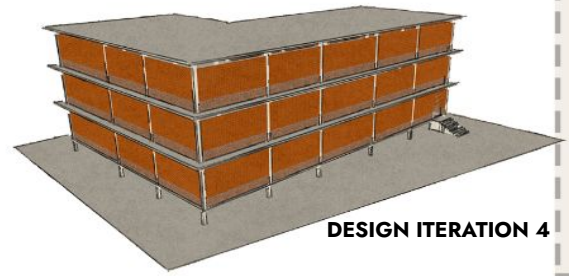
DESIGN ITERATION 1



DESIGN ITERATION 2



DESIGN ITERATION 3



DESIGN ITERATION 4

Fig 39: View of Design Iterations

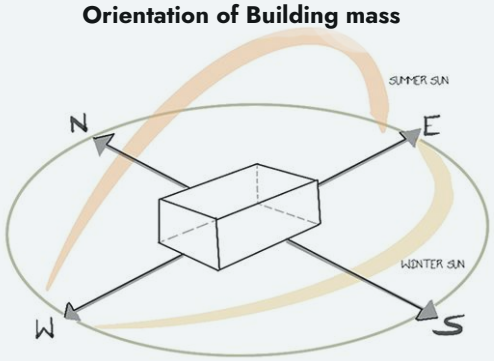
	PROS	CONS
DESIGN ITERATION 1	Provision of a courtyard in the North maximises the north light into the built space. U-shaped built form maximises surfaces exposed to daylight. All spaces are arranged in order to facilitate flow of light and ventilation Increased surface area due to staggered massing of floors, allowing for collection of rainwater	Due to large expanse of southern facade being exposed to harsh solar radiation there is an increase in heat gain
DESIGN ITERATION 2	Courtyard shaded from harsh southern sun. The presence of multiple courtyard maximise wind circulation.	Due to large expanse of southern facade being exposed to harsh solar radiation there is an increase in heat gain
DESIGN ITERATION 3	Storage spaces on south west- behave as a buffer against solar heat gain, thereby reducing solar radiation to other adjacent interior spaces Presence of courtyard on the South west and provision of shaded terrace on south- acts as a buffer. Scope for plantation for shading of built form	The courtyard opening towards the southern side reduces the possibilities of accommodating day time activities.
DESIGN ITERATION 4	Presence of storage, washroom spaces on Western part- preventing solar radiation to spaces that are more frequently used.	Due to large expanse of southern facade being exposed to harsh solar radiation there is an increase in heat gain

Table 20: Comparative table of the iterations

STEP 4: EXPLORATION OF BUILDING STRATEGY ELEMENTS

After evaluating the four iterations in terms of their pros and cons, considering orientation, layout, heat gain, thermal analysis etc., as shown in Deliverable 2, we have decided to move ahead with the most feasible option- **Design Iteration 1**

Orientation of Building mass



Elongated Form

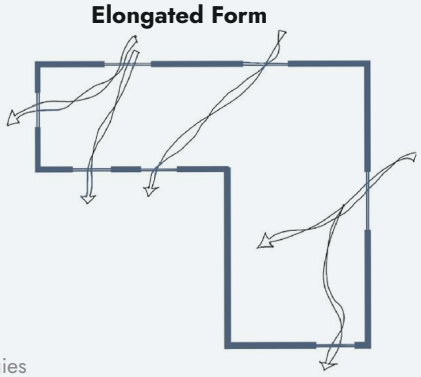
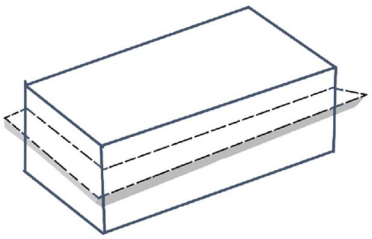


Fig 40: Orientation Strategies

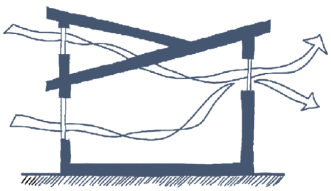
Block with longer sides facing North and South directions. Increasing maximum inlet of light, and reducing the dependency on the artificial sources.

Elongated plans with minimal interior partitions for minimal obstruction of wind flow. Orientation of windows- in line with flow of south-western winds

External Shading Device



Cross Ventilation



Use of screening systems

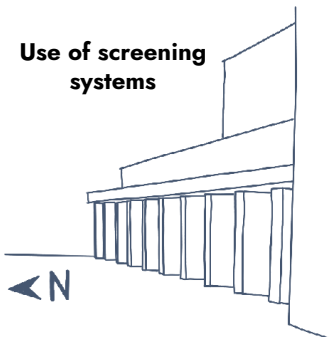


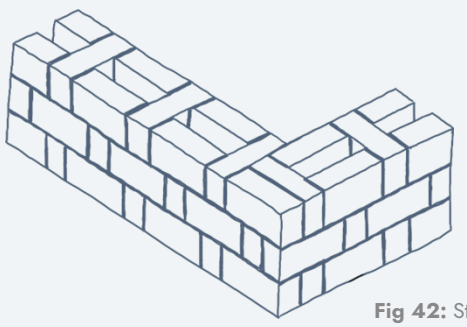
Fig 41: Ventilation and shading strategies

Chajjas, and overhanging eaves to shade the wall and fenestrations. This is used to reduce the solar heat gain, and also protects the interiors from harsh sunlight.

Fenestrations placed at lower reaches of wall for inlet and at higher reaches for outlet of air.

Vertical fins on the North and Western facing facade to reduce glare while allowing penetration of indirect sunlight and also navigate the South western winds into the building.

Rat-trap bond brickwork



Shading of Roof

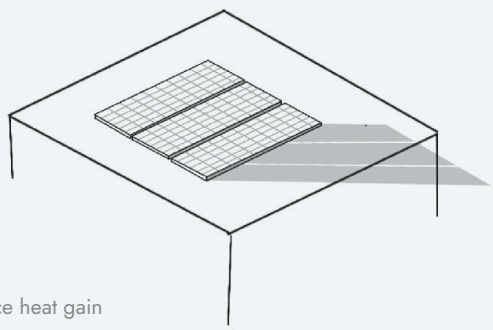
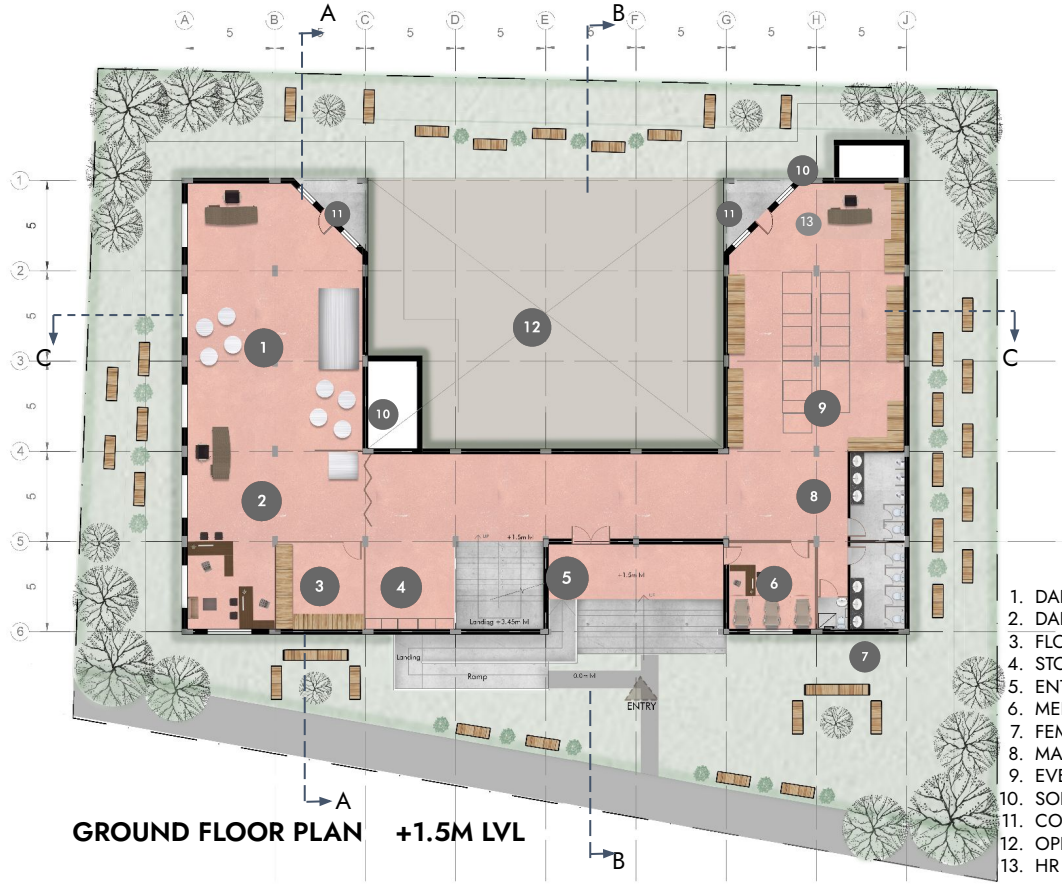


Fig 42: Strategies to reduce heat gain

Rat trap bond brickwork for the external walls create cavities within wall thickness provide thermal insulation

Solar panels above roof, help in shading of the roof form reducing the solar radiation and heat gain.

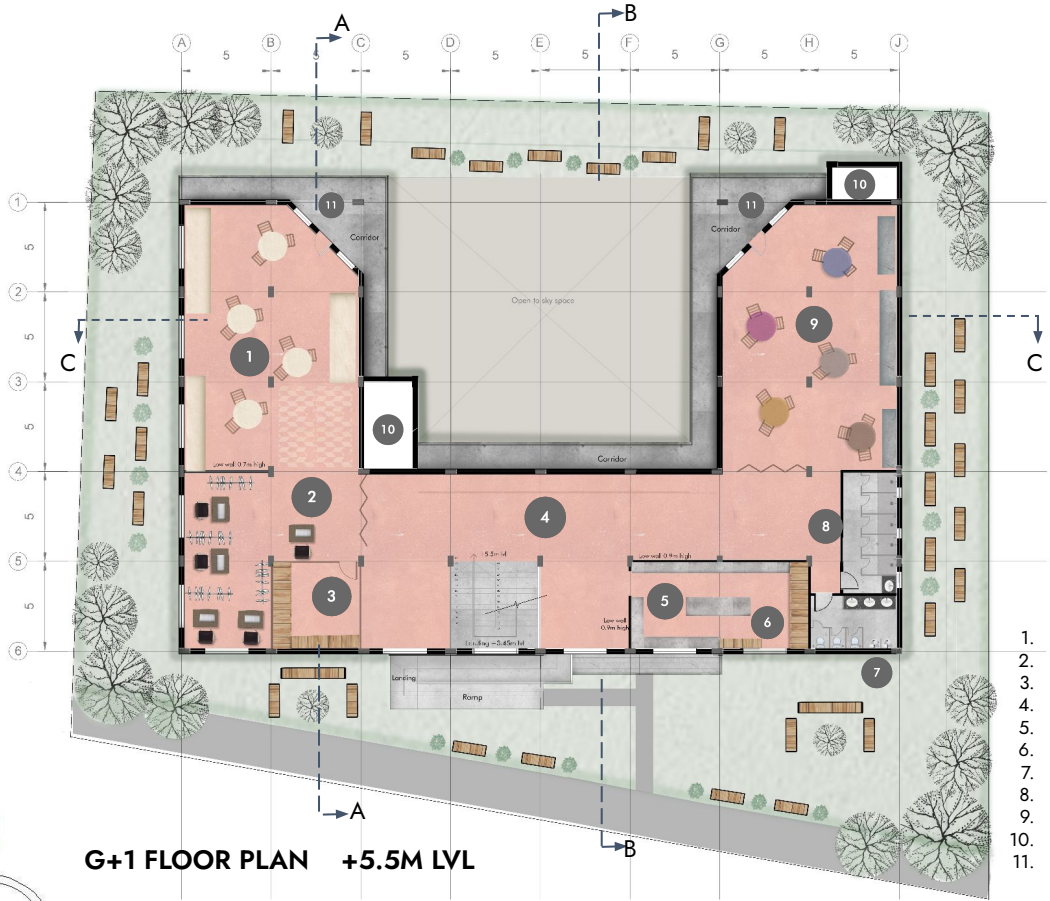
ARCHITECTURAL



LEGEND:

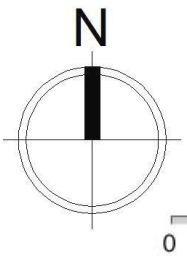
1. DAIRY COOLING SPACE
2. DAIRY PACKAGING
3. FLOOD RELIEF STORAGE
4. STORAGE FACILITY
5. ENTRANCE PORTICO
6. MEDICAL ROOM
7. FEMALE TOILETS
8. MALE TOILETS
9. EVERYDAY RETAIL+ MELA
10. SOLAR CHIMNEY
11. CORRIDORS
12. OPEN TO SKY DECK
13. HR DESK

Fig 43: Ground Floor Plan



LEGEND:

1. DAYCARE
2. TAILORING SPACE
3. STORAGE FACILITY
4. DINING SPACE
5. KITCHEN
6. FOOD STORAGE
7. MALE TOILETS
8. BATH AREA
9. PRIMARY SCHOOL
10. SOLAR CHIMNEY
11. CORRIDORS



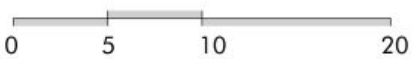
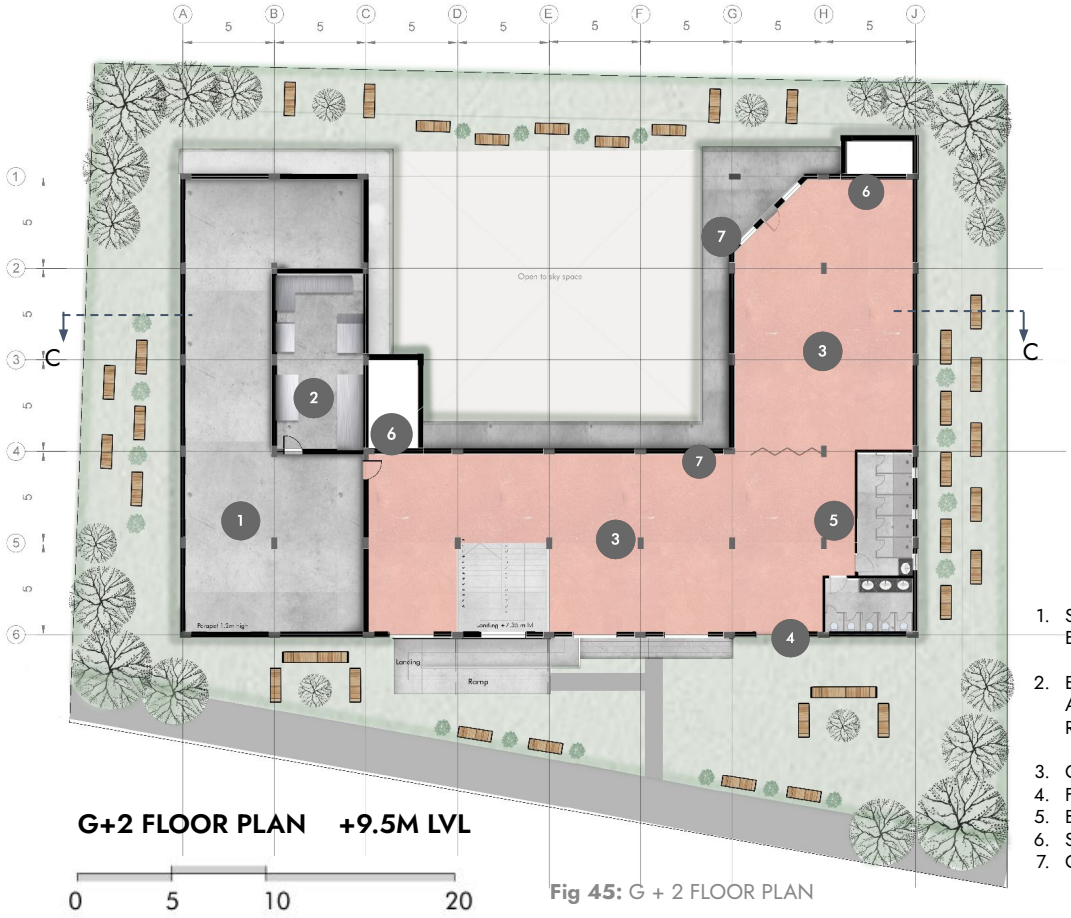


Fig 44: G + 1 Floor Plan

DESIGN

ARCHITECTURAL



LEGEND:

1. SPACE FOR FUTURE EXPANSION
2. ELECTRICAL CONTROL AND COMMUNICATION ROOM
3. CONGREGATION SPACE
4. FEMALE TOILETS
5. BATH AREA
6. SOLAR CHIMNEY
7. CORRIDOR

Fig 45: G + 2 FLOOR PLAN

DESIGN

Fig 46: Sectional view CC'

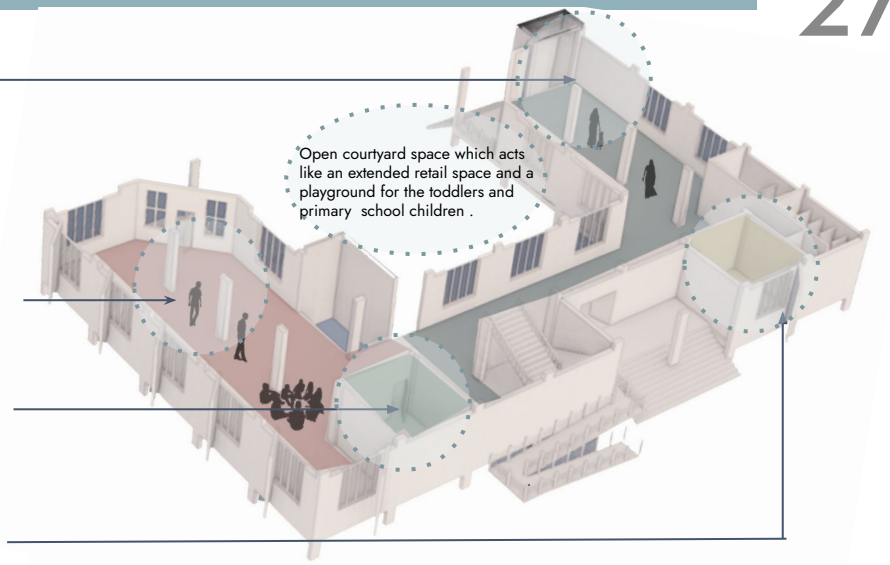


Fig 47: Function of spaces before disaster (Ground Floor)

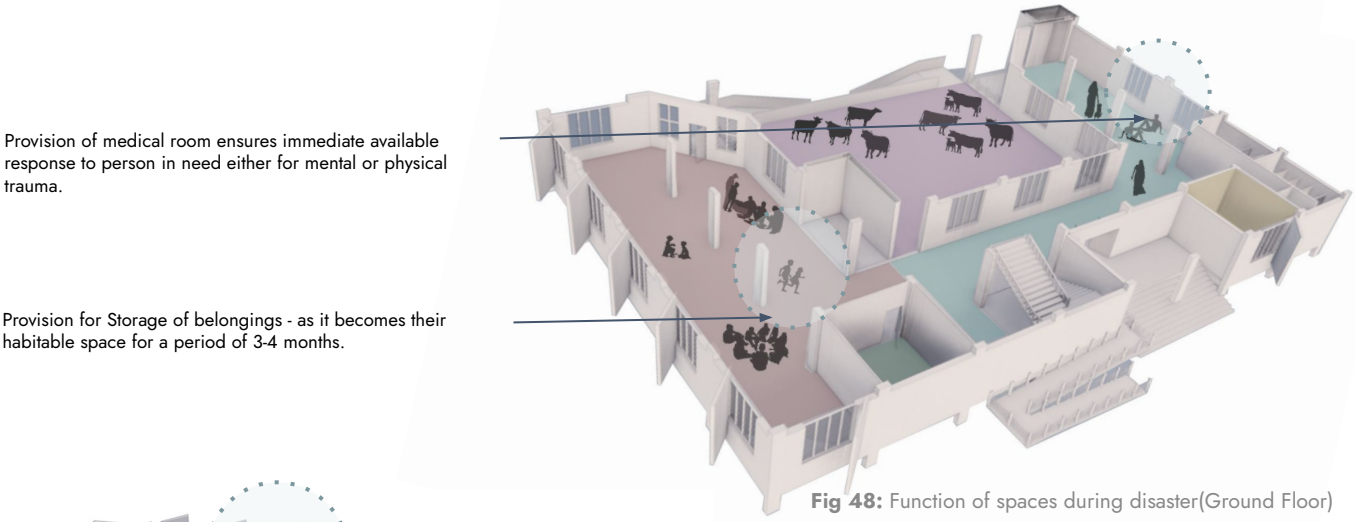


Fig 48: Function of spaces during disaster(Ground Floor)

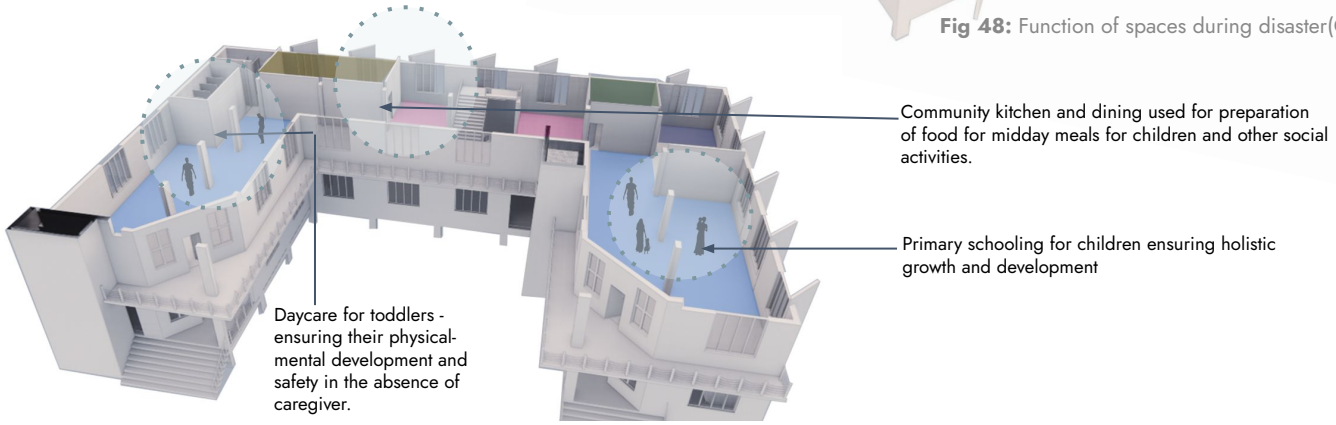


Fig 49: Function of spaces before disaster (First Floor)

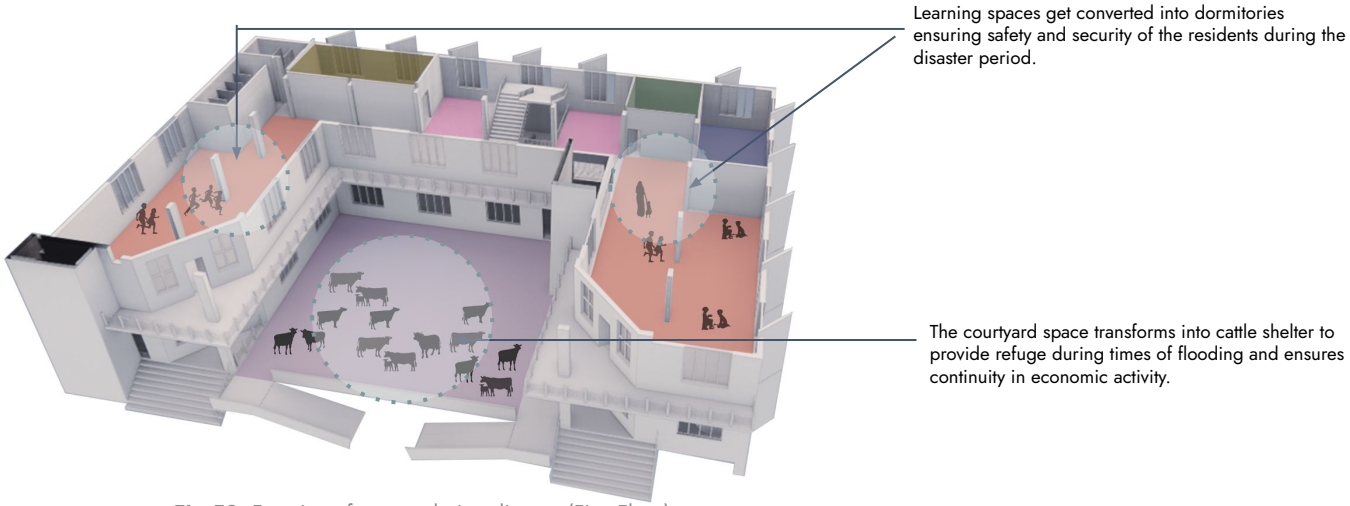


Fig 50: Function of spaces during disaster (First Floor)

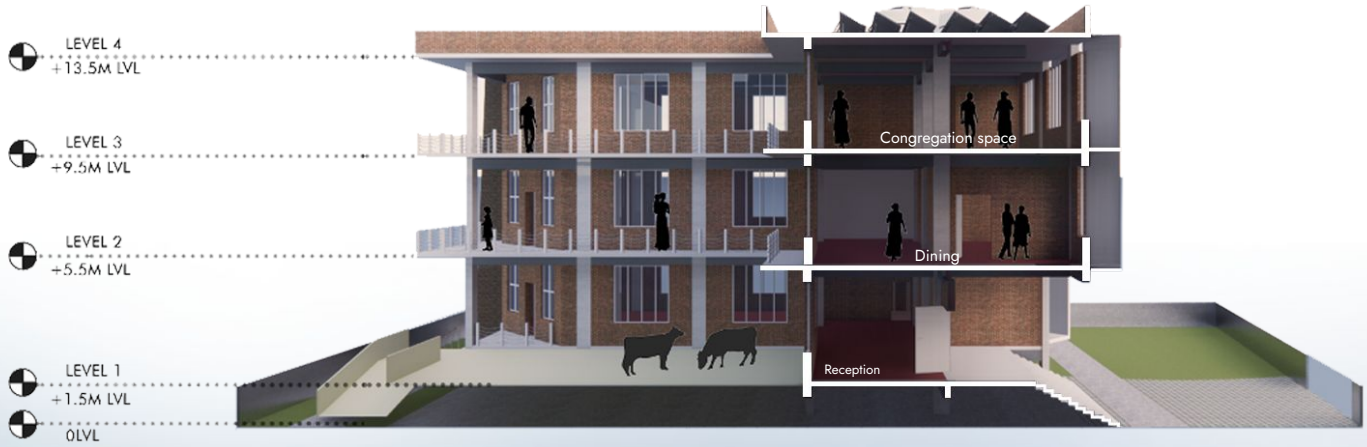


Fig 51: Section **BB'**

Fig 52: Section AA'

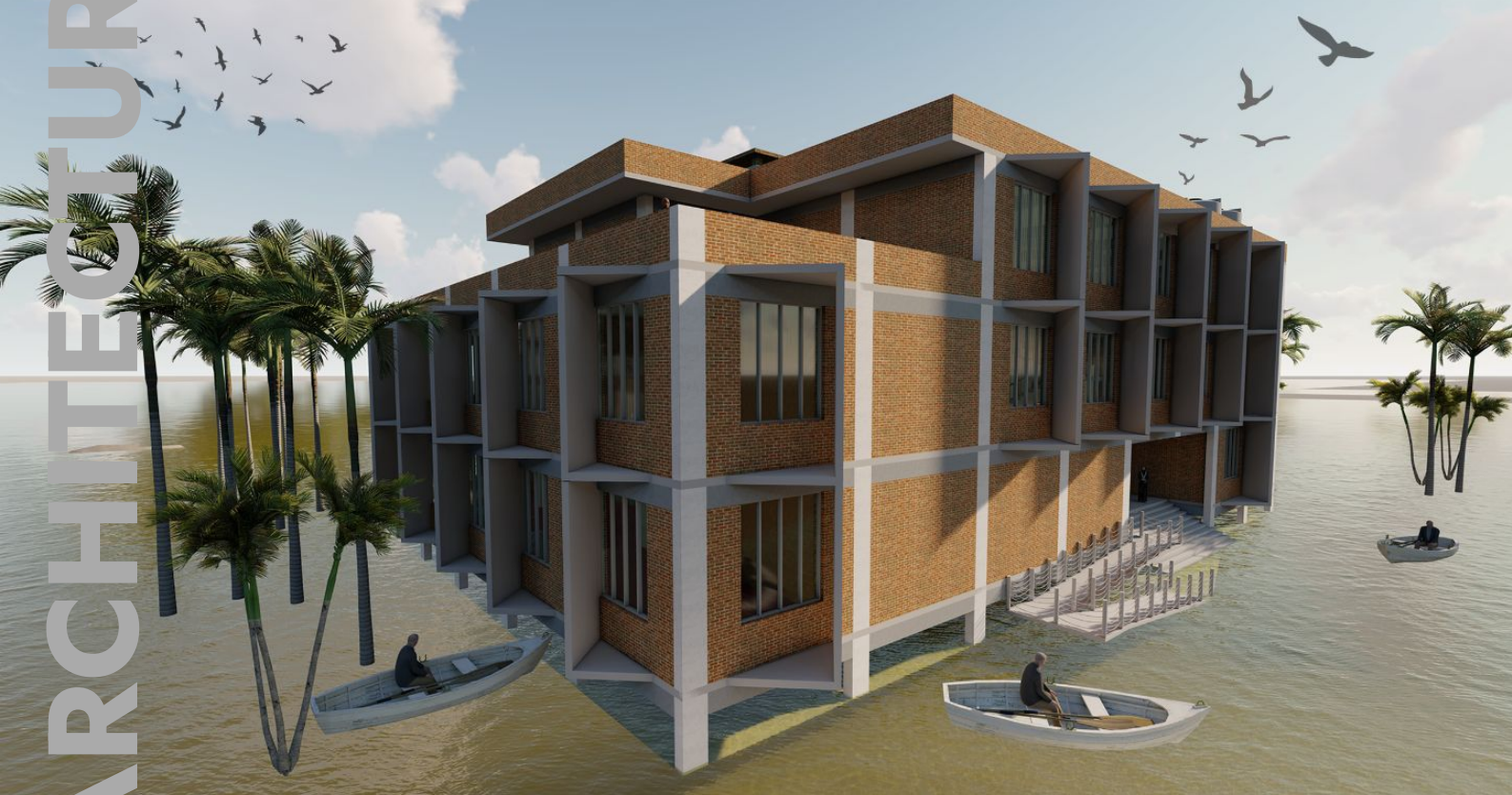


Fig 53: Disaster scenario-Perspective View from South West

4.7 ENGINEERING AND OPERATIONS

The Structural design of the community shelter has been done with a responsive approach towards soil conditions and other challenges. Considering the height and load factor, columns measuring 300x700mm are placed on a 5mx5m grid. The design employs a raft foundation considering the soil type and its bearing capacity of the region(i.e. Clayey soil).

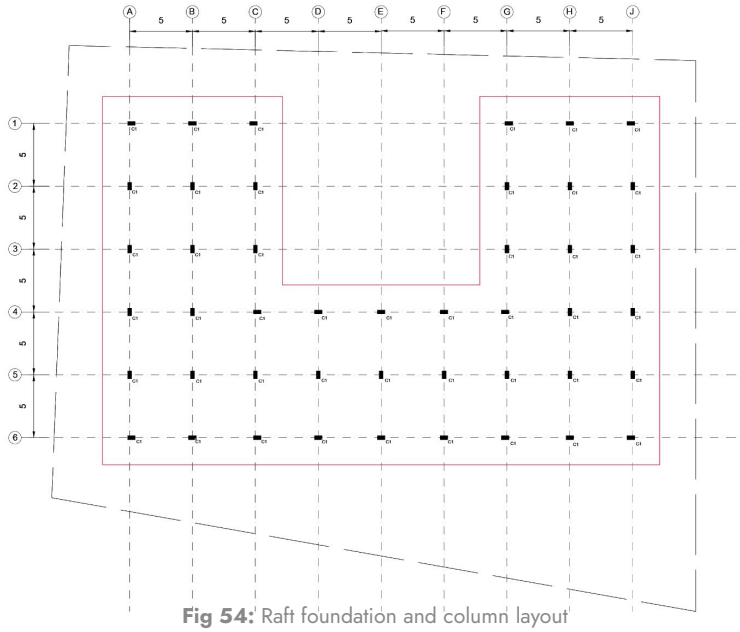


Fig 54: Raft foundation and column layout

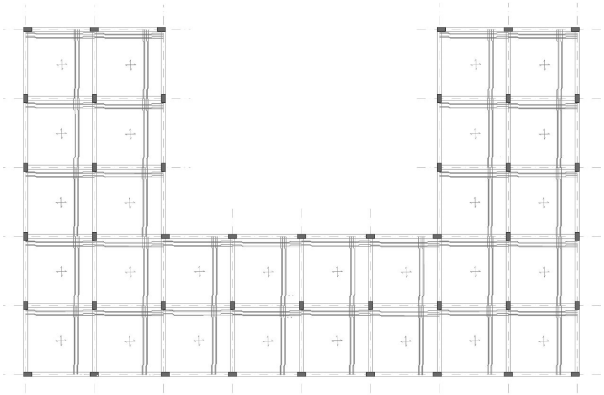


Fig 55: Slab Detail

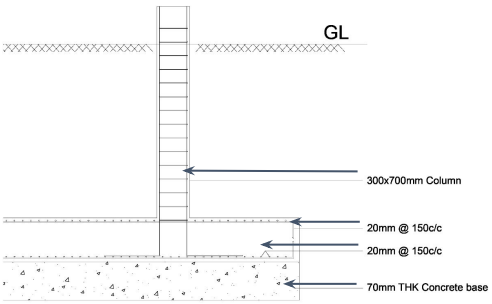


Fig 56: Typical section of Footing

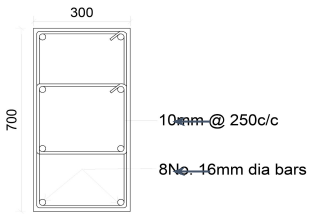


Fig 57: Column Detail

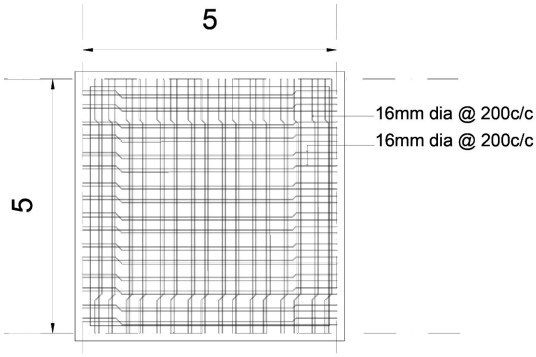


Fig 58: Two way Slab Detail

Fig 59: Beam Detail

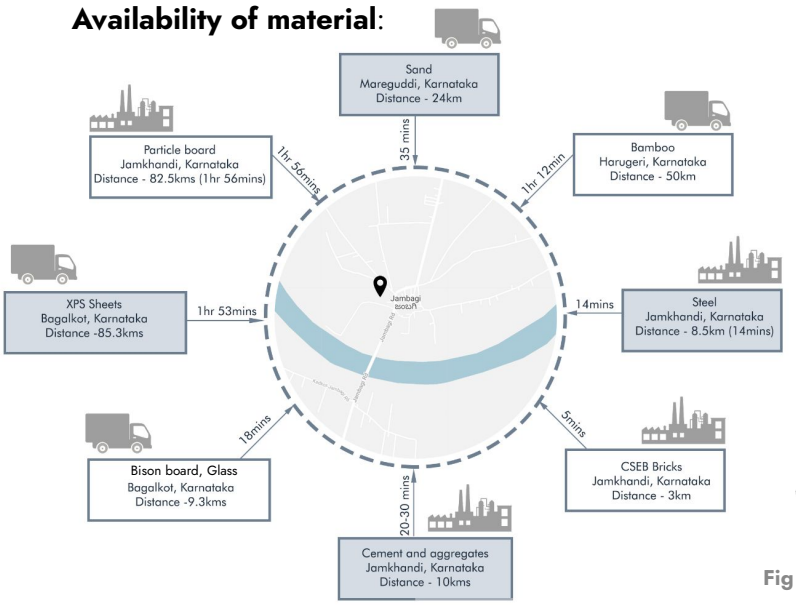


Fig 60: Representation of proximity of Material transport

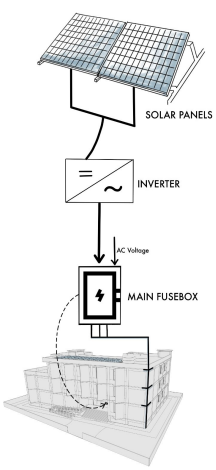


Fig 61: Solar energy Utilization

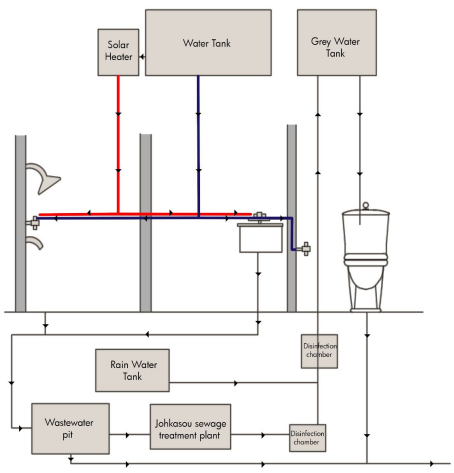


Fig 62: Working of water management across the building

ELECTRICAL LAYOUT

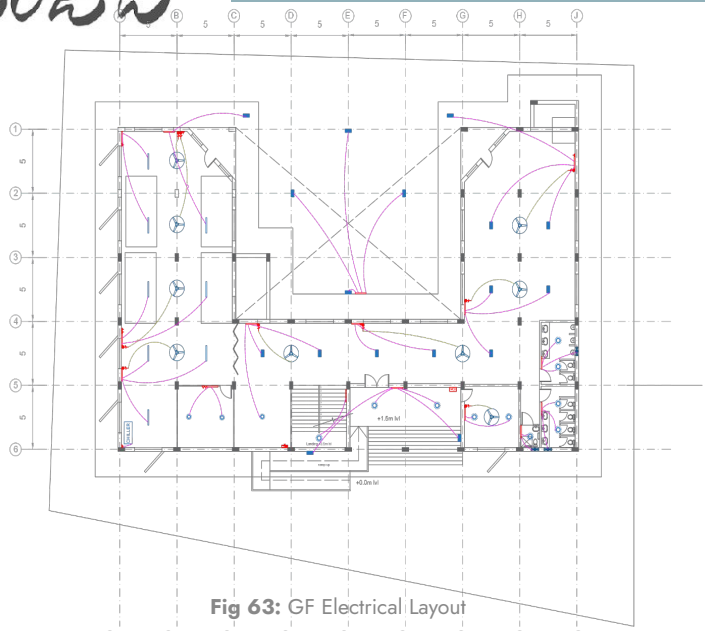


Fig 63: GF Electrical Layout

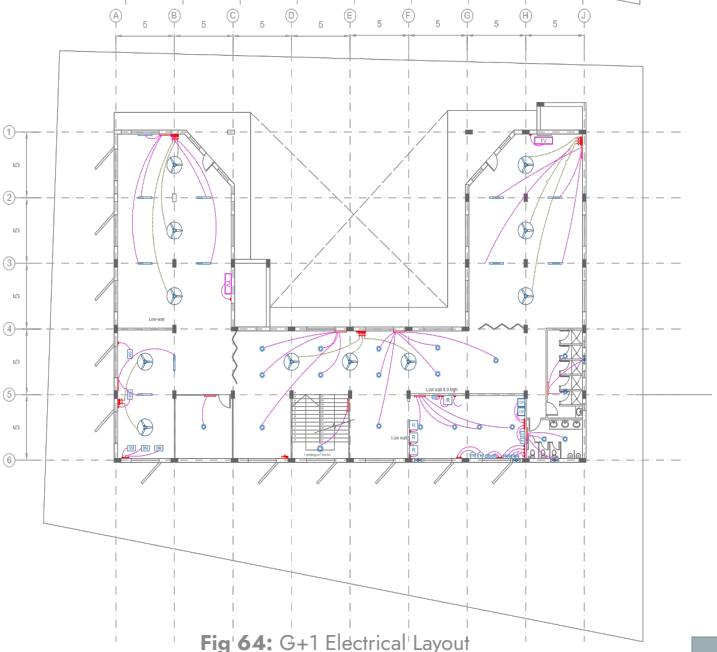


Fig 64: G+1 Electrical Layout

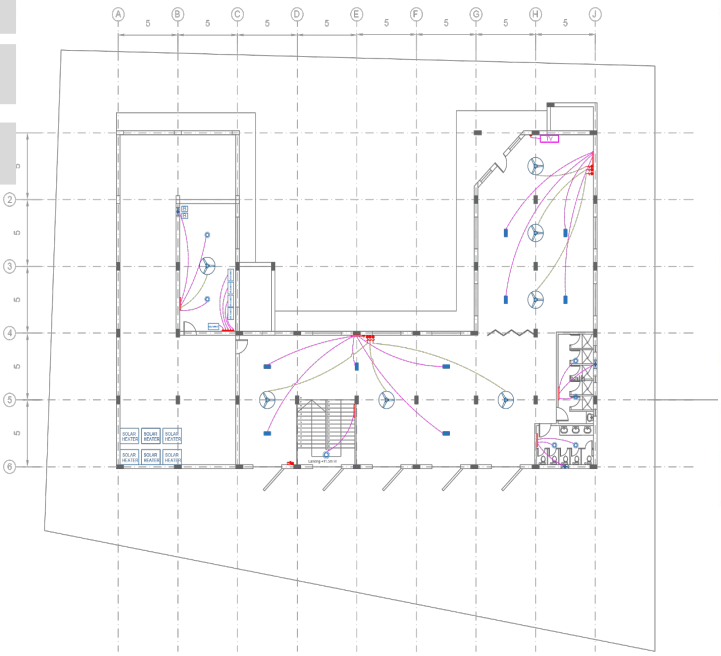
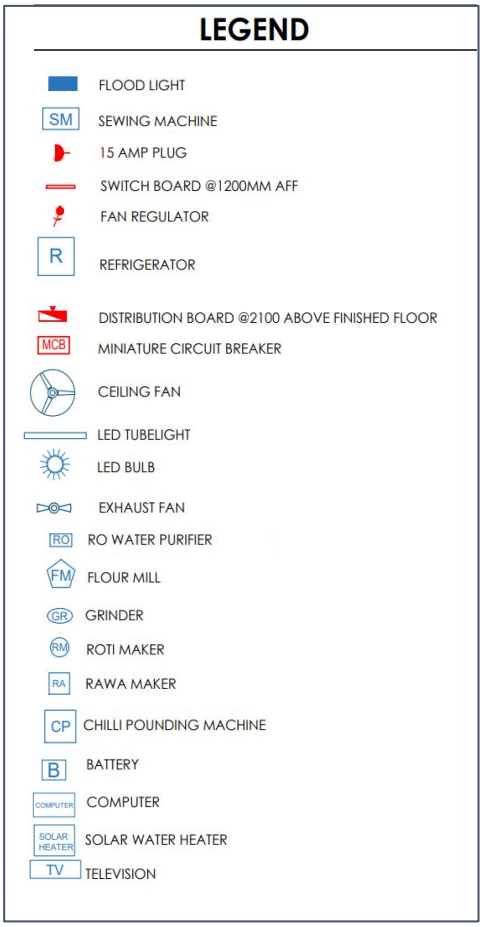


Fig 65: G+2 Electrical Layout



Equipment	Number	Power consumption(Watt)	Total (Wh)	Company	Cost	Lumens	Images
LED Tubelights	20	10	200	Philips	Rs.497	2000	
BLDC Fans	26	20	520	Havells	Rs.2800		
BLDC Exhaust Fans	10	5	50	Havells	Rs.1498	-	
Flood Lights	24	15	360	Murphy	Rs.725	900	
LED Bulbs	36	5	180	Syska LED	100-300	400	

Table 21 : Electrical Fixture specifications

PLUMBING LAYOUT

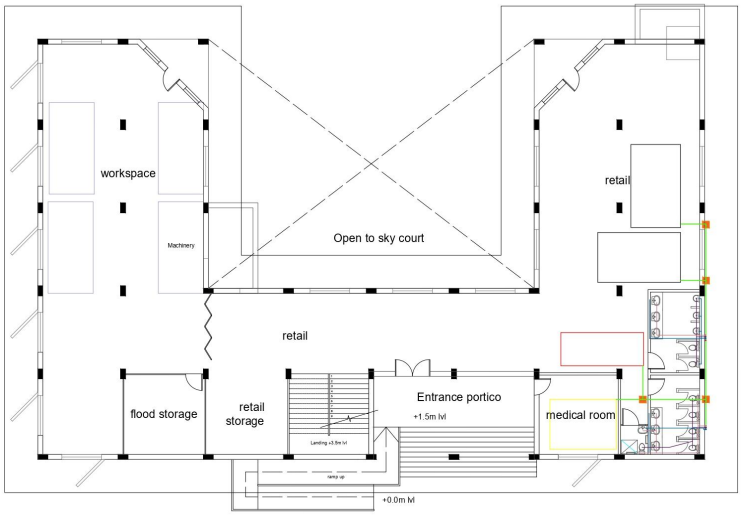
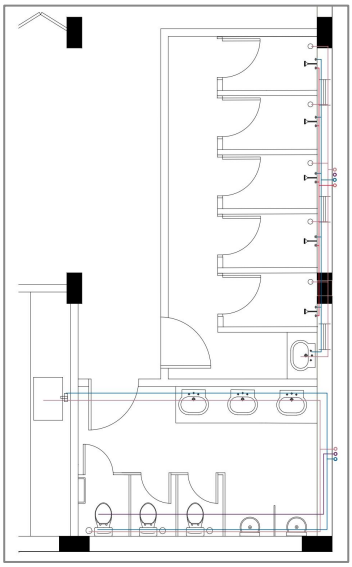


Fig 66: GF Plumbing Layout



DETAIL @ 'A'

Fig 69: G+1 (Detail)

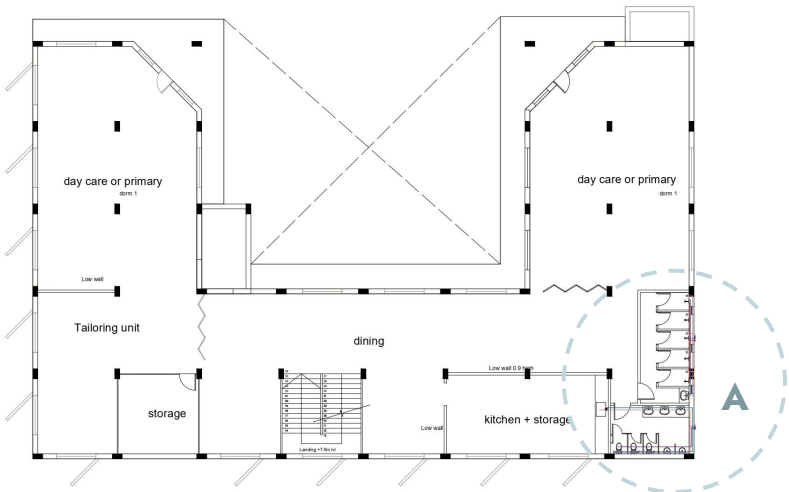
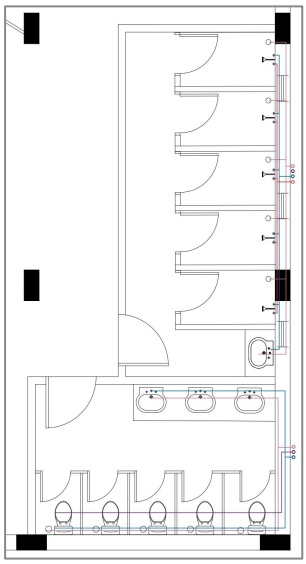


Fig 67: G+1 Plumbing Layout



DETAIL @ 'B'

Fig 70: G+2 (Detail)

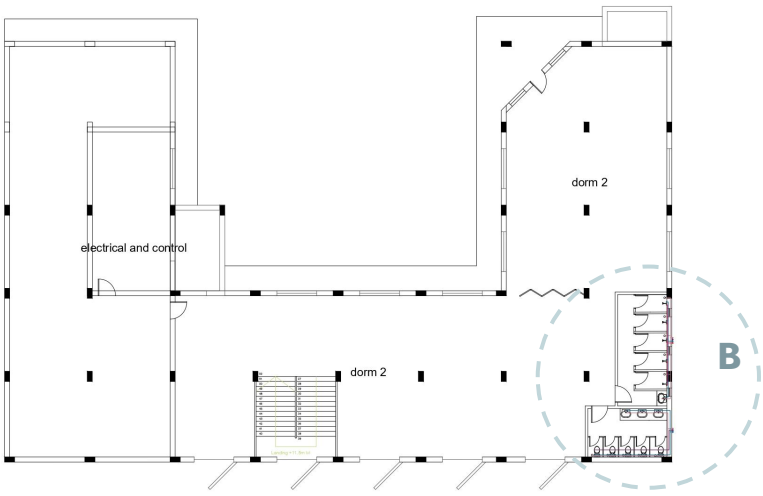


Fig 68: G+2 Plumbing Layout

Sanitary Fixture	Number	Company	Cost for one	Images
Western	15	Hindware	Rs. 3000	
Shower	10	Jaquar	Rs. 850	
Wash Basin	18	Hindware	Rs. 1481	
Health Faucet	15	Hindware	Rs. 700	
Urinals	5	Hindware	Rs. 1300	
Taps	10	Hindware	Rs. 800	

Table 22 : Sanitary Fixture specifications

LEGEND

- SOIL TYPE
- SOLID TYPE
- COLD WATER
- HOT WATER
- Inspection Chamber
- Grey tank
- Sewage tank
- Rainwater tank
- Trench

4.8 AFFORDABILITY

A capital budget of Rs. 28,436 INR/sqm is calculated which is 9.4 % lower as compared to the Baseline Case. Items like civil work, equipment and MEP service has higher CAPEX as compared to Baseline Case, however these strategies helps us in reducing the OPEX. Further, the implementation of governmental schemes and subsidies along with partnership with stakeholders has reduced the overall costs.

The proposed model is highly affordable net-zero solution due to the following achievements in design:

MATERIALS-The materials used in construction like CSEB bricks for walls, red-oxide flooring for interiors are locally sourced, reducing transportation, and also sustainable reducing the embodied energy for our project. We have chosen materials which are low maintenance and have longer lifespans, reducing maintenance and replacement costs

EASY CONSTRUCTION AND REDUCED TIME With the help of local participation and simple column and beam structural system with brick cladding the construction is scheduled for shorter time duration. Creating multifunctional spaces that cater for changing functions, optimizes building utilization and reduces extra costs of construction.

ENERGY EFFICIENCY Using efficient passive strategies like solar chimney for cooling, ventilation, shading devices etc., the energy requirements and consumptions are both reduced, which leads to lower energy costs, and less operational and OPEX costs.Furthermore, energy is produced on-site using solar panels, and given back to the grid(net positive energy system). This can become a potential revenue model of selling electricity to the grid

DESIGN :Design is developed considering passive strategies instead of active ones which will lower repair, maintenance and utility cost to achieve better life cycle cost. ISHRAE Standards were used to establish right sized lighting loads within each space based on task lights, ambient lights and accent lights. WWR was taken from Design Builder simulations to right size the windows for ventilation and natural light. Other passive design strategies for ventilation as well reduce the electrical load and hence reduce operational costs.

SAVINGS ON OPEX: Every room in the house is designed and laid out in such a way that there is cross ventilation. This will assist in maintaining the occupant's thermal comfort while reducing reliance on artificial cooling systems. Solar Chimney, despite their high initial installation costs, resulted in a nearly 70% reduction in cooling loads and minimal life cycle costs

Using of floor finishes like red-oxide flooring, thermal painting, provide cost-effective solutions and low maintenance systems , thereby reducing construction as well as operative cost

Highly efficient, energy saving lighting equipment and fixtures along with water efficient fittings and fixtures in plumbing reduce the consumption demand, thereby reducing the costs.

MODULAR AND PROTOTYPE FORM The project functions as a prototype design that can be used in other situations, with a modular form and adaptable facilities.

S.No.	Particulars	Definition	Baseline Estimate (Project Partner / SOR basis)			Proposed Design Estimate		
			Amount (Million INR)	%	Amount (INR per sqm)	Amount (Million INR)	%	Amount (INR per sqm)
1	Land	Cost of land purchased or leased by the Project Partner	0	0.00%	-	0	0.00%	-
2	Civil Works	Refer Item A, Civil works in Cost of construction worksheet	34.9	53.30%	16,740	35.75	54.00%	17,147
3	Internal Works	Refer Item B, Civil works in Cost of construction worksheet	3.08	4.70%	1,476	2.63	4.00%	1,261
4	MEP Services	Refer Item C, Civil works in Cost of construction worksheet	8.44	12.90%	4,046	8.11	12.40%	3,891
5	Equipment & Furnishing	Refer Item D, Civil works in Cost of construction worksheet	0.66	1.00%	317	0.00	0.00%	-
6	Landscape & Site Development	Refer Item E, Civil works in Cost of construction worksheet	0.19	0.30%	90	0.41	0.60%	201
7	Contingency	Amount added to the total estimate for incidental /misc. exp.	9.45	5.00%	4,5349	4.69	5.00%	2,250
	TOTAL HARD COST		**56.72**	**77.2%**	**27,202**	**51.60**	**76.7%**	**24,750**
8	Pre Operative Expenses	Cost of Permits, Licenses, Market research, Advertising etc	0.5	0.80%	240	0.5	0.80%	240
9	Consultants	Consultant fees on a typical Project	4.00	6.10%	1,918	4.00	6.10%	1,918
10	Interest During Construction	Interest paid on loans related to the project during construction	4.24	6.50%	2,034	3.12	4.90%	1,528
	TOTAL SOFT COST		**8.74**	**13.4%**	**4,192**	**7.69**	**11.7%**	**3,686**
	TOTAL PROJECT COST		**65.46**	**100%**	**31,394**	**59.29**	**90.6%**	**28,436**
CONSTRUCTION BUDGET/ Sq.m (Hard Cost)								**24,750/ sq.m**
CONSTRUCTION BUDGET/ Sq.m (Hard Cost + Soft Cost)								**28,436/ sq.m**

Table 23: Construction budget

SL.NO	CONSTRUCTION ELEMENT	MATERIAL
1	Substructure	Raft foundation - RCC work
2	Stilts and columns	Exposed RCC work
3	Slabs and beams	Exposed RCC work
4	External walls	Rat trap bond walls made up of CSEB bricks.
5	Internal walls	CSEB brick wall of 100 mm thick and Wooden frame partition with bamboo mesh.
6	Floors	Red oxide flooring.
7	Windows	Glass windows with wooden frame
8	Doors	Sal or nahal wood doors
9	Railings	Bamboo posts with rope connections

Table 24: Construction

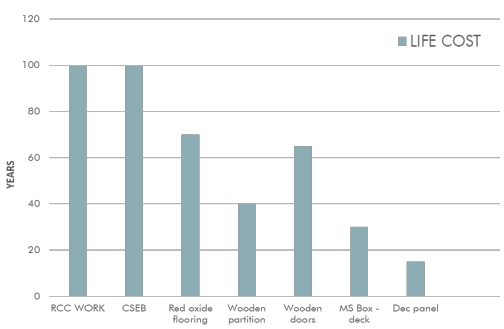


Fig 71: Lifespan of Materials

TIMELINE	YEAR 1				YEAR 2			
	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER
PRE CONSTRUCTION COST								
FINANCING								
EXCAVATION								
FOUNDATION								
WATER PROOFING								
SUPER STRUCTURE RCC FRAME								
ENTRANCE RAMP								
STAIRCASE								
IN FILL WALLS - EXTERNAL								
IN FILL WALLS - INTERNAL								
DOORS AND WINDOWS								
ELECTRICAL WORK								
PLUMBING WORK								
FINISHING WORK								
SOLAR PANELS INSTALLATION								

Table 25: Construction timeline

INNOVATION

1. COURTYARD DECK

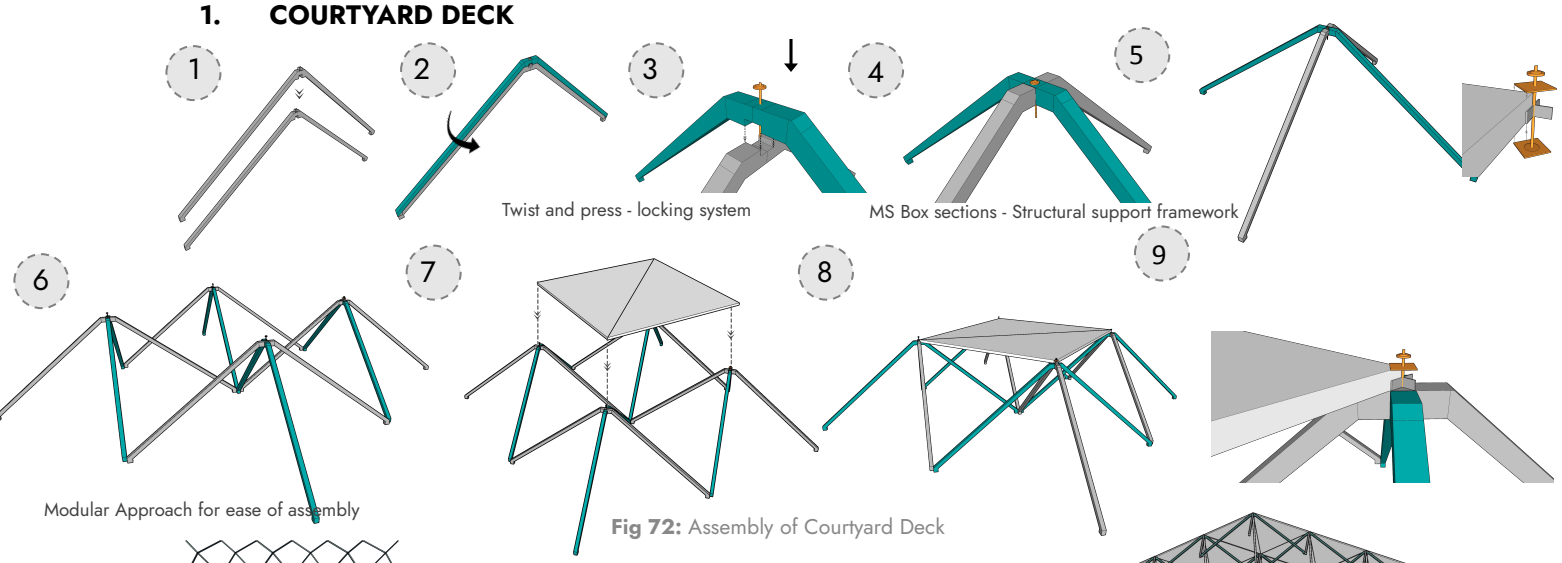
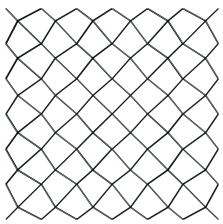
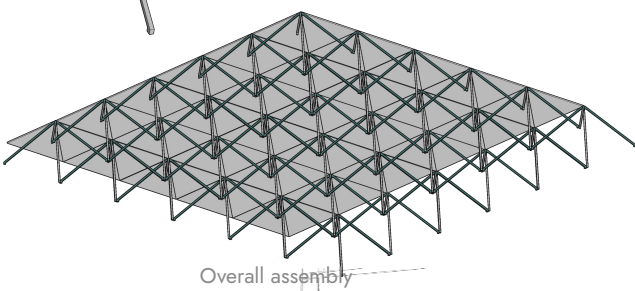


Fig 72: Assembly of Courtyard Deck



Plan layout

The Deck is used as per the functional requirements but especially to provide resilience to the cattle.The design has a 4 legged support system on which Bison board with galvanised sheet is used as backing.



Overall assembly

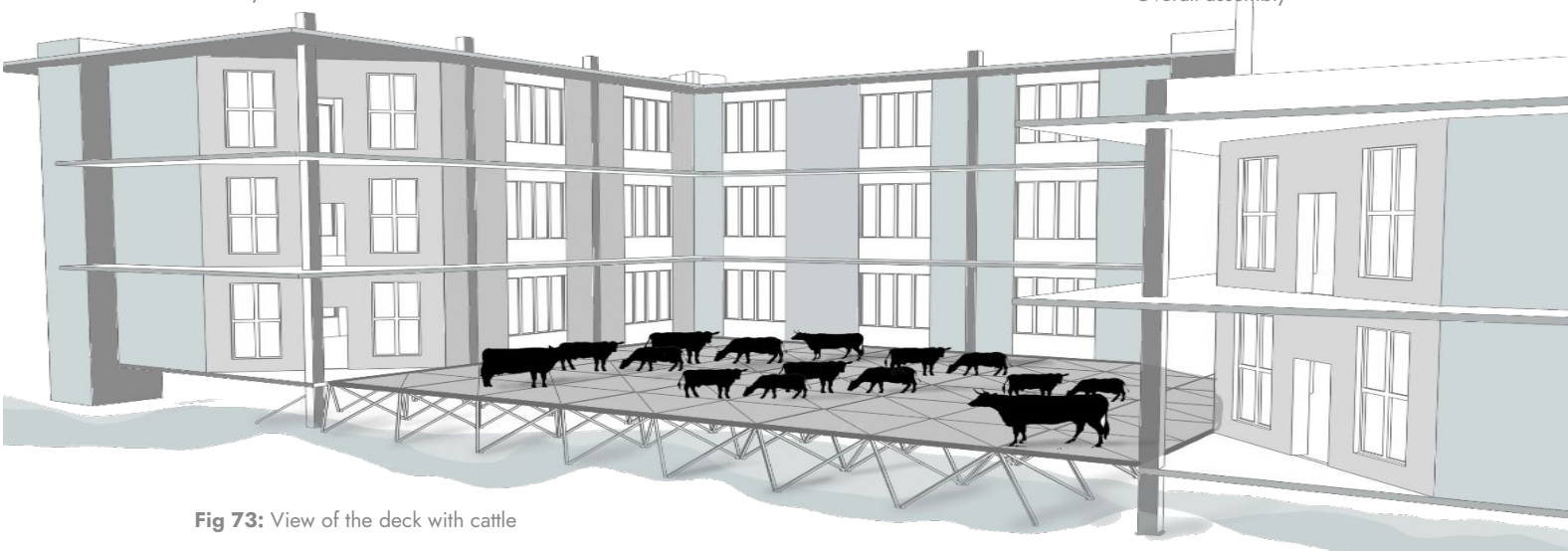


Fig 73: View of the deck with cattle

2. SOLAR CHIMNEY

Idea:
A community building relies on the everyday activities it houses and its functions. Thus, it becomes necessary to achieve comfortable indoor temperatures through mechanical and natural ventilation. Our proposal of the 'Solar Chimney' aims at achieving ambient indoor climatic conditions through bringing about enhanced ventilation, thereby increasing thermal comfort.

Problem:
The presence of high indoor temperatures in addition to high humidity levels creates a disruption in functions in addition to causing discomfort to the occupants.
The solar chimney presents an affordable solution to ensure the smooth running of activities within the structure as well as the reduction of humidity in the interior spaces. The significance of the solar chimney as an alternative energy efficient building design is the highest within semi- public spaces of the building, where a large number of people are present at most times of day.

Working:
A shaft- like chimney is built and painted black to absorb more heat and thus reduce reflection of sunlight. A large surface area of the solar chimney is oriented towards the South to capture maximum solar radiation in the Northern hemisphere. The heat absorbed is then trapped within the shaft due to which an updraft of wind is created. The solar chimney is primarily focused on achieving cooling in addition to the required air changes per hour (ACH). In accordance with our building layout, two solar chimneys are placed at strategic positions to ventilate the frequently used public and semi-public spaces (such as dairy, dining etc).

The shaft has two vents, one at the top of the chimney (for exhaust) while another vent opens to the interior spaces (for intake). Incident solar radiation is responsible for heating of air present within the shaft. The vent at the top of the chimney is kept open to permit the escape of heated air and to create an updraft due to pressure differences. This updraft thus helps drawing in cool, fresh air through windows.

Market:

Solar chimneys are most effective in hot and humid climates. They are also economical and have various benefits, influencing many to protect the environment from pollution and to boost the demand for eco-friendly design approaches.

Hence, the current trends in the construction industry are heavily reliant on strategies that make use of renewable energy sources such as solar energy, and solar chimneys are preferred widely due to their low cost of operation and high impact on indoor environments.

Costs
Solar chimneys are a cost-effective choice for a cooling and heating system due to the lack of electricity or gas needed to power the chimney. Additionally, they employ simple construction measures

Potential benefits and impacts

- help reduce energy use, CO2 emissions and pollution in general.
- improved ventilation rates
- reduced reliance on wind and wind driven ventilation
- improved control of air flow through a building
- improved air quality
- improved passive cooling on hot days
- enhanced performance of thermal mass (cooling, cool storage)
- improved thermal comfort (improved air flow control, reduced draughts)

Fig 74: Thatch blind which controls air flow

The chimney height and diameter are critical design parameters that affect the performance of the solar chimney. An increase in the height and diameter of the chimney can enhance the airflow rate and increase the ventilation performance.

Two solar chimneys are used to cover a effective volume of 800 m^3/s each with 8 ach .
To achieve 8 ach, effective flow rate of 1.7m3/s into the building must be achieved.
To create this flow rate into building 2 factors come into play.

1) The temperature difference in the shaft
2) The size of the openings.

The size of the openings control the flow of air into the building and light entering it. This is done by using thatch blinds .

At the top of the chimney, glass is used on to capture radiation which in turn heats the small volume of air which rises up and is vented out.
The pressure differential required is 7.2 Pa which requires a temperature difference of 12 deg C between the outside air and the top of the chimney.

During the summer this pressure difference is naturally achieved but during the monsoon due to insufficient solar radiation ,only a temperature difference of 8 deg C is achieved.
To create the required pressure difference a centrifugal fan is used which operates during the afternoons .

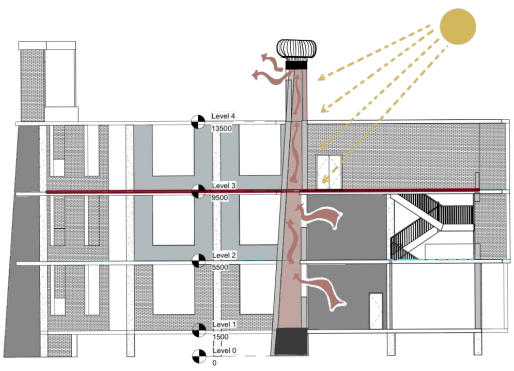


Fig 75: Solar Chimney

4.9 HEALTH AND WELLBEING:

Waste disposal management refers to the collection, transportation, processing, and disposal of waste materials in a safe and environmentally friendly manner. Proper waste disposal management is essential to prevent environmental pollution, health hazards, and to promote sustainable development.

Waste segregation is crucial for effective waste management such that the desired work of action can be employed for their proper disposal.

The waste management plan has been shown in the flowchart

- Biodegradable wastes produced from various functions are used for composting to produce manure. The same can be utilised on site and sold to farmers for use in agricultural fields
- The Non-Biodegradable waste is segregated further into recyclable and non-recyclable waste.The same are disposed off every three days to the local garbage collectors.

The recyclable wastes likes paper, cardboard, plastics could be sold to to local recycling units. Medical wastes could be incinerated or given to the local collectors for treatment.

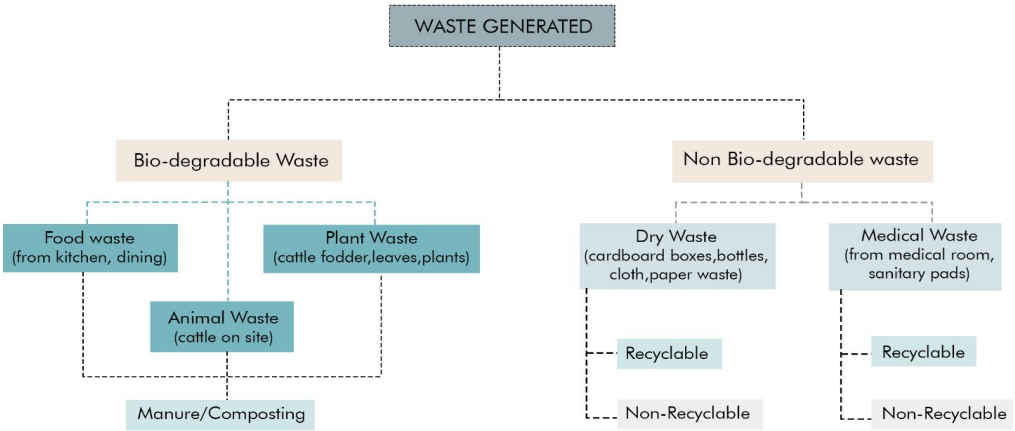


Fig 76: Waste Generation Flowchart

Fig 77: Segregation of waste

THERMAL COMFORT:

Understanding and analysis of the thermal comfort is done using the standards given in ASHRAE.
Keeping in mind the hot and humid context, the outdoor temperature is comfortable for a fraction of 32% of the entire year based **ASHRAE 90% acceptability limits.**
Two methods to reach thermal comfort are:

- high air changes per hour and
- material with high thermal mass

The operating time of the shelter:

a.) during periods of non disaster: 10 hrs
b.) during periods of disaster: 24 hrs

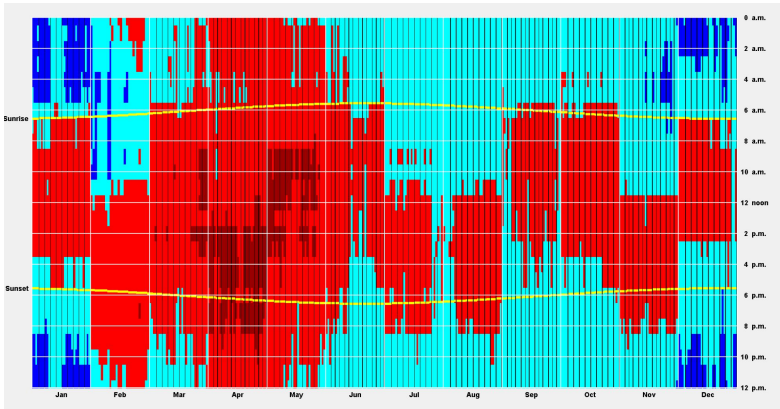


Fig 78: Annual temperature graph

- For the period of flooding, that lasts around 10 months of the year (except the months of April and May), the humidity levels increase rapidly to 80%-90%.
- During the summer months of April - May, thermal comfort is achieved using walls of high thermal mass with cavity walls to increase the thermal lag. Due to presence of the solar chimney , the required air changes per hour (i.e 8) is achieved naturally.
- During the monsoon months of June-October, when temperatures are relatively cooler but humidity is very high, thermal comfort can be achieved by an increase in the air changes using mechanical assistance (through centrifugal fans).
-

Using **ASHRAE 90% acceptability limits;**
Thermal comfort is achieved throughout all spaces for a fraction of 77.53% of the year. The places with the highest footfall are comfortable 2489 hrs out of 3210 hrs of operation over a year.

Using **ASHRAE 80% acceptability limits:**

Thermal comfort is achieved throughout all spaces for a fraction of 91.12% of the year. The places with the highest footfall are comfortable 2893 hrs out of 3210 hrs of operation over a year.

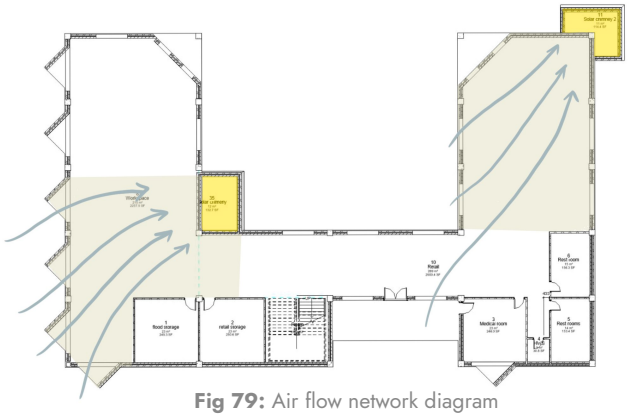


Fig 79: Air flow network diagram

Natural ventilation:
It is achieved with the narrow layout and elongated form of the building, thus facilitating cross ventilation of all interior spaces. The windows are oriented along the directions of wind to maximize flow rate for a given window. As our building is mostly naturally ventilated and is assisted by fans the rest of the time, comfort is achieved during the monsoon months by increasing the air changes per hour (ACH) to 9-12 as shown below.

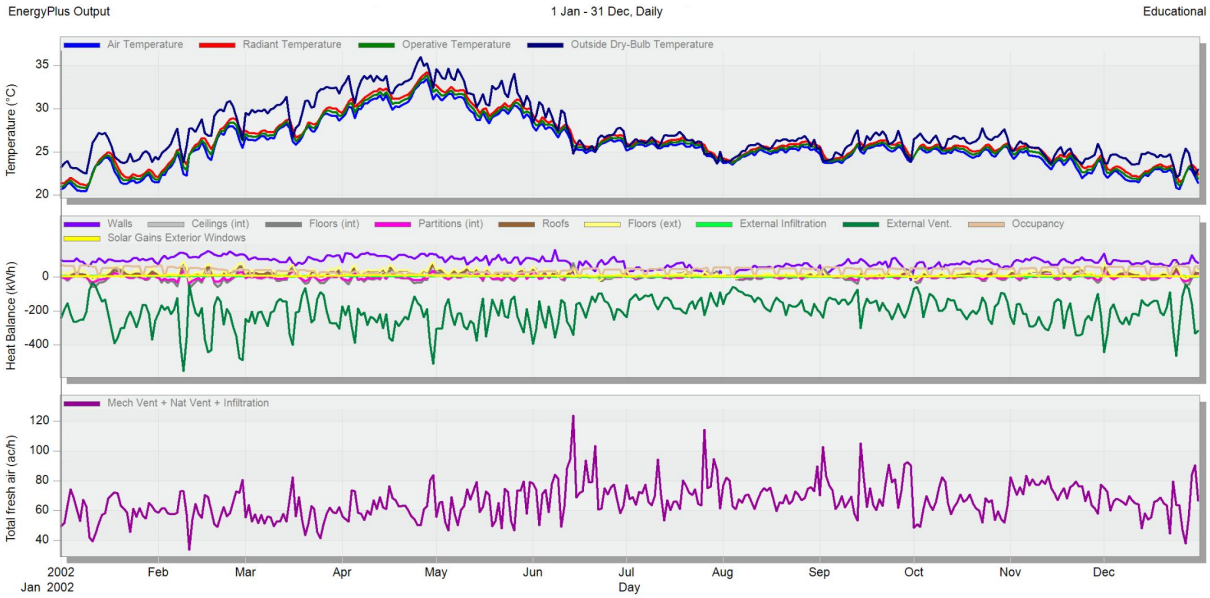


Fig 80: Annual simulation graph

4.10 VALUE PROPOSITION

The design of the community resilience shelter (CRS) has been conceived with a conscious effort towards elevating the lifestyle and living conditions of the affected community by providing them with not just a space to call their own, but also to nurture **economic activity**, **employment opportunities** and **additional sources of income**, thereby providing them a livelihood even during times of disaster.
The center equips the community to be **self sufficient** through the adoption of various strategies and measures that aid in reducing consumption while simultaneously optimising on generation of resources such as energy, water and food during disasters. This **adaptable** nature of the center renders it resilient to changing conditions and scenarios that are likely to arise in the future.

Further, the quick and easy construction of the community resilience shelter makes use of context specific and **locally available materials** that help in reducing costs incurred due to labour, transport and construction, in addition to providing thermal and energy efficiency and lower carbon emissions. **Lower maintenance and OPEX operational costs** are also achieved.

The CRS is aimed to be **all- inclusive**, providing spaces that accommodate activities of various user groups- children, the middle aged, women, and the elderly. It also keeps in mind the requirements and needs of **cattle owned by each of the families** and realises the need to provide resources to aid the generation of economic activity through these cattle in addition to providing them **refuge** within the shelter during periods of flooding when the existing settlements are submerged. In addition, the functioning of the resilience shelter during non-disaster periods brings about a stronger **sense of community and we-feeling** among people as they work together in an environment that **fosters growth** and **mutual support and well being**.

Through our design, we aim to create a **prototype model** for several such centres to be established to cater to such underserved communities. The model would provide an insight into the community's behaviour, their activities, and their response to both scenarios- before and during a disaster. They would function as a **universal template** that could be deployed in any given location and **adapted to the context** accordingly.

APPENDIX A-1: ENERGY CONSUMPTION - EFFICIENCY AND OPERATIONS

ENERGY CONSUMPTION WITH RESPECT TO SPACES				BASELINE						STRATEGIES EMPLOYED	PROPOSED			
Sl.No	Spaces	Spaces	No.Of Unit	Fixtures/Equipments	No. Of Fixtures	No. Of Hours	Power Consumption (Watts)	Power Consumption (Wh- Watt hours)	No.Of Unit	Fixtures/Equipments	No. Of Fixtures	No. Of Hours	Power Consumption (Watts)	Power Consumption (Wh-Watt Hours)
1	Common Spaces	Daycare + Primary School		Fluorescent tube light of 30 W	10	4	30	1200		LED Tube Light	10	3	10	300
			1	fans	8	4	75	2400	1	BLDC fans	6	3	20	360
				Television (Entertainment)	2	4	200	1600		Solar based	2	2	150	600
		Dining + Kitchen(Mid-Day Meal)		CFL Bulbs 20 W	6	12	20	1440		LED Bulb	15	4	5	300
				fans	4	6	75	1800		BLDC fans	3	4	20	240
				Exhaust fans	2	7	50	700		BLDC Exhaust fans	2	6	5	60
				Refrigerators(300 l)	5	24	200	24000		Solar based	5	24	150	18000
			1	RO purifier	6	12	250	18000	1	Solar based	6	10	75	4500
		Mela space + everyday retail		Incandescent 25 W	27	15	25	10125		Flood lights	9	6	15	810
				fans	5	7	75	2625		BLDC fans	4	5	20	400
			1	Sewing Machine (Tailoring Centre)	5	6	75	2250	1	Solar based	5	3	20	300
		Congregation space		Incandescent 25 W	27	15	25	10125		Flood lights	9	6	15	810
				fan	6	4	75	1800		BLDC fans	6	4	20	480
			1	Television (Entertainment)	1	8	200	1600	1	Solar based television	1	2	150	300
2	Other Spaces	Storage for food + Mill (Flour, Dough etc)		CFL Bulbs 20 W	3	3	20	180		LED Bulb	2	3	5	30
				fans	1	7	75	525		BLDC fans	1	5	20	100
				Chilli Pounding machine	2	2	2000	8000		Solar based	2	2	750	3000
				Aata Making machine	4	2	150	1200		Solar based	4	2	100	800
				Rava Making Machine	2	2	745	2980		Solar based	2	1	500	1000
				Flour Mill + Pulverizer	2	3	2000	12000		Solar based	2	2	750	3000
			1	Grinders	2	5	400	4000	1	Solar based	2	3	250	1500
		Workspace (dairy) + retail	1	Fluorescent tubelight of 30 W	8	6	30	1440	1	LED Tubelights	8	6	10	480
				fans	4	6	75	1800		BLDC fans	4	4	20	320
				Chiller unit	1	24	20000	480000		Solar based	1	24	5000	120000
		Cattle shelters	1	Incandescent 25 W	2	3	25	150	1	LED Tubelights	2	2	5	20
		Medical room		Incandescent 10 W	2	6	10	120		LED Bulbs	2	6	5	60
			1	fans	1	4	75	300	1	BLDC fans	1	2	20	40
3	SERVICES	Male Washrooms	2	Incandescent 10 W	3	4	10	240	2	LED Bulbs	2	4	5	40
			2	Exhaust fans	1	3	50	300	2	BLDC Exhaust fans	1	3	5	15
		Female Washrooms	2	Incandescent 10 W	3	4	10	240	2	LED Bulbs	2	4	5	40
			2	Exhaust fans	1	3	50	300	2	BLDC Exhaust fans	1	3	5	15
		Male Bathing Area	1	Incandescent 10 W	3	4	10	120	1	LED Bulbs	2	4	5	40
			1	Exhaust fans	2	3	50	300	1	BLDC Exhaust fans	2	3	5	30
			1	Water heating coils	5	3	1500	22500	1	Solar water heaters	3	3	1000	9000
		Female Bathing Area	1	Incandescent 10 W	3	4	10	120	1	LED Bulbs	2	4	5	40
			1	Exhaust fans	2	3	50	300	1	BLDC Exhaust fans	2	3	5	30
			1	Water heating coils	5	3	1500	22500		Solar water heaters	3	3	1000	9000
		Handicapped Washrooms	3	Incandescent 10 W	1	2	10	60	3	LED Bulbs	1	2	5	10
			3	Exhaust fans	1	3	50	450	3	BLDC Exhaust fans	1	3	5	15
		Electric Room	1	Incandescent 10 W	2	4	10	80	1	LED Bulbs	1	1	5	5
			1	Exhaust fans	1	3	50	150	1	BLDC Exhaust fans	1	3	5	15
		Control Room	1	Incandescent 10 W	2	4	10	80	1	LED Bulbs	1	4	5	20
			1	fans	1	3	75	225	1	BLDC fans	1	3	20	60
			1	Computers (Control Room)	5	4	150	3000	1	Solar based	5	4	120	2400
		Storage (Flood relief equipments)	1	Fluorescent tubelights of 10 W	2	2	10	40	1	LED Bulbs	2	1	5	10
		Storage (Maintenance)	2	Incandescent 10 W	2	1	10	40	2	LED Bulbs	1	1	5	5
		Staircase	1	Incandescent 10 W	3	8	10	240	1	LED Bulbs	3	6	5	90
4	Open Spaces	Softscapes	1	Incandescent 25 W	10	7	25	1750	1	Flood lights	2	6	5	60
		Hardscapes	1	Incandescent 25 W	20	7	25	3500	1	Flood lights	4	5	10	200
			1	Pumps	3	4	750	9000	1	Pumps	3	4	750	9000
			1	STP	1	5	1000	5000	1	STP	1	5	1000	5000
								662895						192950

Table 04: Energy Consumption with respect to spaces

APPENDIX A-2
PERFORMANCE SPECIFICATIONS

CATEGORY	DESCRIPTION	SPECIFICATION
Orientation	Northern courtyard	U-shape north courtyard featuring natural shading and ambient temperature.
Window-wall ratio	20% reduction	The WWR ratio is reduced to 20% on the southern and western facade to reduce solar radiation inside the building.
Shading Devices	Angled vertical shades along with chajjas	Angled vertical shades, present on the southern and western facade to minimize heat gain.
ENVELOPE - U-Value		
Roofing	U-value = 0.2 W/m2 .K of thermal paint U value = 1.5 W/m2.K of concrete	Concrete RCC slab with thermal paint coating(117mm thk). COOL ROOF Heat Reflective Paint has been designed to give relief from roof heat as it is a high albedo paint having high SRI value which makes it most suitable for roof insulation. This high SRI paint acts as heat reducing paint which can be applied as cool roof coating having single objective of roof insulation.
Windows	U-value =3.7 W/m2 .K	Nahar wood frame with single glazed glass + bamboo grills
Walls	U-value = 0.305 W/m2 .K	Compressed Stabilized Earth Block masonry with Rat Trap Bond
ELECTRICAL SERVICES		
Lighting	LED bulbs, tube lights, flood lights	Syska LED bulbs of 5W and 10W. Philips LED tube lights and Murphy flood lights of 10 W. Detailed specification are in Energy Performance contest.
Fans	Brushless direct current motor fans.	Oceco and Havells BLDC fans of 20W each. Detailed specification are in Energy Performance contest.
Solar milk chiller	Solar panels 5-7 kWp 1 No. Battery type Lead acid, 220 Ah (6 hrs backup 1 No. Cooling tank 500-1000 L 1 No. Alternative power source 1-ph (500 L) or 3-ph (1000 L) 1 No. Condenser 3 HP 1 No. Refrigerant As required	Solar bulk milk chilling system instantly cools milk from 35 o to 4 o C without a diesel generator. The system can chill 1000 litres of milk per day, even if there is no power during the milk collection.
RENEWABLE ENERGY		
Solar Photovoltaic	Efficiency = 22.6% Size of each panel = 1.26 sqm	Selco Solar Power Company Monocrystalline Photovoltaic Panels Solar PV, hybrid-model and will be connected to grid for battery charging during non-availability of solar. Solar panel: 12 kWp (300 Wp, 24 V, 115 Nos) 200 Ah, 240 V (200 Ah,12 V x 115 Nos.) Solar inverter 15 kVA, 12.5 kW, 240 V. Detailed specification are in Energy Performance contest.
WATER SYSTEM		
Pump	Solar water pump	Solar water pump, 1hp Motor, 1KW
Package STP	20000 kld capacity.	Johkasou-Packaged Sewage Treatment Plant, detailed specification in Water Performance Contest. The treatment system has an efficiency of 85% which is going to be enhanced by disinfectants.
Rainwater Treatment	Harvested rainwater from roof and nonroof areas.	Rainy Dual-Intensity Rain Water Harvesting Filters FL-500
Filter Element	Converting raw water to potable uses	Slow sand filter with mix aggregates & bamboo charcoal filter
Tanks		
Underground Grey Water Storage Tank	2 tanks of 15 cu.m each	The treated grey water is passed into the discharge tank from where it is further passed to the filtration systems and finally stored in the treated greywater storage tank from where it is pumped to overhead grey water storage tank
Overhead	3 tanks of 15 cu.m each, 2 portable water storage tank 1 grey water storage tank, provided to support smooth water flow	The water from the borewell and the rainwater tank is pumped to the overhead tanks.The borewell water pumped passes through filtration before being passed into the tanks.The greywater overhead tank dispenses water for functions like cleaning, flushing etc.
Rainwater Storage tank	Capacity 12 cu.m	The rainwater after filtration from the FL-500 filters is passed to the underground storage tank from where it is pumped to the overhead potable water storage tank

PERFORMANCE SPECIFICATION

APPENDIX A-3
INPUT PARAMETERS

Input Parameters	Units	Proposed Design Values
General		
Building Area	m^2	2085
Conditioned Area	m^2	0
Electricity Rate	INR/kWh	0 (Generating 100% electricity on site)
Natural Gas Rate	INR/cylinder	1200
Building Occupancy Hours	hours	Non-disaster: 9am - 6pm (9 hours) Disaster : 24 hours (June to October)
Average Occupant Density	m^2 / person	8
Internal Loads		
Interior Average Lighting Power Density	W/m^2	0.085
List of Lighting Controls	No.s	Switch boxes(35), DP MCBs(1), SP MCBs(3)
Average Equipment Power Density	W/m^2	5.3
Minimum OA Ventilation (Building Average)	$l/sec.m^2$	0.3
Envelope		
Roof Assembly U value	$W/m^2.K$	0.2 (COOL ROOF Heat Reflective Paint has been designed to give relief from roof heat as it is a high albedo paint having high SRI value which makes it most suitable for roof insulation. This high SRI paint acts as heat reducing paint which can be applied as cool roof coating having single objective of roof insulation. Being a roof cooling and insulation paint, it will act as a protective coating and best summer cool paint. Its solar reflective properties make it one of the most suitable solar reflective paint) 1.5 for concrete 115mm thk slab
Roof Assembly SRI		122 (COOL ROOF heat reflective paint has SRI value of 122 as per ASTM/LEEDS standards for green buildings.)
Average Wall Assembly U value	$W/m^2.K$	
Window to Wall Area Ratio (WWR)	%	20
Windows U value	$W/m^2.K$	3.7
Windows SHGC		0.25
Windows VLT	%	4
Infiltration Rate	ac/h	1.8
Describe Exterior Shading Devices		Angled vertical shades along with chajjas, present on the southern and western facade to minimize heat gain. The shading device is conceptualized as an abstraction of egg crate shading device, tilted at an angle of 45 degrees in order to avoid direct thermal heat gain and to facilitate the exposure to prevailing winds.
HVAC System		
HVAC System Type and Description	-	No HVAC use. Solar Chimney is used for passive cooling, increasing no.of air changes/hour
Describe Mixed mode strategy in operation/controls of AC and windows	-	Natural Ventilation along with Solar Chimney is capitalised upon to meet the cooling requirements. Fans are provided for mechanical ventilation for extreme heat in summers
Heating Source	-	No heating
Mechanical Ventilation(Fan and Exhaust Fan)	No.s	BLDC fans and exhaust systems (36 in no.)
Service Hot Water		
SHW Type and Description		Solar Water Heaters
Solar Water Heaters	No.s	6 in number of 1 kW/ heater

APPENDIX A-4
OUTPUT PARAMETERS

Output Parameters	Units	Value
Proposed EUI (Total)	kWh/m²/ yr	28.24
EUI Breakdown by End Use		
Heating	kWh/m²/ yr	0
Cooling	kWh/m²/ yr	0
Fans	kWh/m²/ yr	0.1
Pumps	kWh/m²/ yr	1.27
Heat Rejection	kWh/m²/ yr	0
Service Hot Water	kWh/m²/ yr	2.15
Lighting	kWh/m²/ yr	0.59
Equipment	kWh/m²/ yr	24.43
Total Envelope Heat Gain (Peak)	W/m²	40
Cooling Load of Conditioned Area	SF/ Tr	0
Building Electric (Peak)	W/m²	10
Annual Operating Energy Cost	INR/m²	95.92
Annual Unmet Hours	-	
Cooling Capacity	Tr	0
Annual Hours of Comfort without Air Conditioning	hours	4380 (During non-disaster) 3600 + 2520 = 6120 (Considering 24hr occupancy for 5 months of disaster)

Monthly Energy Performance		Generation	Consumption	Total offsetted/ stored
Jan	kWh	9700.25	5532	4168.25
Feb	kWh	9700.25	5532	8336.5
Mar	kWh	9700.25	5532	12504.75
Apr	kWh	9700.25	5532	16673
May	kWh	9700.25	5532	20841.25
Jun	kWh	2078.625	5532	17387.875
Jul	kWh	2078.625	5532	13934.5
Aug	kWh	2078.625	5532	10481.125
Sep	kWh	2078.625	5532	7027.75
Oct	kWh	2078.625	5532	3574.375
Nov	kWh	8660.9375	5532	6703.3125
Dec	kWh	8660.9375	5532	9832.25

From the table, we can see that surplus amount of energy is generated on site. This energy can be utilised and stored for days of autonomy and distress situations or offsetted and given back to the electric grid, through Net Metering, thereby becoming a potential source of revenue generation for the centre

APPENDIX A-5

CASE STUDY 1

Project name: Palicourea House
Architects: BLOCO Arquitetos
Location: Sao Jorge, Brazil
Completed: 2021
Project Type: Sustainability
Program: Multifunction housing

This project is an experiment about a way to inhabit the region- aiming for the preservation and recovery of species from the region's biome.

Energy Source:
• The buildings are equipped with "E.S.S." photovoltaic energy systems - **Offgrid system.**

Water Performance:
• Gutters to collect rainwater periodically pumped by pumps powered by photovoltaic energy - storage capacity of **40.000** liters of rainwater.

Materials:

The buildings is composed of two parts (built independently): the exposed concrete structure and solid brick walls – the "core"-and the glued laminated wood (Glulam) roof.

• To combine local labor and traditional building materials with a large lightweight structure made from reforestation wood, remotely prefabricated, and assembled on site.

CASE STUDY 2

Project name: Highland Centre for natural history
Architects: Haley Constructions.
Location: Yavapai, USA.
Program: Public Learning Centre.

Climate Responsive:
It uses a photovoltaic stand-alone system, which operates entirely off the electrical gridand employs passive heating and cooling, and harvests rainwater. It uses vine-shaded arbors and breezes to cool, sunlight and concrete to heat and an innovative roof design to water its sustainable landscape.

DESIGN ELEMENTS

APPENDIX A-5

CASE STUDY 3

Project name: Khudi Bari House
Architects: Ar.Marina Tabassum
Location: Bangladesh
Completed: 2016
Project Type: Flood relief structure
Program: Housing

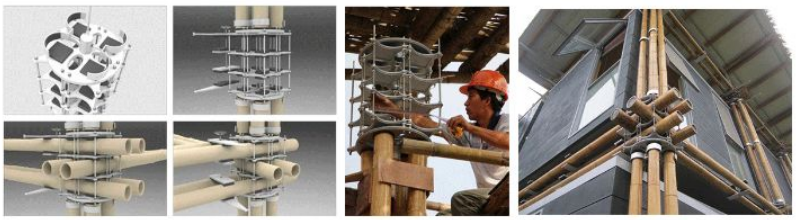
This projest caters to two types of people affected by the flooding in Bangladesh. People whose land is periodically flooded during the rainy season, and people who are continuously on the move because the land is constantly shifting.

Architectural Design:

Khudi Bari is a modular houses can be moved to help communities survive in Bangladesh's waterscape," which is increasingly affected by flooding exacerbated by climate change. A modular structure had two levels, where they could move themselves to upper deck to save themselves and when the water recedes they could start living.
Materials: Bamboo (locally available)

CASE STUDY 4

Project name: Energy Efficient Bamboo House
Architects: Studio Cardenas Conscious Design
Location: China
Project Type: Energy efficient Building
Program: Housing



Innovation:

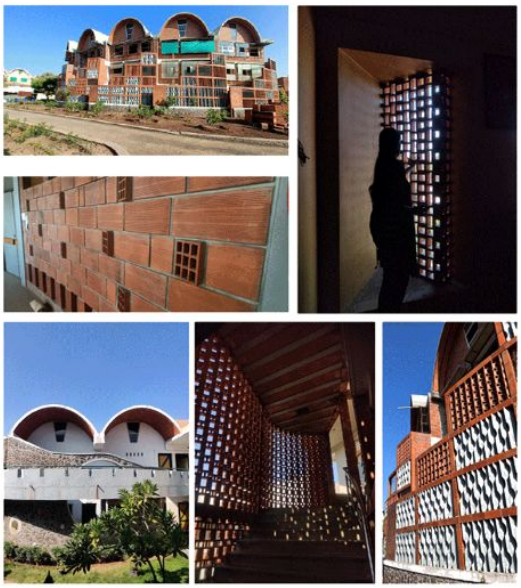
- Designing dry-mounted connections not to weaken bamboo through perforation nor fill it in with concrete, and also to allow the replacement of bamboo poles if needed.

- Designing aluminum connections light and easy to assemble in order that the construction can be done by local workers.

APPENDIX A-5

CASE STUDY 5

Project name: Tungal Memorial School and PU College
Architects: BSB Architects
Location: Vijayapura
Completed: 2016
Project Type: Energy Efficient Building
Program: Education Centre and housing for students



Materials:
Use of local materials like terracota clayblocks, Stone, concrete, Bricks etc

Climate:
Hot and dry climate (relevent to our proposed site climate)

Aim:
The architectural endeavour was to create comfortable, habitable spaces with local materials that could adapt to the changing weather conditions in the generally hot climate of Bijapur.

Inspiration:
Inspired by the historical domes that grace Bijapur.

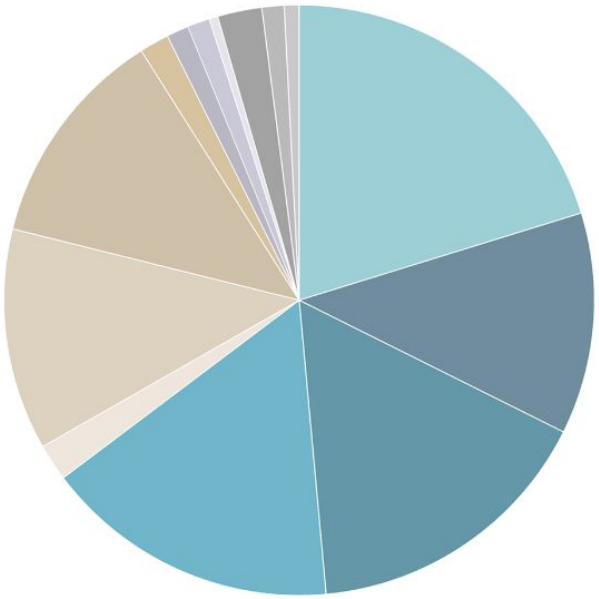
PASSIVE STRATEGIES:

- A passive solar architecture minimising mechanical ventilation was attempted.
- Exposed hollow clay blocks - support composite screens of bricks and Shahbad grey stones.
- To counter the heat transfer they used hollow clay blocks over ribs of steel.
- The screen wall which goes around at varying distance of around 2.5 m to 5 .0 m is made up of composite materials.
- Open to sky space between the classrooms and the screen wall was covered by a pergola of poles that were used for scaffolding during construction.
- Screen wall had stone plates cut and placed in direction opposite to sun to reduce direct sunrays.
- Roof geometries reduce heat absorption and radiation.

AREA PROGRAM

APPENDIX A-6

Site area: 2000 sq.m
Permissible Built up Area: 3000 sq.m
Permissible Ground Coverage: 45% = 900 sq.m
Proposed/ Estimated Built up Area: ~1600 sq.m



- Daycare and Children Cultural Centre
- Mill (Flour, Chilli
- Mela space + everyday retail
- Congregation space
- Storage for food
- Tailoring Unit + retail
- Cattle shelters
- Medical room
- Children Playground
- Male Washrooms
- Female Washrooms
- Handicapped
- Electric Room
- Control Room
- Storage

SL NO.	SPACES	NORMAL CONDITIONS	FLOOD CONDITIONS	NO. OF USERS	AREA PER UNIT	NO.OF UNIT	TOTAL AREA (IN SQ.M)	CONDITIONING
1	Common Spaces	Daycare and Children Cultural Centre	Community Hall	200	350		250	
		Mill (Flour, Chilli	Dining + Kitchen		150	1	150	Unconditioned
		Mela space + everyday retail	Dorm 1	100	200	1	200	
		Congregation space	Dorm 2	100	200	1	200	
2	Other Spaces	Storage for food	Storage for food			1	25	
		Tailoring Unit + retail	Storage for belongings				150	
		Cattle shelters	Cattle shelters		150	1	150	Unconditioned
		Medical room	Medical room	5	20	1	20	
		Children Playground	-	-	-	-	-	
3	Services	Male Washrooms	Male Washrooms	100	1.2	10	15	
		Female Washrooms	Female Washrooms	100	1.2	10	15	
		Handicapped	Handicapped	2	3	2	6	Unconditioned
		Electric Room	Electric Room	1	30	1	30	
		Control Room	Control Room	1	15	1	15	
		Storage	Storage	1	5	2	10	
		Built Up area of Spaces					1236	
		Circulation Space (30% of BUA)					370.8	
		Total Built Up Area					**1606.8**	

Industry Partner Confirmation Letter

Ekam Eco Solutions Pvt.
www.ekameco.com

Date: 17/02/2023

To,
The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, **Ekam Eco Solutions Pvt. Ltd.**, is collaborating with the participating team led by **BMS College of Architecture** on a **Community Resilience Shelter** project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration will be to support the team in designing the net zero habitat system by helping in devising a scheme of water management system along with the guidance in integrating the system with other net zero process guidelines viz. non-conventional energy sources, solid waste management, hygiene parameters like distance of bore well from sewage discharge etc.

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

We would like our organisation's logo to be displayed on the Solar Decathlon India website, recognising us as one of the Industry Partners for the 2022-23 competition.

With warm regards,

SACHIN SHARAD JOSHI
Digitally signed by SACHIN SHARAD JOSHI
Date: 2023.02.21 17:38:01 +05'30'

Sachin Joshi
Co-founder
Ekam Eco Solutions Pvt. Ltd.

Industry Partner Confirmation Letter

Date: 23/02/2023

To,

The Director,

Solar Decathlon India

Dear Sir,

This is to inform you that our organisation, **Aureka**, is collaborating with the participating team led by **BMS College of Architecture** on a **Community Resilience Shelter** project for their Solar Decathlon India 2022-23 competition entry.

Our collaboration will consist in providing reference materials related to CSEB (Compressed Stabilised Earth Block) required for your construction project.

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

We would like our organisation's logo to be displayed on the Solar Decathlon India website, recognising us as one of the Industry Partners for the 2022-23 competition.

With warm regards,

Aleksandr Sineev

Executive

Aureka

aureka@auroville.org.in

9159799517

Project Partner Confirmation Letter

20.09.2022

To,
The Director
Solar Decathlon India.

Dear Sir,

Our organization **SELCO Foundation** has provided information about our project to the participating team led by **BMS College of Architecture**, so their team ***'BMSCA'*** 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 solution this student team proposes and the innovation that results from this.

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

With warm regards,

Nirmita Chandrashekar
Program Manager - Built Environment
SELCO Foundation
nirmita@selcofoundaton.org

BMS College of Architecture
COA Approved | VTU Affiliated

Tel: (O) 080-26622126-127
e-mail: info@bmsca.org
website: www.bmsca.org

Ref/BMSCA/BC/001/UG/2022-23/767

Date: 22.02.2023

WHOMSOEVER IT MAY CONCERN

I certify that the following students are bonafide students of BMS College of Architecture and allowed as a participants in SOLAR DECATHLON, India 2021-22 competition by team BMSCA.

This certificate is issued for the purpose of participation in SOLAR DECATHLON competition only.

Sl.No.	Name of the student/participants	USN
1.	Ankitha P	1CF19AT008
2.	Bindiya S	1CF19AT017
3.	David Stephen	1CF19AT023
4.	Prerna Rajanala	1CF19AT074
5.	Qazi Shadman Qureshi	1CF19AT075
6.	Radha Prem Yadav	1CF19AT077
7.	Samhita Shyam	1CF19AT097
8.	Sanya Kakkar	1CF19AT101

Thanking you,

Regards,

Dr. Mamatha P Raj
Director & Professor

Phone : +91-80-2662 2130-35
Fax : +91-80-2661 4357
e-mail : principal@bmsce.ac.in
URL : www.bmsce.ac.in

B.M.S. COLLEGE OF ENGINEERING

ESTD. 1946

Autonomous College under VTU | Aided by GOK | Approved by AICTE | Accredited by NBA

BMSCE/ACA/UG/CERT/2022-23 Date:20.02.2023

BONAFIDE CERTIFICATE

This is to certify that following students studying in V semester B.E. during the academic year 2022-23. This College is an Autonomous Institution, approved by AICTE, New Delhi and affiliated to Visvesvaraya Technological University (VTU), Belagavi. The duration of the course is four years (eight semesters). The medium of instruction is English. This certificate is issued for the purpose participating in solar Decathlon for designing "Community Resilient Structure"

His & Her character and conduct are good.

Sl No	Name of the student	USN	Department
1	Dharshini A	1BM20AS014	Aerospace Engineering
2	Pannag Bhaskar Kini	1BM20ME105	Mechanical Engineering
3	Manoj M	1BM20ME081	Mechanical Engineering
4	Manish M S	1BM20ME080	Mechanical Engineering

PRINCIPAL

20/2/23