Solar™ Decathlon India

APRIL 2021

FINAL DESIGN REPORT

Team eCache

MULTI-FAMILY HOUSING

+

organo
life.on.a.slow.track.

ORGANO ECO-HABITATS

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School of Planning and Architecture, Vijayawada
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The source of all the figures and tables added in this report are done by Team eCache, unless explicitly mentioned otherwise.

LIST OF FIGURES

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05 EXECUTIVE SUMMARY

Team eCache reflects an integrated design approach with an objective to design a net-zero-energy multi-family housing consisting of 104 affordable dwelling units for a targeted market. The team has partnered with Organo Eco-Habitats to design EcoPod, a proposed row housing community that is located in the peri-urban fringe of Hyderabad. Our target buyers would essentially belong to the higher middle-income group with an inclination towards a Rurban lifestyle that incorporates the benefits of rural and urban living. As its name suggests, EcoPod is envisioned as an eco-sensitive venture with a low adverse environmental impact, which is self-sustaining through its reduced dependence on public infrastructure for amenities such as water, energy, and waste management. EcoPod is complimented by the use of apt systems such as rooftop panels, rainwater harvesting systems, reed-bed filtration, and on-site waste management, that result in net-zero energy, water, and waste. Furthermore, each house also has an individual farm patch that could be used for producing edible crops. This is a step towards self-sustenance and reduces dependence on fast depleting resources. EcoPod distinguishes itself from other real estate development projects that wipe villages out with the wave of rapid urbanization.

Located in a Composite climatic zone, EcoPod is designed to tackle challenges such as high summer diurnal variations and distinct seasons that come along with this climate type, through a data-driven design approach. The site's potential for comfort through natural ventilation was explored at various stages of the design both at the site and the unit level. The design, therefore promotes natural ventilation through cross and buoyancy-driven ventilation and enhances user adaptability to control ventilation and daylight. After several stages of evolution, the form of the dwelling unit is both compact and self-shading, thereby reducing excess heat gain through the building envelope.

The design process included a charette exercise, where the team came up with seven preliminary conceptual design options. The pros and cons of these options were analyzed in terms of usability, user perception, functionality, and climate responsiveness. Similar ideas were integrated to propose two design options which were then simulated for radiation, ventilation, energy performance, and daylight to weigh the positives and negatives of both the options. Based on the preliminary inferences, the final design is a result of optimizing for enhanced energy performance, thermal comfort, visual comfort, adaptability, scalability, affordability, and privacy through iterations and innovations in construction techniques, materials and passive strategies.

True to its name, eCache, has attempted to cache the wealth of resources through our deceptively simple design of EcoPod.

06 TEAM INTRODUCTION

Team eCache is a multidisciplinary team of 13, from SPA Vijayawada, who deem energy and natural resources as a treasure trove. The name eCache reflects the ability of our deceptively simple design to cache the wealth of resources while remaining environmentally friendly and providing for a better economy. We present to you, **EcoPod** a multifamily row-housing project which is being developed with a data driven design approach. The team has been organized into 3 working groups **Design • Metrics • Market**

energy environment economy

M.Arch Sustainable Architecture
Ramya, Hemamalini, Abinaya, Nivedhitha, Veronica Dhananjay, Amuktamalyada & Krishna Kasi (Ph.D. Scholar)
M.Arch Landscape Architecture
Manju Rajeev Kanchan
M.TIP Transport & Infrastructure Planning
Sandeep
M.BEM Building Engineering Management
Darshit Mehta & Arun

+

Passive House Institute specializes in research and development in the field of highly efficient energy use. The Passive House energy standard increases energy efficiency in buildings by a factor of 10.

GreenJams Infrastructures is a startup that focuses on bio-aggregate building materials. The company aims to create building materials out of agricultural wastes that are carbon negative and establish low carbon built environments through inherent energy efficiency and thermal performance.

Hunnarshala is a group of socio-technical development organisations having deep relations with the local communities for over 15 years. It works with traditional artisans and both traditional and innovative building techniques with an objective to capacitate people for reconstruction of their habitat.

Taiba Engineering Consultants is a MEP firm who offer expert consultancy for a range of services including HVAC, electrical, plumbing, fire fighting and green buildings. They also conduct courses to educate the younger lot in the industry

School of Planning and Architecture, Vijayawada was established in 2008 by MHRD, a Centrally Funded Technical Institution. The institute excels in fields of Planning and Architecture, offering specialized programs like Sustainable Architecture, Landscape Architecture, Building Engineering & Management, Architectural Conservation, Urban & Regional Planning, Environmental Planning Management and Transport & Infrastructure Planning. Faculty Lead & Advisor was **Dr. Iyer Vijayalaxmi Kasinath** (Professor of Architecture, Dean - Research) & **Mr.Venkata Krishna Kumar Sadhu** (Associate Professor of Architecture)

07 PROJECT BACKGROUND

i. Project Name : EcoPod

j. Project Partner

Our Project Partner, Organo Eco-habitats pvt ltd is founded by and named after Nagesh Battula, Vijaya Durga and Rajendra Kumar, directors of the FHD Group, one of India's leading design & developer firms based out of Hyderabad. Their maiden venture and brainchild Organo Eco-Habitat is an independent housing project venture driven by principles such as bio-conservation, reviving culture and bringing people together. Having witnessed the success of Organo Naandi, is envisioned to scale up the offering by providing a new affordable model of the rurban lifestyle, by combining the merits of coliving and collective farming.

k. Project - EcoPod

EcoPod is a self-sustainable attached housing community that caters to the contemporary urbanites aspiring a **Rurban lifestyle,** who would love both to own a home with all modern amenities, and grow their food in the backyard.

Location	Chevella mandal, Telangana
Climate	Composite Climate (NBC 2016)
Site Area	13.6 acres (55,085 sqm)
Soil type	Sandy-clay loam 215-270kN/sqm
Terrain	Gradual slope 2.2% (+672.5 m)
Project	Build-Transfer and Operate model

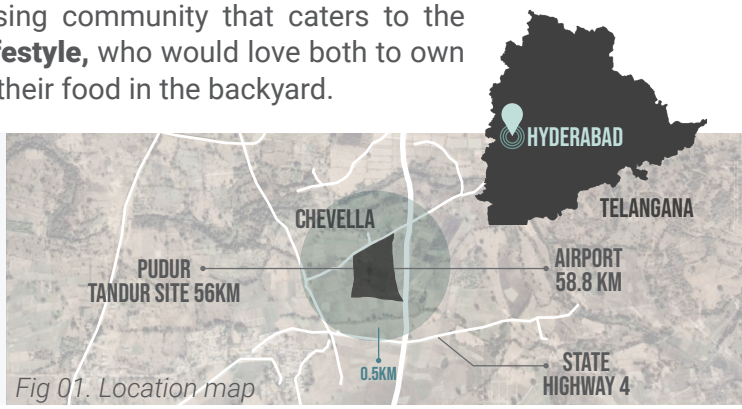
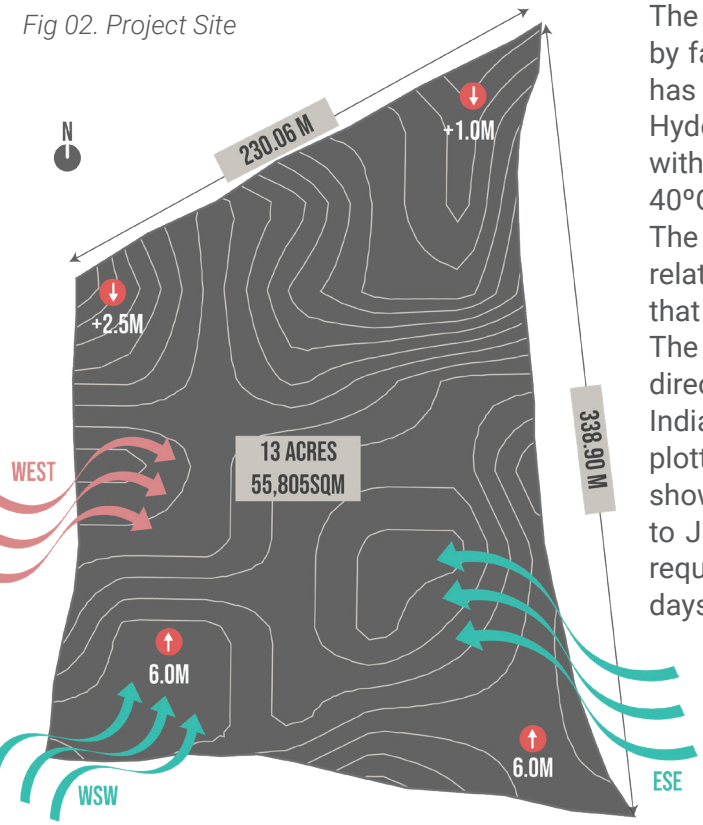


Fig 01. Location map

Fig 02. Project Site



The site is in the agricultural conservation zone, surrounded by farmlands, with one abutting road (9m wide). The site has a gradual slope of 2.2% down from SE to NW corner.
Hyderabad is characterized by large seasonal variations, with mean-maximum temperatures reach up to 38°C to 40°C, while mean-minimum temperatures drop to 11°C. The climate also sees high contrast in mean monthly relative humidity with less than 45% in summer months that go higher than 80% during monsoon/ winter months. The predominant wind direction is along the ESE and W direction.
Indian Model for Adaptive Cooling (IMAC) comfort bands plotted over mean monthly hourly temperature graph show the mean maximum hourly DBT for months of March to June is almost entirely outside the comfort band and requires maximum cooling. The annual cooling degree days are 995 kWh/ year.

The site is located in the outskirts of Hyderabad, in the Chevella mandal and falls under the agricultural conversation zone. The total site, which covers an area of 55085 sqm, is surrounded by large agricultural lands and is accessed via a 9m wide road. The site is 58.8 km away from the Rajiv Gandhi International Airport and 56.1 km from Tandur, a source of limestone which can be used for construction. Antaram, a rural settlement closest to the site is located at a distance of 1 km. The proximity of the site to basic amenities like hospital, petrol bunk and restaurant is less than 6 kms.

Considering a contour for 3km radius with the site as the origin, the site is located on relatively flat land with gradual slope, draining to the north into a distributary of River Musi and other lakes. This topography keeps the site well drained.

Site Topography: The topography of the site is characterized by a gradually declining slope from SE to NW and has a slope percentage of 2.2%. The NE and NW corners are the lowest points of the site with +1.00m (666m) and +0.00m (665m) respectively and SE corner is the highest point, with +7.5m (+672.5m).

Soil Type: The soil in site is a combination of Black clayey loam and Red murram soil. The groundwater table in the Chevella mandal is at 10 to 15 m below ground level. The following are the characteristics of clayey soil: Time Lag: 21 days/meter depth. Bearing capacity of Sandy clay loam (moist)- 215 to 270kN/m2

MICRO MARKET Hyderabad in comparison to major cities accounts for about 7% of the entire Green Building Market in India. But the buyers who understand the savings and benefits in terms of reduced operational cost and better return of investment are quite reluctant due to the absence of structured monitoring systems and regulatory framework. Due to driving factors such as Environmental regulations, healthier buildings and lower OPEX, the market is expected to double by 2021. The sales for residential projects in the year 2019 went up by 21% in annual sales, also there was a dip in unsold sales by 16% and in line with firms allowing employees to WFH since the pandemic, development around the peri-urban is blooming significantly with rise in residential demand.

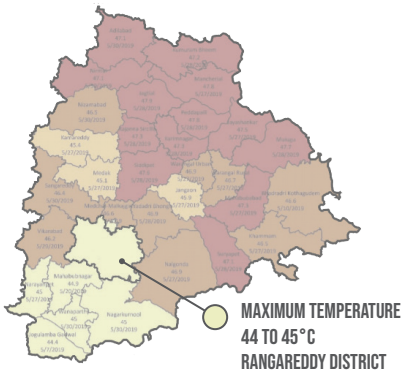


Fig 04. Maximum Temperature map

ENVIRONMENTAL ISSUES IN THE REGION

Nizamabad district in Telangana is highly prone to both extremes of flash flooding and heatwave. As per the Telangana State Heatwave Action Plan of 2020, **unprecedented heat waves** were seen in the summers 2015, 2016 and 2017 with temperatures as high as 47°C in certain districts (highest in Rangareddy 45°C). (Fig: 04).

While much of Hyderabad and surrounding areas are prone to flash flooding, the region was also subjected to **extreme rainfall events** in 2000, 2010, 2016 and 2020. For the record, the single-day highest rainfall record in the state of Telangana is 35.5 cms in October 1983 in Nizamabad.

08 PERFORMANCE SPECIFICATIONS

CLIMATE OVERVIEW & ANALYSIS

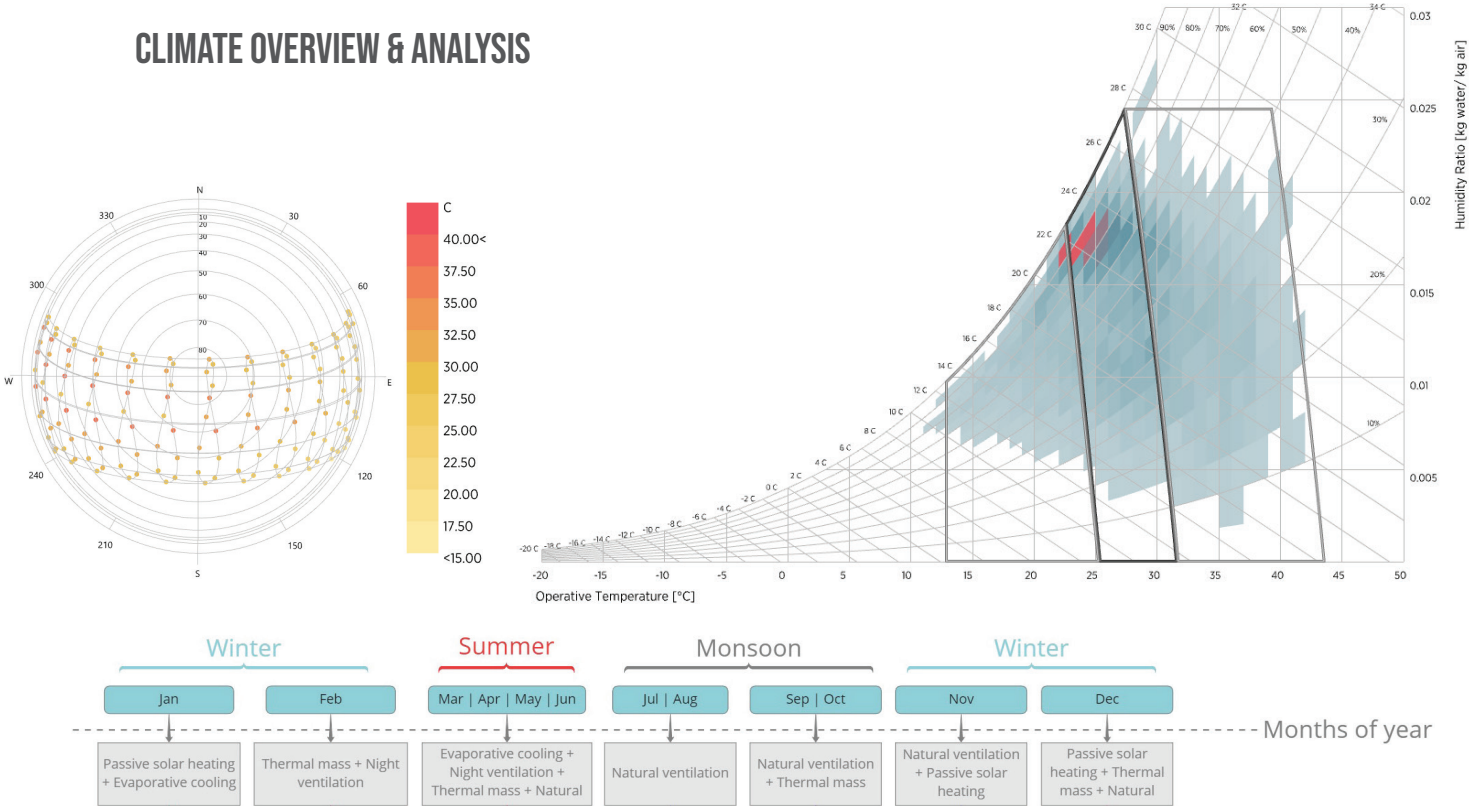


Fig 04. Climate overview & inferences

ENVELOPE SYSTEMS

MATERIAL PROPERTIES		
WALLING		
U value - 0.442 W/(sqm.K)		
0.015m	Perlite plaster	0.104 W/(mK)
0.150m	Agrocrete	0.400 W/(mK)
0.050m	Rockwool	0.035 W/(mK)
0.015m	Perlite plaster	0.104 W/(mK)
ROOFING		
U value - 0.475 W/(sqm.K)		
0.015m	Cool tile-white	0.030 W/(mK)
0.020m	Cement screed	0.410 W/(mK)
0.040m	Rockwool	0.035 W/(mK)
0.125m	RCC slab	1.400 W/(mK)
0.012m	Perlite plaster	0.104 W/(mK)
WINDOWS		
U value - 1W/(sqm.K)		
g value - 0.36		
VLT - 0.37		

HVAC System		
HVAC System Type and Description	-	1Tr split AC for each bedroom ;
Cooling Source	-	Windows, Fans, Split AC
CoP		4.5
CoolingCapacity	kW	4.18
Cooling ISEER		4.7
Star Rating	BEE	5

Interior Average Lighting Power Density	W/sqm	1.1
Average Equipment Power Density	W/sqm	3

RENEWABLE ENERGY SYSTEM		
System type	-	Polycrystalline Solar PV modules | 72 Cells
Installed RE capacity	kW	897.93
Total Energy Generation from RE	kWh	1538.9

WATER SYSTEMS	
System type and description	Dual flush cistren -3/6 lpf capacity, beta valve can be reduced upto 2/4 lpf 7kg front load BEE 5star rated washing machine - water demand - 63ltrs/ load

Table 01. Technical specifications

09 GOALS

TARGET EPI OF 20 TO 29 KWH/SQM/YEAR	22.8 KWH/SQM/YEAR
ACHIEVE 3700 COMFORT HOURS THROUGH NATURAL VENTILATION	5822 HRS
ONSITE RENEWABLE ENERGY OF 3,12,000KWH/YEAR THROUGH PV PANELS	13,81,840KWH/YEAR
EMBODIED ENERGY < 3 GJ/SQM	2.34 GJ/SQM
CO2 EMISSIONS < 250 KG-CO2EQ/SQM.	197.7 KGCO2EQ/SQM
INNOVATE WITH AGROCRETE BLOCKS FOR EFFICIENT CONSTRUCTION	HOLLOW INTERLOCKING BLOCKS
RESILIENT AGAINST FLASH-FLOOD	SWALES & DETENTION POND
OVER 30% OF SITE AREA FOR VEGETATION	12% OF SITE
BUDGET UNDER RS.55,000/SQM	RS.22,300/SQM
RAINWATER COLLECTED ON-SITE OF AT LEAST 500 LITRES/SQM	461 LITRES/SQM

10 DOCUMENTATION OF DESIGN PROCESS - INTEGRATED APPROACH


MEETINGS WITH THE PROJECT PARTNER

Discussions with the project partner at each stage of the design process aided the team in getting a better understanding of their vision and develop our concept while inching towards our goals.


PASSIVE HOUSE TRAINING & MEETINGS

The Passive House Institute offered training for 3 team members which gave a broader perspective on energy efficiency and thermal comfort. Further, periodic reviews and use of PHPP tool enabled us to gauge the performance of design options in terms of cooling, ventilation, energy consumption and, generation.

COLLABORATION WITH GREENJAMS

eCache has collaborated with Greenjams and is working on optimizing the block forms and sizes of Agrocrete, a negative-carbon external walling material, under the innovation criteria.

MEETINGS WITH HUNNARSHALA

Our industry partner Hunnarshala gave us insights and broadened our perspectives on how resilience, water management and , affordability can be addressed through an integrated design approach.



FACULTY REVIEWS & EXPERT MEETINGS

SDI was integrated into our semester as a studio project, involving weekly faculty reviews. Additionally, the team's work was reviewed by practicing architects and experts in the green building industry.

TEAM DISCUSSIONS

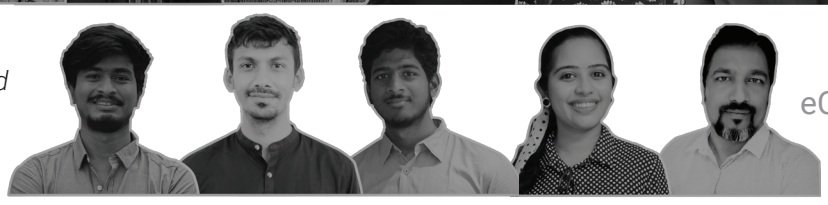
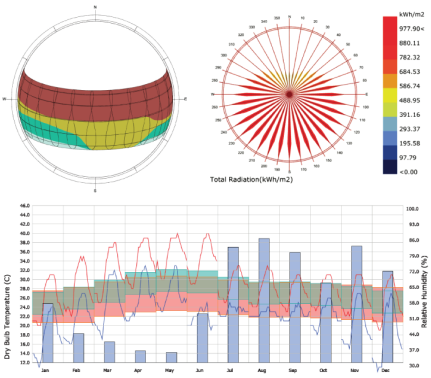



Fig 04. The industry experts and team involved in EcoPod

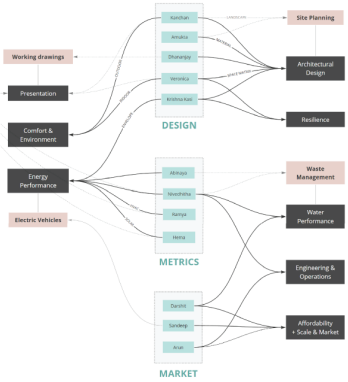
10 DOCUMENTATION OF DESIGN PROCESS - CHALLENGES & SOLUTIONS

CONTEXT + REQUIREMENTS → MULTI-DISCIPLINARY APPROACH

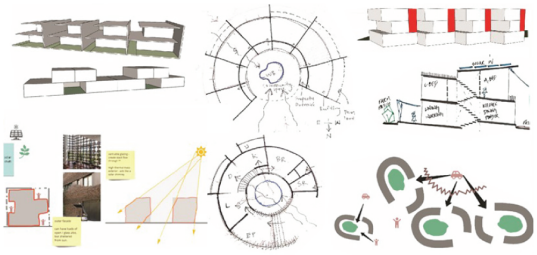


Partner requirements
Row-housing (maximum 8)
10sqm farm patch
Community spaces
No heirarchy among houses
Integrated approach inclusive of nature + technology + people

Solar Decathlon Requirements
Climate- responsive
Net-zero energy + Water
Affordable Market-ready design
8 attached houses (minimum)



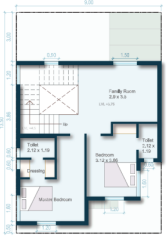
DESIGN CHALLENGES → VARYING LAYOUTS



Reviews and iterations to optimize for Radiation and Ventilation at Site-level and Dwelling unit-level.

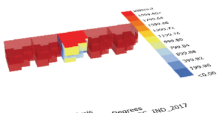
OPEN LAYOUT

COMPACT LAYOUT

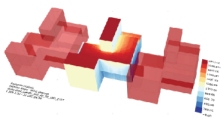


PRELIMINARY ANALYSIS

House 1



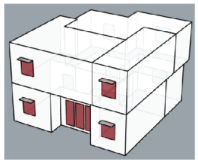
House 2



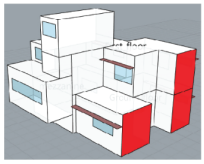
- Orientation
- Overshadowing
- Internal Courtyards
- Massing

Simulation tool:
Rhino+Grashopper+Ladybug

- Material + Inputs
- Internal Layout
- Loads
- Shading elements



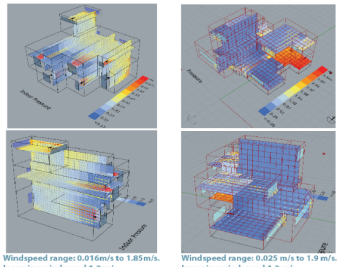
EUI design case: 15 kWh/m2 year
Baseline EUI: 138.2 kWh/m2 year



EUI design case: 20.7 kWh/m2 year
Baseline EUI: 138.2 kWh/m2 year

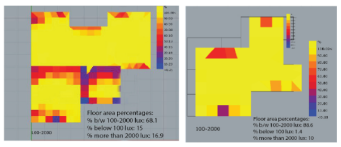
- Stairwell design
- Stack Ventilation
- Window aspect ratio
- External Louvers

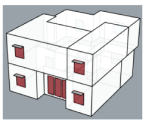
Simulation tool:
Rhino+Grashopper+ Ladybug Tools+ Butterfly + OpenFoam



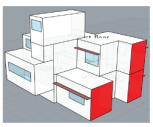
- Window aspect ratio
- External Louvers

Simulation tool:
Rhino+Grashopper+ Ladybug Tools+ Honeybee + Radiance (UDI Analysis)



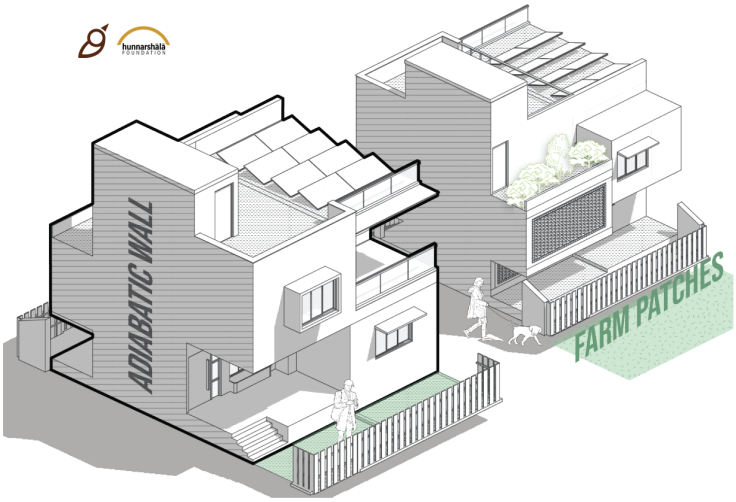


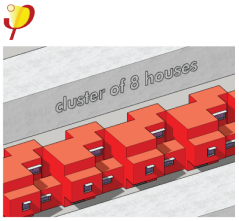
Surface : Volume **0.88**
411/465



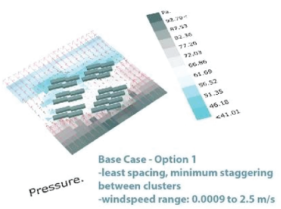
Surface : Volume **0.98**
385/391

AGRARIAN COMMUNITY → VARYING LAYOUTS





Multiple analysis for radiation, ventilation, daylight and energy were conducted to understand optimal envelope designfor the final dwelling unit.



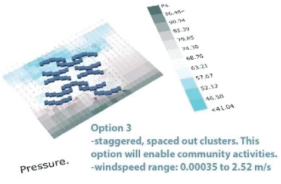
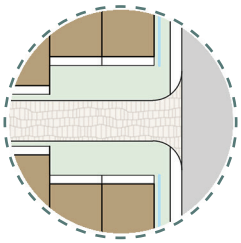


Fig 02. Design evolution and optimization

10 DOCUMENTATION OF DESIGN PROCESS - CHALLENGES & SOLUTIONS

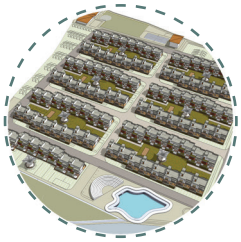
TOTAL BUILT UP AREA AND HARD PAVED SURFACES ON SITE

Around 30% of the site area is allocated for **soft-scape**, i.e. agriculture and landscape. The hard-paved surfaces are reduced overall by **minimizing vehicular roads and maximizing pedestrian pathways** which are laid out by green and permeable paver.



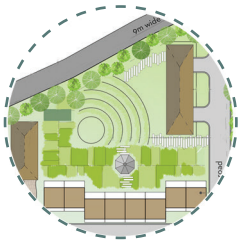
AFFORDABILITY OF ONE UNIT

Affordability of a unit is kept intact by **replicating the module and its services** in rows aligned in the site as grids and **services are centralised** for ease of operation. The site levelling is minimized by following the contour.



HIGH INSTALLATION & MAINTENANCE COST OF MECHANICAL SYSTEMS

Introduction of site revenue generation measures, like **selling of organic animal and plant produce**, rentable banquet and kitchen for commercial activities during weekends. Selling of **surplus energy** generated by solar panels installed on parking.

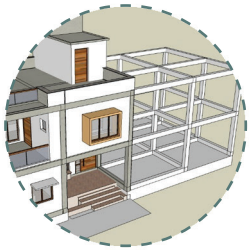


TO ACHIEVE COMFORT BY NATURAL VENTILATION

The extruded volume of mezzanine serves two purposes; facilitating **cross flow of wind** through the self-shading jali and **shade** adjacent surfaces.

TO REDUCE CONSTRUCTION COST AND TIME

Typical construction details and codes are followed for the rigid frame structure, keeping the dimensions for beams and columns **easy to construct**. The efficiency is maintained by keeping the **frame continuous** for a row of 8 units.



TO REDUCE HEAT GAIN THROUGH ROOF

The heat gains through roof by its exposure to solar radiation is reduced by using **solar panels as shading devices** on the terrace.

TO REDUCE DIRECT HEAT GAIN ON ORIENTATIONS WITH MAXIMUM INSOLATION

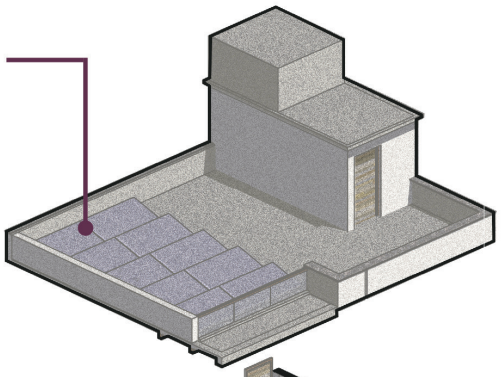
The proposed row housing is an advantage as the West and East walls are shared and **least exposed to solar radiation**. This also reduces the cost for masonry material and construction.

TO MAKE PROJECT MARKET READY

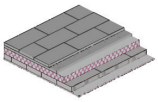
Market ready solutions are incorporated by **right-sizing of amenities** and equipments after an exhaustive market survey

Fig 02. Solutions for challenges and at both site & house-level

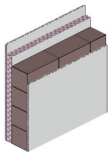
10 DOCUMENTATION OF DESIGN PROCESS - FINAL DESIGN EVOLUTION



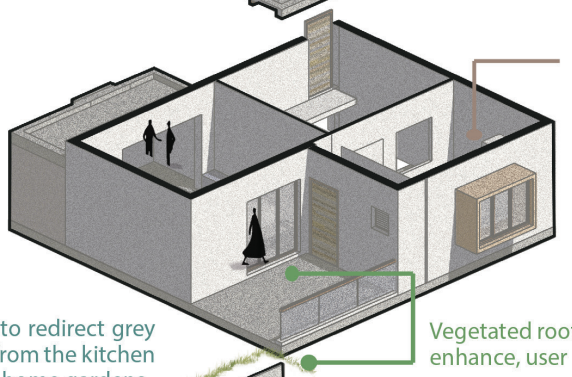
- ENERGY PERFORMANCE
- AFFORDABILITY
- SCALABILITY & MARKET POTENTIAL
- ARCHITECTURAL DESIGN
- WATER PERFORMANCE
- RESILIENCE
- COMFORT & ENVIRONMENTAL QUALITY
- INNOVATION



Roof assembly U-value: **0.623** W/sqmK



Wall assembly U-value: **0.602** W/sqmK



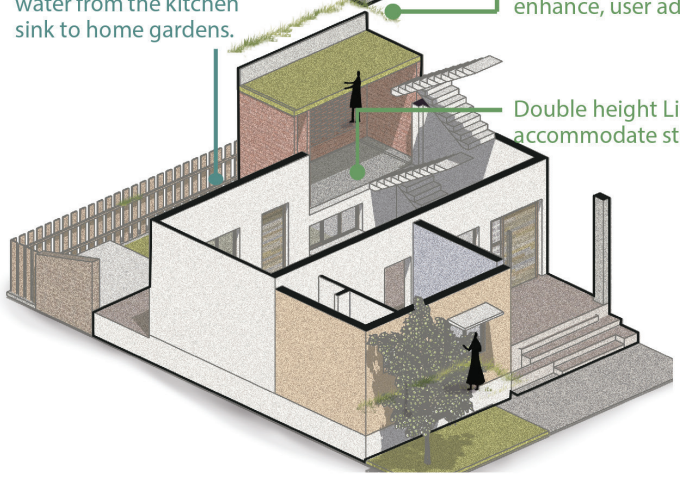
Scalability is ensured by keeping the format simple with conventional structure and common walls while the partition walls are made up of drywalls on studs to speed up construction.

5945 HRS through natural ventilation

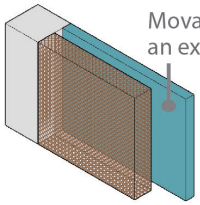
8160 HRS through mixed mode ventilation

Valves to redirect grey water from the kitchen sink to home gardens.

Vegetated roofs, mezzanine, Terraces adjoining bedrooms to enhance, user adaptability and self shading



Double height Living room to accommodate stack ventilation



Movable thermal mass behind an existing wall

Plot size and building size is kept to a minimum in the form of luxury row housing that eliminates side setbacks while maximizing farmland shared by residents for collective farming as a community.

Besides introducing PV panels, scope for energy generation through biomass is being studied to exploit the biowaste that is produced from the ghoshala on-site.

Community courtyards spaced out to enhance ventilation around buildings.

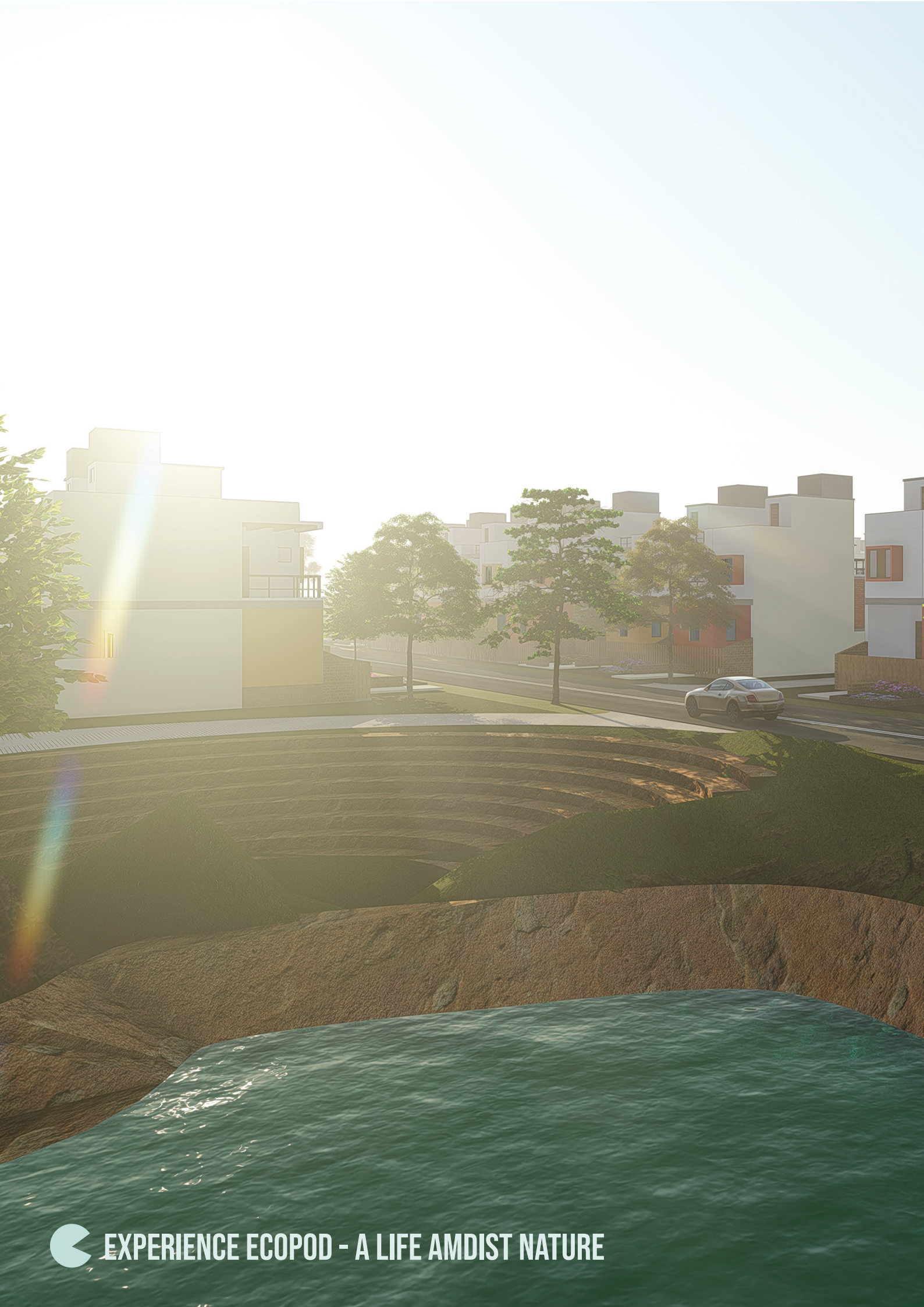
Floor plans that are scalable at cluster level and clusters that are scalable at site level.

Biofencing to avoid unwanted human wildlife conflict

Pollinator garden to bring in necessary fauna onto site

Raincatchers that double as community spaces and solar collectors

Primary semi dry detention pond & bioswales to make the site more permeable.


EXPERIENCE ECOPOD - A LIFE AMDIST NATURE

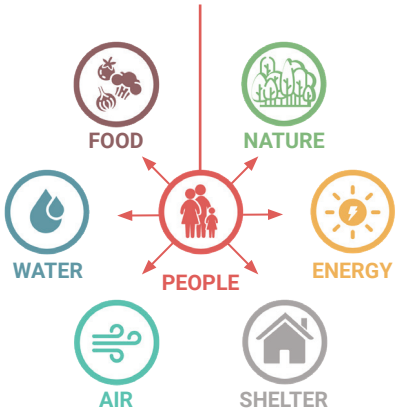
11 DESIGN DOCUMENTATION

WHY? WHO? HOW?

VISION

EcoPod is a multi-family housing community driven by principles such as bio-conservation, reviving culture, and bringing people together.

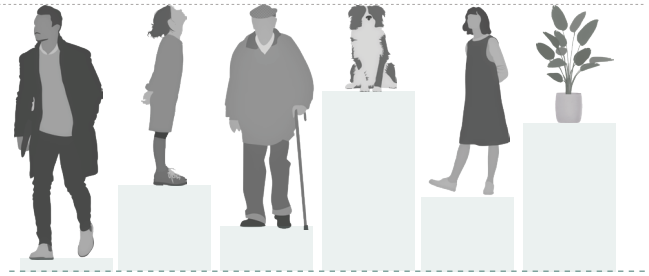
PHILOSOPHY



The project is aimed at making an affordable model of such a rurban lifestyle, by combining the merits of co-living and collective farming. Our project partners and our team envisage offering a rurban lifestyle to the environmentally-conscious millennial families "to tread lightly on this Earth".
Based on **Sapta-Pathas** or seven strands of sustainability - in terms of energy, food, water, shelter, earth, air, and people, Ecopod offers a lifestyle that is sustainable both socially and environmentally.

"The target group is the millennial family who is environmentally conscious, as they spent a good part of their lives in the urban area dealing with the chaos and are now ready for a big change - To get out of the rat race & lead a life that can re-establish harmony with nature.
Suffocated by consumerism, they would love to live away with like-minded people who share the same values. They want to be able to trust the food they eat, and the milk they consume.
The row house format brings with it a psychological feeling of collective living and mental wellness and holistic wellbeing by virtue of living in balance with nature. And effort was taken to establish equity of land, light and space for the residents."

NO HEIRARCY AMONG THE INHABITANTS IN ECOPOD



PEOPLE
+
NATURE

ECOPOD A HOME AMIDST NATURE

Through collective farming, the residents get together with local farmers to grow food in their own farm patches and share the bounty of earth with birds, bees, and animals.

While the local farmers are employed for helping with farming and raising cows among other rural activities on the site, they are also exposed to a host of organic technologies. This helps support local produce and economically supplement the surrounding village dwellers.

Fig. Design concepts and philosophy

11 DESIGN DOCUMENTATION

RURBAN LIFESTYLE

The Rurban lifestyle at EcoPod is encouraged with the provision of urban and rural features in one place. Rural life is brought in with participatory agriculture and animal husbandry. Community area is replica of village squares with tree as its landmark. Urban amenities like clubhouse, cafe, co-working and health care make life at EcoPod truly urban. Grid pattern to facilitate service infrastructure and scalability, with pedestrian avenues, introduction of clean energy and water harvesting techniques makes the project sustainable.

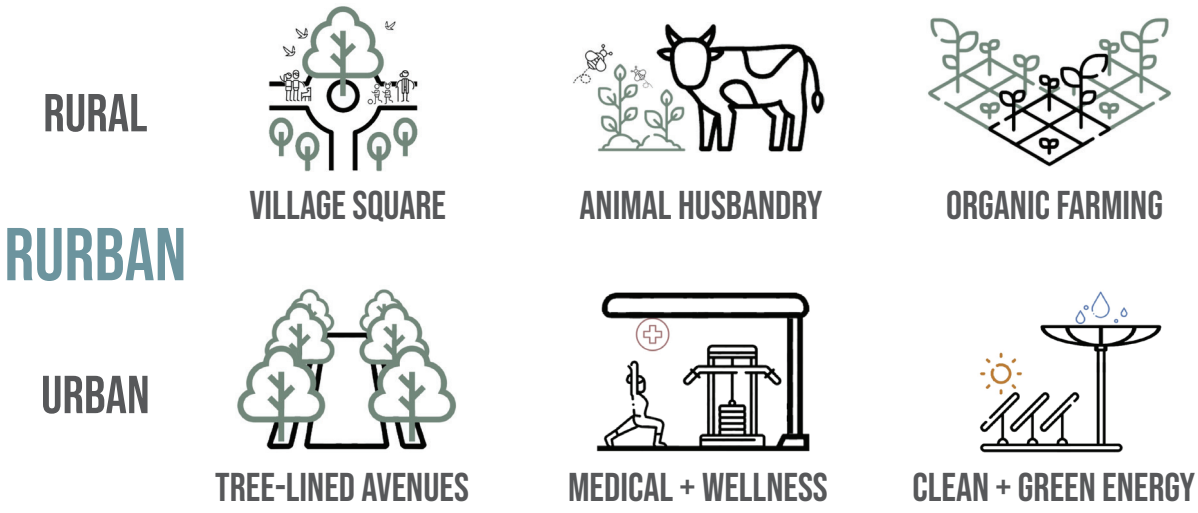
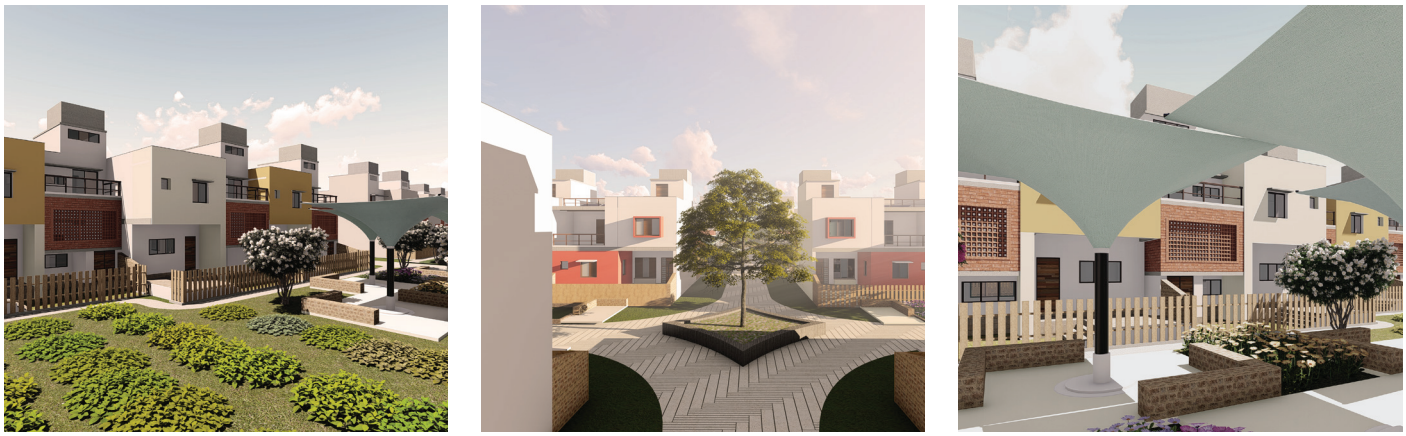


Fig00. Rurban design and amenities



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ECOPOD DESIGN

Fig Exploded design scheme

The open air theatre at the entrance of the site acts as the central community interaction space while also providing a picturesque view of the site and the landscape. The indoor outdoor connection is established through provision of balconies and terraces that act as viewpoints directing towards the cluster level community spaces. Further, the rain catchers double as shaded community spaces. Further, the balconies establish visual connections between different dwelling units. The double-height living room and a mezzanine level, which can be used as an informal lounge or a workspace, provides a sense of connectivity.

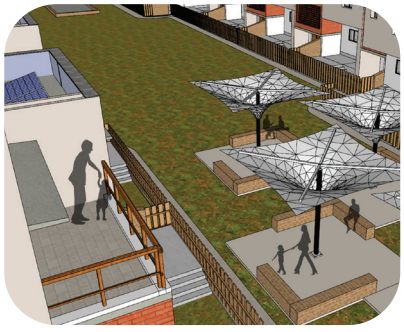


Fig Views

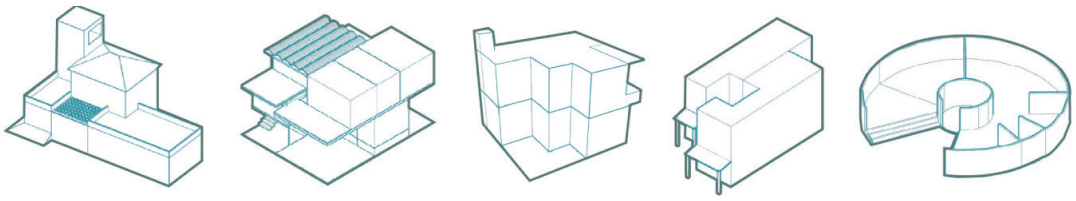
DESIGN DOCUMENTATION

SITE PLAN ECOPOD

Fig Architectural Site plan

11 DESIGN DOCUMENTATION

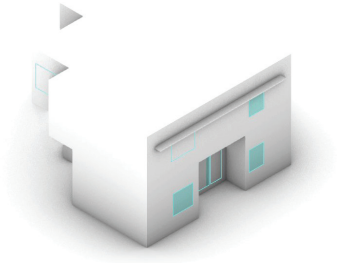
ENERGY PERFORMANCE - DESIGN EVOLUTION



DESIGN CHARETTE

INCORPORATION OF SIMILAR CONCEPTS INTO TWO DESIGNS

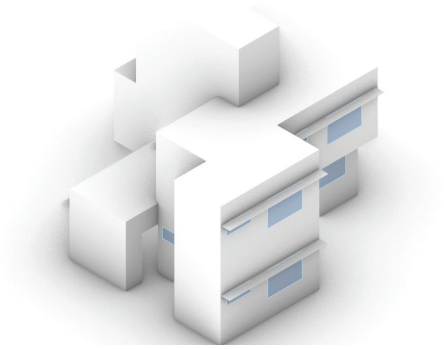
OPTION 1 - COMPACT PLAN



- Indentations and overhangs enhance self shading.
- Poor daylighting due to wider floor plate
- Location of double height stack (diagonal to wind entry)

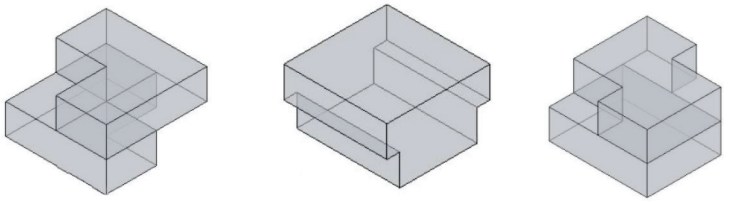
EPI 15.0 KWH/SQM/YEAR

OPTION 2 - OPEN PLAN



- Horizontal interlocking to reduce use of mortar
- Thin flanges (23.6mm) are not feasible
- Airgap of 60mm is good for thermal resistance
- The cavity could have insulation infill

EPI 20.7 KWH/SQM/YEAR



Cross L shaped
226.6 Wh/m2

T shaped
241.3 Wh/m2

Square to staggered
229.1 Wh/m2

FORM STUDY TO UNDERSTAND EFFECT OF SOLAR INSOLATION

The final design has evolved based on the pros and cons of the two options and observations from a form study. The compactness of Option 1 and the openness of plan from Option 2 were imbibed into the final proposal.

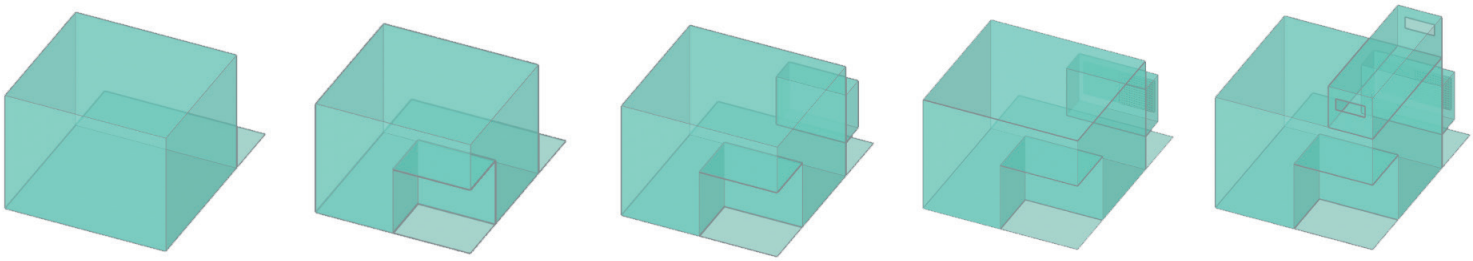


Fig 02. Design evolution sequence

11 DESIGN DOCUMENTATION

ENERGY PERFORMANCE OPTIMIZATION

PHPP TOOL FOR ENERGY MODELLING (PASSIVE HOUSE PLANNING PACKAGE)

The Passive House Planning Package (PHPP) is an MS excel workbook based building energy modelling software used with Sketchup plugin, Design PH, to design a Passive House building. The current energy modelling outputs are for one unit of the design scheme, considering the surrounding context and the adjacent attached units. One model using specifications of the project considering compliance to the competition contests and the other complying with PHI standards. The use of PHPP is to optimize the design and demonstrate approach to Passive House energy standards.

SHEETS	INPUTS	ECOPOD	ECOPOD AS PASSIVE HOUSE
Treated floor area		103.75 sq.m	
Interior setpoint temperature °C	*Winter* *Summer*	22 27	20 25
U-value (W/m2K)	*External wall* *Roof* *External door* *Floor* *Exposed floor slab*	0.442 0.475 2.035 1.982 0.684	0.235 0.191 0.946 0.634 0.211
Components	*Mechanical systems*	-	HRV system with 75% efficiency Additional dehumidification
Ventilation	*Type*	0.37/h ACH with Only window ventilation	0.37/h ACH with HRV effective efficiency 63%
Cooling units	*System*	5kW Split system for 3 rooms	5kW VAV system for the entire unit

BUILDING CHARACTERISTICS WITH REFERENCE TO TFA	UNIT	CRITERIA / ALTERNATIVE	ECOPOD	ECOPOD AS PASSIVE HOUSE
SPACE COOLING				
Cooling & dehum. demand	kWh/m2 a	35 / 60	**81**	93
Cooling load	W/m2	- / 11	**30**	22
NON- RENEWABLE PRIMARY ENERGY (PE)				
PE demand	kWh/m2 a	-	**172**	177
PER demand	kWh/m2 a	45 / 60 *90 (Low energy class)*	**88**	89
PRIMARY ENERGY RENEWABLE (PER)				
Generation of renewable energy (in relation to projected building footprint area = 87.68m2)	kWh/m2 a	78 / 60 *Plus class*	**58**	64

Fig 02. PHPP Tool inputs

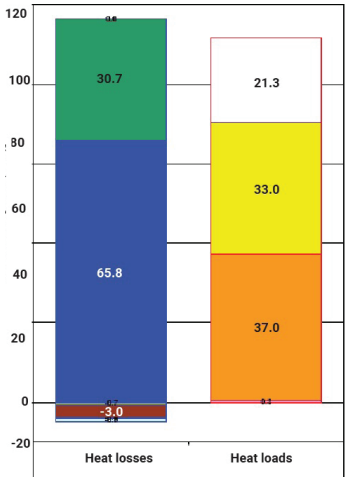


Fig 02. Energy balance of EcoPod meeting passive house criteria

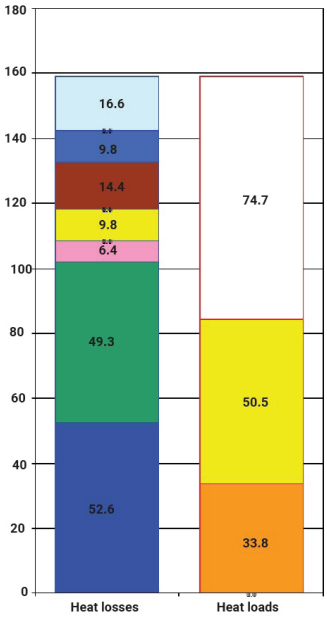


Fig 02. Energy balance of EcoPod

The design and its performance is evaluated based on Passive House energy standard, Class Plus criteria. Table xx presents the building characteristics for both cases against the criteria. EcoPod satisfies the renewable energy generation criteria of 60kWh/m2a with rooftop PV panels in model for PHI and PER demand for low energy of 90 kWh/m2a in both cases.

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PERFORMANCE - NATURAL VENTILATION

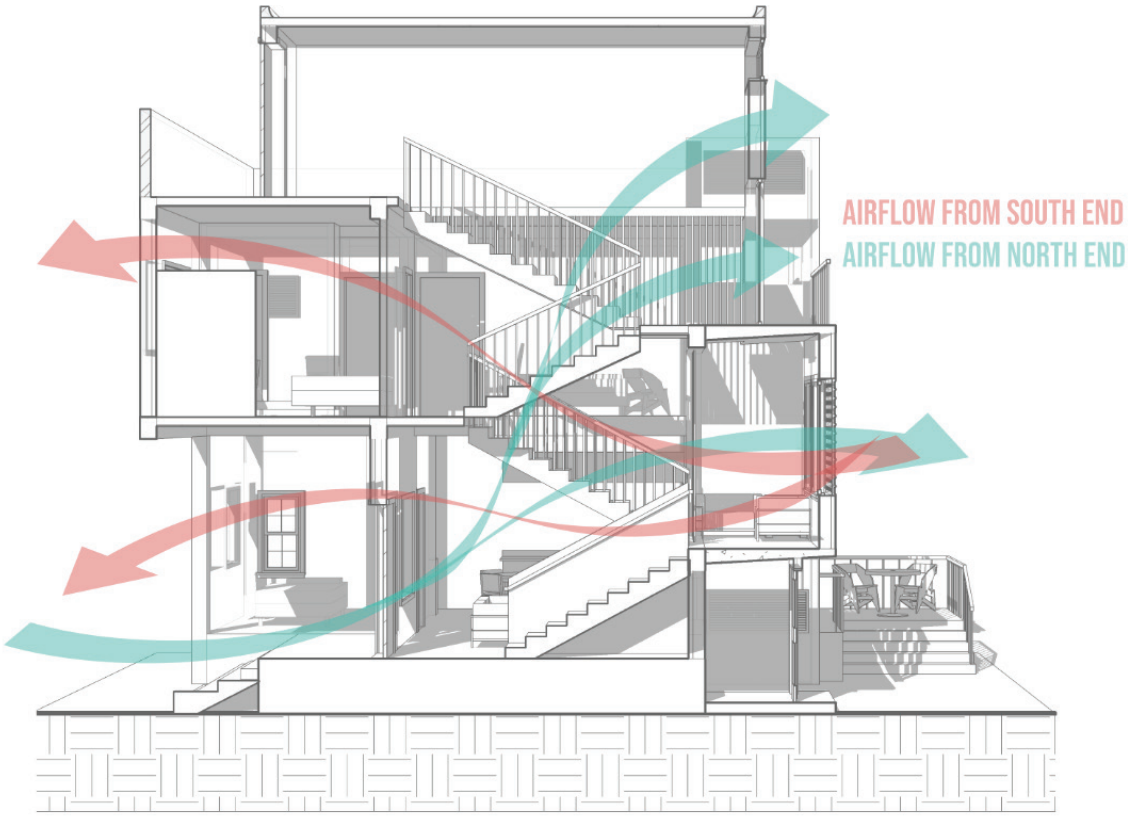


Fig 02. Ventilation scheme for both orientations of dwelling units

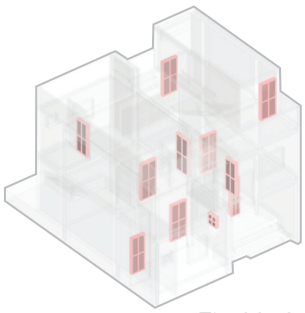


Fig 02. Context for CFD Simulations in Openfoam

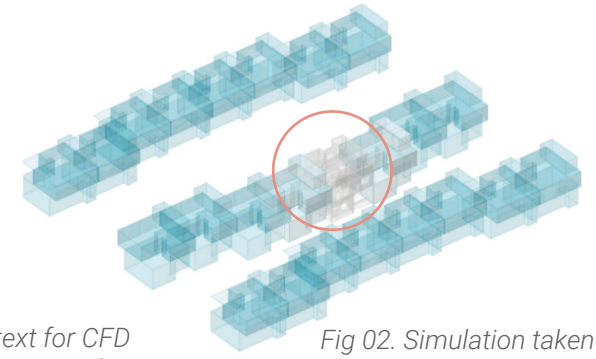


Fig 02. Simulation taken for worst-case scenario

Design of the dwelling units envelope and fenestrations leverage Hyderabad's potential for natural ventilation (upto 3700hrs). The orientation, windows, stack effect enhancing stairwell clerestory windows and perforated jali walls are the design interventions for maximizing ventilation potential

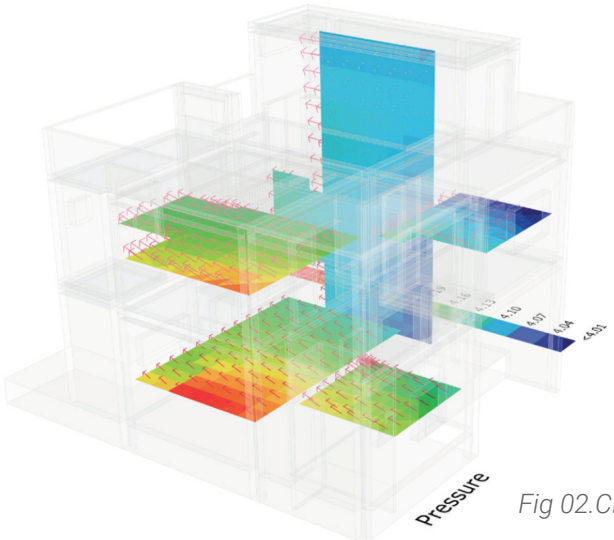


Fig 02.CFD Simulation

INDOOR VELOCITY RANGE IN PLANES 1.2M ABOVE FLOOR LEVEL IS 1.27 TO 2.25 M/S

11 DESIGN DOCUMENTATION

THERMAL COMFORT + VISUAL COMFORT

5822 HRS - NATURAL
6886 HRS - MIXED-MODE

For the purpose of comfort and ventilation, rooms are divided into zones of natural ventilation (NV) and temporal mixed mode (MM) ventilation. Each zone is provided with operable windows which are ideal for opening 6336 annual hours according to outdoor DBT. By wind and buoyancy driven ventilation, annually 5822 hours and 6886 hours of comfort is achieved (based on zone operative temperature) in NV and MM zones respectively. The factor causing discomfort in both the zones is humidity, where the frequency of exceeded humidity is 80.05% and 81.82% respectively. Comfort by natural ventilation in these zones is aided by ceiling fans. Indian Adaptive Thermal Comfort Model (IMAC)'s monthly comfort ranges of Naturally ventilated and Mixed mode spaces for 90% acceptability is used to calculate the comfort hours.

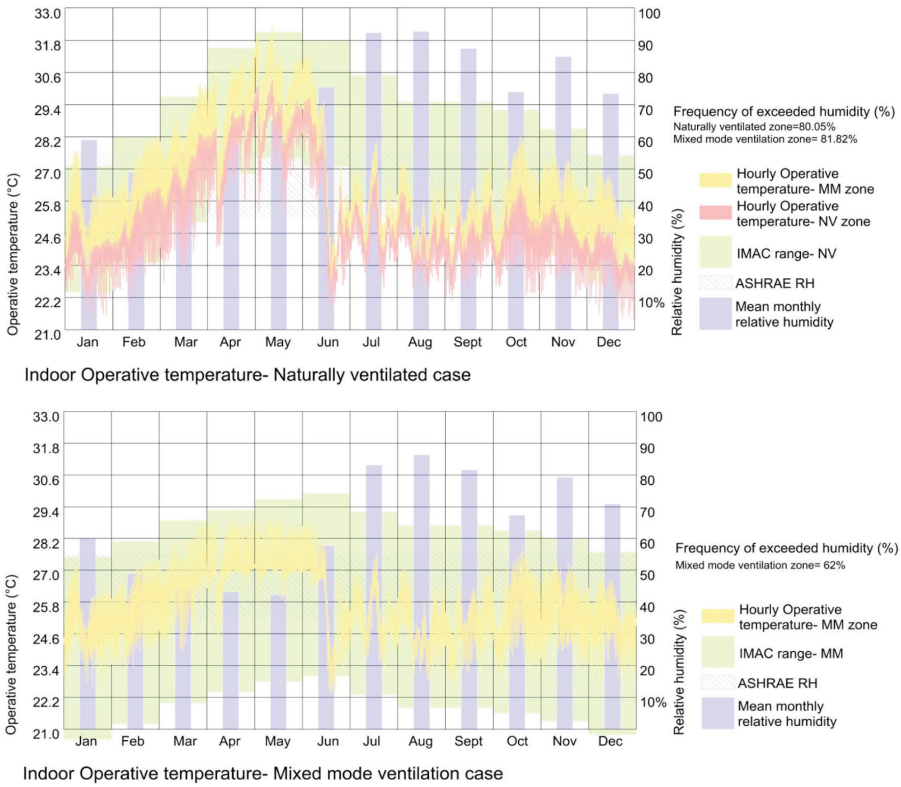
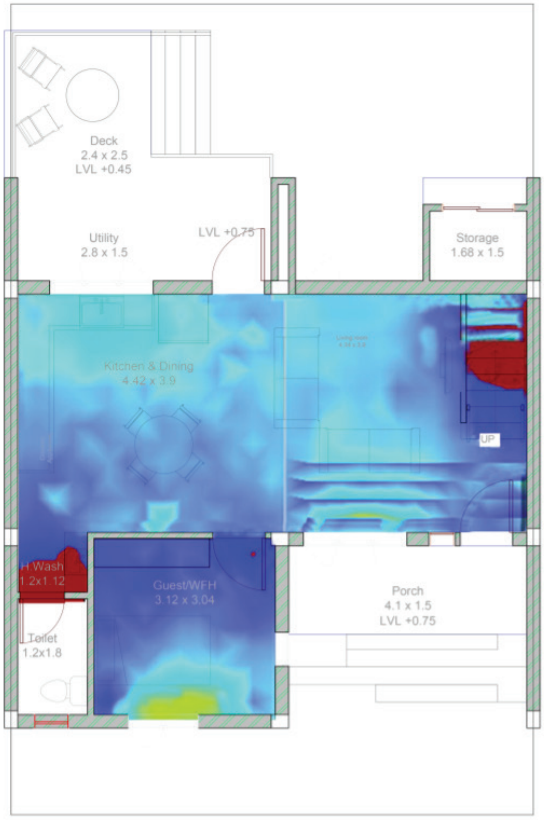


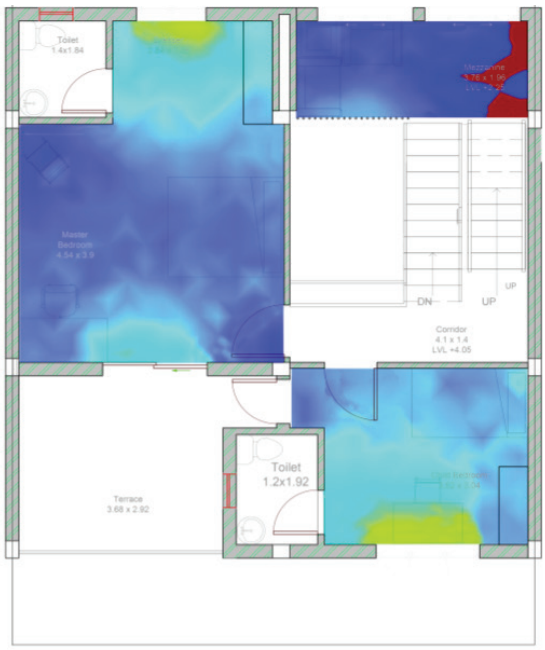
Fig 02.Comfort graphs

GLARE - FREE VISUAL COMFORT

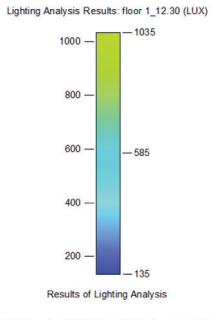
Fig 02.Daylight Simulation



Ground floor plan



First floor plan



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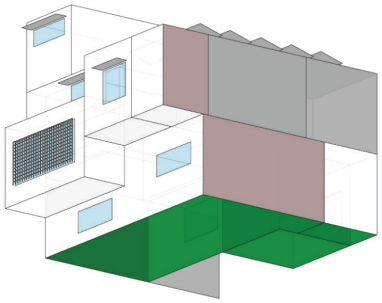
ENERGY CONSUMPTION + GENERATION



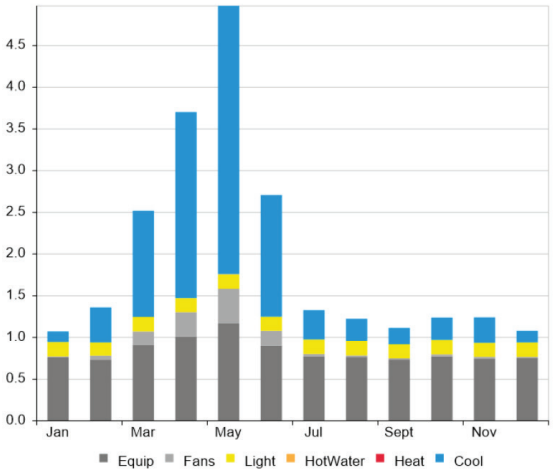


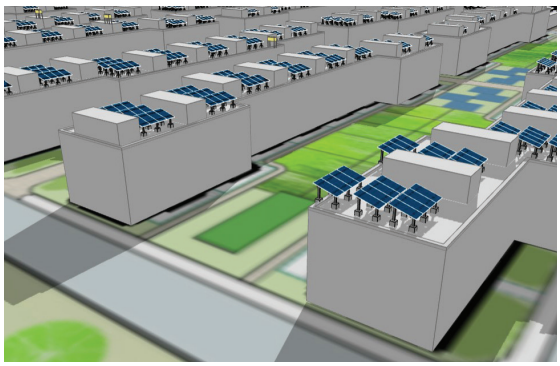
Fig 02. Annual Energy consumption

EPI 23.57 KWH/SQM/YEAR

GENERATION 1538.9 KWH/KWP/YR
PV INSTALLED 897.93 KWP

The use of energy efficient equipment and lighting, along with a high performing envelope reduced the unit's EPI by 66.3% from 70kWh/m2/yr (ECBC benchmark) and **30.6% from 34kWh/m2/yr (SDI benchmark for residential building in composite climate)** to 23.57 kWh/m2/yr. The unit is envelope load dominated, whose heat gains result in high cooling loads during hot seasons. Optimisation of envelope materials and form will further reduce the EPI to achieve set goals for net zero energy.

The solar panels placement and design have been analyzed and optimized to maximize the generation potential. Panels are located above all built-infrastructure including Clubhouse building, Dwelling units, Parking lots, Co-working office and Wellness-center. Additionally the shallow Raincatcher canopy has 4 panels each. The analysis used to optimize were Shadow Analysis, Radiation Heatmap and the Solar Access analysis. A threshold of **80% efficiency** was maintained on all panels.



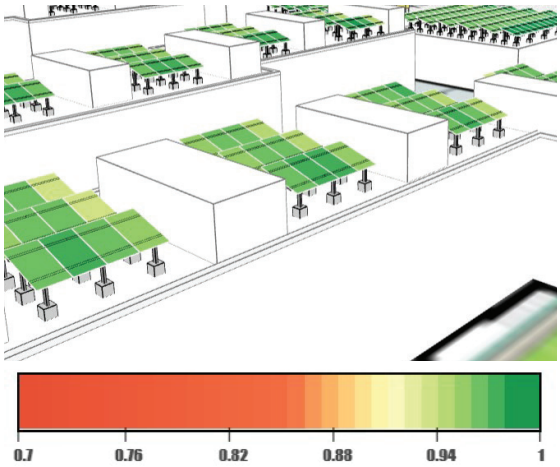


Fig 02. Solar panel analysis

TOTAL SAVINGS	PAYBACK PERIOD	INTERNAL RATE OF RETURN
7561793 INR	1 yrs. 1 mos.	-270825.13%

Fig 02. Renewable energy metrics achieved

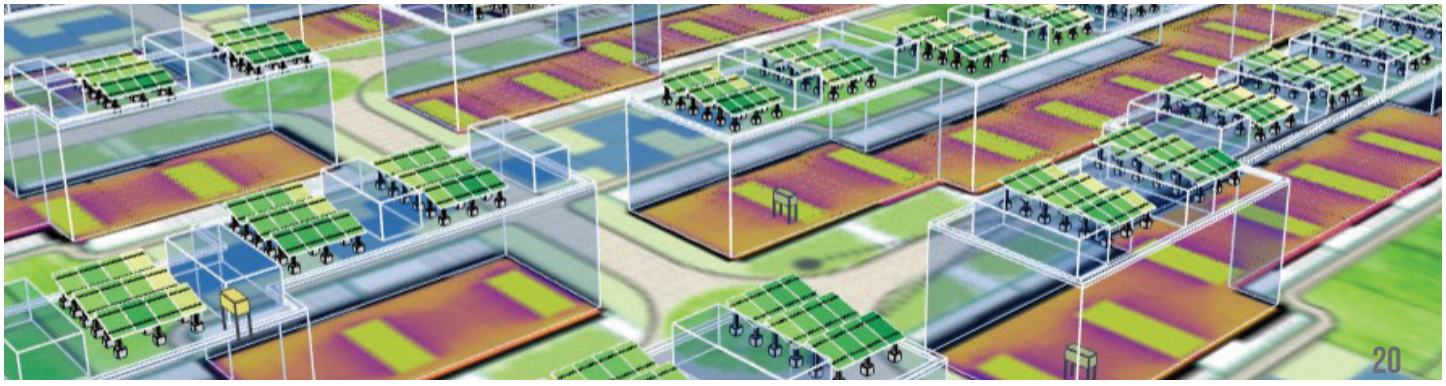


Fig 02. Solar panel analysis - Heatmap + Solar access

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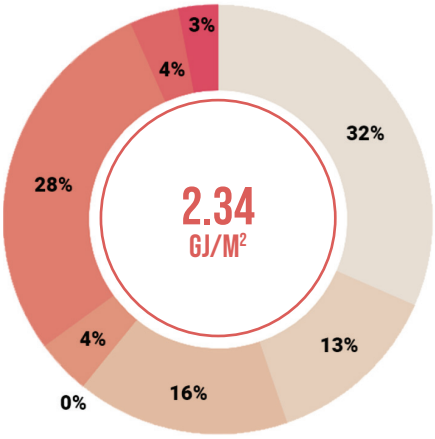
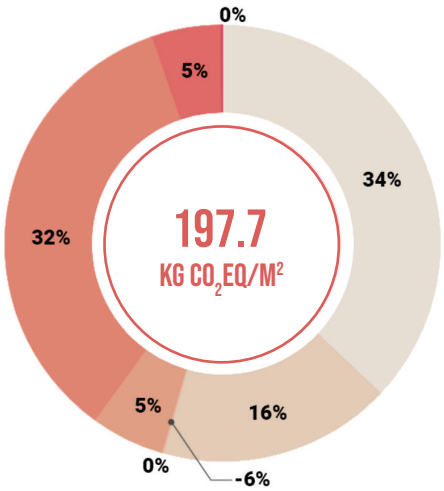
ENGINEERING DESIGN AND OPERATION - MATERIALS



GJ/m²		kg CO_2 eq./m²
0.74	Footing & Foundation	79.58
0.31	Frame structure	37.25
0.38	External wall	-17.17
0.001	Internal wall	0.4
0.1	Floor	11.68
0.66	Slab	74.73
0.09	Overhang & Lintel	10.89
0.07	Door & window	0.34



EMBODIED ENERGY

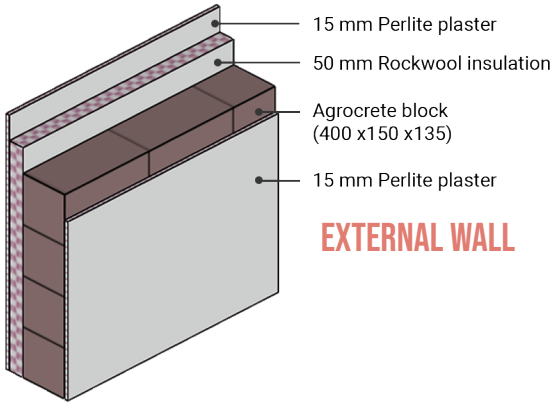
GOAL <3 GJ/M²

GLOBAL WARMING POTENTIAL

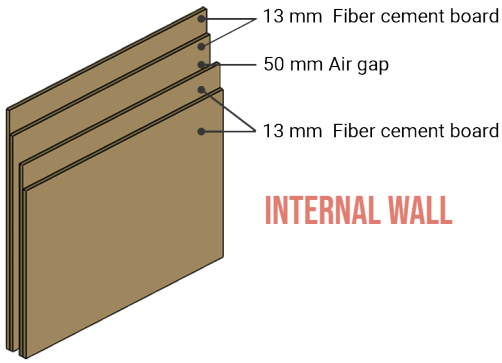
GOAL <250 KG CO2EQ/SQM

Fig 02.Embodied Energy & GWP

Eco sensitivity in the project is realizes by opting for local materials like Tandur stone (56.1km from site) and carbon negative Agrocrete masonry blocks. The masonry construction is improved by interlocking blocks, which use less mortar and removing CO2 from the atmosphere. Embodied energy and Global warming potential are calculated for major civil construction of one house unit to demonstrate its environmental impact.

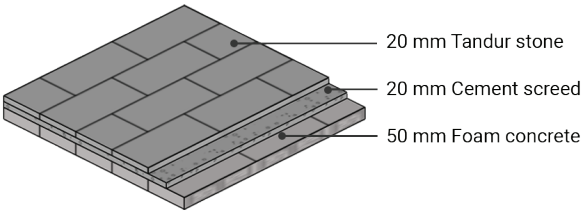


EXTERNAL WALL

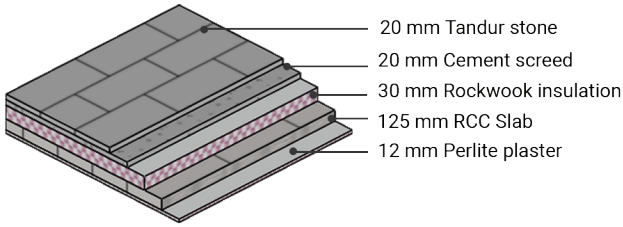


INTERNAL WALL

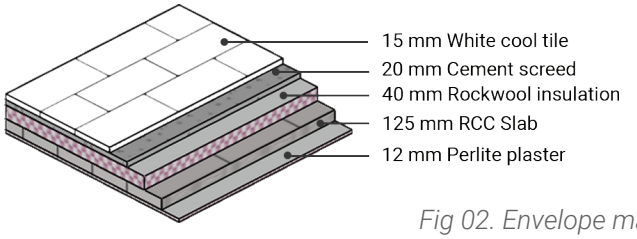
INTERNAL SLAB



FLOOR SLAB



ROOFING SLAB



TERRACE SLAB

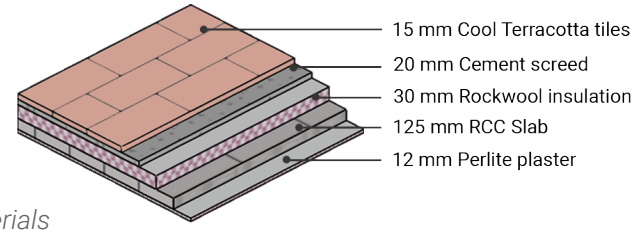


Fig 02. Envelope materials

11 DESIGN DOCUMENTATION

ENGINEERING DESIGN AND SERVICES

Fig 02. Site Electrical layout

HVAC CALCULATIONS

Room	Area	Cooling load	Cooling capacity	Provided
Unit	*m2*	*Btu/hr*	*Tr*	*Tr*
Master bedroom	260	6139	0.59	1
Children bedroom	121	3052	0.29	1
Guest/ WFH room	103	3236	0.31	1
Total	484	12427	1.19	3

Design setpoints:

DBT = 25°C
WBT = 12°C
RH = 55%
AH = 0.13 kg/kg

4.18 kW
COOLING CAPACITY

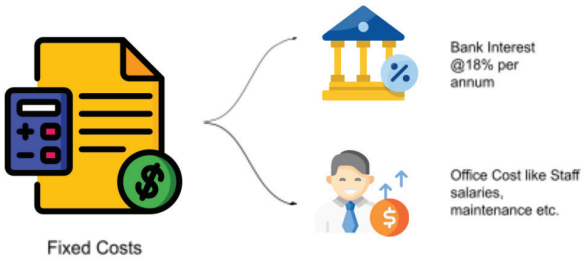
Fig 02. HVAC Calculations

11 DESIGN DOCUMENTATION

CONSTRUCTION SEQUENCE & LOGIC

For the construction, it has been observed that the total project time would be around four years irrespective of the kind of construction technique used. This is because of the statutory requirements. There is a need for land change that needs to be approved from Hyderabad Municipal Corporation. This process of approval will take around two years.

The activities on the site needs to be started as early as possible because of the two reasons 1) There is a loan that is taken @18% per annum for purchasing the land, and 2) There are some standing costs like salary, maintenance, rent etc. that the project developer will occur irrespective of the project progress.



In order to cope with these monthly expenses, the owner will initiate construction work so that he/she could sell the house as soon as it is ready and in this way reduce the monthly expenses he has to pay. So, the following project has two criteria 1) The site activity should start as early as possible and 2) The project completion time is roughly around four years.

In order to deal with this problem, it was decided to optimize the construction sequence so that there is no idle labour at a given time. High capital cost items such as Maivan formwork, precast concrete were ignored so that the project developer can save initial capital money. Work week of six days a week and eight man hours a day is selected to reduce the labour costs. Construction is done in a cluster of 16 houses so that only 16 sets of formwork is required thereby reducing the site storage requirement.

Also, in order to optimize the design-build process it is decided to divide the construction into two stages, namely substructure and superstructure. With this arrangement the construction can begin even when the entire design is not finalized (similar to EPC contract). Slow but steady rate of construction at site is applied. Finally, care is taken so that the external development work does not become critical activity.

Considering the above mentioned points, a Primavera schedule of the site is made. This schedule is given in the annexure x.xx. The total time for construction including the design takes around 1325 days or 3.63 years to complete. Considering a contingency of 10%, the designed schedule is adequate to complete the project in a time frame of 4 years.

11 DESIGN DOCUMENTATION

WATER PERFORMANCE

Water self-sufficiency was achieved by the following strategies:
Reserving rainwater from rooftops of Dwelling units and community building.
As the region is prone to irregular rainfall, Collecting rainwater is crucial to meet the demand during the dry seasons. Besides the roof-top harvesting, additional inverted-umbrella shaped devices are placed around the site to increase the potential for collecting rainwater. Other water-related services like, Overhead tanks and STP were located after considering gravity and site contours.
52.3% of the occupant demand is met by RWH in a cluster (16 DU)
35.5% of the site water demand is met by Harvested rain water
Recycling water on site using Root Zone treatment (RZT) of 80% efficiency.
RZT situated at each cluster courtyard filters the grey-water (1440LPD) from the dwelling units which is then reused both for the flushing cisterns and on-site nonfood irrigation.
About 29.9 % of total demand on site is catered by Filtered grey water.
Reducing water consumption of various activities on site by using resource efficient measures such as energy efficient fixtures, Micro - Drip irrigation, low demand landscape with the help of native trees and plants

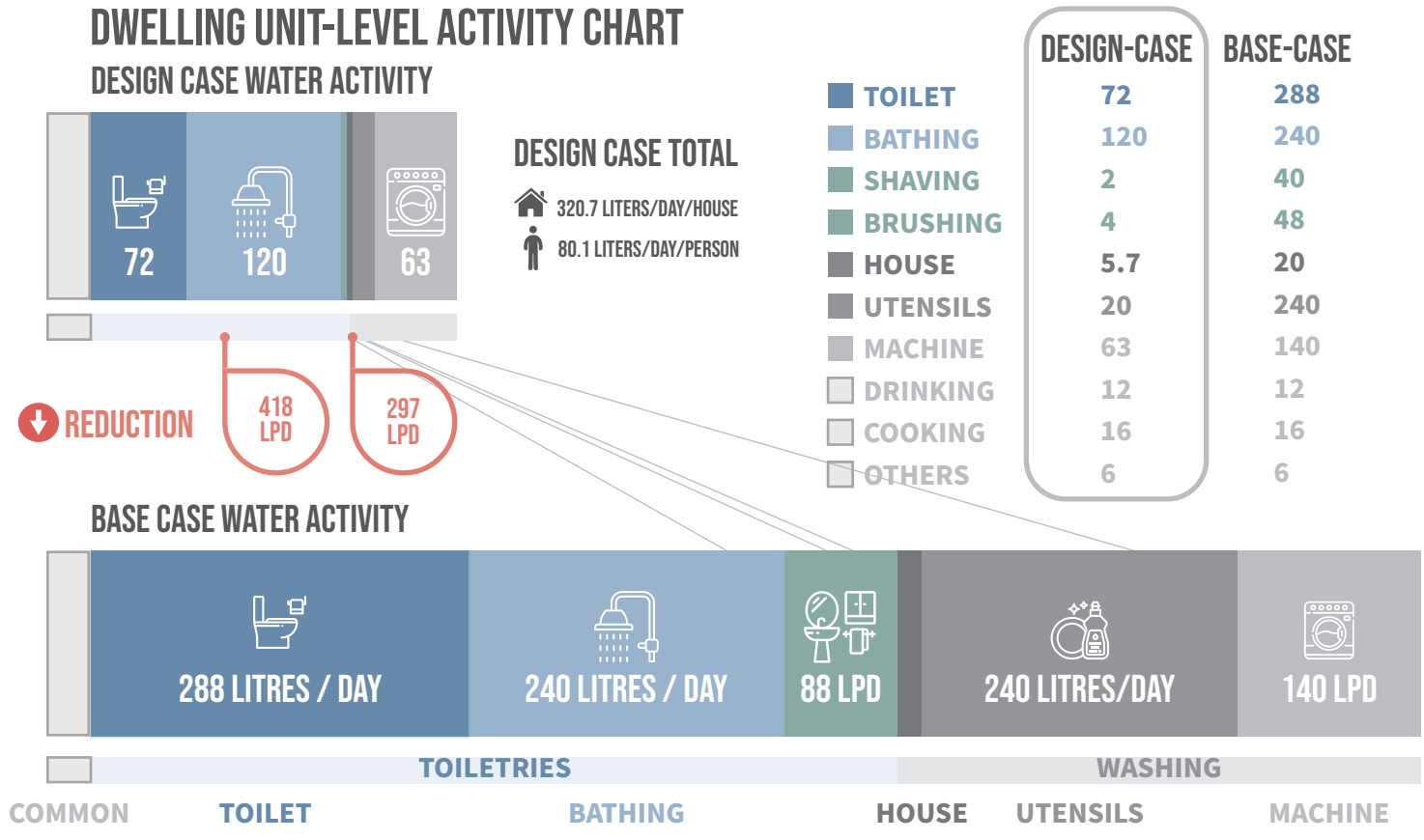


Fig 02. Activity Chart - House level

Water-saving and performance efficient fixtures and appliances **supported by conscious choices of sustainable lifestyle** will help reduce consumption in a household to an extent of 418 lpd for Toilet-related activities and 297 lpd for washing-related activities. Due to such savings, overall consumption for a household may be assumed at 320.7 lpd for a household or 80.2 lpd per resident.

11 DESIGN DOCUMENTATION

WATER PERFORMANCE

Recharging Ground water with rain water drained from site, excess grey water & permeable site surface features inspired by sponge city concept
Over all 40.5% water consumption was reduced with 80.2 LPD compared to NBC 135 LPD in a dwelling unit. Around
69.8% of the total occupant demand in a DwellingUnit is met with RWH and Filtered grey water.
65.4% of the total site demand is met with RWH and Filtered grey water.

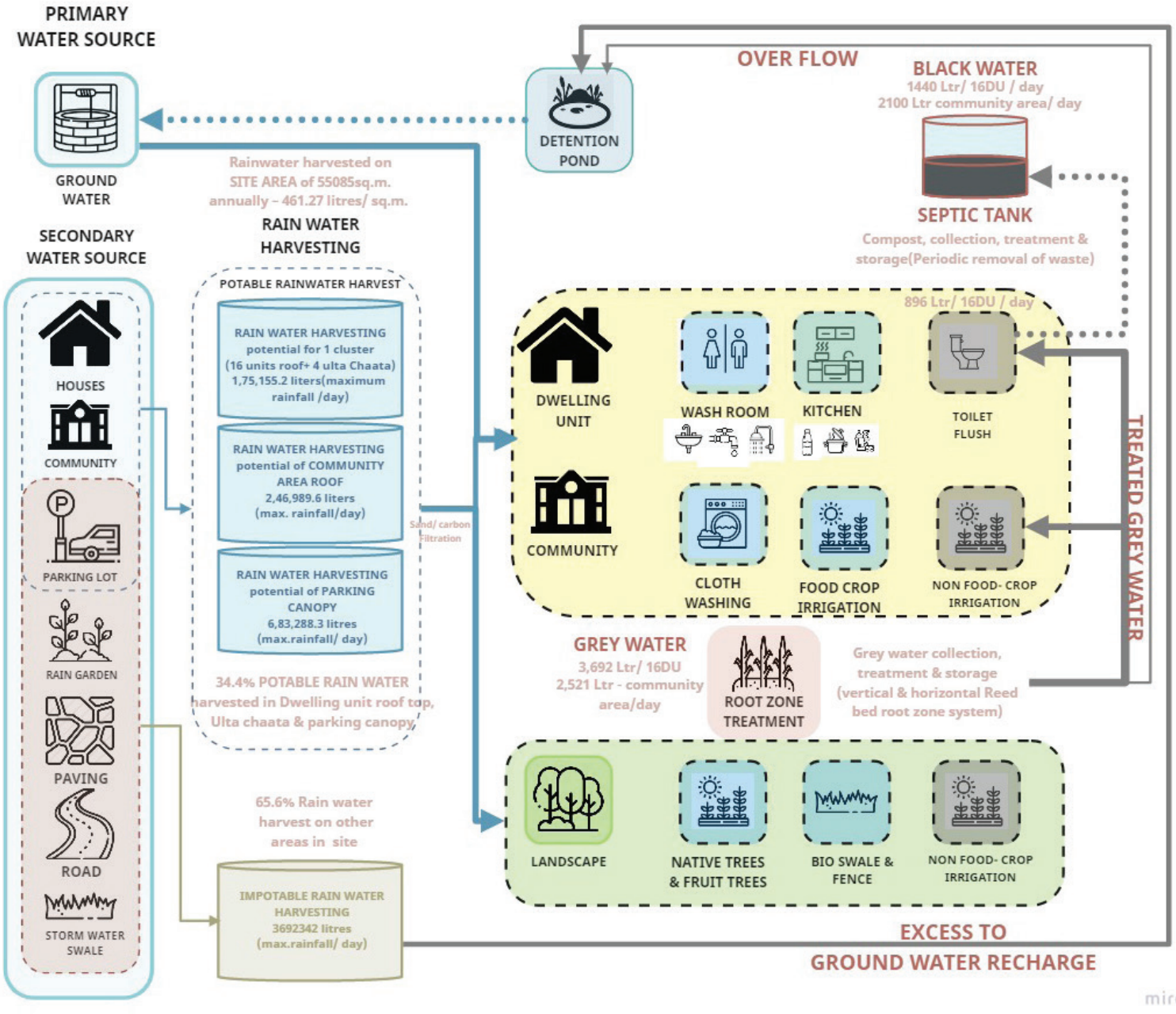


Fig 02.Site-Level water cycle diagram

11 DESIGN DOCUMENTATION

LOW CARBON DESIGN

CARBON POSITIVE IN 5 YEARS

Fig. CO2 offset of Solar panels

The design from conception to selection of equipments has focused on Eco-sensitivity and Carbon footprint. The building materials like Agrocrete (Carbon negative) and use of Solar panels has a significant Carbon-offset. Further, through landscape and vegetation measures Carbon-positive goal can be achived in 5 years.

Materials

Element	Total impact
Building infrastructure	5,695,341.6 kg
Subtotal	5,695,342 kg

Plants

Element	Total impact
Cuban royal palm - Roystonia regia tree	23,364 kg
Neem tree - Azadirachta indica tree	1,094,764 kg
Royal poinciana - Delonix Regia tree	10,100,150 kg
Koko tree - Albezia Lebbek tree	4,538 kg
Blue Jacaranda - Jacaranda mimosifolia tree	11,104,614 kg
Golden shower tree - Cassia fistula tree	616,256 kg
Java Plum - Syzium cumini tree	27,738 kg
Mango tree - Mangifera indica tree	694,143 kg
Guava tree - Psidium guajava tree	79 kg
Kadamba / burflower tree - Adina cordifolia tree	34,346 kg
Banyan tree - Ficus benghalensis tree	2,012,854 kg
Bamboo - Bambusa bambos tree	276,812,399 kg
Rain tree - Samanea saman tree	295,318 kg
Morringa tree - Moringa oleifera tree	79 kg
Purple orchid tree - Bahunia purpurea tree	2,248,400 kg
Subtotal	305,429,788 kg

Operations

Element	Total impact
No-till/Minimal Disruption	0 kg
Subtotal	0 kg

Net Impact over 50 Years 299,734,446 kg CO2-eq

Net Project Impact

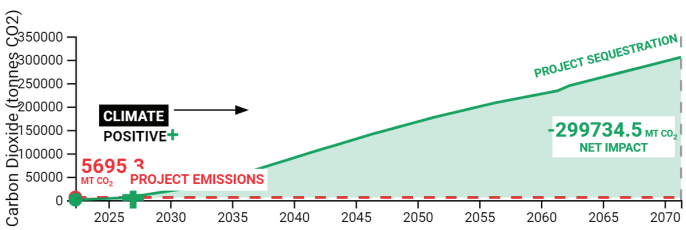


Fig. CO2 Calculation

CLIMATE RESILIENCE

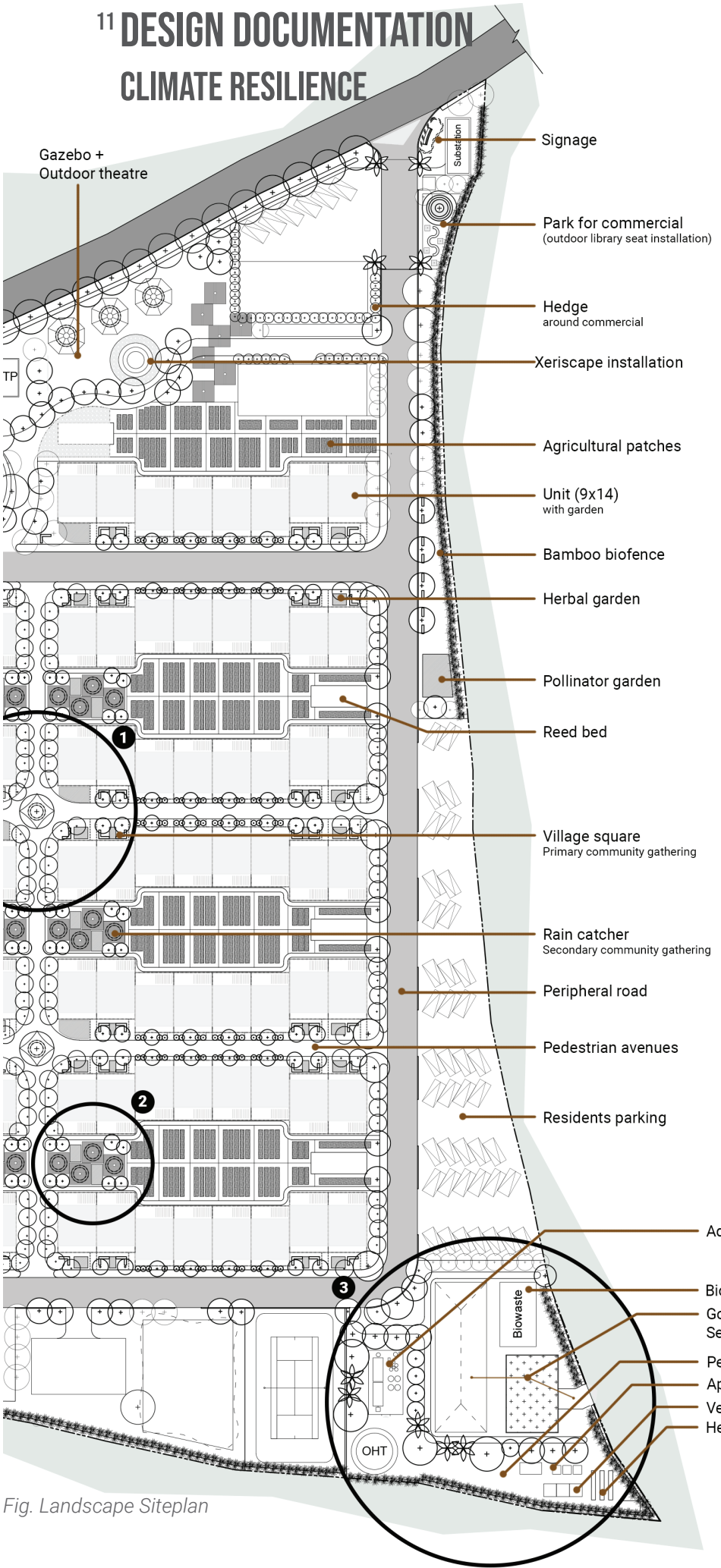
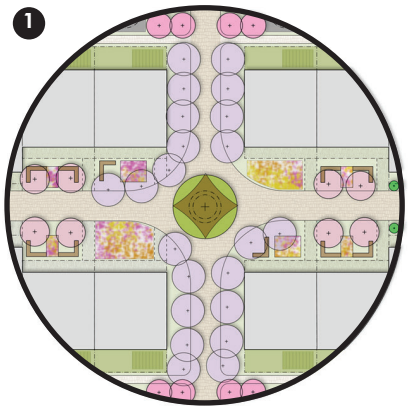
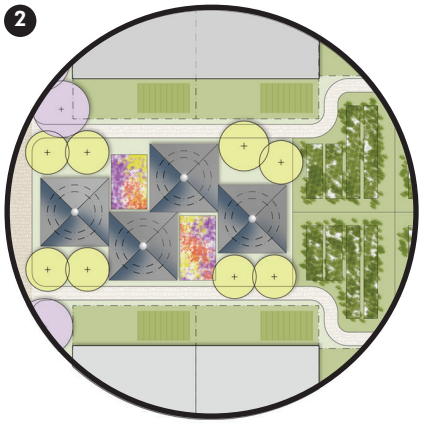


Fig. Landscape Siteplan

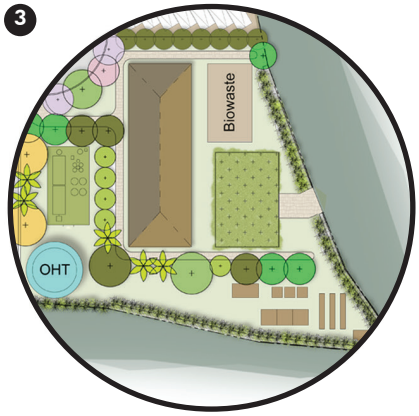
Fig 02. Site layout highlights



PRIMARY COMMUNITY GATHERING SPACE AROUND THE VILLAGE SQUARE



SECONDARY COMMUNITY GATHERING UNDER THE RAIN CATCHERS



ANIMAL HUSBANDRY + ORGANIC FARMING

11 DESIGN DOCUMENTATION
CLIMATE CHANGE RESILIENCE

LANDSCAPE STRATEGIES

PERMACULTURE FARMING AREA AND AQUAPONICS

Abiding by the concept of resilience and to counter potential food insecurity, space for practicing permaculture farming and a demonstrative aquaponics glass house has been proposed on site ; the latter depending on success may be established over individual residences as well.

GOSHALA
Abiding by the concept of resilience and to counter potential food insecurity, a small goshala has been proposed adjacent to the permaculture area as a source of dairy and a potential revenue as well.

HERBAL GARDENS AND POLLINATOR GARDENS
In order to create a resilient ecosystem at a micro level, multiple patches with herbal plants and pollinator attractant species to sustain the farmscapes and other proposed vegetation.

REED BEDS
Reed beds have been proposed at the end of each farmscape within a cluster as a part of phytoremediation.

POCKET PARK
A pocket park has been created near the main entrance of the site with an outdoor seating – library as well.

MULTI - PURPOSE SPACES
Spaces such as the outdoor theatre near the rent – out gazebos, detention ponds which when dry may be used as social gathering or play fields have been proposed across the site so that spatial function may be allocated as per imagination.

HEAT COMBATING LANDSCAPE DESIGN

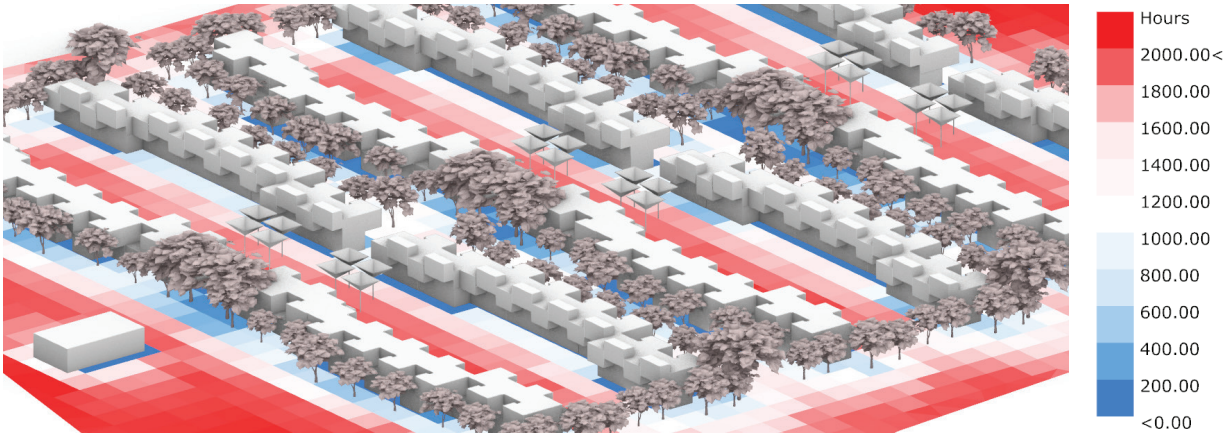


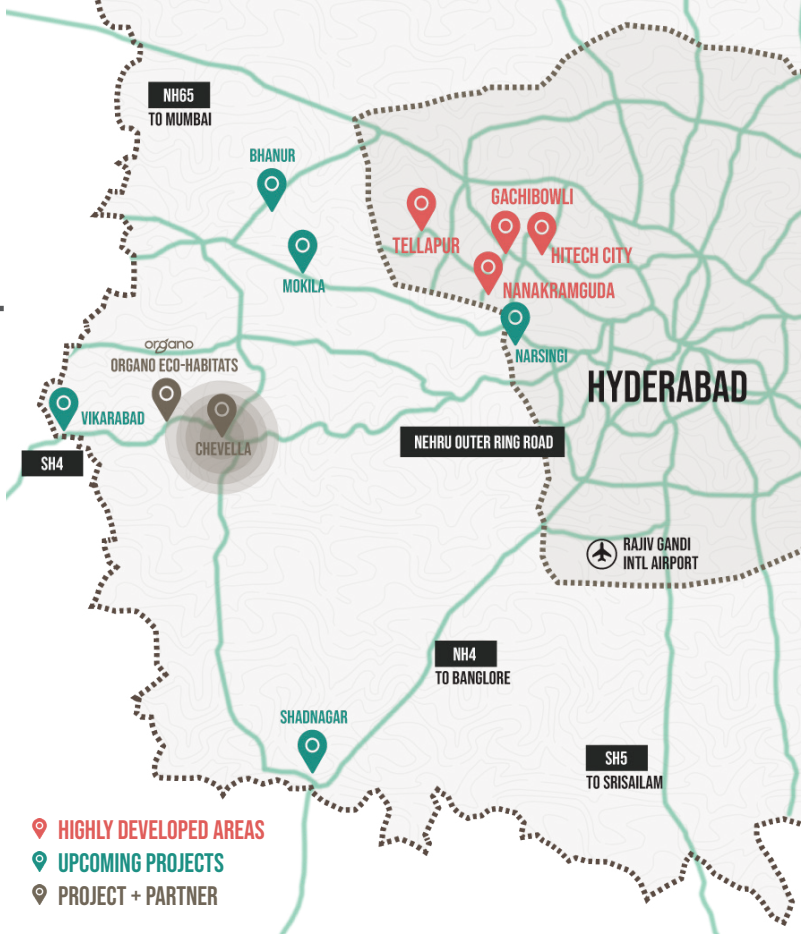
Fig. Landscape for Heat stress resilience

11 DESIGN DOCUMENTATION

SCALABILITY AND MARKET POTENTIAL

Adding to what has been submitted in the previous report, this report provides a brief summary of how the market price is derived for the said project.

For the market study, a list of properties in the vicinity of the site were checked in order to determine the current price trend in Hyderabad for Real Estate Development Project. Properties in Mokila, Narsingi, Chevella, Bhanur, Vikarabad and Shadnagar were taken for the study (ref fig). All these properties are outside the outer peripheral ring road of Hyderabad.

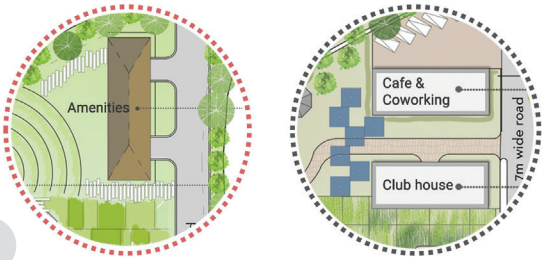


All the properties selected are real estate properties having similar typology as Eco Pod. What we see in Mokila is that there is a price variation in the properties based on the demand. Price range of anywhere from 4350-8500 ₹/sq.ft is achievable based on the project developer, the amenities provided, the percentage of open space provided and the total site area. Also, price change from launch price is common. When we come to projects in Chevella, we can see that the asking price of the project is around 5700 ₹/Sqft. Note that the project taken for study in Chevella i.e., Serene farms by Modi Properties was commissioned in January 2017. Hence, for a project that is in the same vicinity and is expected to be commissioned in 2024, the selling price can be expected at ₹ 7000/sqft or ₹ 75347.3/sq.mt. The **price range of 7000 ₹/sq.mt is economical** when compared with the nearby development because of three reasons: 1) There are certain unique amenities, while Eco-Pod provides Energy and Water Security as a part of dwelling unit, such practise is missing in the conventional real estate market 2) The project area accounts for 50% open space which is at par with the other development schemes and Urban and Regional Development Plans Formulation and Implementation (URDPFI) guidelines and 3) There is an overall increase in amenities which makes the project more attractive, amenities like Goshala, StormWater Management, Soil Rejuvenation and Organic Farming are exclusive to Eco-Pod community. Also note, that all the selling price compared is based on the carpet area, and hence the comparison made in the table is on a similar basis. A common phenomenon in the market is increase in the selling price of the project based on the development works on the site i.e., a fully complete site would fetch higher value than the launch price. This phenomenon is confirmed with the project partner and in order to account for the increase in selling price we assume an increase of 33% in the selling price when the project is fully completed. This increase is distributed in two stages i.e., a different selling price for 34 houses, a different price for 35 houses (increased by 16.5%) and a final price at the project completion stage for another 35 houses (increased by 33%)*. Hence the cost of 34 houses is at ₹ 7000/sqft, the cost of 35 houses (with 16.5% increase in selling price) is at ₹ 8155/sqft and the cost of the last set of 35 houses will be at ₹ 9333.33/sqft. The house carpet area for all the 104 houses is the same at 140 sq mt. Hence considering the different selling price, we can sell the houses (for combined 104 houses) at ₹127.77 crs.

11 DESIGN DOCUMENTATION

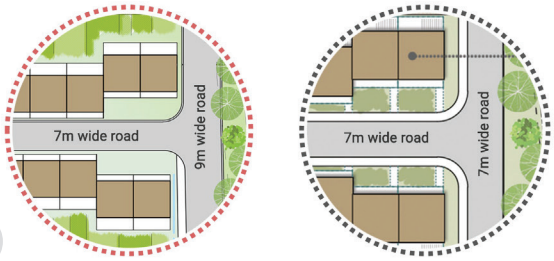
MARKET POTENTIAL RIGHT-SIZING AMENITIES

The amenities for the site are proposed to serve dual purpose of giving a **competitive advantage** when compared to the nearby residential projects, and serving as a **potential revenue-generating model**. Rightsizing of amenities is done by approximating the number of people using the facility at a given time and this is confirmed with the project partner. The amenities are Flexible & multiple-purpose in nature. (Refer Appendix xx for calculations)



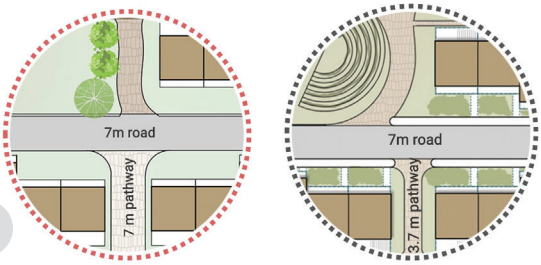
1

The amenities blocks are divided as public Cafe and semi public spaces : Co-working + Clubhouse which are open to the organo community.



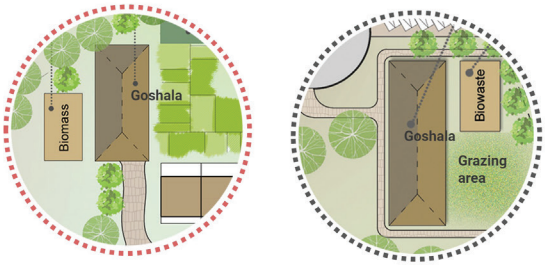
2

The total hard paved area in the site is optimized to provide additional amenities in the site based on micro-market study and partner's requirements.



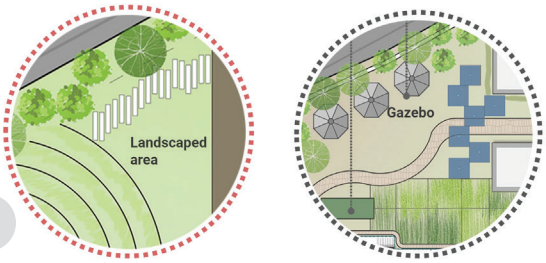
3

The total soft paved pedestrian area in the site is optimized and the total edible landscape area in the site is increased.



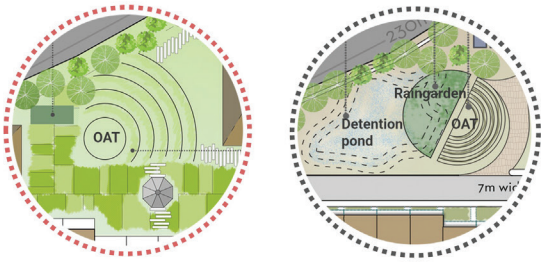
4

The goshala was shifted to the rear end of the site and its area was increased considering the different requirements such as grazing & milking



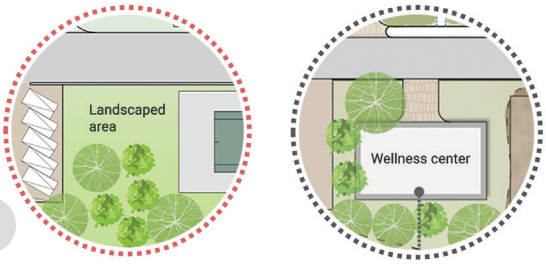
5

Gazebos have been proposed in front of the cafe and can act as community spaces (rentable)



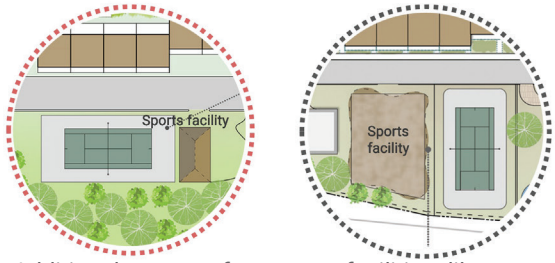
6

The area of the OAT was reduced and integrated with a rain garden and detention pond as a resilience measure.



7

A wellness center, which consists of yoga and gym has been added based on the micro-market study and project partner's requirement.



8

Additional spaces for sports facilities like tot-lot have been added based on the project requirements and micro-market study.

Fig 02. Key plan for Right-sizing

Fig 02. Right-sizing criteria and areas

11 DESIGN DOCUMENTATION

STRUCTUAL

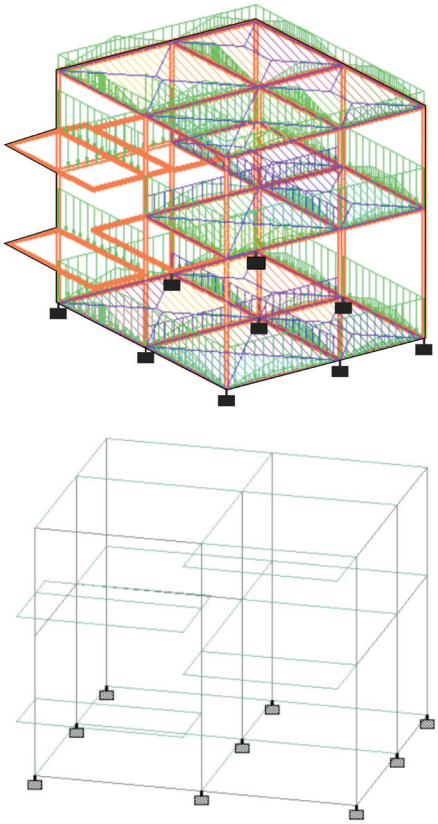


Fig 02. StaadPro drawings

A structural analysis was done using **Staad Pro software**. Only structural members are shown and walls are added as a load. All the columns and beam dimensions are symmetric i.e., 230*300 mm in order to increase the ease of construction. All the slabs except for the cantilever slabs are of 125 mm thickness, while the cantilever slabs are of the dimension 200 mm at the beam and 100 mm at the free end. **Member properties, various loads were applied in accordance to IS 875 Part 1 and IS 875 Part 2.** Dead load in terms of self weight is applied to all the members. In dead load flooring load of 1 KN/m2 is applied considering 50 mm flooring. Self weight of slab is considered as 3.125 KN/m2 is applied as a pressure load. Partition wall load of 6.9 KN/m is applied on the internal beams (except for beams at terrace level). Main wall load of 13.8 KN/m is applied on the outer beam and finally parapet load of 5.4 KN/m is applied on the terrace beams. In order to reduce the redundancy a uniform load of 2.5 KN/m2 is applied as live load. For foundation, was checked for Isolated Footing, the dimensions of the footing that were obtained were much larger and hence it was decided to go with raft foundation. The reasons why the raft was selected as the soil on which this structure is being built is black cotton soil and hence there would be excessive shrinkage and swelling. **Raft foundation is proposed with raft beams of dimension 350*350 mm** connecting the foundation column and raft slab of thickness 350 mm is checked for the loading combination. The foundation is able to take the acting loads and moments and hence the proposed foundation can be used for construction.

ON-SITE REVENUE MODEL

Leveraging the ample opportunities for generating revenue, amenities are selected and zoned near the entrance of the siteallows us to maintain privacy inside for residents.The major source of revenue that can be obtained are from cafe, banquet hall, coworking space, milk produce, outdoor sports, atm, community kitchen and selling of organic fertilizers. Alternatively, there is a little scope of revenue from charged parking and renting of amphitheatre.The revenue was approximated considering the occupancy, event and the mode of revenue generation with guidance from our Project Partner.

In total, a monthly revenue of ₹ 6,70,500 can be generated. This revenue is after considering the maintenance cost of all the amenities. The detailed calculation of the revenue generation model with all the assumptions is given in Appendix x.xx. This revenue in other words is reduction in maintenance cost of the dwellers. A reduction of ₹ 6,447 (6,70,000/104) in the maintenance cost is achievable through the revenue that is generated.

MONTHLY REVENUE ₹ 6,70,500
MAINTENANCE REDUCTION ₹ 6447

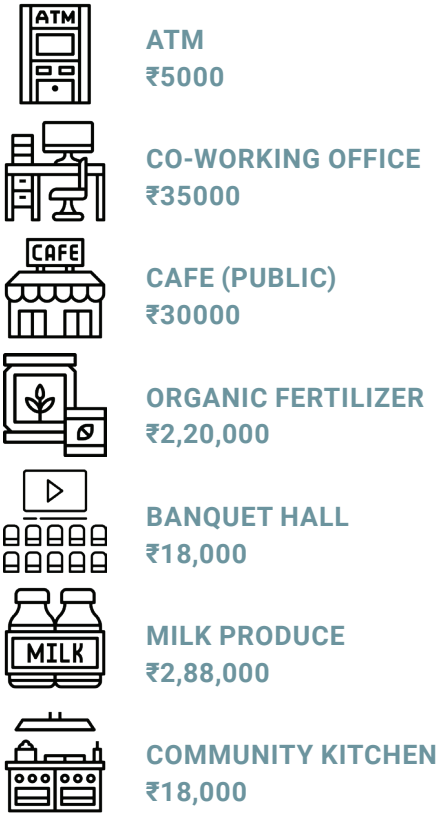
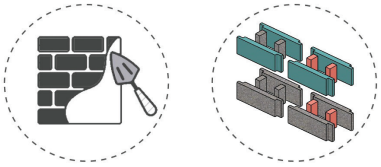


Fig 02. Revenue generating amenities

11 DESIGN DOCUMENTATION

AFFORDABILITY

Various cost effective construction techniques have been adapted in the design case in order to achieve the affordability goals for the target market. Further, alternative building materials have been explored to arrive at the best cost solution while taking into consideration the energy efficiency and eco sensitivity of the building materials. These resulted in reduced construction timeline and increased labour productivity.



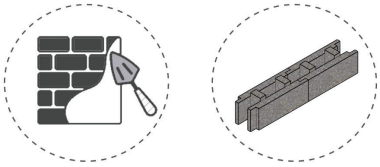
BASE CASE — **Burnt brick (no interlocking)**

ECOPOD — **Agrocrete interlocking blocks**

Use of interlocking blocks
Vertical and Horizontal interlocking mechanism

savings in ***Cost***

51.82 %



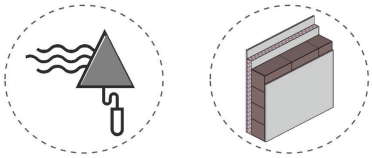
BASE CASE — **Burnt brick**

ECOPOD — **Agrocrete blocks**

Use of Agrocrete blocks
1 block = 5 bricks

savings in ***Cost***

29.38 %



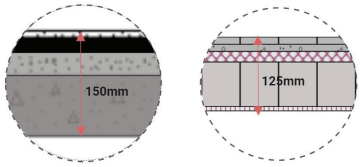
BASE CASE — **Cement Plaster**

ECOPOD — **Perlite plaster**

60% reduced weight than Cement plaster
Perlite plaster

savings in ***Cost***

5.52 %



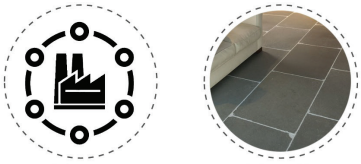
BASE CASE — **150mm slab**

ECOPOD — **125mm slab**

High Volume FlyAsh concrete slab
125mm - by rightsizing the slab thickness

savings in ***Cost***

48.3 %



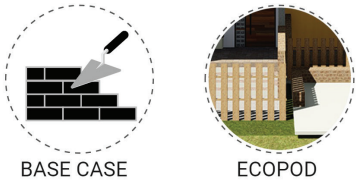
BASE CASE — **Marble flooring**

ECOPOD — **Tandur flooring**

Reduction due to vernacular materials
Local stone flooring

savings in ***Cost***

49.14 %



BASE CASE — **Brick wall**

ECOPOD — **Wooden fencing**

Reduction in use of virgin materials
Salvaged Wooden fencing

savings in ***Cost***

22.26 %

BASE CASE — **Concrete stairs**

ECOPOD — **Salvaged wooden stairs**

Reduction in demand for newly sourced wood
Using salvaged/vernacular wood

savings in ***Cost***

29.4 %

BASE CASE — **Wooden furniture & doors**

ECOPOD — **WPC furniture & doors**

Lower maintenance compared to wood
Wood Plastic Composite doors & furniture

savings in ***Cost***

35.5 %

Fig 02. Conventional vs Affordability measures

11 DESIGN DOCUMENTATION

INNOVATION - INCLUSIVE UNIVERSAL DESIGN

BARRIER FREE DESIGN FOR THE ELDERLY, MOBILITY AND VISUALLY IMPAIRED

We are proposing an option that can be customized for universal accessibility. The dwelling unit is designed in such a way that it can be accessed, understood, and used to the greatest extent possible by all people regardless of their age or disability. This design option takes into consideration the mobility impaired as well as visually impaired. Barrier-free design elements are features like ramps leading to the exterior doors, open floor plan that can accommodate wheelchairs, lower countertops for ease of access. Further, the structural grid allows for effectively increasing the space available in the toilet by moving the walls.

The proposal intends to increase the level of self-esteem and personal independence that can be reached and enjoyed.

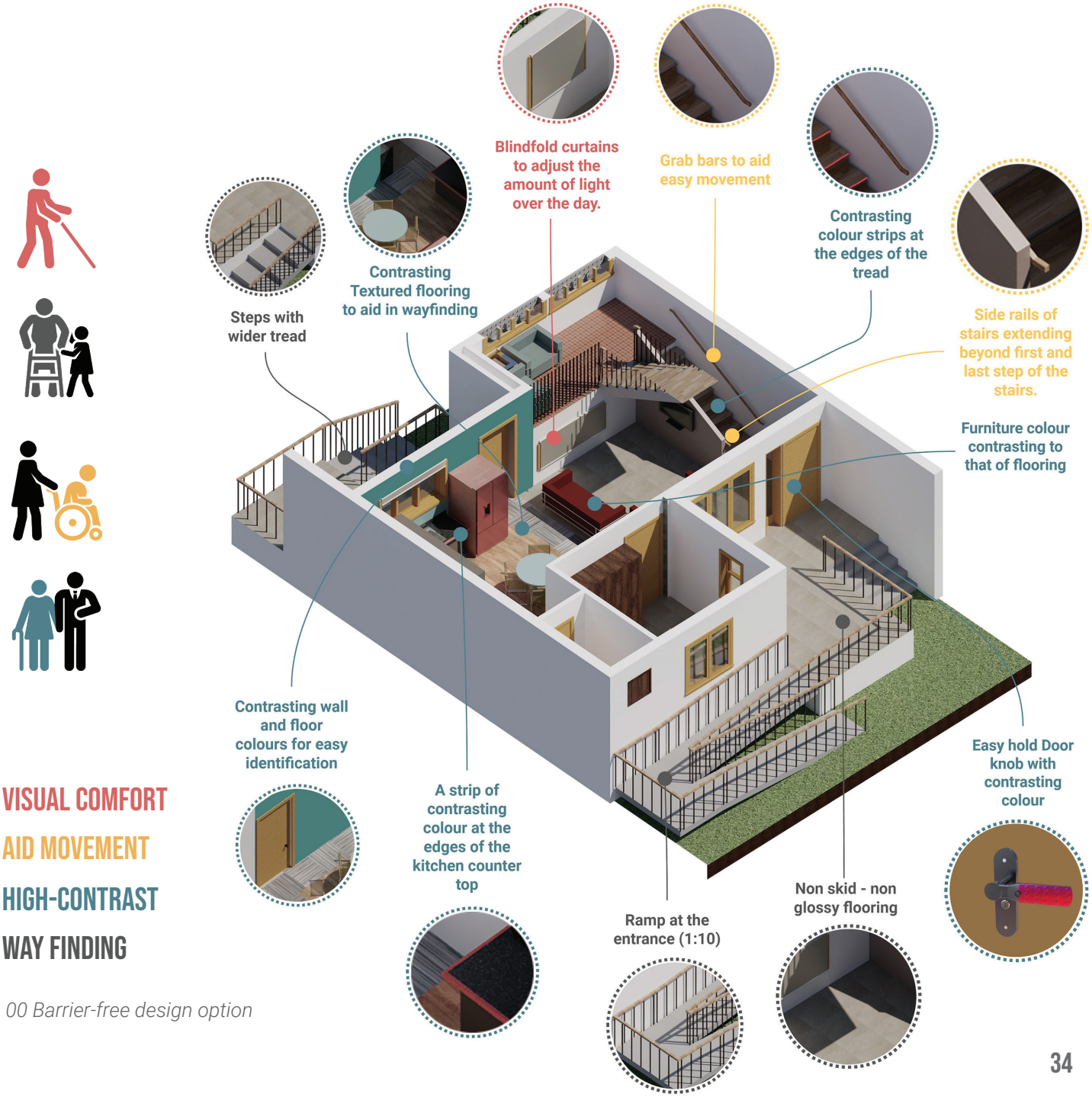


Fig 00 Barrier-free design option

11 DESIGN DOCUMENTATION
INNOVATION - AGROCRETE BLOCK

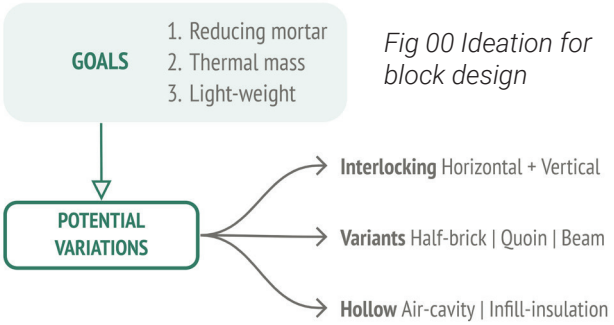


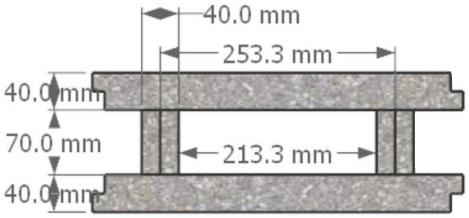
Fig 00 Ideation for block design

ORIGINAL AGROCRETE

Agrocrete, our primary walling material is being innovated as a measure to reduce the construction cost and maintain the Eco-sensitivity of the material by cutting down on mortar requirements. The physical properties of the block are modified by introducing perforations to improve insulation property and interlocking systems using shear-key and lock mechanism.

A

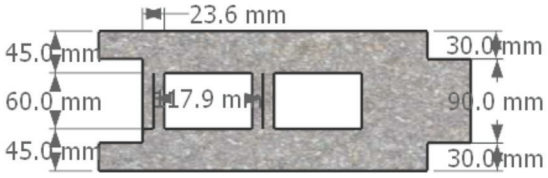
- Horizontal interlocking to reduce use of mortar
- Thick flanges (40mm) are feasible
- Thin Interlocking profile (10mm) is not feasible
- Airgap of 70mm is good for thermal resistance



UVALUE **0.43 W/SQMK**

B

- Horizontal interlocking to reduce use of mortar
- Thin flanges (23.6mm) are not feasible
- Airgap of 60mm is good for thermal resistance
- The cavity could have insulation infill



0.44 W/SQMK

C

- Horizontal interlocking to reduce use of mortar
- Thin flanges (25mm) are not feasible
- 40mm gap is insufficient for thermal resistance
- Intermediate flange(20mm) is not stable

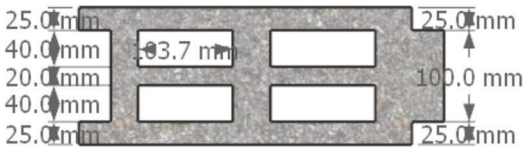


Fig 00 Block options

0.43 W/SQMK

FINAL INTERLOCKING HOLLOW BLOCK

U-VALUE = 0.43 W/SQM.K
HORIZONTAL + VERTICAL LOCKING
HOLLOW BLOCK - 70mm CAVITY

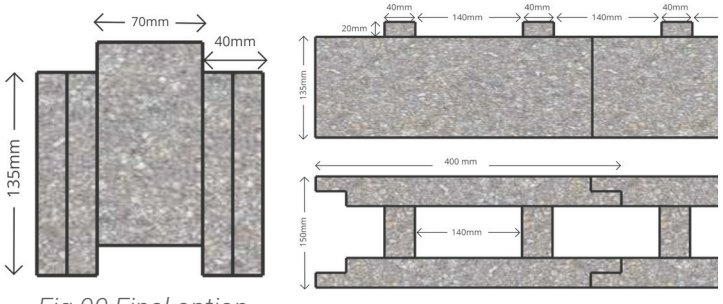
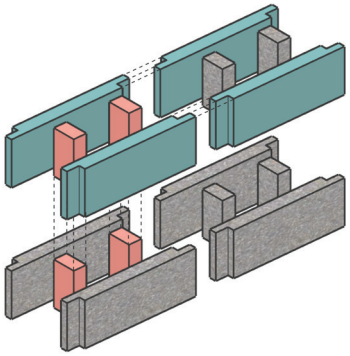


Fig 00 Final option



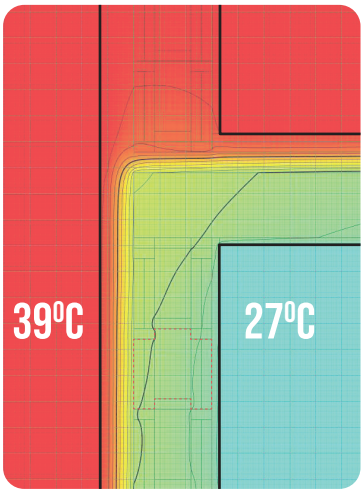
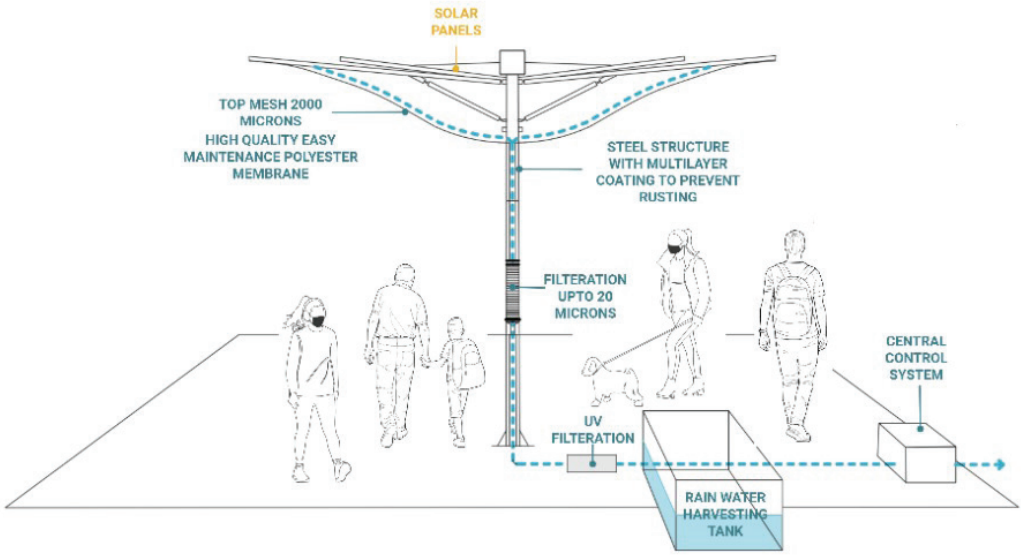


Fig 00 Heat flux

11 DESIGN DOCUMENTATION

INNOVATION - RAINCATCHER



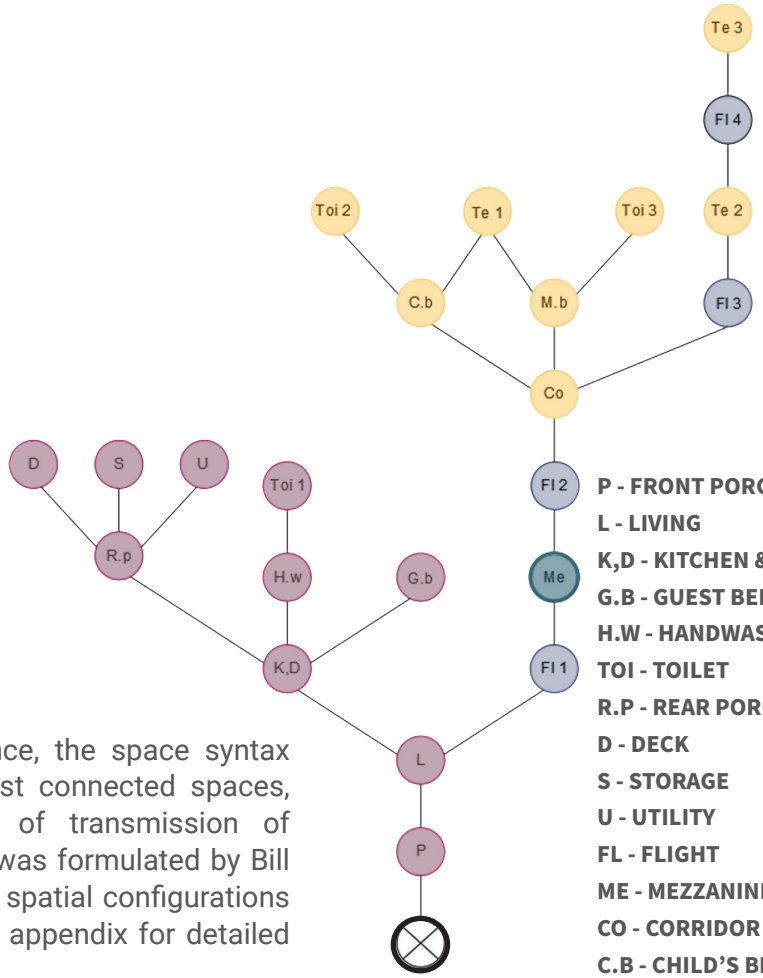
Rainwater harvesting surfaces	Area m^2	Runoff coeffecient	Effective catchment area in m^2
Ulta Chaata - 1	27.8	1	27.8
Ulta chaata - 4/ cluster - 16DU	111.2	1.00	111.2
Annual rainwater harvested			88371
Percentage over overall potable RWH in a cluster			11.2

Fig 00 Raincatcher forming gathering spaces

11 DESIGN DOCUMENTATION

INNOVATION - SPACE SYNTAX

- GROUND FLOOR
- FIRST FLOOR
- STAIRCASE
- MOST CONNECTED

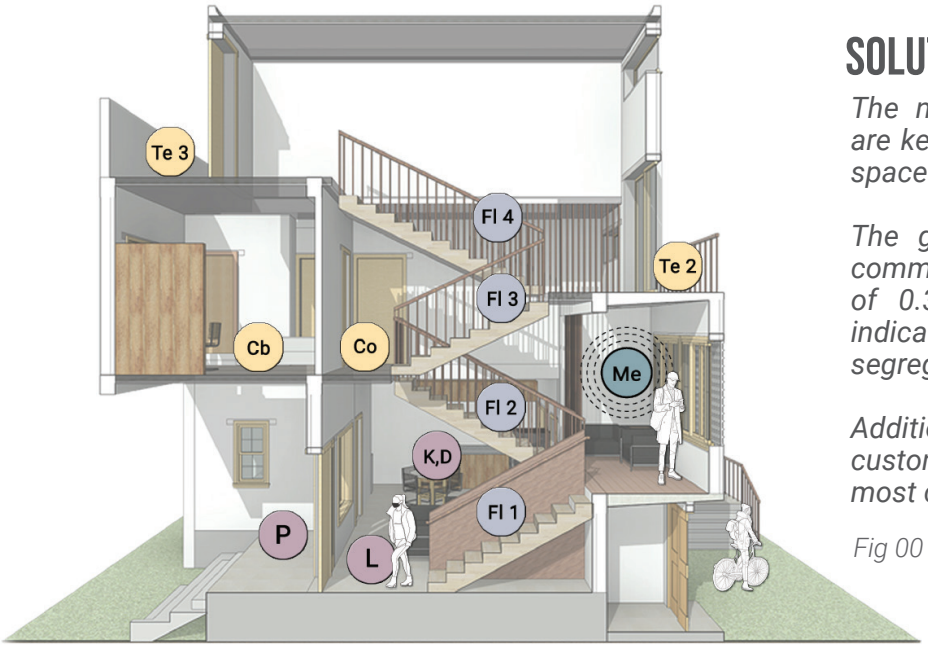


P - FRONT PORCH
L - LIVING
K,D - KITCHEN & DINING
G.B - GUEST BEDROOM
H.W - HANDWASH
TOI - TOILET
R.P - REAR PORCH
D - DECK
S - STORAGE
U - UTILITY
FL - FLIGHT
ME - MEZZANINE FLOOR
CO - CORRIDOR
C.B - CHILD'S BEDROOM
M.B - MASTER BEDROOM
TE - TERRACE

Fig 00 Space syntax

In an effort to address covid resilience, the space syntax method was used to identify the most connected spaces, in order to reduce the probability of transmission of communicable diseases. The method was formulated by Bill Hillier and Julienne Hanson to analyse spatial configurations of built spaces and settlements. Refer appendix for detailed formulae and calculations.

The justified graph (fig. xx) has one or more origin points or spaces that act as the root of all the other spaces in the layout. All the spaces in a layout are positioned according to the number of spaces one needs to pass through from that particular space to the root.



SOLUTIONS

The number of high contact surfaces are kept minimal in the most connected spaces through seamless transition.

The guest bedroom and an adjacent common toilet have an integration value of 0.39 and 0.47 respectively which indicates that these spaces are well segregated from the remaining spaces.

Additionally, the door knobs can be customized as low contact knobs in the most connected spaces.

Fig 00 Space syntax spaces in section

$\bar{d}$	Mean depth of spaces from a particular space	
k	Total number of spaces in a graph.	
Integration value	Ranges from 0 (Maximum integration- no depth) to 1 (Maximum segregation maximum possible depth)	$\frac{2(\bar{d}-1)}{k-2}$

Integration value expresses the relative depth of a particular space from all other spaces in a justified graph (where a certain space is chosen as root and spaces in the graph are placed above according to how many spaces one must pass through to reach them)

12 PITCH TO PROJECT PARTNER

ORGANO ECO-HABITATS

The project partners Organo Eco-habitats Pvt Ltd have a unique vision about building an integrated ecosystem with sustainability principles at its core. The project aims to counter urbanization with a Rurban lifestyle that is in harmony with nature. The proposal is envisioned as a self-growing agrarian-based community of 104 millennial families with individual farm patches, and meets the following objectives:

OBJECTIVES

To give opportunity for more people to own a sustainable home through the affordable nature of the project.
To design homes as a shelter within nature, combining outdoor and indoor space while maintaining biodiversity.
Every dwelling unit to be designed in such a way that it connects to a personal farm patch of 10 sq.m.(minimum)
Common agricultural patch to cover at least 10% of the total site area.
To provide common amenities like cafe, goshala, organic produce, onsite waste handling, clubhouse, banquet, outdoor sports, wellness centre, rain water harvesting, water Supply and UG Drainage, STP, etc

TEAM ECACHE

Team eCache is a multidisciplinary team of 13 from fields of Sustainable Architecture, Landscape Architecture, Building Engineering & Management and Planning programs with accreditations like IGBC AP, CPHD & GRIHA CP. The team is organized into 3 working groups – Design, Metrics and Market based on the area of expertise of each member. Team eCache takes an integrated and data-driven design approach with an objective to design a net-zero-energy-waste row housing.

OPPORTUNITY:

The Satellite towns around ORR show a steady increase in land prices owing to potential development in the future. With an average workplace travel time of 20 to 25 minutes, areas near Mokila and Narsingi exhibit demand for residential villas, witnessing absorption rates above 80%, where the selling price ranges between 2-4 crores per unit.
Organo enjoys a monopoly over sustainable housing in Hyderabad. Because of their unique offering of rurban lifestyle evidenced by the prior success of Organo Naandi, the developer can fetch a premium for selling price with 100% absorption of dwellings before project completion for a specific target group.

Among the source to revenue generation proposed by the team while considering all the possible alternatives to generate revenue, the most feasible options were selected based on analysis of occupancy, events and the modes of generating revenues with current and practical scenarios. In total from various sources of the revenue, a monthly revenue of ₹ 6,70,500 can be generated which is after the deduction of maintenance cost of all the proposed amenities. In addition, it leads to a reduction of ₹ 6,447 (6,70,000/104) from the monthly maintenance cost payable by the dwellers. This income generated can also be used to reduce the cost of maintenance or to increase the amenities or for special needs as per the decision of the housing community.

12 PITCH TO PROJECT PARTNER

Sustainability at Site-level:
Sustainability is achieved right from the preliminary conceptual design stage in the planning of orientation of clusters to minimize incidence of solar radiation and for optimum ventilation. Site level sustainability is also achieved in aspects of harvesting of rainwater, solar power, and landscaping by means of site zoning and site planning.

Sustainability at Building-level:
The reduction in energy consumption is achieved by incorporating passive strategies from an early design stage. Massing options that enhance self shading and aid in channeling the wind around the building envelope have been incorporated. Further, passive features like perforated screens inspired from traditional architecture of Hyderabad are integrated in the design. Elements like stairwell are employed to increase the stack inside dwelling units for ventilation as well as shade a portion of the roof. Knowing factors like age, income group and lifestyle of the specific user group early on also helped in making much of the design decisions.

Sustainability Strategies:
Material choosing criteria - eco-sensitivity for low embodied energy
Reduce surfaces directly exposed to solar radiation through form optimization
Design dwelling units both to enhance natural ventilation and be compact.
Onsite Renewable Energy of 3,12,000kWh/year (approx.) would be generated through PV panels to offset consumption and achieve Net zero Energy.
Integrate rain water harvesting strategies on a site level.
Modularise overall design for scalability on a site and cluster level.
People-centric design:
Furthermore, below strategies are adopted to offer people-centric design
Option to customize for old, visually and mobility impaired.
Interventions for low-contact spaces in spaces that are most connected spaces
Raincatchers canopy to double as informal interaction and gathering spaces
Provision of co-working space, open-air theaters and cafe for the residents
EcoPod

Ecopod is designed to be a self-sustaining community through its reduced dependence on public infrastructure for amenities such as water, energy, and waste management.
Food security is addressed through productive landscape and cultivation of edible crops on site.
Water harvesting and flood management are addressed through site-level interventions such as rooftop panels, rainwater harvesting systems, reed-bed filtration, and on-site waste management, that result in net-zero energy, water, and waste.
Low cost passive strategies that are very impactful for energy performance and comfort have been incorporated from the early design phase (natural ventilation through cross and buoyancy-driven ventilation and enhances user adaptability to control ventilation and daylight.
After several stages of evolution, the proposed dwelling unit is compact and self-shading, thereby reducing excess heat gain through the building envelope.

23.57 kWh/sq.m/year	6886 hours / year	<50%	2.34 GJ/sq.m	5 years	295 litres/sq.m	10% of total site area	55,000 INR/sq.m
EPI	**Comfort hours (Natural ventilation)**	**Cooling loads**	**Embodied Energy**	**Carbon Positive**	**Onsite Rainwater Harvesting**	**Softscape**	**Budget**

13 REFERENCES

GRIHA Council/TERI (2016) 'GRIHA Version 2015'. Available at: http://grihaindia.org/

#1 Real Estate Directory Portal, News, Advisor in Hyderabad (no date). Available at: https://propertyadviser.in/ (Accessed: 12 April 2021).

Bob, B. S. A. M. (2012) 'Municipal Administration and Urban Development Department–Andhra Pradesh Building Rules, 2012', pp. 1–373.

IGBC - Smart Cities & Green Building Concept in India (no date). Available at: https://igbc.in/igbc/ (Accessed: 12 April 2021).

International Finance Corporation (2017) 'India Construction Materials Database of Embodied Energy and Global Environmental Indicators for Materials Warming Potential Methodology & Results Version 1.0 METHODOLOGY REPORT', pp. 1–100.

Kumar, S. et al. (2018) 'Projecting National Energy Saving Estimate from the Adoption of Adaptive Thermal Comfort Standards in 2030', (September). Available at: http://www.aeee.in/.

NBC (2016) 'National Building Code 2016, clause 6.2, Part 8 Building Services, Section 3, Air Conditioning, Heating and Mechanical Ventilation, page 19 of Volume 2', National Building Code of India, 2, p. 97.

Bureau of Energy Efficiency (2017) 'Energy Conservation Building Code, 2017: Design Guide'.

Real Estate | Property in India | Buy/Sale/Rent Properties | MagicBricks (no date). Available at: https://www.magicbricks.com/ (Accessed: 12 April 2021).

Schemes | Ministry of New and Renewable Energy, Government of India (no date). Available at: https://mnre.gov.in/solar/schemes (Accessed: 12 April 2021).

de Klein, J. J., & van der Werf, A. K. (2014). Balancing carbon sequestration and GHG emissions in a constructed wetland. Ecological engineering, 66, 36-42.

Gu, C., Crane, J., Hornberger, G., & Carrico, A. (2015). The effects of household management practices on the global warming potential of urban lawns. Journal of environmental management, 151, 233-242.

McPherson, EG.; Simpson, JR. (1999). Carbon dioxide reduction through urban forestry: Guidelines for professional and volunteer tree planters. Gen. Tech. Rep. PSWGTR-171. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.