MANUAL OF PRACTICE

THE INFORMAL HOUSING THERMAL COMFORT PROJECT

MARCH 2023

CBALANCE
carbon • cost • community • climate

ACKNOWLEDGEMENTS

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I. ABOUT THE PROJECT

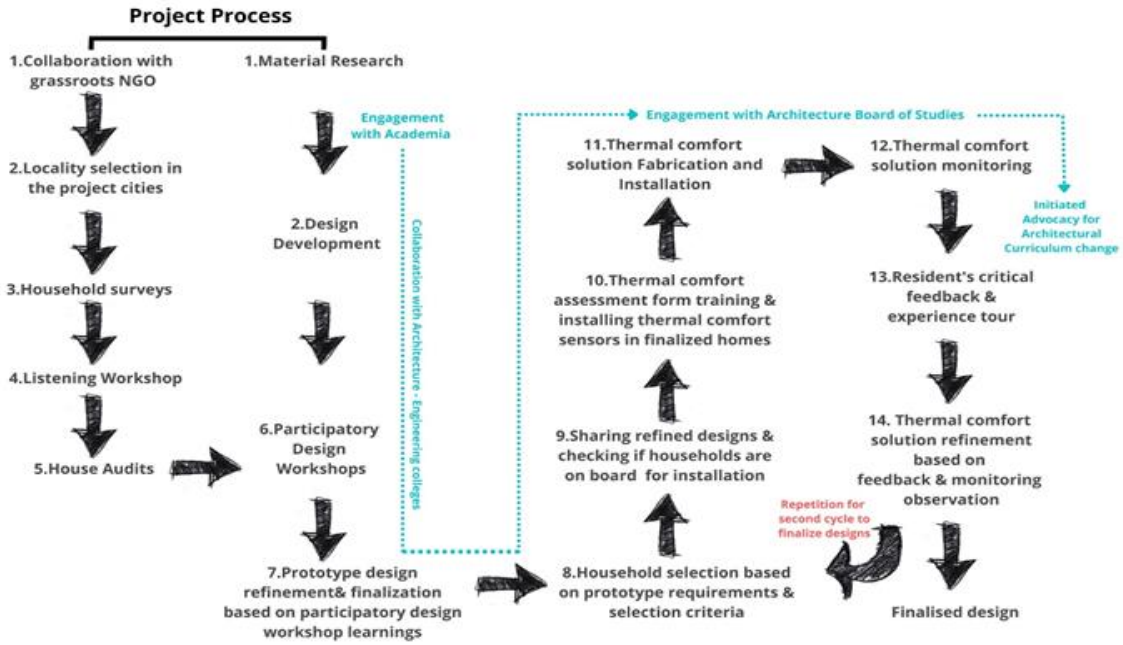
The Informal Housing Thermal Comfort Project (Pilot) is a multidisciplinary and multi-stakeholder experimental project aimed at co-creating thermal comfort solutions with informal housing communities with support from (formal and informal) built space professionals and academia.

The intervention was implemented in two cycles– the prototype design cycle and the design finalization cycle. The stakeholders that were a part of this multi-disciplinary project include NGO partners, community members, designers, architects, engineers, fabrication and installation persons, academicians and the board of studies of Architectural colleges.

The first cycle of the project comprised of listening, participatory design, critical feedback workshops, thermal comfort assessment form filling training and resident experience tours amidst other community engagement endeavours. The focus of the prototype design cycle was to contextualize the thermal comfort solutions 'with' community members and to test the effectiveness of materials and mechanisms from a list of shortlisted solutions such as Ecoboard, Alufoil, etc. At this stage, solutions were installed in a few houses in two cities (Pune and Bangalore) respectively in homes of residents who agreed to work on experimenting with the co-created solutions which were monitored for a month. They were then revisited for the second iteration of designs. Students from architecture and engineering colleges contributed to the first cycle under as part of their internship program.

During the design finalization cycle, the aim was to refine the design of instillations that needed enhancements and install them in a few more houses respectively, in addition to reinstalling certain installations that needed refinement in the initial houses. There were houses that dropped off from the experiment and new houses that joined midway. The second cycle involved a few community engagement endeavours similar to the first stage which included a meeting to share refined designs and the list of selected households, thermal comfort assessment form filling training, critical feedback workshops and experience tours to harness resident feedback to support the process of finalizing the designs. Additionally, engagement with Architecture Board of Studies members to advocate for curriculum change to incorporate informal housing and sustainable architecture perspectives in university curriculum was also initiated during this cycle.

The flow chart provides an overview of the process flow of each cycle.



Considering the installations were already carried out in cities of Pune and Bangalore as pilot phase of our endeavour working towards the issue of Heat stress in Informal settlements, there were already a set of learning on functioning of materials, collaboration with local organizations, material research, etc. Considering this as a base certain steps in the above flow chart were skipped for our work in Mumbai and Delhi, such as Household surveys (which were prior identified and partly combined with house audits), first design cycle (installation happened directly over 9 selected houses), Thermal comfort solution refinement and Engagement with Academia.

II. ABOUT THE MANUAL

This manual shares the 'How' of the work undertaken as part of the 'Informal Housing Thermal Comfort' project in four cities till now starting with Shindevasti in Pune and Jyothipura in Bangalore; followed by Rahulnagar, Lalmitti in Mumbai and Bhalswa landfill area in Delhi.

It therefore focuses on 'Approaches to co-create and implement experimental Informal Housing Thermal Comfort retrofits' and comprises of 2 broad sub sections - Community Engagement Process and Technical Process.

The Community Engagement section is divided into three major parts: 1. Initial Engagement and Co-creation 2. Community Engagement after Design Refinement and 3. Post Installation Engagement.

The Technical Process section is also divided into three major parts: 1. General Design Process 2. Stage Wise Understanding and 3. Solution Specific Information.

These sections share the rationale and approach to the various steps that were undertaken to facilitate the project in collaboration with diverse stakeholders. They comprise of questionnaires, checklists, workshop designs and other elements, as applicable. These components are placed in boxes in the manual.

It is advisable to note that the 'approaches' shared in this manual are not hardbound and can and must be tweaked to suit different contexts. For instance, there have been instances where different approaches have been undertaken in different cities and tweaks were made instantaneously on the site to respond to the need of the hour. A community engagement approach that works in one community, therefore might not necessarily work in another.

Similarly, it is also vital to understand that while some of the thermal comfort interventions mentioned in this manual might work in certain contexts, they might not necessarily work in others. The weather conditions, spatial characteristics of a region and the receptiveness of a homeowner to a given solution are few crucial factors among a host of other factors that culminate to ensure that an intervention truly serves peoples thermal comfort needs.

The dynamic nature of 'experimental' and 'community centric' interventions is a key characteristic that warrants attention.

Therefore, the intention is also to keep revising the content of this manual, as new learnings emerge on this journey of ensuring thermally comfortable living conditions by working 'with' inhabitants of marginalized urban settlements.

III. APPROACHES TO CO-CREATE AND IMPLEMENT EXPERIMENTAL INFORMAL HOUSING THERMAL COMFORT RETROFITS.

A. COMMUNITY ENGAGEMENT PROCESS

The community engagement process was initiated by identifying and collaborating with grassroots NGO partners in Mumbai and Delhi. Collaboration was followed by identifying a project locality in each city. This was followed by rapport building endeavours with community members through household surveys, followed by 'workshops' to 'listen to' and 'co-create' thermal comfort retrofit designs with the community. 'House audits' were conducted and preceded 'community meetings' to share refined designs with the households that had been modified based on their inputs during the participatory design workshop, proceeded the community workshops. The 'meetings' were also a space to share the criteria for household selection along with the list of households who were selected during the first and second cycle of the project, respectively. Consent was sought to proceed with installations and partner households were trained on filling thermal comfort assessment forms and thermal sensors were installed in their homes. This was followed by fabrication and installation of the thermal comfort retrofits. Critical feedback workshops and household visits were facilitated to harvest resident's feedback post installations, to learn about any refinements that could support enhancing the installations to support with finalizing the designs.

Engagement with residents is still continuing to ensure that the thermal comfort endeavours spirit of working 'with' the community is alive and endures with time. Following are a few community engagement guidelines that are applicable across all community interactions

COMMUNITY ENGAGEMENT GUIDELINES

1. Objectives of the project should be the primary guideline for engagement.
2. The interests of the community should be top most priority.
3. Strictly define areas of intervention and non-intervention
4. Do not give assurance of anything outside the scope of the project.
5. Consent and transparency:
    a. Seek consent before speaking, documenting discussions (in any form), etc. with community
    b. members.
    c. Be transparent about how/where information that will be documented as part of various
    d. interactions will be shared.
    e. Be clear about our reasons for wanting to work with the community, what you are hoping to
    f. offer and your approach at working towards it.
    g. Let the community know that you want to work 'with' and 'not for' them.
6. Empathetic interaction: Speak and interact with the community, the way you'd like people to speak and interact with you. Place yourself in the shoes/slippers/sandals of the people you interact with. Be respectful, honest and kind.
7. Stay grounded: Sit with the community, eat what they offer you (if you cannot- decline politely), preferably wear garments that resonate with the community.
8. Build a rapport with the community: Recognize that you are engaging with the community to build a relationship with them and work together. You are not there as just data collectors! Besides, good rapport can support meaningful and authentic conversations.

9. Build a rapport with the community: Recognize that you are engaging with the community to build a relationship with them and work together. You are not there as just data collectors! Besides, good rapport can support meaningful and authentic conversations.

10. Have a community led discussion : In all interactions create a space where community members recognize themselves as knowing more than you do (which they obviously do!) about their situation. Besides intermittent prompts, let the community lead conversations. Use symbols, illustrations and other means of communication to facilitate discussion with members who might not be literate. Convey that no one else is better suited to discuss their situation and decide what they need and do not need. (As a facilitator: Listen more, speak less)

11. Have a community led discussion: In all interactions create a space where community members recognize themselves as knowing more than you do (which they obviously do!) about their situation. Besides intermittent prompts, let the community lead conversations. Use symbols, illustrations and other means of communication to facilitate discussion with members who might not be literate. Convey that no one else is better suited to discuss their situation and decide what they need and do not need. (As a conversation/discussion facilitator: Listen more, speak less)

12. Non- intrusive documentation: Non-intrusive documentation is essential to avoid disrupting authentic conversations. (options - taking notes, audio recordings etc, with community consent)

13. Respect: Respect community member's boundaries (time, privacy, topics they express discomfort with, etc.), opinions, and culture.

14. Patience: Sessions might be delayed, community members might have quite a few questions for you, community members might express scepticism, etc. Be patient with them and yourselves as you embark on the journey of knowing each other.

15. Create an empathetic and safe listening space: Pay attention to non-verbal cues by community members that hint at discomfort, etc. and address the situation accordingly. Create a space where community members feel comfortable discussing themselves and their lives/people in their lives. A space where there is no feeling of privacy invasion or being forced to speak. A space where anyone feels free to walk away from the space if they want to without feeling obliged to sit, speak, and interact with you.

16. Humility: Acknowledge your privileges and viewpoints that emerge from your position. Recognize that as an outsider, you know a fragment about community members and their journeys. Be humble enough to recognize the things you might not know/understand and seek clarity from the community about the same.

17. Be willing to unlearn: Let go of the socio-cultural, academic, experiential baggage you come with, when you engage with the community. Every person /community has different stories to tell, that need to be acknowledged and not subjected to our baggage's. As far as possible, prevent your baggage from influencing your engagement.

18. Speak from personal experience/ I: Encourage participants and yourselves to take responsibility for your experiences. Eg. Replace 'he/she did'.... with 'I felt --- when--- happened', etc

The following sections provide information on the rationale and approach to different community engagement steps.

1. INITIAL ENGAGEMENT AND CO-CREATION

1.PARTNERING WITH GRASSROOTS NON-GOVERNMENTAL ORGANISATIONS (NGO)

RATIONALE:

To collaborate with grassroots NGOs partners to help facilitate rapport building with local communities in project locations

APPROACH:

1) Identify NGOs working in your project city through existing networks or online research
2) Narrow down on NGOs based on the work they are engaged in (preferably those engaged in the realm of informal housing upgrades)
3) Explore the NGOs values and approach of interacting with the community and their relationship with the community to check if it resonates with your projects engagement approach (eg. Do they consider the community as partners, do they respect and harness the communities' knowledge? Do they have authentic relationships of trust with the community? Or do they impose solutions and disregard the communities' knowledge and experience?)
4) Reach out to NGOs that align the most with your projects values and approach
5) Share details about the 'Why', 'How' and 'What' of your project and inquire if they would be interested in exploring ways to work with you.
6) If the NGO expresses interest in engaging with your organisation, set up a meeting and 'listen' to the NGOs 'Why', 'How' and 'What' of working with the stakeholders they engage with.
7) Explore ways to engage meaningfully with the community, through meaningful and respectful exchange of ideas with the partner NGO
8) If the NGOs work and approach to working resonates with the overall approach of the project, proceed to:
    1. Discuss the project duration
    2. Share and agree upon specific areas of the project where the NGO partners support will be needed
    3. Share and agree upon the roles and responsibilities of the NGO partner and the project team
    4. Share and agree upon the effort hour contribution that is feasible based on the project funding capacity
9) Draft a 'partnership agreement' with the above-mentioned and other relevant information.
10) Share a signed copy of the partnership agreement with the NGO partner for their signature.

    Selected places where the NGO partner supported with community engagement are mentioned in the respective steps.

2.LOCALITY SELECTION

RATIONALE:

To identify a locality that aligns with the projects needs

APPROACH:

1. Make a list of locality selection criteria, which could include:
    a. A tenure protected informal settlement
    b. Has members engaging in home-based work
    c. Locality is particularly vulnerable to heat stress/adjacent to heat-generating industries/ factories/ any economic activity
    d. Locality will not be affected by large scale infrastructure projects in the future

e. Community Space: Potential areas of thermal comfort intervention could be a space utilised by the community for various purposes (for eg. Balwadi centre). Such a space could also be useful in engaging with the community members collectively, for the purpose of workshops or training sessions, for example.
f. Households in the community are primarily built with heat trapping materials
g. NGO partner have a presence in the community
h. Locality has some history of participation either with NGO partner or the community is proactive in solving its own problems
i. Desirable: Locality is close to the organisation's office/primary field members' home

2. Draft a questionnaire based on locality selection criteria.

The following questionnaire can be used as a basis for locality selection :

Questionnaire - Locality Selection

Field Visit no:

Date of visit:

Location (City):

Settlement name:

GPS Coordinates(Optional):

NGO representative details (Name, contact no):

CB team member name:

---

*Note for field team:

Kindly click photographs of:

1. House structures
2. Location geography (open spaces, green cover, waterbodies, etc.) - [*in case this is not possible, we can navigate for the same on google earth, based on GPS coordinates.]*
3. Other notable aspects, based on your judgement.

Place your photographs based on the template in the following folder: ---(add folder location details)

Kindly upload interview responses to the following file ---(add file details)

Questions:

Social Attributes (Questions for NGO partner):

1. What is the duration of the NGO partner's relationship with the community?
2. How many households does the settlement comprise of?
3. What is the population of the settlement?
4. Do the households belong to a particular caste, religion, work group or is it a mixed community?
5. What diverse occupations are community members engaged in?
6. Are there community members who are engaged in home-based work? (approx. how many households)
7. Does the community have a history of being proactive in solving their problems?
8. Is the settlement tenure protected? (can also check city development plan)
9. How is the relationship between the community and local politicians? (prompts: has there been a history of prolonged resistance, etc or are issues resolved collectively)

10. Are there any existing community groups/associations in the settlement? If yes, what issues do they work on and who is part of these groups?
11. Are there any infrastructure projects planned in this location in the future that might demand resettlement/rehabilitation?
12. Is heat stress an issue residents are concerned about? (based on NGO partners' judgement)
13. If yes, what are these claims based on?
14. Would you recommend that we engage with local politicians before initiating project work?
15. Miscellaneous details

Physical attributes (Can be noted during field visits/in conversation with NGO partner):

1. Distance of the settlement from Pune office/Bangalore field members home (in km)
2. Does the settlement design indicate a lack of daylight/ventilation? *(can substantiate this with photographs, if possible)*
3. Are there any notable factors indicating that the locality is vulnerable to heat stress? (eg. adjacent to heat-generating industries/ factories/ any economic activity)
4. What are the house structures in the settlement? (a healthy mix of house structures is preferable)
    a. Semi kuccha - tin roof and tin walls
    b. Semi pucca - Brick wall and Tin roof
    c. Pucca - Brick wall and Concrete slab
    d. Others (please specify)
5. Are houses in the community primarily built with heat trapping materials? (eg. asbestos roofs,etc.)
6. Are there any community spaces (eg. Balwadi centres, community hall, etc) that could serve as spaces for pilot prototype implementation/installation?
7. Miscellaneous details

3.LISTENING WORKSHOP

RATIONALE:

- To create a space for people inhabiting informal settlements to share their experiences on issues they face across different seasons during the year.
- To understand already existing heat battling mechanisms and practices followed by the communities.
- To listen to community's discomforts, concerns and suggestions
- To emphasize the projects approach of 'co-creation' and 'participatory' action to community members to facilitate a spirit of 'partnership' and 'collaboration'

APPROACH:

1. Run the design of your workshop by the NGO partner and tweak the design to suit the context, based on the NGO partners' suggestions.
2. Identify a place and time that is convenient to interact and facilitate listening workshops with the NGO partners support.
3. Invite community members to the workshop and check if the suggested day and time works for them.

Details of role, responsibilities and workshop design are mentioned below.

(Please note: While the description and information below encapsulates all elements that were planned for the workshop, elements were tweaked and/or eliminated based on the need of the hour)

A. Facilitation team roles and no. of members

(*Note: All team members to participate in the introduction and icebreaker session*)

1. Documentation persons (note taking, audio recording, photography): 2
2. Facilitators: 2-3
3. Community mobilization persons (NGO field team members): 1-2

B. Material:

Charts with symbols (1), sketch pen set (1), pencils, erasers, book for note taking, pen, audio recording device (phone), post-its, refreshments, garbage bags.

C. Setting & Participants:

Community space, rugs/mats or chairs that can be moved. (Community members and facilitators sitting on the floor in a circle. Elderly members, people with health conditions who are unable to sit on the floor sit at elevated positions and are part of the circle too.)

D. Workshop Flow (max. 2 hours):

1. Group introductions, ice-breaker and check-in (20 mins):

a. Community members and CB members state their name and share anything else they want to about themselves (eg. what is your favourite thing to do).
b. Ice breaker- Common ground/The sun shines on

(Format: Place chairs side by side in a circle with one less chair than number of people. Person in the centre says, "The sun shines on ...." filling in the blank with a statement that is true for them. All others in the circle for whom it is also true stand up and switch places (those for whom the statement does not apply stay seated) with the person making the statement trying to take someone's place. The person in the centre then repeats the statement filling in with some other 'truth'. It is best to start with simple visible statements. E.g. "...all those wearing white", "...having pockets", "... carrying keys", "...hair tied up". Can also include statements which have varied interpretation or not visible. E.g. "who's birthdays are between June and December", "who don't like chocolate".)

Or

Interacting in twos (switching after a couple of rounds)
{*sample prompts: What I ate for dinner, last night's dream, the place (or the view from the place) I spend most of my day, I can talk about} or could ask the group to come up with 2-3 questions they would like to ask each other*}

c. Check-in (How are you feeling right now?)

2. Introduction, consent and setting the tone (20 mins)

a) Introduce your organisation
b) State how you got to know about the community, your relationship with the partner NGO and community members who you may have met before (and will support in facilitating the session.)
c) Explain why you are here:
- Share your project story
- Purpose of the listening session:
  (Suggested script: *We have experience in the domain of thermal comfort, however, we want to understand your perspective and know if this is an issue you experience and would like to work towards resolving. We want to hear from you and understand your situation before we explore possibilities of collaborating to address thermal comfort and other related issues. You are the leaders and we will just facilitate this session. The purpose of this session therefore is for us to learn from you and understand your situation, since nobody knows your needs better than you.*)

d) Give the community space to ask us questions / suggestions they might have for the session- (A space to co-create principles for the session- eg. phones off, one person speaks at a time, etc)
e) Seek consent for documentation.
f) Create a safe space i.e. Ensure that community members feel safe, comfortable and own the space: Give them the option to speak in the group discussion, speak to anyone from our team after the discussion, share thoughts in any other form that is comfortable.

3. Problem Diagnosis: **Illustrating and listening (40 mins)**

a. Illustration

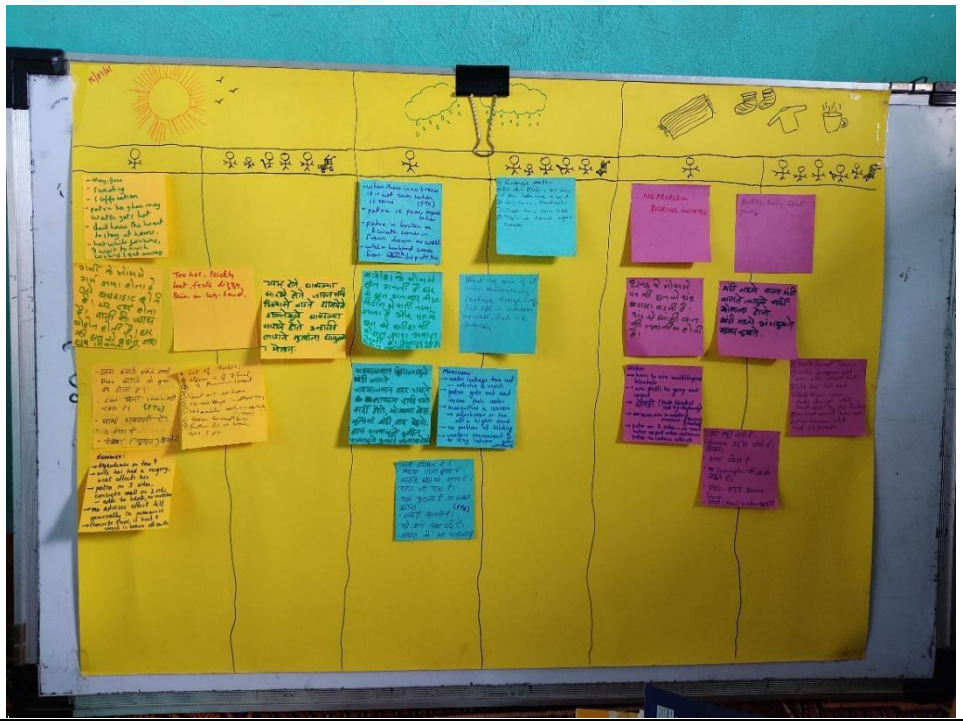
Suggested script: *As discussed before and if you are now ready to engage with discussing issues prevailing in your households and community, we would like to begin with an activity: We have three charts before us. Each of them represent different seasons of the year* ***(Summer, monsoon, winter****- we can have symbols drawn).*
[**The chart is divided into two parts to indicate - Individual issues (an image of a woman/man drawn on the chart to symbolize this) and community issues (symbols of men, children, elderly, physically disadvantaged, etc drawn to indicate this on the chart)]*

We would like to ask you to think about issues you face at an individual level, as men/women who are involved in household activities, caregiving, livelihood generating activities and possibly other activities, too and at the community level, [prompts: eg. in summer there might be issues of water shortage (you could draw a tap to indicate this if you cannot write), electricity cuts, difficulty sleeping, travelling long distances for work, leaky roofs in rainy season, flooding, illnesses in monsoon, lack of toilets, etc] and you can draw/write issues you notice at the community level [eg. unemployment, difficulty studying due to electricity cuts, lack of health facilities, heat strokes in summer, etc.] It is okay if the issues overlap across the seasons.
Format: Focus on one season at a time. Distribute post-it's across the room at the start of each season issue mapping exercise. Facilitators and other team members can support the community with writing and/or illustrating, as applicable.

b. Listening

Format and prompts for discussion:

- *Thank you for sharing these issues. Could some of you explain a few of them in detail.*



- *Which of the above mentioned issues have you'll addressed/are addressing as a community?*
- *Who are the people that are involved in addressing these issues?*
- *What are the challenges you/other members face as you go about addressing issues? and how do you overcome them? (e.g. Stakeholders who support them, hinder them, etc.)*
- *Are there any governance mechanisms in place?*

4. Exploring concerns and possibilities of collaboration (30 mins) :

a) Discuss probabilities of addressing thermal comfort related issues and other co-benefits through engaging with the community (eg. addressing roof related issues that might be interlinked with passive cooling retrofits, etc.)
b) Check with the community: *What has been your experience with previous such projects? What are your concerns? Even judgments? Hopes? What needs are important to you in the process?*
c) After hearing everyone: *how are you feeling about all this? What comes up for you?*
d) If the community considers thermal comfort or other related issues as issues they would like to work toward resolving ask them if they would like a day or two to reflect and give them an overview of future steps of the project (e.g. workshops, etc.)
e) Final Closing Around: what else do you want to share with the group? what are you leaving with?

4. PARTICIPATORY DESIGN WORKSHOP

RATIONALE:

- To harness information to facilitate the co-creation of context-specific thermal comfort solution designs with local communities.

APPROACH:

1. Run the design of your workshop by the NGO partner and tweak the design to suit the context, based on the NGO partners' suggestions.
2. Identify a place and time that is convenient to interact and facilitate the participatory design workshop with the NGO partner's support.
3. Invite community members to the workshop and check if the suggested day and time works for them.

Details of role, responsibilities and workshop design are mentioned below.

(Please note: While the description and information below encapsulates all elements that were planned for the workshop, elements were tweaked and/or eliminated based on the need of the hour)

A. Facilitation team roles and no. of members

a. Documentation persons (note taking, audio recording, photography): 2
b. Facilitators: 2
c. Team members well versed with designs – One per design
d. Community mobilization persons (NGO field team members): 1-2

B. Material for the session:

Physical design models, note taking book, pen, chart paper, sketch pens, phone audio recording device,

C. Setting & Participants:

Community space, rugs/mats or chairs that can be moved. (Community members and facilitators sitting on the floor in a circle. Elderly members, people with health conditions who are unable to sit on the floor sit at elevated positions and are part of the circle too.)

D. Workshop Flow

Option 1 (approx 2.5 hours)

1. **Introduction and check-in (10 mins)**
   ThermIC team and community members share their names and what they do (if there are new members present) and how they are feeling.
2. **Introduce the flow of the workshop and the Why of the workshop/project** (5 mins)
   a. Listening workshop recap, including community knowledge harnessed and any visuals of that. (any more ideas you want to share before we explore the prototypes?)
   b. Sharing prototype ideas with the community: *We will introduce a few options to address issues of thermal comfort, which might also address ----(water tightness, etc….) These are just suggestions and through this engagement we are hoping to refine these/ eliminate options you think might not work, so that we can develop a final model that can be integrated in your house. Please keep in mind, we are exploring solutions with you, this is an experiment,and we are inviting you to participate with us in order to co-create solutions that can be useful to you and many others to come.*
3. **Sharing prototypes and brainstorm with the community (1 hour 20 min) :-**

a.World Cafe style (1 hour 5 min) – separate 'stations' for each model and the participants divide themselves into groups. First send participants to the station for the model they will likely be getting. They will have extra time in this first station - 20 minutes. Then ask the participants to go to another station (not as a group, each household goes randomly to a new station) while the facilitator/host remains at their same station. They will have 10 minutes each in these stations. Can have a chart paper in each station to capture thoughts/feelings about the prototype.

(Here is a sample script you can use: "*Now we will explore 6 different models that we will are hoping to experiment with as potential roofing solutions to be installed in your homes. We first want to describe how each of these prototypes works and explore their properties. Then we want to hear input and ideas from you, including any modifications you may suggest. We have 5 stations set up around the hall, one for each prototype. Everyone will get time to visit all 5 stations. You can begin with the station for the model that we consider most suitable for installing in your home.*

We will have a host at each station. There is a model of the prototype at each station. The host will help describe each model, the properties of the materials involved, the costs and demonstrate the installation process on the small model. You can ask questions or share your experience and ideas as well. There will be a chart paper in each station, you can use this to capture any ideas or feelings about the prototype, including any suggested modifications. Feel free to draw as well. The chart paper will remain in each station, this way the next group can see what you captured.

We invite you to divide yourselves up and explore each station with your family member. You will have 20 minutes for the first station, and 10 minutes for each station after that. The host will stay in their station. Any questions?")

b. The host describes the model, highlighting properties, costs, pros and cons, installation process, etc. They also invite questions and discussion, especially drawing out if any participants have had experience with such a model. This can include a brainstorm of possible modifications (for example, replacing one material with a local material).

(Tentative points to consider sharing with the community while sharing prototypes:

- Name of the prototype
- Material
- Installation process
- Working mechanism (note: Use relatable examples to explain the working mechanism of the model eg. to explain alufoil, you can explain how it works as a cap creating a barrier between the sun and the person inside the house.)
- Lifespan
- Weight of the installation
- Benefits and limitations- ventilation, noise, day/night benefits etc
- Estimated heat stress reduction
- Degree of alteration (how will the intervention impact the house structure?)

(Reminders: Leave space for questions to encourage community participation, keep a track of the time)

At the end of the 5 rounds, give them 5-10 minutes back in their first station again for a final review.

4. Brainstorm for Future Experimentation (in whole group, 15 minutes)

"We really would like these solutions to be a co-creation. You all are experts in your homes, your needs, and resources available. We would like to start by having a brainstorm of new ideas, this could involve modifying one of the existing prototypes or a new idea altogether. For this brainstorm, all our ideas are welcome, we will not be criticizing them. We encourage you to be creative. This is all part of an exploration and experimentation, to discover what is possible. These ideas may be used as part of future prototype design." Any new ideas, suggestions?

5. Discussion: Project team architects and community (20 mins)

Architects and the community discuss any questions or concerns about the prototypes or the new suggestions.

6. Way Forward (10 mins)

Explain the next steps and approx. dates for next engagement with the community.

7. Wrapping up (5 mins):

a. *Any final questions?*
b. *A couple of words of what you are leaving with*...

Option 2 (approx 2.5 hours)

*Note- Kindly refer to content from option 1 for description/tentative narratives of specific parts.

1. Introduction and explaining workshop flow : 20 mins

- Introduction and check-in (5 mins)
- Revisiting listening workshop to draw a connection with the participatory design workshop (5 mins)
- Explaining the purpose and flow of the participatory design workshop (10 mins)

*****Seek consent to click photographs, take notes, record videos...

2. Explaining models and brainstorming (15 mins per model) - 1 hour 10 mins

(Based on the space available you can choose to bring one model in the room at a time. If you have two rooms, you can ask residents to move from one room to the other, etc. Use any approach that seems suitable to the context)

- Design team member shares basic details of the working model
- Residents are asked what they think about the model

(Pause to let residents think and share what they feel about the model (go around the room and give residents space to pass their turn to speak to another resident if they need some more time to think. Come back to them later)

- Pose prompts to trigger discussion
- Make space for residents to share their concerns and note them down
- Make space for residents to share how they'd resolve certain issues they observe with the models?
- Ask residents to provide other suggestions etc. for the model

Participatory Design workshop, Pune

3. Give residents time to experience the models in a room alone - 7-10 mins

4. Final thoughts on the models (Questions, concerns, suggestions) - 10 mins

5. Way Forward - 10 mins

2. COMMUNITY ENGAGEMENT AFTER DESIGN REFINEMENT

1. HOUSEHOLD SELECTION DECISION SHARING

RATIONALE:

- To share refined prototype ideas with community members
- Share reasons/criteria for prioritizing certain households as experiment partners
- Share residents' responsibilities (eg. thermal comfort assessment, etc), next steps of the project

APPROACH:

1. Work on household selection criteria.

The selection criteria for this project comprised of:

- Structural feasibility of a household for a particular design
- Houses with poor conditions

- Age of the structure (old houses were preferable)
- Residents preference
- Residents with a unique prototype preference
- Other social characteristic based criteria (wherever applicable)

2. Identify a place and time that is convenient to interact and facilitate the meeting with community members with the NGO partners support.
3. Invite community members to the meeting and check if the suggested day and time works for them.

Details of role, responsibilities and meeting design are mentioned below.

(Please note: While the description and information below encapsulates all elements that were planned for the meeting, elements were tweaked and/or eliminated based on the need of the hour)

b) Facilitation team roles and no. of members

- Documentation persons (note taking, audio recording, photography): 2
- Facilitators: 2
- A design team member: 1
- Community mobilization persons (NGO field team members): 1-2

c) Material for the session:

- Images/videos of final prototype design
- Be prepared with information about selection criteria, next steps and approx days/dates for next engagements.
- List of households who have been shortlisted as experiment partners

d) Meeting flow

Note* The meeting outline for the first and second cycle were similar. However, information conveyed to residents varied in relation to the no. of houses that were selected etc. were based on the cycle requirements. The information below reflects details that were shared during the first cycle.

Option 1: Timespan (45 mins)

- Welcome and make space to share any feelings/thoughts etc. since our last interaction (5 mins)
- Share purpose of this meeting (2 mins)
- Share selection criteria (10 mins)
- Share refined designs we have worked on based on the community's suggestions - show prototype images/videos and explain modifications (10 mins)
- Discuss questions, concerns, etc. (10 mins)

OR

- Explain one prototype at a time and take questions/concerns etc related to that prototype immediately. (20 mins)
- Are you okay with these suggestions and ready to embark on this experimental journey with us? Or would you like some time to think about this and consult your family members and get back to us in a day?

[Note : Make clear that if it doesn't work for them, you will remove the structure and we will share a form on the day of the thermal comfort assessment to formalize the partnership that will mention your teams responsibilities towards the community and also mention the support you will need from them before and after installation]

- Share next steps, expectations from participants and discussion

Suggested text: *If you agree, we will also give you a document saying that you are willing to partner with us which will mention the support we need from you and our responsibilities, both. Someone from our team will sign this and we'll need one of your family members to sign this as well. We'll share this in detail during our meeting on ------ (day of thermal comfort assessment meeting)*

Post-meeting: after a selected period of time, go to the 5 households individually and check if they agree. If anyone drops out, then households on the waitlist will be informed and invited to join.

Visit households who are not shortlisted at the moment and update them on the status of the engagement progress. Household visit interaction format is shared at the end of this section.

Option 2:

Same as option 1 but combine 2-3 prototype groups together. Households who have prototypes with similar working mechanisms and completely different working mechanisms could be clubbed in the same groups, respectively (eg. Group 1: Ecoboard, Alufoil, Group 2: Dormer window, wool panel, Group 3: rooftop gardening, PET bottles). (Suggestion: Can invite waitlisted households to the meeting as well and households who are not selected can be informed individually)

Option 3:

Large group meeting:

Approach is to bring all households together (selected and shortlisted) so they hear about their status from us, all at once, rather than from others where conflict may brew for some time before we can address it. The suggested text for subsections are same as option 1.

- Welcome and appreciating everyone for joining in this *experiment* (5 min)
- Describe modified prototypes based on suggestions (10 min)
- Explain household selection criteria (10 min)
- Read off households: (5 min)

First phase, second phase, then 'waitlist' pending if anyone drops out

- Take any concerns or comments about process or about prototypes (20 min)
- Next steps - give people time to think about it before agreeing or not (for example 2 days).

Make it clear that if it doesn't work for them, you will remove the structure (5 min)

---

e) Household visit interaction format:

Suggested text for explanation: How *have you been? Thank you for your suggestions during the workshops, they were very helpful and our team has been working on them. As discussed during our workshops we have the capacity to work only with 15 households, as part of our experiment. For now, we have selected few households. We selected the households based on a few criteria:*

- Structural feasibility
- Prioritize houses with poor conditions
- Age of the structure (old houses are preferable)
- Top three priorities of residents
- Whoever has a unique prototype preference

We will work on installing prototypes in these 5 households for now and hope to monitor them for 2-3 months, initially. This will help us understand if we need to make any more modifications before proceeding with installations in the next 10 households. If we find that a particular prototype is inappropriate, we will eliminate it from the next set of installations and replace it with another option. We will organise visits to these households as well and will invite you for the same when these happen. On this day we'll also give you

the opportunity to share your preference list again.

Learnings from the homeowner's experience, our observations and your feedback as well will help us understand if we need to modify/eliminate any prototypes. This entire process will take approximately 2 months from now.

We will get back to you after two months to inform you if you have or have not been shortlisted for the next phase. We have a workshop and also a small training session then. Do you have any questions? concerns?

3. PARTNERSHIP AGREEMENT

RATIONALE:

- To seek residents consent to participate in the experimental installation in writing
- To seek residents' cooperation towards supporting with monitoring work post-installation
- To assure the residents of the project teams responsibility towards attending to any issues that might arise due to the installation

APPROACH:

1. Draft a consent form
2. Translate the form in the local language.
3. Identify a day and time to meet residents and share consent form details with residents with support from the NGO partner
4. Read the form/ask residents to read the form
5. Check if the content of the form is agreeable to residents
6. Fill the form details/Ask residents to fill the form details
7. Project team and resident to sign the form
8. One copy to be kept with the project team and the other to be kept with the resident

The template of the 'Partnership Agreement Form' is shared below.

Informal Housing Thermal Comfort Project

Partnership Agreement – Community Resident and cBalance

I …… and my family, residents of ……., volunteer to be part of the 'Informal Housing Thermal Comfort Project' experiment and agree to have the thermal comfort solution ……installed as part of our house structure.

We agree to keep the installation as part of our house structure for a period of 12 months to support the monitoring process. (From ……to…….).

We also agree to have the thermal comfort sensors installed in our house for monitoring purposes during the months of March, April and May 2022, and 15 days in the Month of October 2021 and October 2022, respectively. We will notify the Project team incase any issues arise due to the sensor and will leave it untouched unless necessary. We will also support filling the thermal comfort assessment form during this period.

I am aware that this is an experiment. Therefore, in case there are any unforeseen damages/dangers that might emerge during the monitoring period we will request the cBalance team to remove the installed solution. After residents contact the cBalance team incase of any critical issue, cBalance will remove the solution within 2-5 days after evaluating the situation with the residents.

Since this is an experiment, the cBalance team will bear all costs associated with installation, maintenance, monitoring and removal of the thermal comfort solution for a period of 12 months from ……to……

The cBalance team ensures that all information available in relation to …… (solution name) has been shared with the household.

The cBalance team will reimburse any costs that might emerge due to damages caused by the prototype installation for a period of 12 months, since the date of installation. However, cBalance will not reimburse damages caused due to factors beyond control for eg. Natural calamities, fires, etc.

At the end of 12 months since the date of installation, if the residents express a desire to remove the solution cBalance team would get it removed.

Post 12 months since the date of installation, if residents express interest in retaining the solution, the cBalance team will not support any maintenance and would not be responsible for removal of the installed solution.

Signatories:

Home Owner Name: ……..

Sign/Thumb Impression of Home Owner & Date:……

Tenant name (if applicable) :……..

Sign/Thumb Impression of Tenant & Date:……

cBalance team member name :……

Sign/Thumb impression of cBalance team member & Date: ……..

In consultation with:

NGO partner name: ……

Name:……..

Sign/Thumb impression & Date:……

4. THERMAL COMFORT ASSESSMENT FORM TRAINING

RATIONALE:

To train residents to document subjective thermal comfort data based on lived experience before and after installation to assess the effectiveness of a given installation.

APPROACH:

1. Identify a place and time that is convenient to interact and facilitate the meeting with community members with the NGO partners support.
2. Invite community members to the meeting and check if the suggested day and time works for them.

Details training method and the assessment form template are mentioned below.

A. Training Team Roles:

- A team member to explain the form filling process
- Team members to support residents to fill the demo form

B. Material:

- Form Booklets translated in the local language
- Pens

C. Training Approach:

- Explain the purpose of the form to residents
- Go through the form guidelines with residents
- Explain the purpose of each question in the form
- Give space to residents to clarify any doubts after each question
- Fill information under the 'General Information' section of the form booklet after explaining the booklets contents
- Ask residents to fill a demonstration form which will be the first form on the booklet, which will support with assessing their understanding of the form and also serve as a reference when they proceed to fill the forms at their houses
- At the end of the meeting inform residents that your team will be available in case they have any doubts while filling the forms later.

Assessment Form Content

a. Guidelines to fill the form-

- It is suggested that the score card be filled by all family members.
- Elders of the family can help kids to fill out forms.
- Keep the form preferably at the convenient position of the house.(So that you don't skip scoring).
- The form has to be filled 3 times a day for a period of 15-days.
- In the period of 15 days, 7-8 days have to be filled before the installation and 7 days after the installation of the prototype.
- Add exact time range below the time period.
- It is recommended to score all the indoor comfort levels by sitting /standing at the center of the house.
- It is recommended to score all the outdoor comfort levels by sitting /standing open space (Not under a tree or any shade). (you don't have to go very far from the house)
- There are 3 clothing types to choose from:
  - Light clothing = single layered clothing preferably cotton/ sleeveless/ half-length sleeves shirts, half-length pants, nightwear gown.
  - Medium clothing = Half-length/Full length sleeve Shirts, Full pants/trouser, sarees, dress,
  - Heavy clothing = Woollen sweaters, Jackets

- There are 3 activity levels to choose from:
  - Light Activity = Sitting, standing, reclining seat, sleeping.
  - Medium activity = Walking
  - Heavy activity = strenuous work like cleaning, washing, cooking, exercise, running.

- If you are not at home at any time you can skip the cell.
- Few questions have to be score from 1 to 5, where-
  - 1 is for Unbearable
  - 2 is for Low comfort
  - 3 is for Bearable
  - 4 is for Comfortable
  - 5 is for Pleasant

---

b. General Information:

- Prototype Installed:
- House no.:
- Name of the representative household member:

---

c. Form Template

Day 1
Date:

Name of the family member			
Time-Range	Breakfast	Lunch	Dinner
Exact time of reading			
	Note: Kindly check the guidelines above for Light/Medium/Heavy		
What is the level of activity before filling the form?	☐ Light ☐ Medium ☐ Heavy	☐ Light ☐ Medium ☐ Heavy	☐ Light ☐ Medium ☐ Heavy
What cloth are you wearing while scoring?	☐ Light ☐ Medium ☐ Heavy	☐ Light ☐ Medium ☐ Heavy	☐ Light ☐ Medium ☐ Heavy
Is the fan switched on or off?	☐ On ☐ Off	☐ On ☐ Off	☐ On ☐ Off
	Note: 1 is for Unbearable, 2 is for Low comfort, 3 is for Bearable,4 is for Comfortable, 5 is for Pleasant		
Rate the thermal comfort - Inside	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Rate the thermal comfort - Outside	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

3. POST INSTALLATION ENGAGEMENT

1. EXPERIENCE TOUR

RATIONALE:

- To learn about community's general acceptance of the installed solutions and their willingness to invest in them.
- To understand community member's inclination to have the prototypes that have been piloted in a few homes in their vicinity, installed in their homes
- To understand the possibility of the community owning and facilitating the retrofitting solutions through local women cooperatives.
- To learn of any improvements that need to be made to the installation to suit the community's need and context, better.

The aim of understanding the above mentioned aspects was gather insights on augmenting informal housing thermal comfort efforts in more informal settlements in the future, with support from women's cooperatives across different cities in India

APPROACH:

1. Share the tour plan with the NGO partner for refinements
2. Fix a date and time for the tour with support from the NGO partner
3. Check if the date and time works for community members

Details of roles, responsibilities and tour design are mentioned below.

B. Roles and Responsibilities:

a. Tour Guide - To lead community members to different houses during the tour and click photographs during the tour.
b. Coordinator
   - To give an introduction to the tour
   - To coordinate between groups to ensure the smooth flow of the tour and also click photographs.
   - To also be available for any intermittent support needed during the tour /open house period (eg. to be at a given house when other team members need bio breaks, etc)
c. Information sharing and data gathering person - To stay stationed at a given house and share information about a given prototype with tour participants and other visitors.
d. Snack and drink distribution person - To be available at the snack and drink distribution counter and serve them to residents at the end of the tour.

C. Material: Tour route sheet, feedback form booklets, pens

D. Tips:

- Remember to take everything that comes in the spirit of learning eg. more/less people might come to the tour than expected and the tour might not go as planned, therefore approaching this event without any expectation might help deal with how things go on field gracefully.
- If you are unsure about your response to certain questions posed by residents you musn't be ashamed to admit it and can say that you will check with other team members and will inform the homeowner about the response later. In such cases make a note of the person's phone number so that you can get back to them.
- If someone is judging a solution in front of the homeowner and it seems like the homeowner is

being negatively impacted by the comments, you can try and ask the person what they like about it to create a balance between positive and negative feedback.
- Keep the experimental nature of this process alive for the community eg. sharing failures with relevant prototypes.
- Emphasise to community members that the sole purpose of this exercise is to document their thoughts on these prototypes. This was an experiment through which your team hopes to learn about the effectiveness of these prototypes. Once we get feedback our intention is to refine the designs as needed and share these designs and skills with womens groups who can manufacture this by themselves and provide these solutions to more communities.

E. Tour format:

- Tour participants and guides gather in one place at a pre-decided time and a short introduction is given about the tour.
- Tour guides to follow the pre-planned route and lead participants to different houses.
- Residents who are willing to complete the tour are led to all houses. Those who choose to discontinue the tour after an hour or in between are encouraged to continue but are not forced to stay.
- One CB representative to be present in each house to share prototype details and collect feedback based on the feedback form when tour participants visit the house

F. Suggested script/s for interacting with residents:

- Before beginning the tour/ for any resident who comes to the open house and is not part of the tour (bits and pieces from the script can be used as applicable) :

Welcome and thank you for coming!

We will be visiting some houses where we have worked on different thermal comfort solutions with the residents over the past year. These people came for some meetings where we had discussions about these experimental solutions and they gave us their suggestions too. There have been some cases where we installed a prototype and there were some issues with them for eg. there was some leakage during the rains, and that was problematic to houses with dormer window, alufoil etc. All the residents have stood by us as we worked on making these experimental solutions better.

Now we have worked on a total of 8 different solutions with support from community members. We have installed these in 15 houses overall in Shindevasti. We will share details about the thought behind these solutions and want your feedback on them to understand your thoughts on the installations. We will not be installing in any more houses at the moment, because in the future we aim to work with women's groups who can start manufacturing the useful and affordable solutions by themselves and this will help more communities deal with heat stress and also give women a source of income, without being dependent on external entities for support. Therefore, we will be grateful if you can give us feedback so that we can learn about what works and what doesn't work and can take things forward, in other places, accordingly. We do not have any intention to commercialise these products.

Any questions?

- **At the house:**

- *Welcome!*
- *This is called —---------- (make sure to pronounce the name clearly, in parts)*
- *Let people observe the solution (2 mins per person)/ in cases where people cannot observe the solution keep videos/images handy*
- *This is how this cools the place (Explain the working principle and mechanism using relatable examples)*
- *Do you have any questions?*

G. Feedback Questionnaire:

Feedback Questions for Residents:

Name:
Sex : Male /Female
Age : .....

A. How much would you rate this experimental solution?

☹ 😕 😐 🙂 😄
1 2 3 4 5

B. How would you rate how much the installation is helping with thermal comfort/cooling inside the house?

☹ 😕 😐 🙂 😄
1 2 3 4 5

C. How much would you be willing to pay for this/What do you think would be a reasonable amount to pay for this? .....

D. Any feedback (things you like, things you don't like, concerns or questions?)
.....
.....
.....
.....

E. For CB- If you do not have an answer to any question/is posed by residents :
   a. Make a note of the question/s here
      :.....
      .....
      .....
      .....
   b. Residents Phone number :.....

F. Can you think of anything that can make this solution better?.....
.....
.....
.....

2. CRITICAL FEEDBACK

RATIONALE:

- To create a space for residents who have thermal comfort solutions retrofitted in their houses to share their views and honest feedback on the issues, benefits of the installed prototype in their houses
- To receive inputs on a reasonable investment amount for the installation of a given solution in their homes.
- To receive inputs on ways to enhance the approach of working with communities for future reference.

APPROACH:

1. Run the design of your critical feedback by the NGO partner and tweak the design to suit the context, based on the NGO partners' suggestions.
2. Identify a place and time that is convenient to interact and facilitate the critical feedback workshop/meet them at their houses with the NGO partners support.
3. Invite community members to the workshop/inform them about the planned time of your visit to their home and check if the suggested day and time works for them.

Details of role, responsibilities and workshop/interview design are mentioned below.

(Please note: While the description and information below encapsulates all elements that were planned for the critical feedback, elements were tweaked and/or eliminated based on the need of the hour. The critical feedback methods varied for the first and second cycle, given that the duration between the first set of installations and the critical feedback was shorter by a few weeks, as compared to the second cycle.)

First Cycle Feedback:

A. Roles and Responsibilities:

a. Interviewer: 1
b. Note taker: 1

B. **Material:** Interview question sheet, note taking book and a pen
C. **Format:** One-on-one interviews with residents at their homes.

D. Interview Questions:

1. How has your experience been with the installation?
2. Observed benefits

(Refer to household survey for and listening workshop notes for prompts : Health benefits based on initially mentioned health issues, sleep benefits, time spent indoors & outdoors, ease of working in the house, impact on children's studies, etc.)

4. Issues faced
    A. Any feedback from extended family, friends, neighbours, etc..
    B. Recommendations:
5. Anything you would change about the installation process/installation itself?
6. Would you recommend that others invest in this solution?
7. Is there another solution you might prefer now? (ask only after they've experienced it for a few months)
8. Do you think it would be beneficial if your community as a whole invests in this?
9. Any other thoughts, comments, or questions?
10. Wrapping up:*Thank you for sharing your thoughts and experiences with us. We are here in case you need any maintenance support, etc.*

Second Cycle Feedback:

A. Team Roles and Responsibilities:

a. Facilitator: 1
b. Design team members (to respond to community's questions): 1
c. Documentation person (note taking and photography): 1
d. Community mobilization person/s: 1

B. Material:

0. Workshop flow document
1. Images of installations
2. Video capturing the projects journey in the locality (optional)

C. Workshop Flow (Approx. 1.5 hours)

1. Introduction (5 mins)

*(*Suggested Script*: Welcome! Thank you for working with us over the past year and for all the love and we have received*

from you. You'll have made us feel at home here and we are grateful to you for that. We are grateful that you stood by us even when things did not work out, in terms of issues that you faced during the rains, etc.). You'll were also patient with us during the installation process, especially during times when we took more time to work on the installations than expected. There are some of you who were not there with us from the beginning and still trusted us and decided to work with us. Your trust in us is helping us move forward hopefully.

We want to show you a video to take you down memory lane: video (2 mins)

We want to remind you as we had shared with you at the start that this is an experiment and as we go further on this journey, this will help us to learn about what works and what does not work which will help us when we work with women's groups in the future. The intention is to work with women's groups so that they can manufacture these solutions and provide them as products in their own communities. Therefore, your feedback is very valuable. We know that some of you gave us your feedback when we came to your homes, last time. However, it has been a while since then and we hope to learn about any more experiences you have to share with us today.

These are the —--- installations we will be discussing today. (show images))

Before commencing the critical feedback: Make an agreement that one person speaks at a time.

2. Critical feedback questions

- **General feeling:(5 mins)**

- How are you feeling about the installation in your house?
- Happy/Not happy

(go around the room- the same format can be followed for the next subsections)

- **Issues: (30 mins)**

- For those who are not happy - what are the issues you are facing with these installations?
- Project team addresses concerns (if applicable)
- *Any issues that are coming to your mind after listening to this?* (to others)
- Project team addresses concerns (if applicable)
- Issues you are anticipating in the future (during different seasons - summer, winter, monsoon)
- Project team addresses concerns (if applicable)

- **Benefits: (20 mins)**

- *We would like to know how this installation has benefitted you and your family members so far?* (Prompt : *Do you remember that initially, we had discussed a range of issues you'll face in summer such as difficulty in sleeping, doing housework, loss of appetite, children finding it difficult to study and the elderly finding it difficult to stay indoors)*

(prompt residents to share benefits during the day and night, both)

- **Recommendations: (10 mins)**

- Any recommendations for things we can improve in the installations?
- Any recommendations for things we can improve on based on how we have interacted with you?

- **Thoughts on investment: (10 mins)**

- Would you recommend that others invest in this solution?
- What do you think would be a reasonable investment/ideal cost for these solutions?

- **Other thoughts: (5 mins)**

- Is there any other solution you might prefer now?
- Any other thoughts, comments, etc.…? / questions from others. (10)

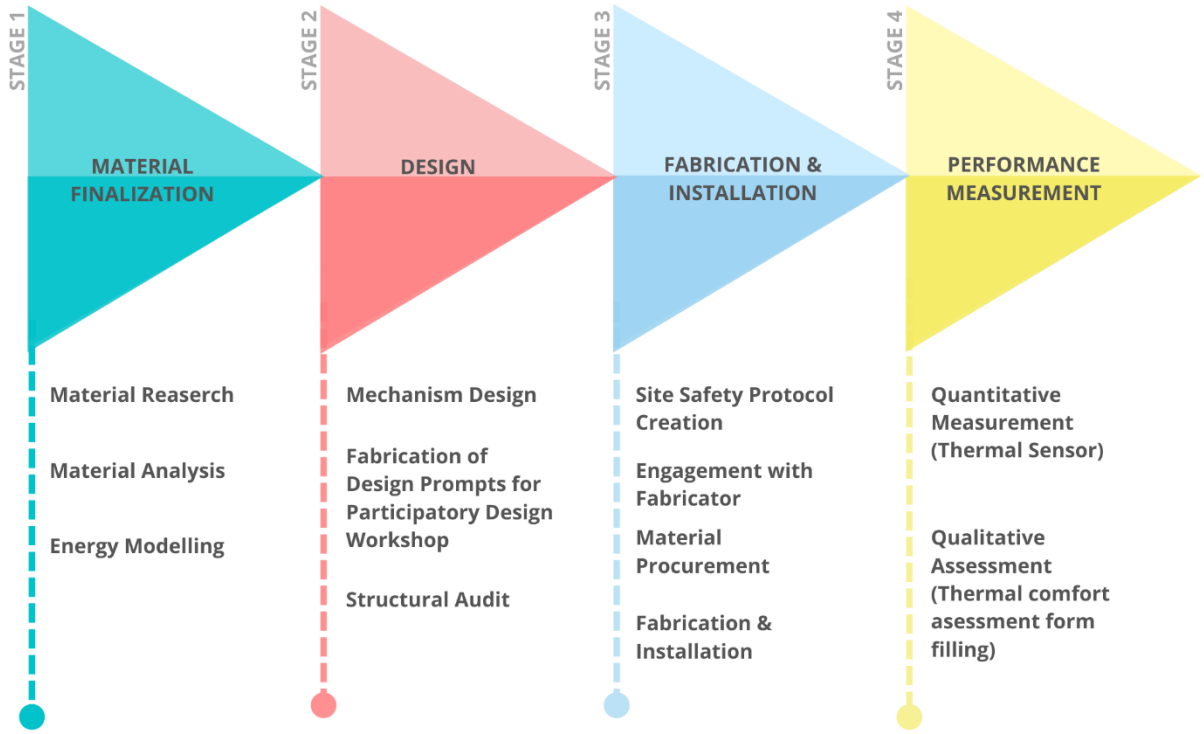
3. Wrapping up:

Thank you for sharing your thoughts and experiences with us. Our work here is not over, but it has just begun. We will keep coming to hear about how the installations are functioning. We are here in case you need any maintenance support, etc.

IV. THE TECHNICAL DESIGN PROCESS

1. OVERVIEW

The design process occurred in 4 re-iterative stages which included material research and study, energy modelling, mechanism design, fabrication and installation. The material research focused on identifying materials that support combatting solar heat. During the material study phase, shortlisted materials were analysed against a scoring sheet. The materials were studied to understand certain physical properties like fire resistance, corrosion resistance, thermal conductivity, weight capacity, water absorption, etc. Thereafter, design mechanisms were worked on to support using the material to support with minimizing indoor temperatures in informal structures. The design process was facilitated by internal design team members with guidance from academic design mentors. After the tentative finalization of selected designs, working models were fabricated and shared with community residents at 'Participatory Design Workshops' as design prompts to support co-creating and contextualizing the designs before finalizing them for installation. Inputs from the participatory workshops led to iterations in the initial designs. A structural audit was conducted across homes to decipher which solution may be appropriate for each household. Once the designs were finalized and suitable house structures were identified and residents' consent was sought for the installation, fabricators were brought on-board before the final stage of design for an integrative design-build process, leading up to the installation stage. After installation, readings from sensors were recorded along with the feedback from residents regarding their thermal comfort through 'thermal comfort assessment forms' to understand the performance of the solutions both quantitatively and qualitatively. The stages and steps are illustrated in the diagram below.



2. OVERARCHING DESIGN STAGES

This subsection provides an overview of the overarching stages that were common for all the thermal comfort retrofits that were designed as part of the project. The stages described span material finalization, design, fabrication, installation and performance measurement.

STAGE 1 – MATERIAL FINALISATION

The material finalization processes happened parallel to the pre-installation community engagement process. This section primarily elaborates on 3 aspects: 'Material research and methodology', 'Detailed material study parameters and analysis process' and 'Energy Modelling of the materials.

1. MATERIAL RESEARCH

RATIONALE:

To have a list of materials that can be possibly used as retrofitting materials over the existing roofs of informal settlements to reduce the indoor temperature of informal structures.

APPROACH:

1. Prepare a list of heat combatting materials for detailed material study and analysis through online research.
2. Identify material dealers and manufacturers through online research.
3. Conduct a market study of streamlined materials by connecting with authorised dealers and manufacturers.
4. Gather applied knowledge and wisdom from allies who are working or have experience in the domain of structure cooling based on your networks or through online research.

2. MATERIAL STUDY

RATIONALE:

To study and analyse the selected materials in detail to support finalizing suitable materials for prototype design and installations.

APPROACH:

- Analyse each material identified during the material research stage based on the following criteria:
    - Scientific principles: Thermal conductivity, thermal mass, density, fire and corrosion resistance, water absorption and resistance and UV absorption.
    - Engineering aspects: Weight, load bearing capacity, thickness, sturdiness and wind resistance.
    - Environmental aspects: Embodied energy, water footprint, reusability, recyclability, energy footprint and local availability of the material.
    - Socio-economic aspects: Cost, lifespan, maintainability, local install ability.
    - Applicability (Architectural or Utilitarian): Spatial and structural application patterns, infrastructural requirement and roof application of the material or solution.
- Conduct a comparative analysis of the materials
- Rule out materials that are not suitable
- Conduct a secondary round of analysis for shortlisted materials

3. ENERGY MODELLING AND FULL-SCALE PROTOTYPE TESTING

RATIONALE:

To analyse the projected impact of reduction in temperatures of the selected materials

APPROACH:

Conduct building heat simulations of the shortlisted materials using Design Builder Software (or any other software) for building heat simulation for different type of houses in informal settlements i.e. Kutcha (tin roofed and walled), Semi-pucca (tin roofed and brick walled) and Pucca (brick walled and concrete slabbed) houses.

STAGE 2 –DESIGN

This subsection gives an overview of the design process. The process was initiated after the material finalization stage. It was a re-iterative process which took multiple iterations to reach the final design. This section includes 2 other parts apart from the primary focus on 'Mechanism Design', namely 'Design Prompts' and 'Structural Audit' both of which informed the final design.

1. MECHANISM DESIGN

RATIONALE:

To design a range of simple, affordable and effective thermal comfort solutions comprising over and under the roof, static and dynamic solutions.

APPROACH:

1. Identify criteria that can support the mechanism design process. The criteria for this project included:
    - Simplicity
    - Affordability
    - Local availability materials
    - Experiment with certain sheet or panel-based solutions to test mechanisms based on the concepts of Radiant Barrier + night sky radiation
2. Inform design team members to conduct research about different mechanisms.
3. Ask team members to brainstorm each solution to come up with a design drawing.
4. Schedule weekly internal review sessions with team members to make space to share work progress and receive inputs from other team members.
5. Seek inputs from experienced design persons such as academic and product design mentors on bi-weekly basis.
6. Work on initial design prompts that can be presented to the community for their input.
7. Present the first cut of designs to the community at 'participatory design workshops' to facilitation the co-creation and contextualisation of designs based on their inputs.

2. DESIGN PROMPTS FOR PARTICIPATORY DESIGN WORKSHOPS

RATIONALE:

To fabricate working models that would serve as design prompts for the residents in the participatory design workshops. These were made to highlight some of the working mechanism ideas for the finalised solutions and to also prompt the residents to come up with more ideas

APPROACH:

1. Make a design drawing for each solution and explain it to the fabricator.
2. Evaluate options for locally available materials.
3. Work on identifying simple fabrication techniques for each solution with the fabricator.
4. Ask for the fabrication of 3 ft by 3 ft models for all the design ideas.

Design Prompt: Ecoboard Sliding

Design Prompt: Dormer Window

3. STRUCTURAL AUDIT

RATIONALE:

1. To understand the structure of the house to support refining the design.
2. To decide on which solution is best suited for a particular house structure.

APPROACH:

1. Create a structural audit questionnaire (can be found below)
2. Visit each house and fill the questionnaire with support from residents who are willing to support the audit process.

Questionnaire to Study Existing Structure for Prototype Designing

Team Member Name:

Date & Time:

House No. & Address:

House owner Name:

Note:

Attach photographs for reference.

Take all measurements in meters.

- **General:**

1. What are the dimensions of the structure?

Dimension	Value (in metres)	Comments/ Additional Remarks
Length		
Width		
Height		

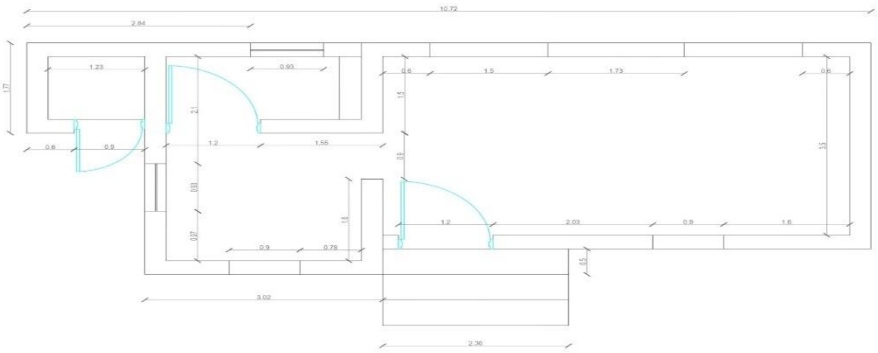
2. What is the temperature during the survey? (Average of 3 measurements/ readings)

- Surface temperature of the walls (℃)
- Surface temperature of the roof (℃)
- Surface temperature of the floor (℃)
- Inside Dry Bulb Temperature (℃)
- Inside Wet Bulb Temperature (℃)
- Outside Dry Bulb Temperature (℃)
- Outside Wet Bulb Temperature (℃)

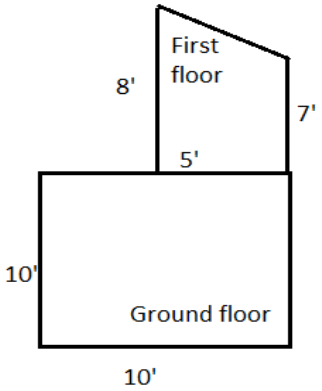
1. What is the layout and orientation of the house? (Direction towards north)

Note:

- *Carry hardcopy of the map of the area to be audited.*
- *Mark the house and its given number on with the help of Google Maps live location. The North will be fixed on the hardcopy.*



Plan



Section

- *To be more precise, in the box given below sketch SLD (single line diagram) PLAN and SECTION of the house with the rooms and other details.*
- *Check the North direction with the help of a compass and note is beside the plan.*
- *While sketching the Plan of the house/structure, label the existing doors (D1, D2), windows (W1, W2) and ventilators (V1, V2).*
- *Get the following details:*

1. *How many rooms are available in the house? (Example- 1 room, 1 toilet, backyard etc.)*
2. *Are there any adjoining structures around the house? If yes, how many and in which direction (N/S/E/W)?*
3. *Is there roof access for installation and maintenance? Ex. Staircase*
4. *Are there high-tension electric wires on the rooftop?*
5. *Do we have outdoor space access for the operation of dynamic mechanisms? (eg. Alufoil chain sprocket needs minimum. 3 feet gap on at least one side of the house)*

6. *How is water stored for use? (Ex : Overhead Tank, Sump, Hand Pump and Drums)*

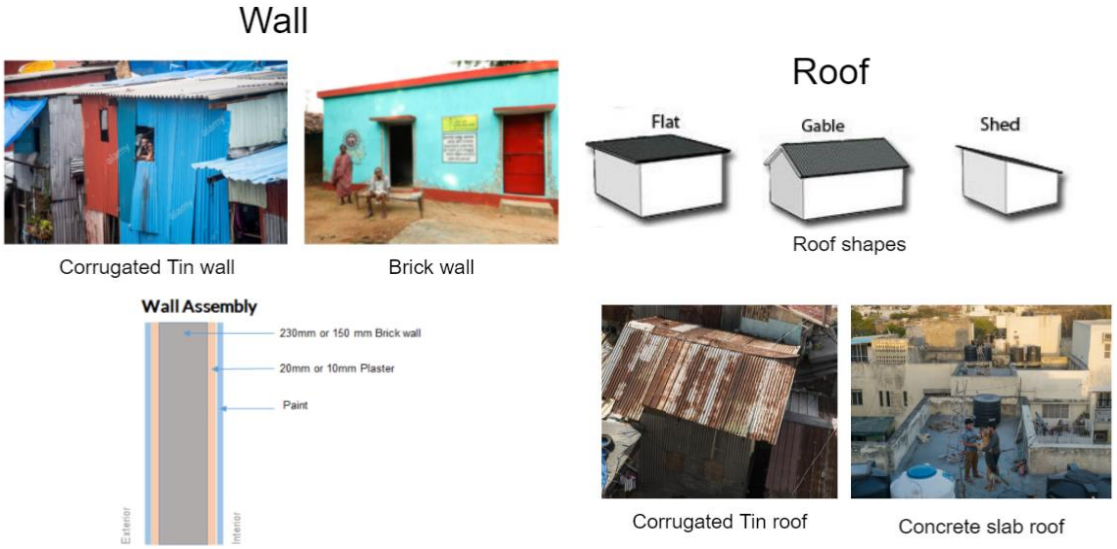
- Structural Details of Walls, Roof and Floor -

1. Structure Assembly:

Structure Component (Composition - Assembly)		Type*	Layer 1	
			Material*	Thickness (in mm)
Roof	Flat, Gable, Shed			
Wall	Brick wall, Corrugated tin wall			
Parapet	No type available	NA		

**Notes:*

(i) Roof types; Wall types; Floor types (check reference images below)



(ii) If the roof is sloping, measure the angle (slope). (Below are the instructions to measure roof angle)

Smaller Wall Height (m)	*Larger Wall Height (m)*	*Wall Width (m)*	*slope= tan-1(Larger Height - Smaller Height Wall Width)*

(iii) Enter NA if something is not applicable

- Other details of the Structural components:

*Note: *Ask Residents if the auditor can't see any leakage. **Attach pictures of damp surface*

Structural Component	Year of installation/ latest repair	Cracks	Leakage*	Corrosiveness*	Fire Resistance
		Good: approximately <5% area affected Average: 5-10% area affected Bad: >10% area affected	Good: approximately <5% area affected Average: 5-10% area affected Bad: >10% area affected*	Good: No corrosion Average: <5% area affected Bad: >5% area affected	Good: Fireproof Bad: Fire prone
Roof					
Wall					
Parapet					

- <u>Daylight and Ventilation</u>
- How is the Day lighting and Air ventilation in the structure?
  Note: Take this measurement in the center of the structure.
  Measure through Lux Light Meter by keeping it on the floor, switch off all lamps in the structure and measure only daylight

  What is illuminance? _____ lux
  (*Note: Illuminance is a measure of how much the incident light illuminates the surface*)

  a. Daylight - (rate on the scale)

- Very Poor
- Poor
- Sufficient
- Strong
- Very strong

  b. Ventilation - (rate on the scale)

- Still

- Slightly Still
- Just Right
- Slightly breezy
- Too breezy

- How many openings are available in the house?

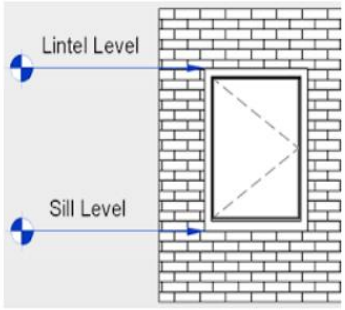
a. Door-

b. Window-

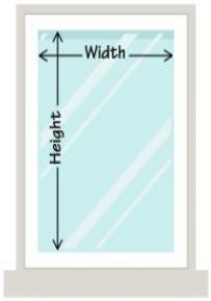
c. Ventilator-

	Window Name	**Window Size**	**Door Name**	**Door Size**	**Ventilator**	**Ventilator Size**
	e.g.W1/W2	**(In metres)**	**e.g.D1/D2**	**(In metres)**	**e.g.V1/V2**	**(In metres)**
Height						
Width						
Sill Level						
Lintel Level						

**Note: Keep the labelling for the doors/windows/ventilators same as the sketch in the General Section. Reference images given below:*



Sill Level and Lintel Level of an opening



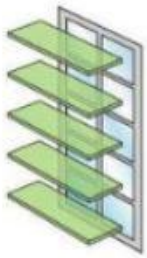
Height and width of an opening

- What are the types & sizes of shading devices in the household?

Shading Device

Chhajja

Awning



Horizontal shade

Vertical shade

Ventilator

Exhaust Fan

Jhali Window

Opening in the wall

Sr. No.	Opening name (eg. D1, W1)	Type of shading device used*	Size of shading device used (length x width x thickness)
1			
2			
3			

Note:

1.Keep the labeling for the doors/windows/ventilators same as the sketch in the General Section. Reference images given below:

2.Reference image of shading devices

3.Anything above Lintel level which helps in air and light exchange is a Ventilator.Ex: Exhaust fan, Jhali, Opening in the wall etc

- Additional Information

1. Roof (Supporting) Structure Material - on which the roof is resting or is set up (Example - GI sections/ wood/ bamboo)

2. Water supply system available in structure?(If yes How many tap connections) mention if any leakages found.

3. Rate the structure strength (out of 10)? Post scoring, Kindly describe and elaborate further.

   Note : Sturdy support, no structural enhancement : 7-10 , Medium support, need a few structural enhancements : 4-6, Poor/Damaged support, needs complete structural revamp : 0-3

4. Which day would be preferable to you for the participatory design workshop?

- Sunday
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday

5. What time would be preferable to you for the participatory design workshop?

- Morning
- Afternoon
- Evening

- Solution Specific Questionnaire:

Sr. No.	Solution Name	Selection Criteria	Applicability on current structure	Reason
1	Alufoil (Static)	• Tin walls or brick walls (both are fine) • Sloping or flat roof both are fine • Should have a frame or brick wall to fix the ms sections	Yes / No	
	Alufoil (Dynamic)	• Wall type - Sturdy? • Roof strength - Adequate beam support? • Roof integrity - Any	Yes / No	

		cracks/leakages present? • Roof Parapet - Can a MS Box section structural frame be fixed on the roof parapet?		
2	Modular Roofing Panels	• Sturdy, brick walls • Sloping or flat roof both are fine • Should have a frame or brick wall to fix the ms sections	Yes / No	
3	Fiberglass Insulation	• Flat or slight slope preferred • Structure should have high roof (9-10ft) • Waterproofing needs to be in place (Walls & roofs)	Yes / No	
4	Dormer Window	• Metal roof • Sturdy, brick walls • Sloping roof • Direction of Slope - Ideally facing North and North-East; but can also be installed in North-west, West and East directions	Yes / No	
5	Rooftop Urban Gardening	• Sturdy, brick walls • Sloping roof to drain out water • Accessible roof height (single storey) • 2 side access preferred • Should have own or nearby water source	Yes / No	
6	Water-filled PET-bottles	• Sturdy, brick walls • Flat or slight slope preferred • Accessible roof height (single storey) • Should have own or nearby water source	Yes / No	
7	Wool Panels	• Clear height of the room • Stable walls (Brick / RCC). • The roof should be stable for bearing the load of the installation. • Space between existing roof	Yes / No	

		structure and solution to devise the installation mechanism		
8	Ecoboard static	• Sturdy, brick walls • Flat or slight slope preferred • Structure should be rectangular or square in shape.	Yes / No	

STAGE 3 – FABRICATION AND INSTALLATION

The section provides an overview of 3 processes which were common for the fabrication and installation of all the prototypes. It elaborates on 'Site Safety Protocols', 'Engagement with Fabricators', 'Material Procurement' which supported the final 'Design and Installation Process'

1. SITE SAFETY PROTOCOLS

RATIONALE:

- To ensure safe and dignified working conditions for project workers
- To ensure the safety of inhabitants who open their homes to be part of the experimental endeavour

APPROACH:

1. Reflect on the processes involved in the fabrication and installation to determine possible spaces where caution is warranted to ensure safe and dignified living and working conditions during site work
2. Create a check list of factors that need to be taken care of before, during and after site work

The checklists below can be referred to for site safety procedures.

Safety Protocol Checklist

Date: ..... **Safety supervisor**: .....

Pre installation work:

- Have a handover call with the previous day's team to get updates on the following:
- Any safety measures to be mindful of in relation to today's work.
- Any eatables that need to be purchased.
- Any medical supplies that need to be purchased.
- Arrive at the material storage room 20 minutes prior to the scheduled installation time.
- Ensure the availability of the following items:

- Water (not packaged)
- Biscuits
- Fruits (e.g., Bananas)
- Torchlight
- Grievance booklet
- Log booklet
- Pen

- Check that the first aid kit with the following material is available.
  - Gauze
  - Electral powder
  - Soframycin
  - Dettol
  - Band aid
  - Scissors
  - Cotton
  - Surgical tape
- Have a contact list of the following available to address unforeseen events:
  - Hospitals
  - Clinics
  - Fire station
  - Police station
- Carry the above-mentioned food items, booklets, and first aid kit to the installation site.
- After reaching the site, ensure that arrangements are made for residents (whenever applicable)
  - Food arrangements
  - Arrangements to move to a temporary safe space/location during installation
- Check that the installation supervisor is present on site.
- If child labour is present, follow steps mentioned in the 'Emergency Protocol' checklist.
- Check that the following are available at the site:

- A sturdy ladder
- A wooden stick

- Check that the project workers are wearing/have carried the following safety equipment:
  - Hand gloves (rubber gloves in case of electrical work)
  - Protective glasses (in case of welding and grinding)
  - Safety helmet
  - Safety shoes.
- Facilitate a safety protocol meeting with the installation supervisor and project workers before commencing installation work.

During installation work:

- Regular/Timely tasks during the installation process
- Remind project workers to wear protective gear as and when required.
- Remind project workers to drink water after every hour.
- Check that the water bottles are filled.
- Check that ladders have firm footholds and handholds before a project worker climbs.
- When a ladder is used, inform the installation supervisor to hold the ladder firmly from the lower side.
- Warn by-passers about possible dangers if they are near the installation work.
- Check that no harm is done to the inhabitants and their belongings
- Attempt to resolve any grievances by project workers and residents non-violently.
- For minor injuries/ accidents, use the first aid kit.
- For major injuries/accidents take the injured person to the nearest clinic or hospital.
- For electrical hazards follow the steps mentioned in the 'Emergency Protocol' checklist.
- In case the installation work continues when it is dark, ensure that a torch is used.

Post installation work:

Daily tasks:

- Allocate 5-10 minutes post installation to:
- Update the logbook
- Make a note of any grievances by project workers and residents in the grievance book.
- Check the status of eatables and first aid kit supplies and make a note of anything that needs to be

purchased the next day.

- Place the following in the material storage room:
- first aid kit
- Wooden stick
- Eatables
- Booklets and checklists.

Additional tasks on the last day of installation at a given household:

- Share numbers of project team members with household members after wrapping up installation and inform them to reach out immediately in case of installation related issues.
- Remind household members to fill the thermal comfort assessment forms for 7 days post-installation and inform them that they can reach out to project team members in case of any queries and concerns.

Emergency Protocol Checklist:

In case of Child Labor

- Halt the work
- Inform the fabricator that we do not support child labour and will make a call to 1098 (Childline India Foundation Helpline) if we learn that this practice will continue in the future.
- If the fabricator ensures you that child labour won't continue in the future, make him/her state the same in writing and sign his/her declaration.
- One the fabricator signs the declaration, ask him/her to make provisions for a legal-aged project worker to support the installation process.

If a person meets an electric current

- Disconnect the power supply (if possible) or use a wooden stick to separate the person from the electric current.
- Don't attempt to touch the person until you're certain the power supply is cut.
- As soon as the victim has been freed from the electrical source, call for an ambulance or medical help.
- While waiting for the ambulance, check whether the patient is conscious and breathing.
- If the person is unconscious and has stopped breathing, begin Cardiopulmonary Resuscitation (CPR).
- Keep doing CPR until medical help arrives.

- Place the patient in a recovery position if he or she is already breathing.
- You can prevent shock by laying the patient flat on the ground, with the head slightly lower than the body.
- If the person is conscious and breathing is normal, and if burns are present, cover with gauze, and do not apply ointment or lotion.

1.ENGAGEMENT WITH FABRICATOR

RATIONALE:

To engage with local fabricators humanely and equitably to support the thermal comfort retrofit fabrication process.

CRITERIA:

To identify:

- A fabricator who is ready to and has the capacity to undertake the work in the long-term
- A fabricator based in and around the locality.
- A fabricator who agrees to adhere to safety protocols during the fabrication process.

APPROACH:

1. Send a questionnaire to potential fabricators. (The template questionnaire is in the box below)
2. Analyse the fabricators response to the questionnaire and proceed with the next steps if the fabricators response to the questionnaire indicate potential.
3. Show the designs of the specific solutions to the fabricators to understand their capacity to fabricate the thermal comfort retrofit.
4. Visit their fabrication spaces to gauge their fabrication capacity
5. Select a fabricator who seems most suitable for the project work based on the above mentioned evaluation.
6. Sign a contract signed with the selected fabricator, (a template contract is in the box below the questionnaire under this section)

Interview Questionnaire for Fabricators

1. Name of the Fabricator
2. Location
3. You will provide fabrication for which solutions? (Select all that are applicable)
    a. Alufoil
    b. Wood Wool Panel
    c. Rooftop Urban Gardening
    d. Ecoboard
    e. Water-filled PET bottles

f. Dormer Window

4. How many employees present?
    a. 0-5
    b. 6-10
    c. 11-15
    d. 16-20
    e. 21-25
    f. 25+
5. How many machines present in the workshop?
    a. 0-5
    b. 6-10
    c. 11-15
    d. 16-20
    e. 21-25
    f. 25+
6. Approx. annual turnover in Rs.
    a. 0-1 lakh
    b. 1-3 lakh
    c. 3-5 lakh
    d. 5-7 lakh
    e. 7-10 lakh
    f. 10 lakh+
7. Child workers present?
    a. Yes
    b. No
8. What are some ways in which you will look to reduce wastage of materials?
9. What are some ways in which you will look to recycle materials?
10. Are you willing to provide warranty for your fabrication? If yes, how much?
11. What is the cost quotation for the selected design(s)? (If possible, provide cost break-up of solutions)

Fabricator Contract

cBalance Solutions Pvt. Ltd. is a knowledge-centric social enterprise rooted in sufficiency and social equity. We build tools to reduce carbon footprint and bridge the gap between climate-crisis knowledge and action by hand holding collectives into integrating the climate-emergency and climate-justice into their actions.

Someshwar Associates is a --- based company working in the field of construction, fabrication and installation.

This contract would lay down the guidelines on Safety, security and humane equity of all stakeholders involved on the fabrication site. Project Lead from Fabricator side, cBalance side and/or involved CSO side would require it to thoroughly go through it and ensure its implementation on the ground.

Safety and Security Guidelines:

- There is enough supply of basic personal protective equipments (*Safety glasses, Flame-resistant gloves, Ear plugs / earmuffs, Welding helmet, Oil-resistant shoes, protective clothing*) for all involved in work.
- All workers should always wear safety gloves and glasses without exception.
- Keep your fabrication shop/site organised, clean and free to clutters. All tools and equipments are kept in their places before and after use. Disorganized floors and messy areas can lead to falls and other injuries, so keep everything organized to ensure the highest safety precautions for you and your team members.
- Emergency contact numbers (Local Ambulance, Fire Station, Local Police station, local doctors, co-workers, important people, etc) be displayed at visible locations and be educated to all regular working people on the site.
- Fire Extinguishers be installed on the site and checked regularly for its proper functioning.
- Ensure a working ambient clean environment is maintained on the site. Enough natural sunlight, air ventilation, and fans are available.
- Basic Medical Kit box be available with all required items in it.
- Clean drinking water and appropriate basic sitting facilities are available.
- Communicate safety rules clearly and hold people accountable.Safety policies must be communicated clearly and effectively to all staff members, including visitors and new team members.
- All the waste generated (oils, metals, plastics, hazardous materials, etc) be appropriately segregated and disposed of which is not harming the environment in any sense.

Humane Social Equity Guidelines

- No child labour be involved during the work on the site.
- No exploitation of labour - labour laws to be followed, minimum wages as per the laws and market to be paid to the workers and helpers.
- Dignity of Labour to be maintained and followed at all levels, especially during conflicts.

- In case of any minor/major injuries or casualty, immediate nearby medical assistance be provided to the victim irrespective of his/her social or economic background.
- Maintain respectful, mindful & professional relationships with all team members and visitors, be it internal or external.

Since the project involves installation activities in the selected houses in the informal settlement, the work should be commenced keeping in consideration certain levels of safety, social equity by both installers and cBalance team coordinator, to ensure fairness and undisturbed environment by the retrofitting related processes and activities. Below are some of the checklists and protocols requested to be kindly followed:

For Installers:

- The installer needs to thoroughly check the installation after the prototype has been installed, in order that no gaps or loose ends are left, which could lead to a variety of happenings such as water leakages, rats, insects, etc. coming in from the gaps. It should be confirmed before the house is re-inhabited.
- Similarly, in case of prototypes which are to be opened/slided open or closed, the mechanical apparatus and functionality of it should be checked after the installation.
- In the installations with electrical work, safety measures to be followed so that no person in the house is harmed due to any carelessness.
- Safety gears and protective implements should be worn and used by all the workers.
- Lighting facilities such as flood lights, hand lights and area lighting should be placed in case of dark working conditions.
- A certain sense of organization and cleanliness be followed while working, the implements or tools should not be spread on the floor in the house. No garbage or leftovers, leave the place better than you found it.
- Child Labour is strictly prohibited. No child below 14 years of age shall be employed to work.
- Labour laws shall be followed, and minimum wages as per the laws and market shall be paid to the workers and helpers.
- No person/animal shall be harmed while the work and installation is being conducted and carried out.
- Medical assistance in case of any injuries be handy and available.
- The time and dignity of the families in whose house the work/installation is being commenced, be respected and the work schedule be adjusted according to their timings and comfort. This is primarily because, the community we are working in are a part of Informal economy i.e., daily wage earners. The time and livelihood conditions to be taken at the priority.
- Sufficiency of materials shall be followed, with minimal waste while at work.

For cBalance team:

- Thorough checking of the prototype installation before re-inhabitancy, so that no casualties or injury is incurred on the inhabitants of the house.

- Work shall be commenced with minimum interference to the surroundings so as not to create any pedestrian blockage or obstruction and prevention of injuries. The cBalance team member should be coordinating the timings and installation logistics with the family, before and after the installation.
- Make sure that the safety measures are followed on site, at work.
- Fair working hours and compensation shall be provided for all the project workers.
- Provide project workers with accessible means to raise workplace concerns. Discipline/ harassment and grievance procedures shall be made available for all.
- All accidents leading to personal injuries and/or property damage shall be reported immediately to the supervisor from cBalance Team.
- In case there are any injuries onsite, caused due to the installations/work fault at any stage of the work, the required medical assistance be provided by the team. First-aid kits including sterilized dressing, cotton wool and antiseptic cream shall be made available at readily accessible places.
- Materials provided by the cBalance team as listed below. Someshwar Associates will have to procure rest of the assembly materials except these given below.

Sr. No.	Material	Concerned Solution
1	Wood wool material sheet	Wood wool insulation

Fabricator Deliverables

Sr. No.	Installation
1	Wood wool panels in household 1
2	Wood wool panels in household 2
3	Pet bottle installation in household 3
4	Pet bottle installation in household 4

Payment Terms:

Sr. No.	Category	Percentage	Amount (INR)
1	Advance Payment	60%	30,000
2	Payment After Installation	40%	20,000

	Total	100%	50,000

Duration of partnership:

15th December 2021 to 24th December 2021 (Extendable subject to installation period)

Authorization:

_____	_____
Fabricator Name **Fabricators Shop name**	**Organisation Member Name** **Organisation Name**

2.MATERIAL PROCUREMENT

RATIONALE:

To procure materials for fabrication and installation.

CRITERIA:

1. To look for places where materials can be purchased at a reasonable cost
2. To look for places closest to the installation site

APPROACH:

1. Come up with the Bill of Material for each solution.
2. Conduct research of material selling places located near the installation site.
3. On identifying a suitable place, ask for the materials to be transported to the installation site.

3. FABRICATION AND INSTALLATION

RATIONALE:

To fabricate and install experimental thermal comfort retrofits.

CRITERIA:

- To use simple fabrication techniques.
- To ensure that the fabrication gets completed in a timely manner.
- To carry out installation with minimum disturbances to the residents and neighbours.

APPROACH:

The approach to fabrication and installation is described in the checklist below.

Fabrication and Installation Preparation Checklist

With external entities (fabricator, community members and NGO partner):

- Check if installation consent is sought from the households.
- Discuss the non-negotiables with the fabricator
    - Safety Protocol
    - Adherence to timelines
    - No child labour
- Discuss list of safety material needed during fabrication process
    - Hand gloves (rubber gloves in case of electrical work)
    - Protective glasses (in case of welding and grinding)
    - Safety helmet
    - Safety shoes
- Discuss prototype designs with the fabricator.
- Visit households to evaluate feasibility of installation with the fabricator.
- Strategize prototype design implementation based on house structure evaluation with fabricator.
- Discuss the types of installation material required based on implementation strategizing discussion with fabricator.
- Discuss the quantity of installation material required with the fabricator.
- Get a tentative daily schedule from the fabricator for material procurement and installation.
- Check if suggested installation day/time is suitable for households.
- Connect with households before installation to understand the need to make arrangements for food
- Connect with households before installation to check if there is a need for a place for family members to stay during installation.
- Arrange for a place in the community to store fabrication material with support from NGO partners.
- Arrange for a room for residents to stay during installation with support from NGO partners.
- Check for community members who can support food preparation with support from NGO partners.
- Find an electrician in the community with support from NGO partners.
- Get an electrical audit done by the electrician for each household to ensure safety.

- Check if the neighbours' walls or roofs are going to be affected due to the installation.
- Seek consent from the neighbours in case their walls and roofs are getting affected due to the installation.

Within the team:

- Orient team members to the purpose and use of the site supervision checklist.
- Conduct mock site-supervision 'role play' / situation-simulation session.
- Orient team members about the prototypes to be installed.
- Arrange for torches for workers and supervisors if working in the evening past sunset.
- Print site supervision checklist, logbook and grievance book.
- Purchase first aid kit material.
    - Gauze
    - Electral powder
    - Soframycin
    - Dettol
    - Band aid
    - Scissors
    - Cotton
    - Surgical tape

<u>Fabrication and Installation Supervision Checklist</u>

Date: ..... Installation supervisor: .....

Pre installation work:

- Have a handover call with the previous day's team to get updates on the following:
- Work done the previous day.
- Work to be done today.
- Any other specific installation suggestions.
- Checklist and logbook availability on site.
- Any property damages
- Charge your phone fully before you leave for the site.

- Arrive at the material storage room 20 minutes prior to the scheduled installation time.
- Check that installation material is available at the site before work begins.
- Check for the presence of the safety supervisor.

During installation work:

- Discuss installation details with the fabricator before the work begins.
- Don’t let the installation work begin unless there are a minimum of 2 workers to support the process.
- Regular/timely tasks during the installation:
- Halt the work if a minimum of two workers are not present on site at any point in time.
- Check for minimum interference/ obstruction in the pedestrian pathway.
- Click photographs and videos after every hour.
- Provide project workers with a torch in case of dark working conditions.
- In cases of property damage note the cost of reimbursement in the logbook.
- Check that no loose ends or gaps remain at the end of the installation.

Post installation work:

Daily tasks:

- Update the logbook with the day's installation details.
- Discuss the work to be done the next day with the fabricator and enter details in the logbook.
- Decide on the reporting time for the next day and note it in the logbook.
- Check that installation material is cleared from the resident's house.
- Check that the waste is segregated and appropriately disposed of by the fabricator
- Update the residents about today's work and the work that will happen tomorrow.
- Inform residents about the installation team’s reporting time for the next day (if applicable).
- Keep the checklist and logbook in the material storage room.
- Schedule a call with the next day's supervisor to share installation updates.
- Upload photographs to the pre-decided documentation database at the end of the day.
- Communicate property damage (if any) to the admin team the next day and commission reimbursement to the house owner thereafter

Additional tasks on the last day of overall installations:

- Ensure that the material storage space is cleared by the fabricator.
- Pay the room rent for the material storage space to the owner and collect a receipt for the same (as applicable).
- Inform the room owner that the work is complete and that the space has been cleared

STAGE 4 – PERFORMANCE MEASUREMENT

This subsection gives an overview of the thermal comfort performance measurement process. It consisted of two parts, the quantitative measurement and the qualitative measurement, the processes of both have been documented below.

1. QUANTITATIVE MEASUREMENT (PHYSICAL SENSORS)

RATIONALE:

To objectively measure the thermal comfort performance of the thermal comfort retrofits.

APPROACH:

1. Install a memory card in the thermal sensor to capture readings
2. Tag the name of the person who's house the sensor will be installed in on the sensor
3. Install sensors in each house 7 days prior to the installation
4. Install one sensor in a house in the neighbourhood where no installation has/will be undertaken
5. Install one sensor outdoors to capture outdoor measurements
6. Remove the sensor eight days after the installation
7. Analyse the data to estimate the thermal comfort performance of each household in comparison to the surroundings and neighbouring house temperature

2.QUALITATIVE MEASUREMENT (THERMAL COMFORT ASSESSMENT FORM FILLING)

RATIONALE:

To subjectively estimate the thermal comfort performance of the households

APPROACH:

1. Prepare a thermal comfort assessment form (refer to the 'Thermal Comfort Assessment Form Training' sub-section under the 'Community Engagement' section of the manual for the form template)
2. Train residents to fill the form
3. Ask residents to fill the form continuously 7 days prior to the installation and 8 days after installation
4. Collect the form from residents 8 days after the installation.
5. Analyse the data to understand the subjective thermal comfort performance of each solution.

3.SOLUTION SPECIFIC INFORMATION

This section provides a detailed description of each thermal comfort retrofit experimented with as part of this project. Each subsection provides a basic description of a given retrofit followed by describing its working mechanism. It shares its material requirements and describes the fabrication and installation process followed by maintenance guidelines, as applicable. This information is supported by the working drawing and installation image for each retrofit.

A. ECOBOARD

DESCRIPTION

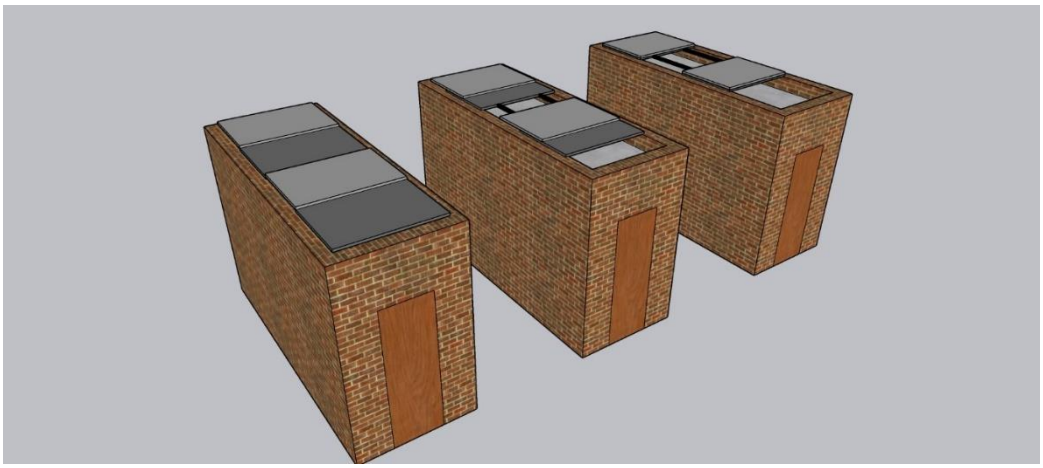
These boards are made from multi-layer plastic which are hard to recycle and end up in landfills usually. Tetra packs and other plastic objects are compressed under high temperature to create a consolidated board that can later be used to make furniture, as doors and other objects.

MECHANISM 1 – SLIDING

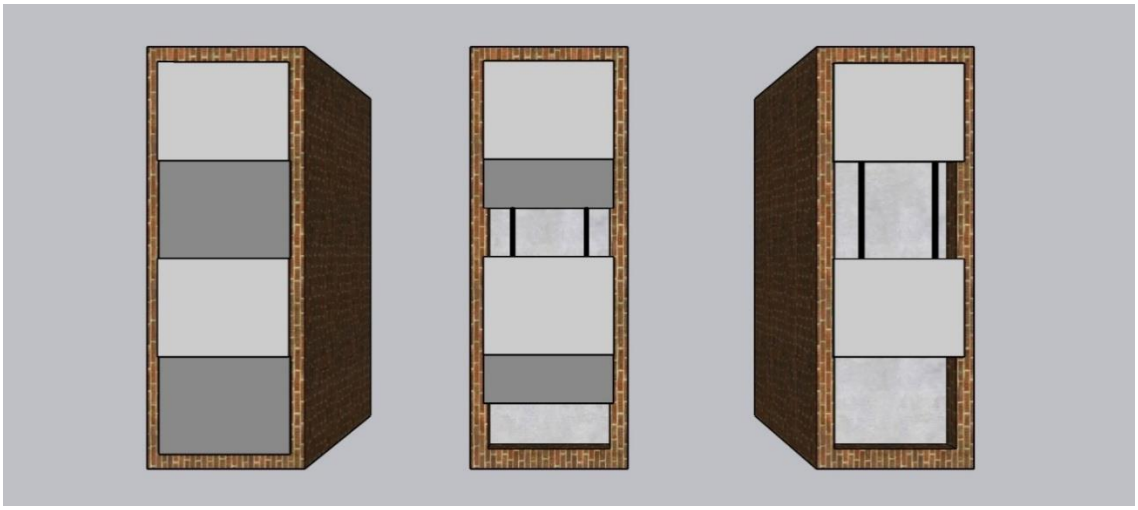
1. MECHANISM DESCRIPTION

The sliding mechanism operates like sliding drawers, wherein channels and rollers help slide the boards to one end of the house to allow night sky radiation to facilitate cooling within the house at night. A pulley mechanism is incorporated within the system to handle the sliding movement.

2. WORKING DRAWINGS



Sliding mechanism (upper view): (left to right) closed, opening, open



Sliding mechanism (upper view): (left to right) closed, opening, open

3. MATERIAL REQUIREMENTS

Eco board, metal pipe with square cross-section, metal-based c-type channels, metal strips, nuts, bolts, long bolt, metal pipes

4. FABRICATION AND INSTALLATION

1. Make fractal design of 12 ft x 8 ft.
2. Calculate the fractals required for the roof.
3. Work out the geometry of the fractals on the roof.
4. Build a metal framework base on the roof.
5. Bolt the framework base to the roof with bolts.
6. Make the static frames on top of the framework by welding the strips.
7. Fix the material on this frame.
8. Beneath the static frame, make another frame through welding the metal strips to house the material.
9. Provide c-channels on the sides for the bottom frame to slide in them.
10. Weld the connecting pipes on the frame.
11. Weld the other side of connecting pipes to the other similar frame.
12. Fix the material on these frames.
13. Weld the nut beneath the base frame.
14. Weld long bolt beneath the bottom frame and ass it through the nut. This is called the half-nut mechanism.
15. Provide a long handle on the nut and bring it down to human height.

5. INSTALLATION IMAGE

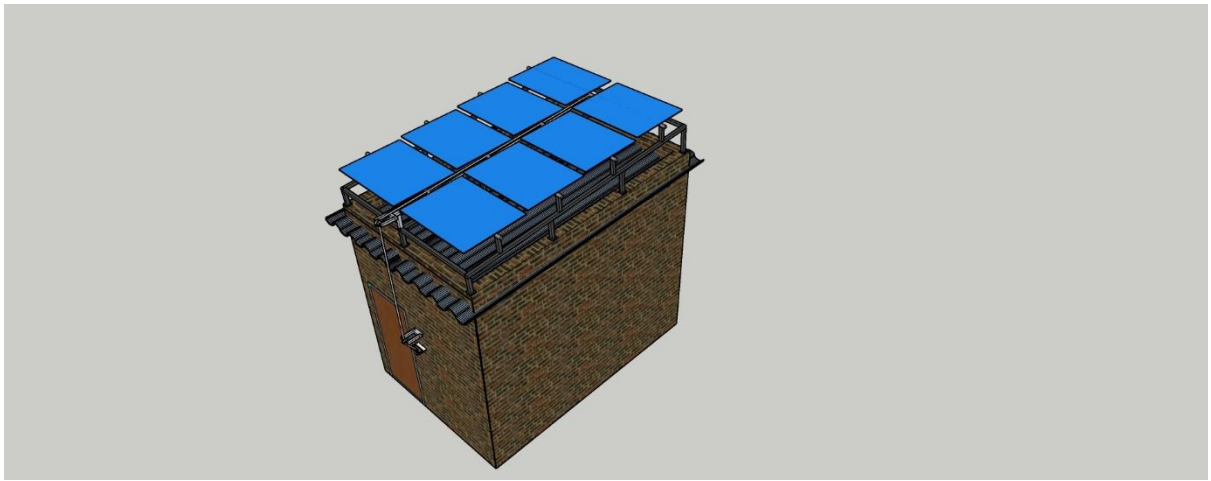
Ecoboard Sliding (Closed)

MECHANISM 2 – CHAIN AND SPROCKET

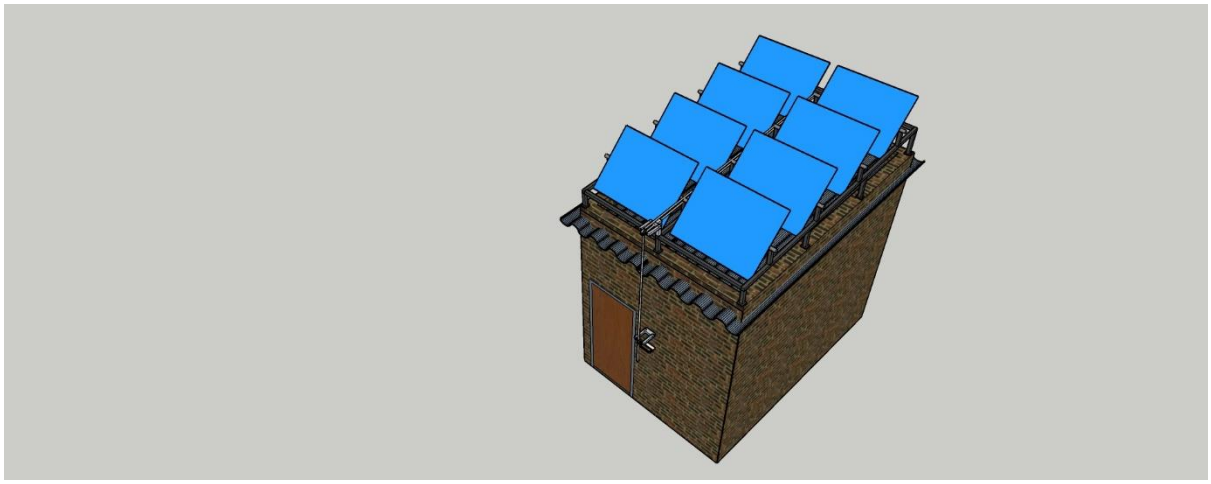
1. MECHANISM DESCRIPTION

The chain-sprocket mechanism works on the principle of louvres, wherein all the panels of the louvres can be opened and closed at the same time to allow radiant barrier and night-sky radiation as required. The movement is enabled with the help of chain and sprockets. It is operated with the help of a bicycle pedal which can move the chain in both the directions to a certain extent to enable the dynamic motion.

2. WORKING DRAWING



Chain-sprocket upper View- Closed Panels



Chain Sprocket Upper view: Open Panels

Chain Sprocket Operation

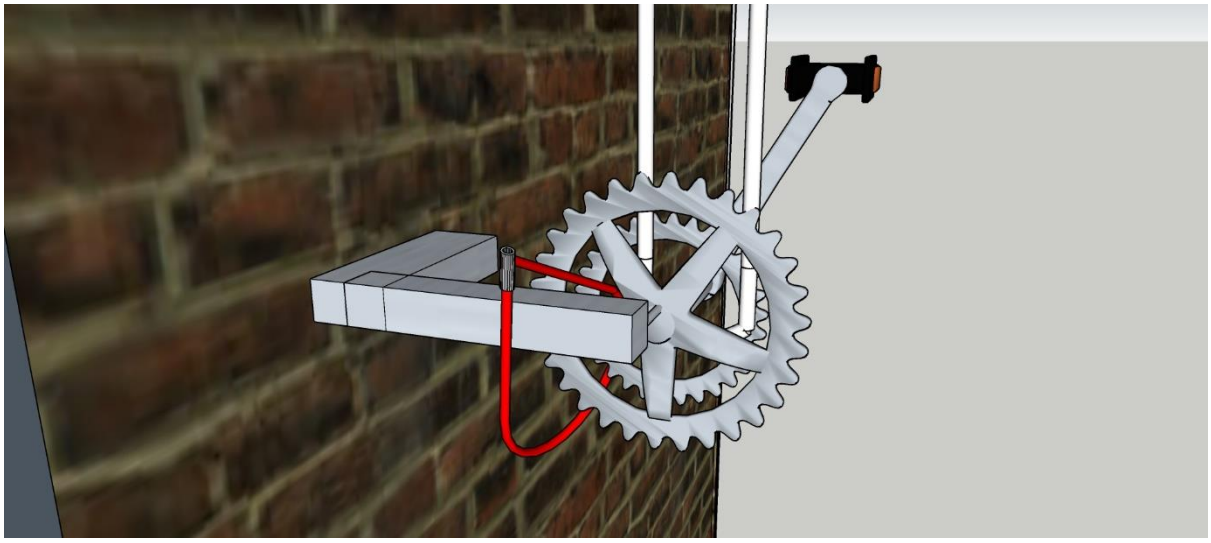
3. MATERIAL REQUIREMENTS

Ecoboard (Conduct aerodynamic analysis of the panels on a software (eg. Ansys fluent) to determine the optimum panel size), metal pipe with square cross section, metal pipe with circular cross section, metal strips, PPGI/GI sheet, bearings (the inside diameter of bearing should match the outside diameter of round pipe), chains, sprockets, self-screws, pulley.

4. FABRICATION AND INSTALLATION

1. Make a fractal design of 12 ft x 8 ft.
2. Calculate the fractals required for the roof.
3. Work out the geometry of the fractals on the roof.
4. Make base frame using square pipes.
5. Weld the support on the base frame using square pipes.
6. Fix base frame on the roof.
7. Weld bearing support pillars using flat metal strips.
8. Weld bearing collars on the metal strips.

9. Fix bearings inside the collars.
10. Insert sprockets inside the round pipe and weld them.
11. The sprockets need to be aligned and welded perfectly in a straight line for smooth functioning of the chains.
12. Synchronize the chains and fix them.
13. Insert the pipes inside the bearing.
14. Make frames using metal strips.
15. Fix the Ecoboard on the frames.
16. Place the framed ecoboard on the round pipe and ensure that there is no sagging.
17. Proceed to weld frames on the round pipe.
18. Fix the pulley in front of the first frame.
19. Fix another pulley down in line with the last pulley so that it is accessible to the human hand
20. Fix chains between the last two pulleys
21. Fix a pedal on the last pulley.
22. Provide a pedal lock on the pedal for locking the mechanism in one position.



Pedal System : Zoomed view

5. INSTALLATION IMAGE

Ecoboard Chain Sprocket (Closed and Open)

B. ALUFOIL

DESCRIPTION

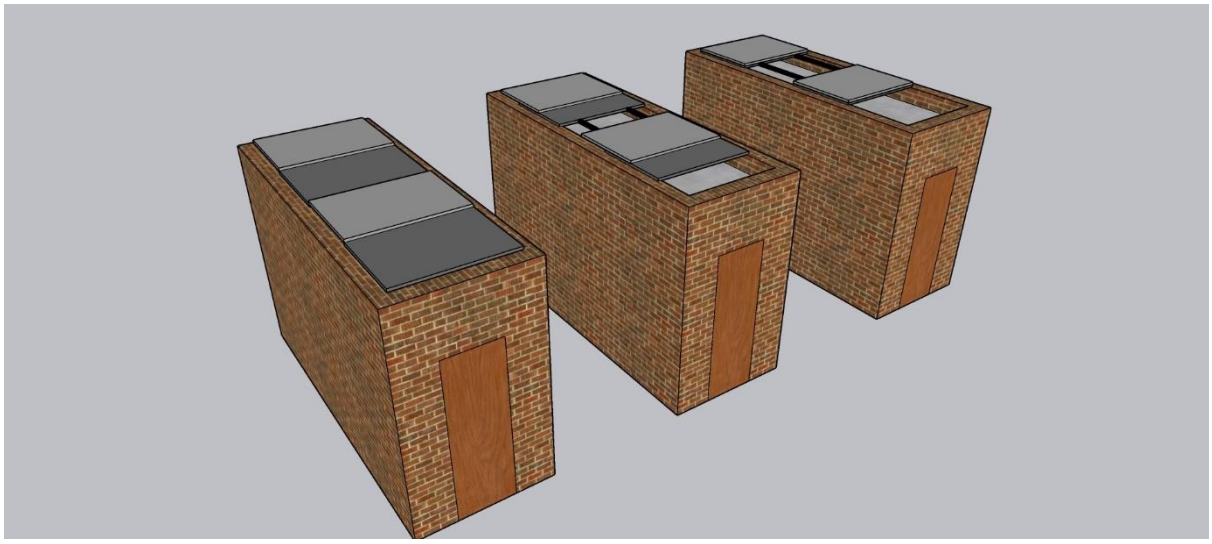
Cross-linked polyethylene foam (also known as XLPE) is a closed-cell foam characterised by a compact feel and resistance to water. It is covered with a low-emissivity and high reflectivity aluminium coating on one side which ensures no heat is emitted inside the space.

MECHANISM 1 – SLIDING

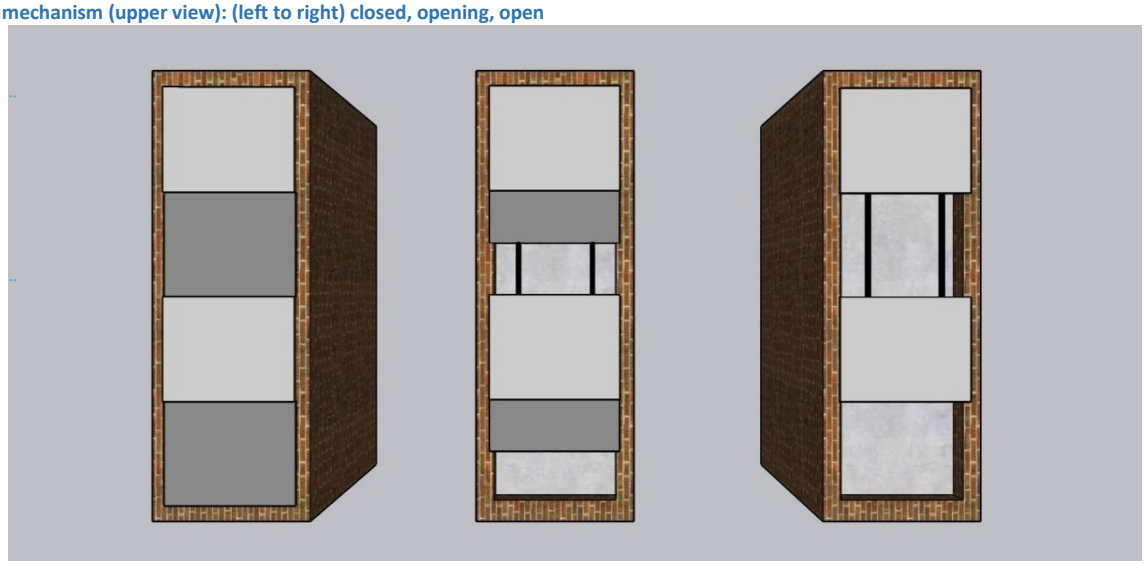
1. MECHANISM DESCRIPTION

The sliding mechanism operates on the principles of sliding drawers, wherein channels and rollers help slide the boards to one end of the house to allow radiant barrier and night sky radiation principles at play. A pulley mechanism is incorporated within the system to handle the sliding movement for the resident.

2. WORKING DRAWINGS



Sliding mechanism (upper view): (left to right) closed, opening, open



3. MATERIAL REQUIREMENTS

Alufoil, metal pipe with square cross-section, metal-based c-type channels, metal strips, sliding roller bearings, nuts, bolts, pulley, rope

4. FABRICATION AND INSTALLATION

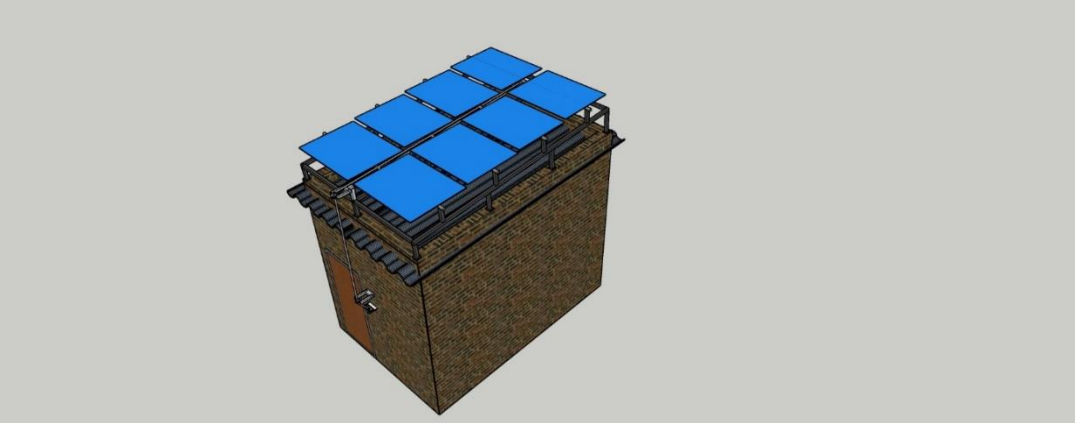
2. Make fractal design of 12 ft x 8 ft.
3. Calculate the fractals required for the roof.
4. Work out the geometry of the fractals on the roof.
5. Build a metal framework base on the roof.
6. Bolt the framework base to the roof with bolts.
7. Make the static frames on top of the framework by welding the strips.
8. Fix the material on this frame such that the shiny side is facing down.
9. Attach GI sheets on top of the material.
10. Beneath the static frame, make another frame through welding the metal strips to house the material.
11. Fix the material on this frame such that the shiny side is facing down.
12. Attach GI sheets on top of the material.
13. Provide c-channels on the sides for the bottom frame to slide in them.
14. Weld the connecting pipes on the frame.
15. Weld the other side of connecting pipes to the other similar frame.
16. Weld the nut beneath the base frame.
17. Weld long bolt beneath the bottom frame and ass it through the nut. This is called the half-nut mechanism.
18. Provide a long handle on the nut and bring it down to human height.

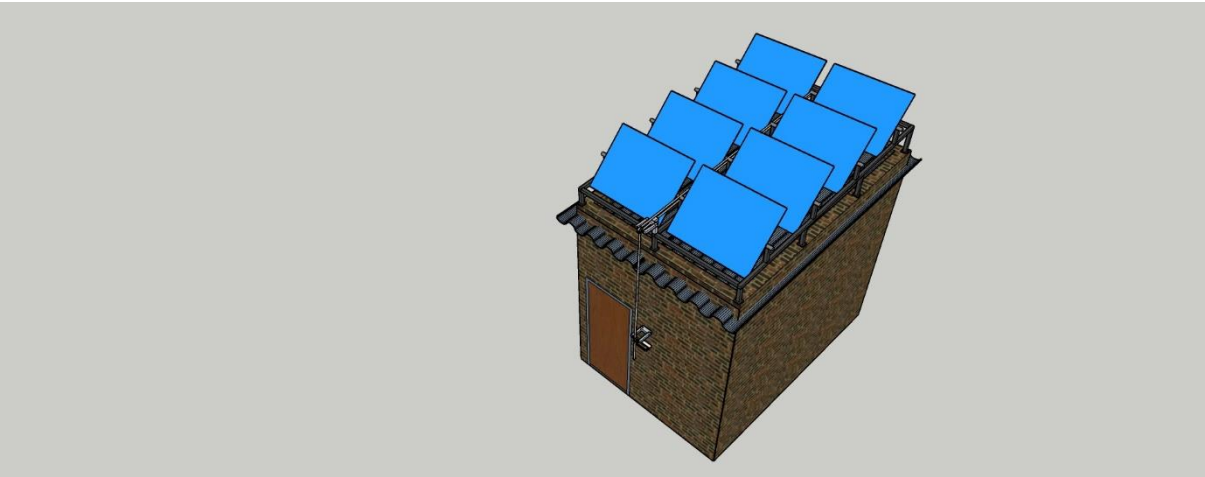
MECHANISM 2 – CHAIN AND SPROCKET

1. MECHANISM DESCRIPTION

The chain-sprocket mechanism works on the principle of louvres, wherein all the panels of the louvres get opened and closed at the same time to allow radiant barrier and night-sky radiation as required. The movement is enabled with the help of chain and sprockets. It is operated with the help of a bicycle pedal which can move the chain in both the directions to a certain extent to enable the dynamic motion.

2. WORKING DRAWING





Chain sprocket upper view: Open panels

Chain sprocket: Operation

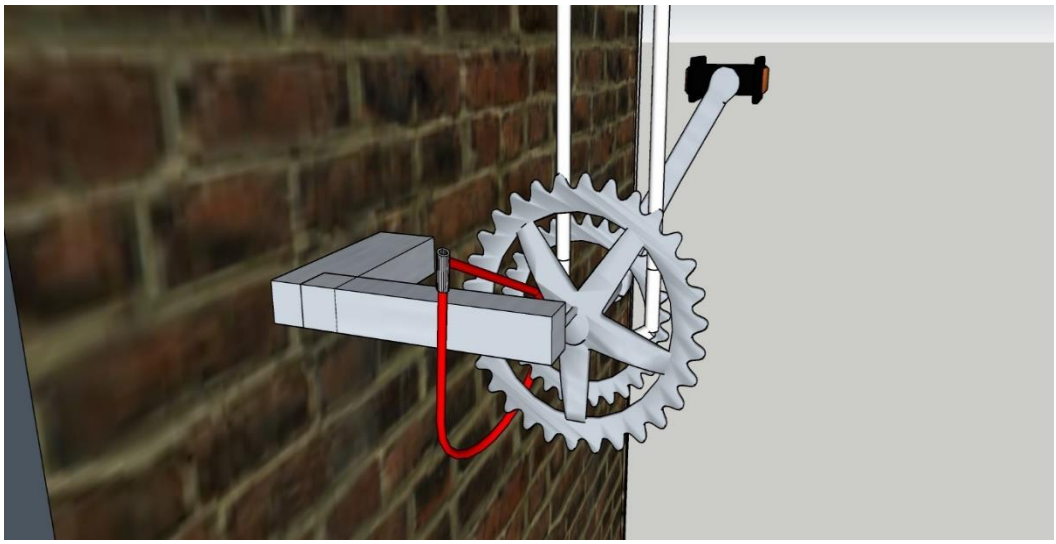
4. MATERIAL REQUIREMENTS

Alufoil, metal pipe with square cross section, metal pipe with circular cross section, bearings (The inside diameter of bearing should match the outside diameter of round pipe), chains, sprockets, self-screws, pulley, rope

5. FABRICATION AND INSTALLATION

1. Make a fractal design of 12 ft x 8 ft.
2. Calculate the fractals required for the roof.
3. Work out the geometry of the fractals on the roof.
4. Make base frame using square pipes.
5. Weld the support on the base frame using square pipes.
6. Fix the base frame on the roof.
7. Weld bearing support pillars using flat metal strips.
8. Weld bearing collars on the metal strips.
9. Fix bearings inside the collars.
10. Insert sprockets inside the round pipe and weld them. The sprockets need to be aligned and welded perfectly in a straight line for smooth functioning of the chains.

11. Insert the pipes inside the bearing.
12. Make frames using metal strips.
13. Fix the GI sheet on Alufoil using self-screws. The non-shiny side of the alufoil should be facing the GI sheet.
14. Fix the GI sheet with alufoil on the frames with the alufoil facing the roof i.e., the GI sheet should be facing the sky.
15. Weld frames on the round pipe.
16. There should be no sagging in the round pipe
17. Synchronize the chains and fix them.
18. Fix the pulley in front of the first frame.
19. Fix another pulley down in line with the last pulley so that it is accessible to the human hand
20. Fix chains between the last two pulleys
21. Fix a pedal on the last pulley.
22. Provide a pedal lock on the pedal for locking the mechanism in one position.



Pedal System: Zoomed view

6. INSTALLATION IMAGE

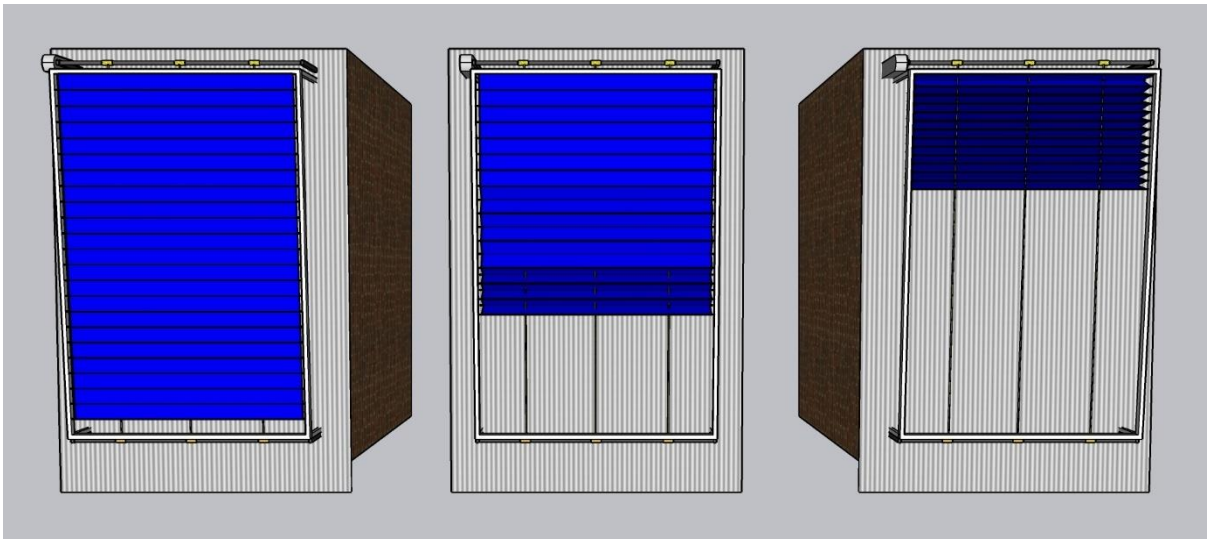
Alufoil Chain Sprocket Installation

MECHANISM 3- PIPE MOTOR

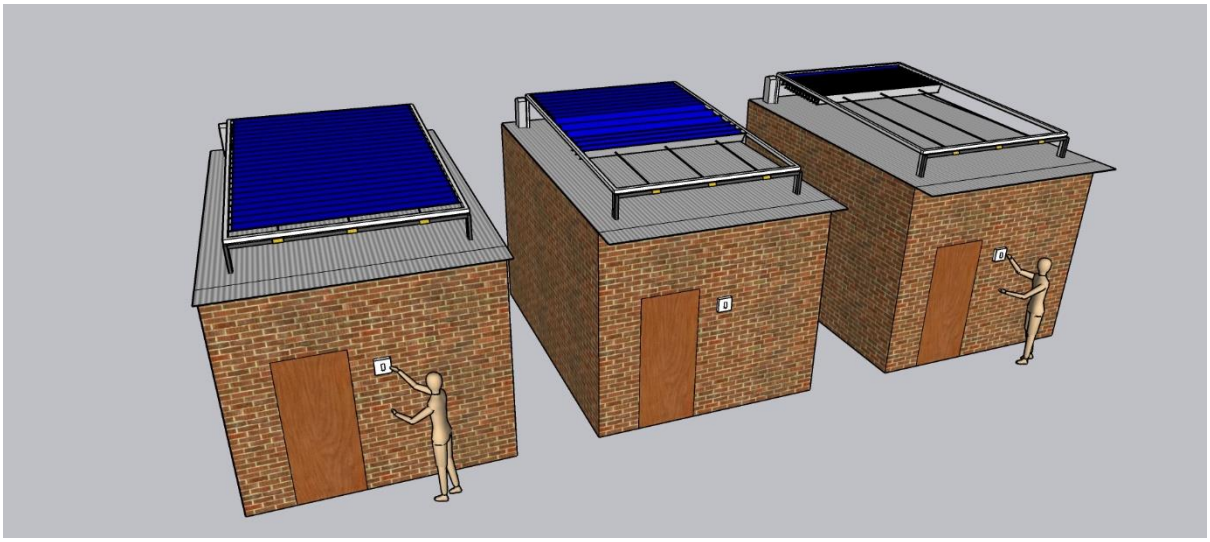
1. MECHANISM DESCRIPTION

The pipe motor mechanism is like an automated curtain mechanism where the Alufoil sheet can be folded and unfolded as required to work as a radiant barrier during the day and facilitate night sky radiation at night. The Alufoil is supported on a rope which winds and unwinds to enable opening and closing the alufoil that is resting on it. The rope is wound on the pipe which is controlled by a motor. There is a switch to enable the opening and closing of the mechanism.

2. WORKING DRAWINGS



Pipe motor mechanism (uper view): (left to right) closed , opening, open



Pipe motor mechanism operation: (left to right) closed , opening, open

3. MATERIAL REQUIREMENTS

Alufoil (The thickness of the alufoil should not be more than 8 mm) , metal pipe with square cross section, metal pipe with circular cross section, bearings (The internal diameter of bearing should match the outside diameter of round pipe) , chains, sprockets, self-screws, steel wire rope with pvc coating, silpaulin (The

silpaulin needs to be at least 120 gsm to ensure long life), nylon rope, thread and needle for sewing alufoil, motor, motor coupling, motor housing, motor cover, hole buttons, silpaulin sewing thread and needle.

4. FABRICATION AND INSTALLATION

1. Make a fractal design of 12 ft x 8 ft.
2. Calculate the fractals required for the roof.
3. Work out the geometry of the fractals on the roof.
4. Make base frame using square pipes.
5. Weld the support on the base frame using square pipes.
6. Weld inverted u-channels on the sides.
7. Put runners inside these channels.
8. Fix the base frame on the roof.
9. Weld bearing support pillars using flat metal strips.
10. Fix bearings inside the collars.
11. Fix pipe inside the bearings such that pipe goes through the bearing and extends on one side.
12. Fix the motor housing.
13. Fix the motor inside the housing.
14. Fix the motor cover on top of the motor
15. Connect the extended pipe and motor with the help of a coupling.
16. Divide the silpaulin into equal number of parts such that each part doesn't exceed 2 feet.
17. Make creases at every division.
18. Put a hollow steel pipe and sew it at every division to make the crease more visible.
19. Install hooks on the sides of these pipes.
20. Connect the hooks to the runners installed inside the side channels.
21. The hooks need to be exactly beneath the runners to avoid it being dragged behind them.
22. Towards the top side of each division of the creased silpaulin, make holes from which the rope will pass.
23. Fix the hole buttons in these holes.
24. Cut the Alufoil strips of the size of each panel.
25. Sew the Alufoil on the underside of the silpaulin such that shiny side is facing downward using Speb 7 or Fevicol SR 996.
26. Wind the steel wire ropes on the round pipe in one direction.
27. Pass the ropes from the hole buttons.
28. Pass the ropes over the pipe on the other end and bring it back to the initial position.
29. The mechanism should not experience sagging. For this tension in the rope is critical.
30. Wind the ropes on the pipe in the opposite direction.
31. Attach flip switch to the motor with the help of an electrician which rotates in the opposite direction when flipped.
32. The pipe which is connected to motor needs to be in one line with no sagging.

5. INSTALLATION IMAGE

Alufoil Pipe Motor (Closed)

MECHANISM 4 – STATIC

1. MECHANISM DESCRIPTION

This is a fixed/static installation and does not involve moving parts.

2. MATERIAL REQUIREMENTS

Alufoil, Fevicol SR 996/Speb 7 adhesive, metal pipe with square cross-section, metal strips, GI sheets, self-screw, paint

3. FABRICATION AND INSTALLATION

APPROACH 1 (under the roof installation):

1. Apply adhesive on the underside of the roof.
2. Apply adhesive on the non-shiny side of the alufoil.
3. Paste the alufoil onto the roof. Ensure the shiny side faces down.
4. Stick from one direction to ensure that no air gaps get created.

APPROACH 2 (over the roof installation):

1. Cut GI sheets according to the roof measurements.
2. Cut Alufoil sheet according to the size of the GI sheets.
3. Stick the alufoil sheet to the GI sheet. The adhesive must be applied on the non-shiny side of the alufoil.
4. Cut square cross-section metal pipes according to make a frame.
5. Place this frame at 0.5 ft height from the roof to ensure there is provision for little airflow beneath it.
6. Paint the frame.

7. Fix the alufoil with GI sheet on the metal frame using self-drilling screw. Ensure the shiny side is facing down.

4. INSTALLATION IMAGE:

C. ROOF TOP GARDENING

DESCRIPTION

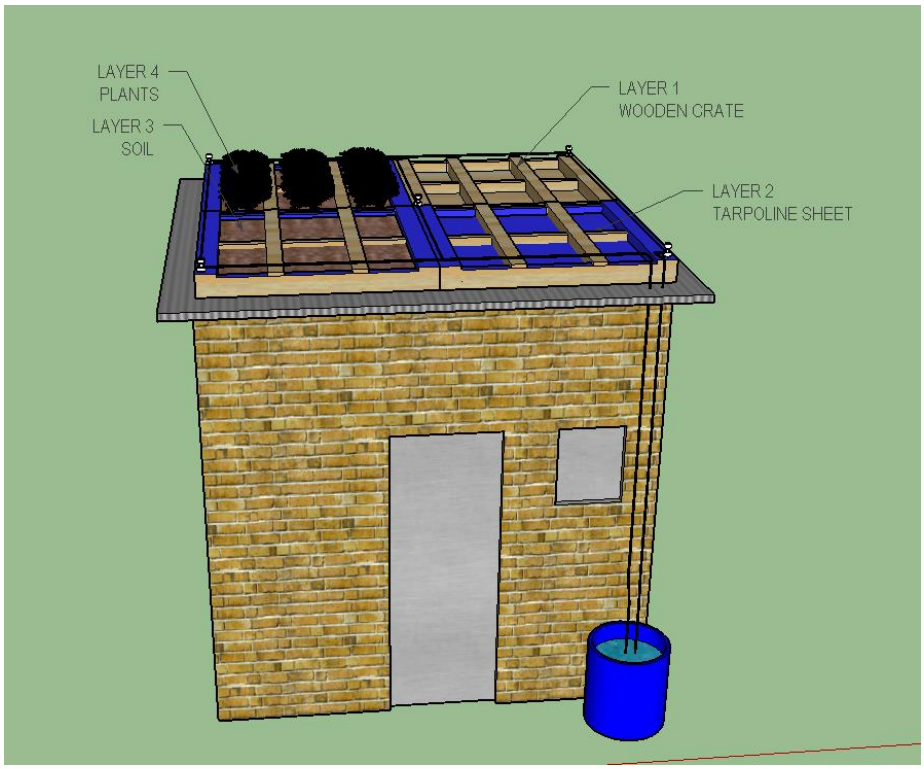
A layer of vegetation cultivated in diverse ways on the roof eg. In pots, brick beds, wooden crates, grow bags, etc.

MECHANISM 1 – WOODEN FRAME

1. MECHANISM DESCRIPTION

A rectangular or square structure with wooden planks installed on the roof serves as a growing space for vegetables and fruits which facilitate shading and cooling through the thermal mass of the soil, in addition to serving as a source of food for the homeowner.

2. WORKING DRAWING



3. MATERIAL REQUIREMENTS

Wooden planks, soil, compost, manure, cocopeat, native seeds (avoid seeds of plants like pumpkin, gourd, etc to avoid heavy load on the roof.), native seedlings (avoid plants like pumpkin, gourd, etc to avoid heavy load on the roof.), red-oxide paint, tarpaulin sheet, green net, bamboo sticks or wooden planks, zip locks, irrigation system (motor pump, PVC pipes, driplines, valves)

4. FABRICATION AND INSTALLATION

1. Ensure that roof is strong enough to bear the load of the soil, water and people who walk on the roof.
2. Vertical support beams of the house structure on which roof is laid should be grounded at least 1 foot deep.
3. Once it is ensured that structure has the capacity to bear the load of the installation the installation work can be commenced by cleaning the rooftop.
4. Apply red oxide paint on the roof and allow it to dry for 30 mins.
5. Spread a tarpaulin sheet over the roof.
6. Prepare a wooden frame according to the shape of the roof. It should be placed over the tarpaulin sheet.
7. The frame should be situated along the slope of the roof.
8. Ensure that a walking space of at least 1 foot is available at all edges of the roof.
9. Keep a holding rope along the pathway to support homeowners walk along the pathway.
10. Make holes on frame towards the lower side of the roof slope to support water drainage.
11. Fix chicken wire mesh (1.6 mm gauge) at the opening of the hole from outside the structure.
12. Prepare potting mix with soil, cocopeat, compost, neem cake/bonemeal powder. Suggested composition is soil (30%), cocopeat (45%), compost (20%), Neem cake/bone meal (5%). It is

recommended that the amount of soil be added and more biomass along with Biochar/charcoal be added to the potting mix.

13. Put the potting mix on the tarpaulin and spread it equally on all sides of the structure.
14. Ensure that the soil depth is at least 4-6 inches (Note: 15 bags of potting mix with 25 kgs in each bag is sufficient for a 40 square feet structure of 8 inches' depth.)
15. Sprinkle water so that the entire soil layer is wet.
16. Check for any cracks or bending under the roof.
17. If a bend is observed, immediately stop the work and provide extra beam support to the roof structure, so it can bear extra load.
18. Implement a drip irrigation system on the structure. For this:
    - Lay the drip lines on the soil
    - Fix the valves for every drip line and connect all drip lines with a common pipe
    - Connect this pipe to a water motor (1/2 hp capacity) kept in the house near water tank.
    - Connect the water motor to an electricity source.
    - Check that the water drops fall inside the bag and not outside
    - Fix any issues of water leakage on the path of pipes or on the roof.
    - Depending on the height of the roof and pressure of water, adjust time of watering so soil gets irrigated well.
19. After installing the irrigation system, raise 4 bamboo sticks on the roof.
20. Using zip-locks tie the green net to the bamboo sticks at a height of at least 3 feet from the roof.
21. Give an extra support stick from the centre of the green net. It should look like a cone-shaped elevated green shade net structure.
22. Place trellis sticks at the edge of the structure.
23. Separate sowing lines for each plant type to be made in the soil with fingers.
24. Ensure plant lines are at least 2 inches away from water drip line.
25. Put seeds of vegetables and plants (as appropriate for the season) at maximum depth of 2 inches in the soil.
26. Cover the seeds gently with soil.
27. Apply a light layer of dry grass on the soil as mulch.

5. MAINTENANCE GUIDELINES

1. Ensure that a staircase is available to access the roof whenever needed.
2. Limit frequent walking on the roof.
3. Check the soil moisture and overall health of plants periodically (at least once a week).
4. Regular checks to be made for rats, cats, dogs and other small animals who might build their homes or sleep in the soil.
5. Evaluate for any water leakage or cracks in pipes of drip irrigations system (at least once a week).
6. Evaluate for any water leakage or cracks in pipes of drip irrigations system once a week.
7. The roof should be checked regularly for any bending due to the weight.
8. If bending is observed the strength of the structure should be enhanced or the weight of the intervention will need to be reduced.
9. Ensure water availability in the water tank daily.
10. In case of failing of automated watering or no electricity, water the plants manually.
11. In case green net structure falls due to heavy winds or any other reason, reconstruct it back quickly.
12. Follow seasonal multi cropping of seeds.
13. After each season (3-4 months), rehash entire soil and mix more compost, cocopeat or manure to it and layer the soil again. Keep remnants of previous plants as biomass.
14. Keep irrigating the soil at least twice a day in summer season.

15. Clean the chicken mesh at drainage holes at least once in 3 months.
16. During monsoon, if water logging in the soil is found then manually remove the water.
17. Replenish with soil if too much of erosion is observed.

6. INSTALLATION IMAGE

At the end of the next section (with growbags)

MECHANISM 2– GROW BAGS

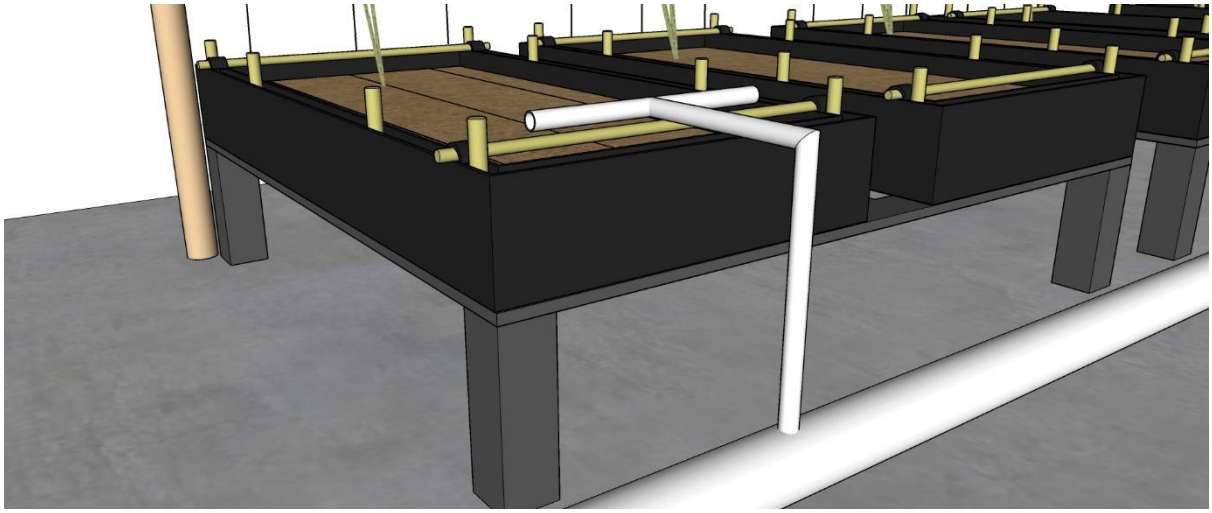
1. MECHANISM DESCRIPTION

Vegetables and fruits are grown over the roof in growbags. Growbags are made up bio fibre material. This installation supports cooling through shading and thermal mass of the soil, in addition to serving as a source of food for the homeowner.

2. WORKING DRAWING

Rooftop garden: zoomed out view.

Rooftop Garden: zoomed in roof view.



Rooftop Garden: Watering System

3. MATERIAL REQUIREMENTS

Growbags (4*2 square feet), bricks, soil, compost, manure, cocopeat, native seeds (avoid seeds of plants like pumpkin, gourd, etc to avoid heavy load on the roof.), native seedlings (avoid seeds of plants like pumpkin, gourd, etc to avoid heavy load on the roof.), green net, bamboo sticks or wooden planks, zip locks, irrigation system (motor pump, PVC pipes, driplines, valves)

4. FABRICATION AND INSTALLATION

1. Ensure that roof is strong enough to support the load of the soil, water and people who walk on the roof.
2. Vertical support beams of the house structure on which roof is laid should be grounded at least 1 foot deep.
3. Once it is ensured that structure is ready to bear the load of the installation the installation work can be commenced by cleaning the rooftop.
4. Make stands for grow bags with a height by welding square pipes.
5. Place growbags on the stands such that the longer side of the bag is along the slope
6. Ensure walking space of 1 foot at least is left from all edges of the roof.
7. Keep at least 2 feet between 2 growbags as walking space.
8. Prepare potting mix with soil, cocopeat, compost, neem cake/bonemeal powder. Suggested composition is soil (30%), cocopeat (45%), compost (20%), Neem cake/bone meal (5%).
9. Put the potting mix in the bags and spread it equally on all sides of the bag.
10. Ensure soil depth is at least 4-6 inches (Note: One growbag can have 100 kgs potting mix with soil height of 3 inches.)
11. Fix bamboo sticks (of 1 foot each) at all the 4 corners, so a proper rectangular shape of bag is maintained.
12. Tie ropes in a mesh form to make guideways for creepers to grow.
13. Sprinkle water over the entire soil layer.
14. Implement a drip irrigation system on the structure. For this:
    - Lay the drip lines on the soil
    - Fix the valves for every drip line and connect all drip lines with a common pipe
    - Connect this pipe to a water motor (1/2 hp capacity) kept inside the house near water tank.
    - Connect the water motor to an electricity source.

- Check that the water drops fall inside the bag and not outside
- Fix any issues of water leakage on the path of pipes or on the roof.
- Depending on the height of the roof and pressure of water, adjust time of watering so soil gets irrigated well.

15. After installing the irrigation system, raise 4 bamboo sticks on the roof.
16. Use zip-locks to tie green net to the bamboo sticks at a height of at least 3 feet from the roof.
17. Give an extra support stick from the centre of the green net. It should look like a cone-shaped elevated green shade net structure.
18. Place trellis sticks at the edge of the structure.
19. Separate sowing lines for each plant type to be made in the soil with fingers.
20. Ensure plant lines are at least 2 inches away from water drip line.
21. Put seeds of vegetables and plants (as appropriate for the season) at maximum depth of 2 inches in the soil.
22. Cover the seeds gently with soil.
23. Apply light layer of dry grass on the soil as mulch.

5. MAINTENANCE GUIDELINES

1. Ensure that a staircase is available to access the roof whenever needed.
2. Limit frequent walking on the roof.
3. Check the soil moisture and overall health of plants periodically (at least once a week).
4. Regular checks to be made for rats, cats, dogs and other small animals who might build their homes or sleep in the soil.
5. Evaluate for any water leakage or cracks in pipes of drip irrigations system (at least once a week).
6. The roof should be checked regularly for any bending due to the weight.
7. If bending is observed the strength of the structure should be enhanced or the weight of the intervention will need to be reduced.
8. Ensure water availability in the water tank on a daily basis.
9. In case of failing of automated watering or no electricity, water the plants manually.
10. In case green net structure falls due to heavy winds or any other reason, reconstruct it quickly.
11. Follow seasonal multi cropping of seeds.
12. After each season (3-4 months), rehash entire soil and mix more compost, cocopeat or manure to it and layer the soil again. Keep remnants of previous plants as biomass.
13. Keep irrigating the soil at least twice a day in summer season.
14. During monsoon, if water logging in the soil is found then manually remove the water.
15. Replenish with soil if too much of erosion is observed.

6. INSTALLATION IMAGE

Rooftop Garden: Grow Bag (left), Wooden Frame (right)

Rooftop Garden Irrigation System

D. DORMER WINDOW

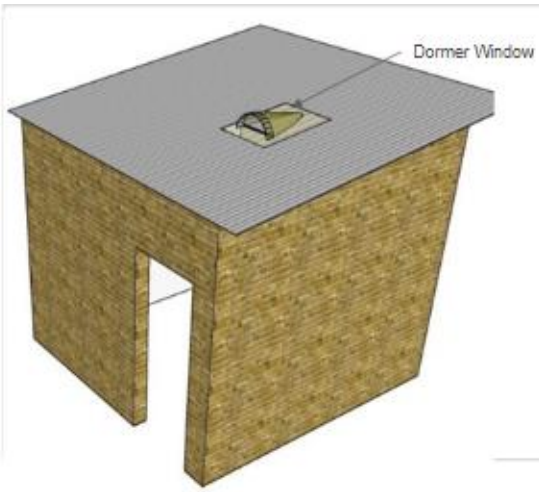
DESCRIPTION

Dormer window is a hump shaped window that is designed to be retrofitted onto existing corrugated steel/tin/cement roofs. It is made of fibreglass moulded into a hump to be retrofitted. The pane is made of translucent plastic to diffuse light and avoid glare.

1. MECHANISM DESCRIPTION

The mechanism works on the principle of convective ventilation where warm air rises up and vents out of the Dormer window. The window ideally needs to be fit on the highest available height for the principle to function. The fibre reinforced plastic is moulded into a hump with an opening at the bottom towards interior of the house to allow warm air to circulate and vent. The gap is covered with a metal net to prevent insects and other animals from getting in the house.

2. WORKING DRAWINGS



Over the Roof View

Under the Roof View

3. MATERIAL REQUIREMENTS

Hump shaped male and female mould made up of wood, fibre reinforced plastic (FRP) sheet (3 mm), roofing sheet cutter, nuts and bolts, cement, waterproofing solution, metal net.

4. FABRICATION AND INSTALLATION

1. Fabricate and prepare the hump shaped mould with the curved part at a height of at least 15 cm (this is the height up to which water splashes after hitting the roof during rains, hence this height will avoid the water to enter through the window's opening) that can be used to fabricate every dormer window structure in one piece.
2. Fabricate the base of the dormer window as per exact measurements of crest and trough of the roofing sheet of the structure where the dormer window will be installed.
3. Manufacture and cast the dormer window in one piece using the mould technique so that no cracks or openings are left for water inlet or leakage, based on the following steps:
    - Lay the FRP sheet over the male part of the mould.
    - Heat the FRP sheet
    - Put the female mould on the sheet and press it

- Mould the plastic sheet in such a way that the semi-circular opening is covered with a small overhang of around 4-5" to prevent the rains from coming in the house.

4. Cover the semi-circular opening that will be facing outward above the roof with a metal net for preventing insects, animals and birds from entering the house through the dormer window.
5. Identify a suitable location on the roof to install the dormer window using the guidelines below:
    - The highest part in the room.
    - Opposite the existing window or the door for the stack ventilation principle to work in the house, where the door/window becomes an inlet and dormer acts as an outlet.
    - Maintain at least a 4 feet distance of the opening from the fan, so it does not create counter air pressures that can pull and circulate the warm air that collects at the top
6. Cut the portion of the roof identified through the above analysis based on the dormer window dimensions.
7. Install the front part i.e., the opening of the dormer window towards the slope of the roof to prevent the rainwater coming in the house.
8. Install the opening of the window facing the leeward side.
9. Fix the dormer window with the help of self-tapping screws as well as adhesive in between the sheet of dormer window and the roof with the horizontal holds resting on the existing roof.
10. Apply a coat of silicon along the joint between the window and existing roof to prevent water leakage and strengthen the joints.
11. Provide u-channels from the periphery of the dormer window from the inside and extend them outside the house to make guideways for water that might enter the house.
12. Include sliding mechanism to open and close the window from the inside by using aluminium sliding mechanism.

5. INSTALLATION IMAGE

E. WOOD WOOL PANEL

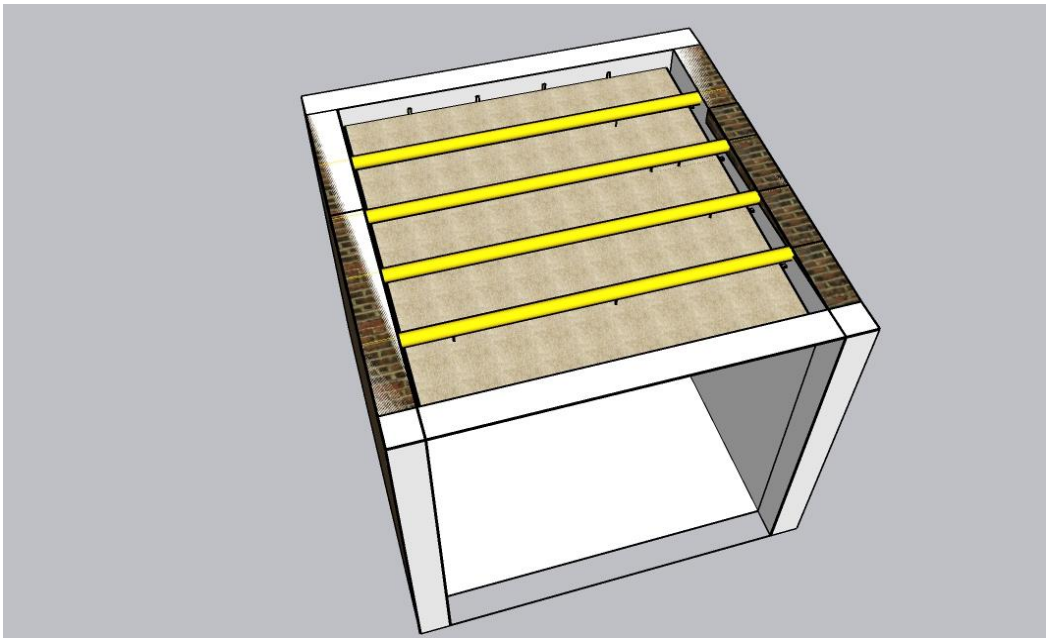
DESCRIPTION

Wood Wool Panel is an environment-friendly, recyclable material made from wood wool, cement and water. It is installed under the roof.

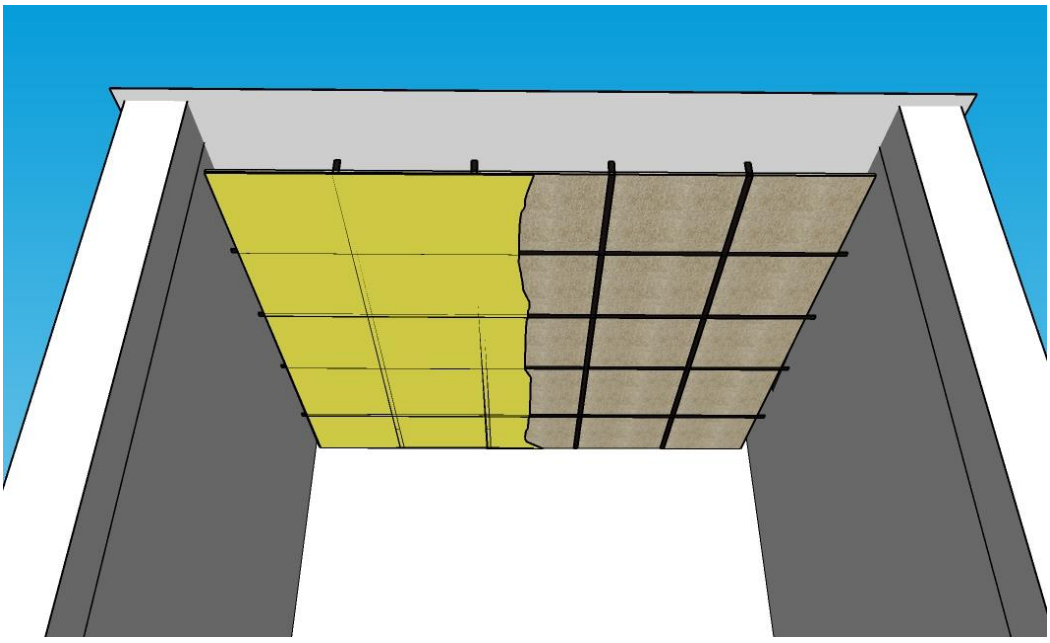
1. MECHANISM DESCRIPTION

This is a fixed/static installation and does not involve moving parts.

2. WORKING DRAWING



Wood Wool: Upper view (minus roof)



Wood Wool: Under the roof view (panels and silpaulin both visible)

3. MATERIAL REQUIREMENTS

Wood wool panels, L-angle metal plates, Small metal pieces for support, GI wire

4. FABRICATION AND INSTALLATION

1. If there are cracks on the roof close/seal the cracks by using adhesives, stick tar sheet. Place a tarpaulin sheet or extra roofing sheet over the cracks if none of the other sealing solutions are available.
2. Cut 4 L-angles each being of the size of the edge of the wood wool panel.
3. Paint them
4. Weld one L-angle on one end of the house beneath the roof
5. Weld the second L-angle at a distance equal to the width of the panel
6. Weld the third L-angle connecting one end of the above two sides
7. Fix the panel inside these three-support frames
8. Weld the fourth L-angle
9. Repeat the process for the other panels
10. Stick a tarpaulin sheet from beneath to prevent any particles falling from the board

5. INSTALLATION IMAGE

F) WATER FILLED PET BOTTLE

DESCRIPTION

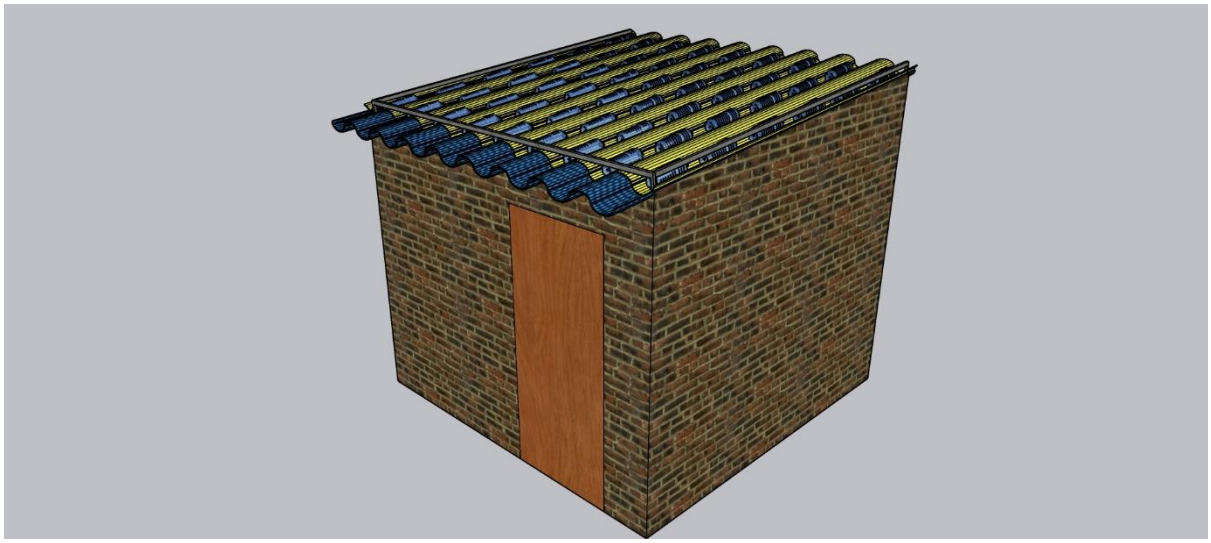
Plastic PET Bottles which are generally used for packaging water or beverages are filled with water and placed above the roof.

1. MECHANISM DESCRIPTION

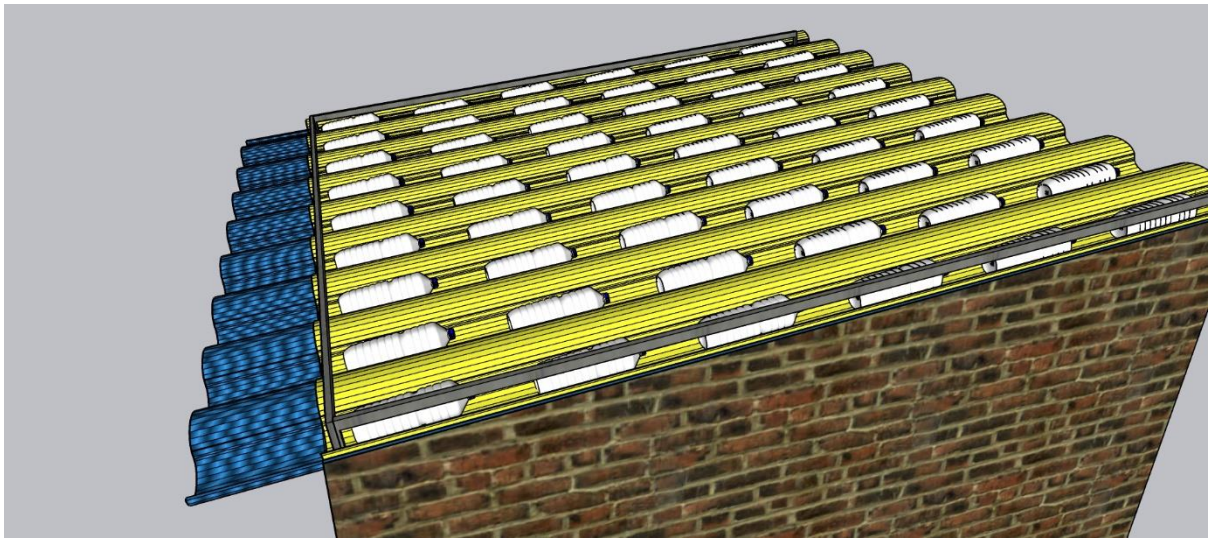
Water has the highest specific heat capacity than any liquid. Specific heat is defined as the amount of heat one gram of a substance must absorb or lose to change its temperature by one degree Celsius. For water, this amount is one calorie, or 4.184 joules. Thus, it can absorb a lot of heat before its temperature rises. This trait helps it to stabilize temperature in its surroundings. To benefit from this heat resisting property of water,

discarded PET bottles are filled with water and stuck on the roof. This low cost, zero energy passive thermal comfort solution increases the thermal mass of the roof i.e., its ability to store heat, for a longer duration before letting it seep into the house through the day and reversing the heat transfer process of the water during the night, since the warmed water during the day gets cooled during the night due to the drop in ambient temperature, which in turn keeps the roof cool the next morning even when the sun starts to heat up.

2. WORKING DRAWING



Water filled PET bottles: Zoomed out view



Water Filled PET bottles: Zoomed-in view

3. MATERIAL REQUIREMENTS

Old or new plastic bottles without any cracks, water to fill bottles, HDPE material tarpaulin sheet, good quality adhesives - Fevicol SR 996 &Speb 7 adhesive.

4. FABRICATION AND INSTALLATION

I. Bottle Preparation :

A. METHOD 1: The bottles are stuck without any coating and with an estimation of 1 bottle/sq. ft.

B. METHOD 2: The bottles are painted with white reflective paint. An average thermal comfort improvement of 1 deg C as compared to the base case has been observed through this method by experimentation.
C. METHOD 3: The bottles are coated with low-emissivity plaster. An average thermal comfort improvement of 1 deg C as compared to the base case has been observed through this method by experimentation.
D. METHOD 4: The intensity of bottles is increased to 2 bottles/sq. ft. to increase the thermal mass on the roof through higher volume of water. An average thermal comfort improvement of 2 deg C as compared to the base case has been observed through this method by experimentation.

II. Bottle Installation

1. Remove dust or any obstacles from the roof.
2. Apply adhesive on the roof and place a double layer of tarpaulin over it. (Single layer of tarpaulin is also sufficient; however double layering gives an extra protection from monsoon.)
3. Wait for minimum 15 minutes for the tarpaulin to stick to the roof.
4. Check at random points, if tarpaulin is glued adequately to the roof or not. Come down from the roof post this activity.
5. Remove all labels from the bottles.
6. Fill all bottles with normal temperature water and fix the caps tightly. Ensure there is no water leakage from any side of the bottle.
7. Gently carry the bottles on the roof and place them at a regular interval from each other.
8. The points below share guidance on how to place the bottles:
    - If roof has trough and crest (like a wave) then place bottles in trough gaps. This will ensure that water does not get stagnant on the roof due to the bottles.
    - Point the cap of the bottle in the opposite of the slope of the roof.
    - Good spacing would be 4-6 inches between two bottles.
    - Leave half foot space on all the edges of the roof for walking.
    - If the structure has very high strength (e.g., Very strong roof sheet, good supports), no. of bottles = 2 x roof area in sq. ft.
    - If the structure has high strength (e.g., Adequately strong roof sheet, adequate supports), no. of bottles = 1.5 x roof area in sq. ft.
    - If the structure has average strength, no. of bottles = roof area in sq. ft.
    - If the structure has weak strength (e.g., cracked sheets, weak support), no. of bottles = 0.75 x roof area in sq. ft.
    - Ensure that bottles are not fixed on broken or bent parts of the roof.
9. Apply Fevicol or SR 996 adhesive to one side of PET bottle and to tarpaulin sheet.
10. Place each PET bottle over the glue and apply some pressure, so that it sticks firmly.
11. Perform a random check to see if the bottles are glued well to the tarpaulin.
12. Install a pipe frame on the periphery of the roof at low height (lower than the width of bottle) on three sides (lower end and on the sides) to prevent the bottles from falling down in case it comes off.

5. MAINTENANCE GUIDELINES

1. Check the roof once a month for any cracks or misplaced bottles.
2. Replace bottles as applicable.

6. INSTALLATION IMAGE

C.ACADEMIC ENGAGEMENT PROCESS

'Academic engagement' was part of the effort to catalyse the heads, hearts and hands of the architects of the future to work with people living in marginalized urban spaces.

The engagement comprised of:

1) Collaboration with students of architecture and engineering as part of college internships to create space for them to collaborate with the project team and build their capacities and work towards ensuring thermally comfortable homes for inhabitants of informal settlements

2) Engaging with the Architecture Board of Studies to advocate for the seamless integration of Informal Housing, sustainable cooling and related socio-ecological justice perspectives in Architecture curriculum.

The steps undertaken to facilitate the two engagements are mentioned below.

1. COLLABORATION WITH ARCHITECTURE AND ENGINEERING COLLEGES

RATIONALE

- To create a space for architecture and mechanical engineering undergraduate students to develop their skills and manifest their academic knowledge in practice by working hands-on on the issue of heat stress with communities inhabiting informal settlements in a participatory manner.
- To sensitize professors of architecture to the issue of thermal comfort in informal settlements and create a space for them to contribute to the co-creation of solutions by playing the role of design mentors in the project.

APPROACH

1. Identify specific areas of engagement for architecture and engineering students within the project
2. Connect with professors of local architecture and engineering colleges in your project area to introduce the project
3. Propose the thought of engaging with students through the internship
4. If professors' express interest, co-create the internship engagement with them and identify a suitable time period to engage students in the internship
5. Propose the idea of professors playing the role of design mentors who guide students through the internship in collaboration with the project team
6. Send internship invitations with the project details to students and get to know them through a suitable method such as a form filling exercise to assess their motivation and/or a in person interview
7. Reach out to students who are selected
8. Orient students to the overall work of the organisation and share details of the projects 'Why', 'What' and 'How'.
9. Ensure that students are getting mentored by the team members on specific tasks. However, don't spoon-feed them
10. Create a safe space for students to share their suggestions, questions and concerns uninhibitedly, throughout the project process
11. Share specifics of student's roles and responsibilities
12. Schedule periodical reviews with students, mentors and the project team to guide, receive inputs and assess the progress of the work
13. Involve students in desk work and on-field engagement both, to ensure a holistic learning experience that nourishes their head, hearts and hands i.e. involve students in material research, etc design,

curriculum review, community engagement, house audits, installation supervision and other places where they can contribute and learn, parallelly.

14. Ask students to document their project work in writing
15. Schedule a review call with students at the end of the internship to learn about their experiences and understand how such engagements can be sustained and replicated in the future

2. BOARD OF STUDIES ENGAGEMENT FOR CURRICULUM CHANGE

RATIONALE:

To analyse and identify architecture curriculum gaps through the lens of exclusion of Informal Housing, Thermal Comfort and sustainable architecture perspectives and make a case for the inclusion of these perspectives to Board of Studies members.

APPROACH:

1. Identify the architecture university/s your project team would like to collaborate with.
2. Download the most recent curriculum from a university website.
3. Review the curriculum at a preliminary level to understand its overall flow
4. Invite architecture students to share their first-hand experiences on curriculum gaps they observe as 'learners'
5. Critically analyse each subject of the curriculum to identify gaps and potential spaces for the seamless integration of Informal Housing, Passive (sustainable) design and thermal comfort that can facilitate contributing to socio-ecological justice related architecture perspectives through architecture education.
6. Make suggestions for the integration of missing elements in the curriculum (This can be in the form of a theory subject or an activity)
7. Summarize the findings from the curriculum analysis to make the case for the integration of missing perspectives through a position paper
8. Create a 'Pedagogy Manual' which encapsulates all the activities suggested in the curriculum.
9. Identify and reach out to the heads of BoS of universities of the analysed curriculum.
10. Share the position paper to catalyse them to engage in the effort for curriculum change
11. Once Board of Studies members express interest in working on curriculum change, reach out to them to understand pathways to facilitate participatory curriculum modelling.
12. Understand the change management process of the University to identify the ideal time to propose curriculum change based on their curriculum change schedule/ cycle.
13. Identify appropriate communication models based on the curriculum change cycle of the university. (eg. Since one of the universities that was engaged with as part of the project was already in between its curriculum change process, the curriculum change recommendations were shared with them, which was followed by engaging over a collective session with all the BoS members over a meeting. In the other university, one-on-one listening approach was considered to listen to BOS members views on the proposition for the inclusion of informal housing, thermal comfort, passive design topics as part of the curriculum. The engagement was halted after this step, since the BOS members were not at the curriculum change stage of their work and were supposed to be re-elected in the year to come)
14. Propose a visit to the 'Informal Housing Thermal Comfort' intervention site for grounding in the issue, followed by a roundtable where Board members and project team can meet and co-create the curriculum and move towards capacity building on new concepts as part of the recommendation.

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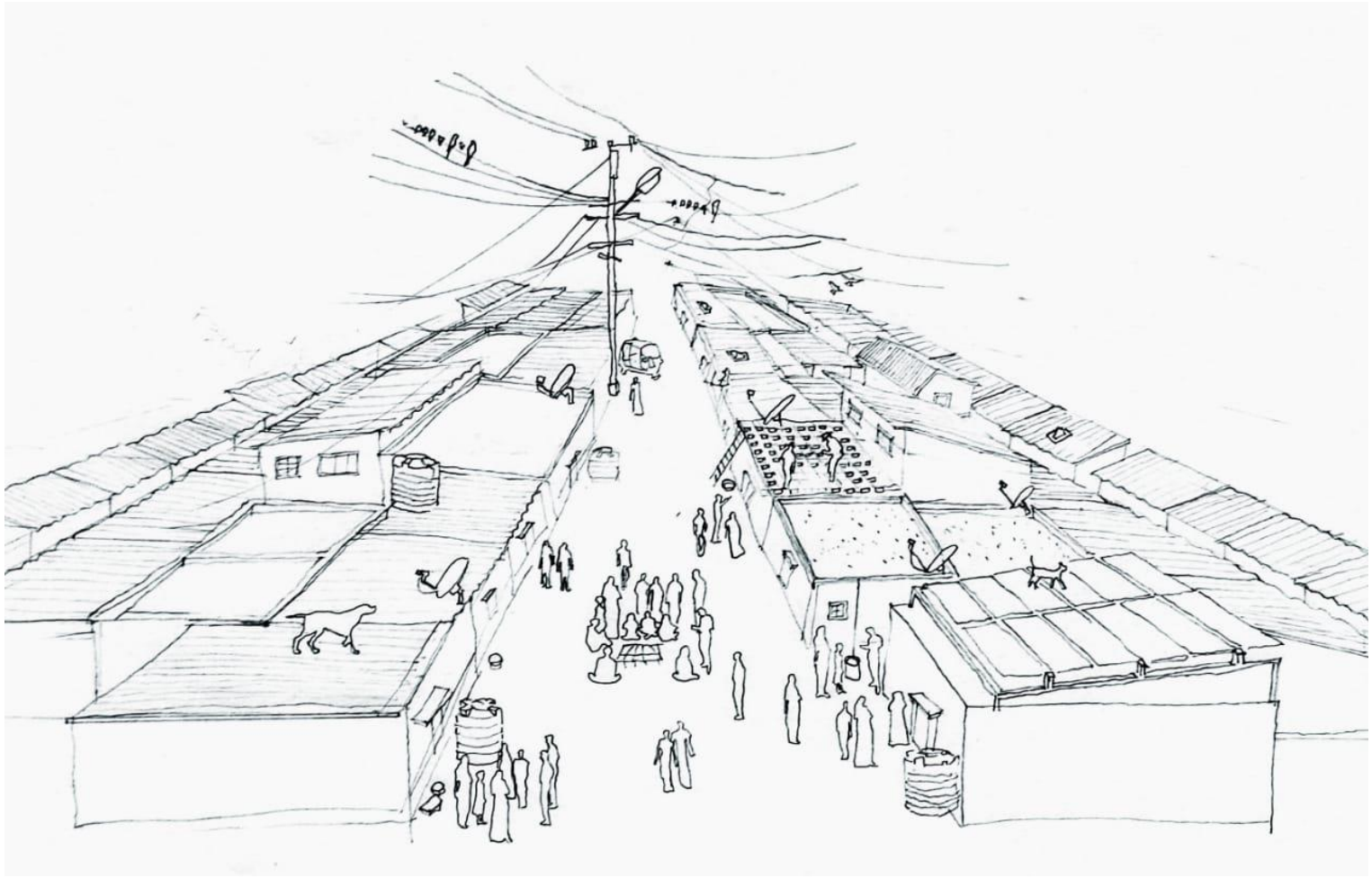

THE INFORMAL HOUSING THERMAL COMFORT PROJECT (PILOT)

INSIGHT REPORT
(OCTOBER 2021-APRIL 2022)

Ashden
Climate Solutions in Action

CBALANCE
carbon • cost • community • climate

ACKNOWLEDGEMENTS

The 'Informal Housing Thermal Comfort' (cBalance) team would like to express their heartfelt gratitude to Mr. Surendra Shah, our lighthouse of hope-through-grass rooted-action in service of climate justice, who catalysed this endeavour in 2015 with spurring, illuminating insights about the systemic neglect of the extreme heat stress endured by residents of informal settlements in our cities, and a possible local contextual response to them – easily fabricated radiant barriers using readily available materials used in the built-space economy.

We are grateful to Kunda Ramgade and Maya Gaikwad - the women who shared their humbling stories of thermal discomfort in the informal structures they inhabit and for their willingness to participate in retrofitting experiments which involved installing an Alufoil barrier in their homes in the year 2017.

We are also grateful to Saath, Mahila Sewa Housing Trust, India Housing Federation, Micro Home Solutions, Shelter Associates, Homes in the City Network, Hunnarshala Foundation, Ghar Bachao Ghar Banao Andolan and Habitat & Livelihood Welfare Association who shared their experience of working with communities in Informal settlements, which supported us as we strategized our work on the 'Informal Housing Thermal Comfort' (Pilot) project.

We would like to express profound gratitude to our academic coordinator and design mentors (Yogesh Dandekar, Chetan Sahasrabuddhe, Gautami Renuse, and Nishant Rathod) and design interns (Shruti Srivastav, Manasi Jadhav, Zarina Partapurwala, Bhupesh Garg, Leelavathy, Dhananjay Andhale, Noel Prabhakar, Vaishnavi Deshpande and students from the Ananth National Fellowship cohort) who have made invaluable contributions to this endeavour. We are also humbled and encouraged by the contribution of professors from colleges affiliated with BNCA, Pune and Allana College of Architecture, Pune who mentored us through the design process and encouraged their students to participate in this thermal comfort effort as part of their curriculum.

We are grateful to the grassroots organisations 'Hasiru Dala' and Maharashtra Social Housing and Action League (MASHAL) who anchored our engagement with communities in Bangalore and Pune respectively. Their rapport with the local communities and their knowledge on how to navigate through different scenarios encountered on field, has helped us persevere mindfully on this journey.

This experimental endeavour would not have been possible without the love, support and participation of the community members inhabiting the settlements of Shindevasti in Pune and Jyothipura in Bangalore. Words fall short for us to express the joy we have experienced while working with these communities and we are truly indebted to them for their love towards our team and for the knowledge they have shared with us, ever since we started engaging with them in April-May 2021.

We would like to express our heartfelt gratitude to the Ashden (Fair Cooling Fund) team for believing in this endeavour and for its empathetic engagement with us, throughout.

Ashden Climate Solutions in Action

CBALANCE carbon • cost • community • climate

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INSIDE THE REPORT

This report provides an overview of the journey and learnings from the implementation of the 'Informal Housing Thermal Comfort' project in two cities of India; Bangalore and Pune, spanning October 2020 to April 2022. This was the 'pilot' phase of the project. Its objective was to address and work towards addressing the issue of heat stress experienced by inhabitants of Informal settlements, through an approach of participatory co-creation of sustainable cooling roof retrofits for tin-roofed houses.

The intention of the report is to share learnings that can support organisations and individuals who are motivated to facilitate similar thermal comfort endeavours across informal settlements in India and similar contexts around the globe.

The report is structured in four sections:

The first section of the report summarizes the primary motivations that stimulated both 'the work' and 'the approach', on the issue of thermal comfort in India's Informal Settlements. It encapsulates observations on the energy-related injustices in Urban India, the shortcomings of the 'top-down' developmental approach and the need for capacity building amongst built-space professionals; to catalyse their head, heart and hands to contribute and work in a participatory manner especially with inhabitants of marginalized sections of our cities. It also includes a flowchart showcasing the project processes. It further summarizes ' Key Learnings' that emerged during the project process which validate the projects motivations. It ends by providing an overview of the projects progress until April 2022.

The second section provides an overview of the projects locations; the settlements of Jyothipura and Shindevasti situated in the cities of Bangalore and Pune, respectively.

The third section focuses on sharing detailed 'insights' derived from experiences of working in the above mentioned settlements. It begins by presenting learnings derived through interactions with NGO partners and community members during community workshops, meetings, trainings, installations and monitoring endeavours as part of the projects' 'Community Engagement' efforts. It further expands to the design process and insights, squaring down to each prototype design specific learnings in the 'Prototype Design and Installation' subsection. This is followed by sharing insights from 'Engagement with Academia' acquired through interactions with students and professors of architecture and engineering, which was an effort towards sensitizing and building the capacity of Architectural academia to work on the issue of thermal comfort in marginalized settlements. This section further shares learnings from interactions with Architectural Board of Studies (BOS) members as part of advocacy efforts for the seamless integration of sustainable cooling techniques and informal housing in architecture curricula.

The final section of the report i.e., the 'Way Forward' provides an overview of where the program is headed over the coming years and the long-term vision to work on augmenting 'Informal Housing Thermal Comfort' efforts across different cities in collaboration with local grassroots organisations, government entities and women's cooperatives who can spearhead this movement in varying capacities.

I. ABOUT THE PROJECT

A. THE ISSUE

1. THERMAL COMFORT-BASED INJUSTICES IN URBAN INDIA

Sleepless summer nights, unbearable daytime temperatures inhibiting household activities, health conditions such as nausea, headaches, heart palpitations and dizziness- these are few of the many heat stress related issues plaguing the lives of communities inhabiting ventilation deprived, tin roofed structures in marginalized settlements in urban India. While people in affluent urban neighbourhoods seek thermal comfort from energy intensive Air Conditioners (1) , many of them even having back-up power sources to support them during power cuts, their underprivileged counterparts inhabiting marginalized urban settlements can only afford minimal refuge from the heat through fans in addition to bearing the brunt of power cuts even during peak summers. Women, the elderly and children who spend more time indoors are disproportionately impacted by these occurrences. Further, while the elderly and children might be able to sit outside their homes to escape the indoor heat during peak summers, women who bear the inequitable responsibility of household responsibilities are forced to stay indoors to perform their chores.

On a climate collapsing planet battling with rising temperatures, addressing energy and thermal comfort-based injustices has become a non-negotiable necessity and inevitably necessitates working towards sustainable and affordable cooling techniques 'with' people inhabiting marginalized settlements.

2. INEFFECTIVE DEVELOPMENT APPROACHES

The exclusion of those who bear the brunt of socio-ecological injustices from decision-making processes aimed at addressing these injustices demands reconsideration. An approach of working 'with' people is essential for the meaningful implementation of any endeavour given that development programs based on 'top-down solution-imposing approaches' are short-lived. Top-down initiatives are often based on a 'one-size fits all approach' which are non-contextual and therefore lack meaningful impact. Additionally, in most cases once a program implementation body exits a locality, access to the solution and skills associated with the program are lost in their absence. These programs are mostly target oriented and do not focus on capacity and skill building of the community. Therefore, an approach that focuses on working in a 'participatory' manner with communities, to build their capacities and address thermal comfort issues, rather than simply providing direct solutions is warranted. This can support sustained impact and meaningful community led changes without external intervention. An effective approach to address the issue of thermal comfort based injustices in informal settlements would mean co-creating solutions with residents of informal settlements including members of women's groups and building

[1] A typical one ton split-AC in India consumes as much power as 25 ceiling fans

their capacities to manufacture, install and maintain these solutions. Such an approach can support communities in income generation and empower them to spearhead the movement for thermal comfort in their own localities.

3. INADEQUATE INFORMAL HOUSING BUILT SPACE PROFESSIONAL CAPACITY

Another major lacuna in the implementation and augmentation of efforts to co-create and work with communities in marginalized settlements is a lack of empathy, knowledge and skills that are needed to facilitate meaningful collaboration between built space professionals and local communities in marginalized settlements. Architects unquestionably have the agency to support the enhancement of the living conditions in these settlements. However, only 100 out of India's 427 architecture colleges offer even a single course that addresses energy efficiency. Of those, only 3 to 4 out of the 72 courses over the bachelor's degree course encompass the environment. Thus, even if sustainability centric building codes such as the Energy Conservation Building Code (ECBC) in India becomes mandatory there would be a lack of workforce to adequately handle its implementation. This observation culminated with the exclusion of informal housing perspectives in architecture curricula mandates a beginning-of-pipe approach to nurture architectural empathy, skills and knowledge to address thermal comfort and other spatial issues in informal settlements.

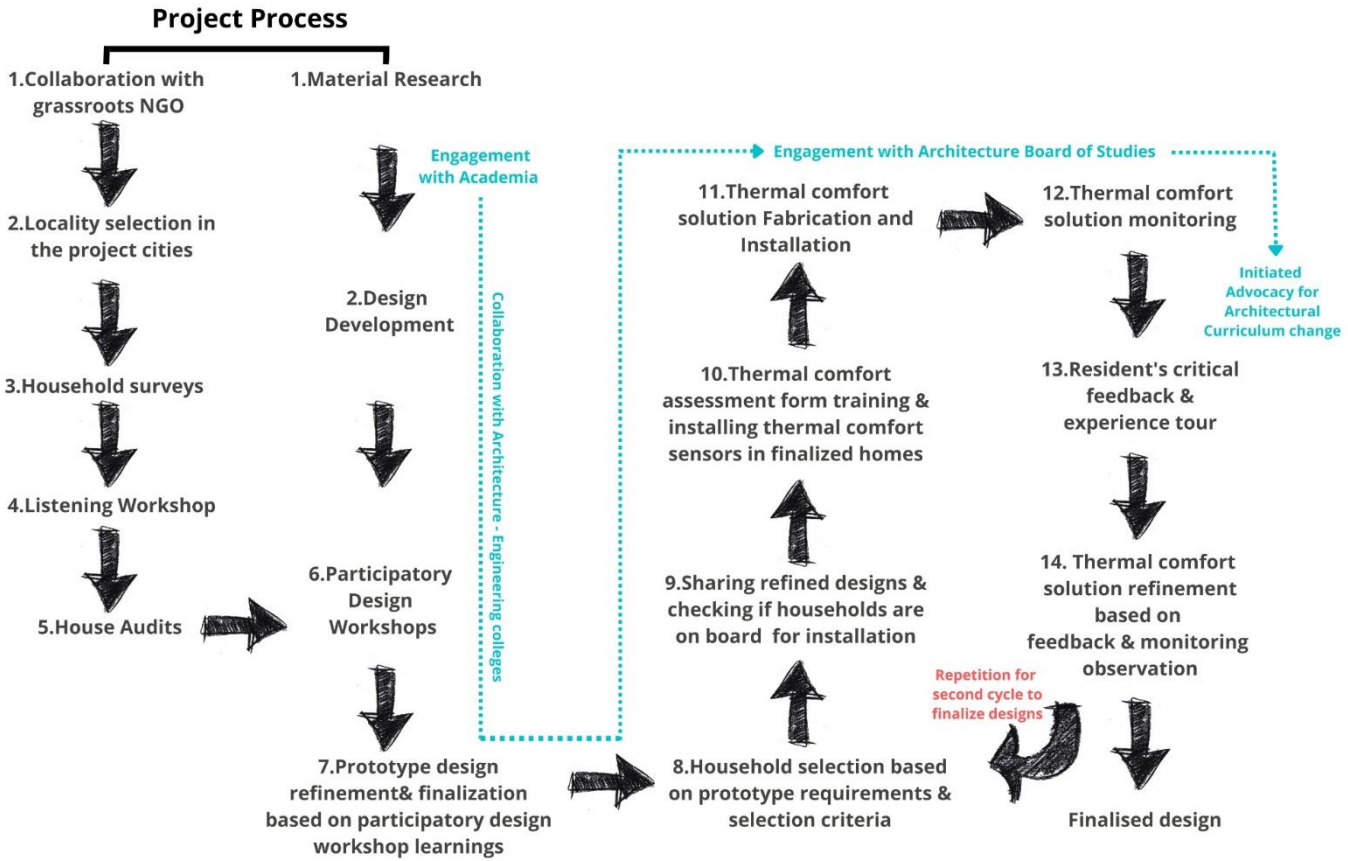
Therefore, in the current scenario of ballooning socio-economic and ecological injustices triggered by climate breakdown the phenomenon of architectural services being reserved for socio-economically privileged individuals demands transformation and architecture academia need to act now to spearhead this movement. There is an urgent need of realigning the current architecture education system to equip future architects with the inclination and required skills to co-create and provide built space design support to marginalized communities in urban areas.

The Informal Housing Thermal Comfort project therefore aims at addressing both participatory co-creation with the community and initiating advocacy with academic institutions for integrating Informal housing perspectives in their curriculum. The following section highlights the project processes, details and progress of the project as of April 2022.

B. THE INTERVENTION

The Informal Housing Thermal Comfort Project (Pilot) is a multidisciplinary and multi-stakeholder experimental project aimed at co-creating thermal comfort solutions with informal housing communities with support from (formal and informal) built space professionals and academia. The intervention was implemented in two cycles– the prototype design cycle and the design finalization cycle. Given that it was a new pilot initiative, the project aimed at working with a cohort of 15 houses in Pune and Bangalore, respectively, across both stages. The stakeholders that were a part of this multi-disciplinary project include NGO partners, community members, designers, architects, engineers, fabrication and installation persons, academicians and the board of studies of Architectural colleges.

The first cycle of the project comprised of listening, participatory design, critical feedback workshops, thermal comfort assessment form filling training and resident experience tours amidst other community



engagement endeavours. The focus of the prototype design cycle was to contextualize the thermal comfort solutions 'with' community members and to test the effectiveness of materials and mechanisms from a list of shortlisted solutions such as Ecoboard, Alufoil, etc . At this stage, solutions were installed in 5 houses in Pune and Bangalore respectively and were monitored for a month. They were then revisited for the second iteration of designs. Students from architecture and engineering colleges contributed to the first cycle under as part of their internship program.

During the design finalization cycle, the aim was to refine the design of instillations that needed enhancements and install them in another 10 houses in Pune and Bangalore, respectively, in addition to reinstalling certain installations that needed refinement in the initial 5 houses. There were houses that dropped off from the experiment and new houses that joined midway. The second cycle involved a few community engagement endeavours similar to the first stage which included a meeting to share refined designs and the list of selected households, thermal comfort assessment form filling training, critical feedback workshops and experience tours to harness resident feedback to support the process of finalizing the designs. Additionally, engagement with Architecture Board of Studies members to advocate for curriculum change to incorporate informal housing and sustainable architecture perspectives in university curriculum was also initiated during this cycle.

The flow chart above provides an overview of the process flow of each cycle.

The next section provides a glimpse at 'Key Learnings' from the project intervention process.

C. KEY LEARNINGS

This section provides a glimpse of key learnings that emerged during the project process which validate its current approach of working local communities and academic institutions and future vision of working with women's cooperatives among other relevant entities.

A) MEMBERS OF INFORMAL HOUSING COMMUNITIES MIGHT BE CARRYING STIGMA FROM PREVIOUS DEVELOPMENT PROJECTS 'TARGETING' THEIR BETTERMENT WHICH CAN IMPACT THEIR INITIAL INTERACTIONS WITH ORGANISATIONS INCLINED TOWARDS WORKING 'WITH' THEM.

Community members were hesitant to express their opinions during initial stages of engagement with the project team. They had to be constantly reminded about the fact that no one other than they themselves have the agency to share local knowledge which can support the process of 'co-creating' contextualized thermal comfort solutions that are best suited to address their local needs.

B) CREATING SPACE FOR EMPATHETIC DIALOGUE BETWEEN LOCAL COMMUNITY MEMBERS AND PROJECT PROPONENTS TO 'LISTEN' TO EACH OTHER AT THE INITIAL STAGES OF ENGAGEMENT IS VITAL TO ENCOURAGE AN APPROACH OF 'CO-CREATION'

The listening workshops facilitated at the initial stages of community engagement created space for community members in project locations to discuss issues they experience across different seasons of the year in addition to sharing any already existing mechanisms in place to address these issues. They were constantly reminded of the vitality of sharing their knowledge and experiences to contribute to the change making process. This encouraged a spirit of 'partnership' and 'co-creation' which was evident during community engagement processes that followed the 'listening workshops' where community members expressed their opinions without inhibition and were vocal about matters that they both; agreed and disagreed to.

C) COMMUNITY MEMBERS ARE MOST SUITED TO ARTICULATING COMPLEX INTERCONNECTED ISSUES OF THERMAL COMFORT, SPACE USE AND COMPETING REQUIREMENTS THAT THEIR DWELLINGS MEET ADEQUATELY OR INADEQUATELY AND DESIRABLE INTERVENTIONS.

Invaluable knowledge and experiences associated with heat stress, water ingress during monsoons and related structural and spatial issues were shared by community members during the listening and participatory design workshops. These were contextual issues which would be impossible for an external entity to decipher without engaging in meaningful and empathetic dialogue with the community. This knowledge was vital in supporting the process of contextualization of the experimental thermal comfort solutions that have been installed in the homes of partner households as part of the pilot phase of the project.

D) THERE IS A NEED AND POTENTIAL TO SUPPORT INFORMAL HOUSING COMMUNITY MEMBERS TO SPEARHEAD THE MOVEMENT FOR THERMAL COMFORT IN THEIR LOCALITIES WHILE CONTRIBUTING TO INCOME GENERATING ACTIVITIES SIMULTANEOUSLY.

On ground discussions with communities on the vision of the project team to work with women's cooperatives and other local entities on building their capacities to fabricate, install and maintain thermal comfort solutions in informal housing communities were received positively by community members. They resonated with the approach of community members themselves being equipped to address the issue of thermal comfort which can simultaneously contribute to livelihood generating activities within the community. There were instances where after witnessing the positive impact of a few installations, community members who were not associated with the project expressed their desire to have thermal comfort installations in their own houses, in addition to wanting to learn about the process of installing certain thermal comfort installations, in a few instances.

E) CO-BENEFITS RELATED TO POSSIBLY MORE MATERIALLY SIGNFICANT AND ACUTE HOUSING RELATED ISSUES MUST BE EXPLORED SYNCHRONOUSLY WITH ISSUES OF THERMAL DISTRESS

Community engagements in Pune and Bangalore enunciated the need to recognise that the discourse related to material realities, resource constraints, housing quality related needs etc. in each informal settlement are unique and locality specific. The plurality of these experiences must be respected and a 'one-size-fits-all' approach

to development endeavours is incapable in addressing the needs of these remarkably heterogeneous lived realities. For instance, our experience has emphatically underscored that in some localities residents are significantly more inclined to participate in responses to ameliorating water leakage from roofs than one that is purely thermal-comfort centric. Therefore, assuming that thermal discomfort is the most acute 'threat' to safe, dignified housing quality in all circumstances would be a gross simplification of the pulriverse issues plaguing the lives of inhabitants of informal settlements.

F) HEAT GENERATED THROUGH ACTIVITIES WITHIN THE HOME, DIMISHED CAPACITY TO 'LOOSE' HEAT FROM WITHIN THE HOME AND 'STUFFY' CONDITIONS ARISING FROM INADEQUATE VENTILLATION ARE SIGNIICANT CONTRIBUTORS TO THERMAL DISTRESS. MECHANISMS TO BLOCK AND REFLECT THE SUNS HEAT FROM THE ROOF ALONE MIGHT BE INADEQUATE.

Heat generated through cooking activities, a high density of persons living within inadequately sized rooms, and hazardous neglect of provisions for air movement, ventilation, fresh air etc. need to be concomitantly addressed in addition to mitigating heat ingress through solar radiation.

G) PERFORMANCE TESTING OF PROTOTYPES THROUGH IN-FIELD INSTALLATIONS, TO EXAMINE INFLUENCE OF EXPECTED AND UNEXPECTED FACTORS IS SIGNIFICANTLY MORE VITAL THAN LABORATORY TESTING, SCALED-MODEL TESTING OR SOFTWARE MODELLING

While small-scale prototype fabrication, lab-scale testing and software modelling of thermal comfort and mechanical operation performance are useful tools, the multitude of external variables (including presence and influence of neighbouring high-tension electrical cables that can prove lethal to installation personnel, stray animals, water, humidity, dust, winds along with human interface) cannot be accounted for in any meaningful way through 'classical' methods of off-site or 'dislocated' assessment. There is therefore a need to work on intensifying efforts involved in on-site, in-field testing of prototypes while engaging in 'human-centric' experimental endeavours.

H) WORKING ON HOUSING RELATED ENDEAVOURS 'WITH' COMMUNITIES INHABITING INFORMAL SETTLEMENTS DEMANDS THAT PROJECT TEAM MEMBERS EMBRACE A MULTIDISCLIPINARY ROLE AND BREAK AWAY FROM A SPECIALIST DOMAIN 'EXPERT' APPROACH TO ENSURE A WHOLESOME CONTRIBUTION TOWARDS THE ENDEAVOUR

The Informal Housing Thermal Comfort Project Team comprise of individuals with an 'formal' education in diverse disciplines comprising architecture, material science, product design, mechanical engineering, social science, behavioural psychology. A spectrum of situations which required an expansion of thinking and doing faculties, well beyond an individual's professional domain 'expertise' were experienced at various stages of the project, highlighting that a deliberate 'blurring' of boundaries and amplification of intersectional practice areas is greatly warranted and desirable for housing related participatory endeavours which involve interactions with community members, fabrication and installation persons among other stakeholders. For instance, professional architects were required to 'think' and 'work' as community-oriented facilitators during the participatory design workshops and team members with experience of community facilitation had to learn how to read

architectural design drawings and apply site-safety protocols in practice with fabrication and installation persons during thermal comfort retrofit fabrication and installation.

I) SENIOR MANAGEMENT PERSONNEL IN ARCHITECTURE ACADEMIA IN INDIA CAN BE GENERALLY EVASIVE ABOUT THEIR CURRICULUM'S SYSTEMIC NEGLECT OF INFORMAL HOUSING ISSUES, AND INCORRECTLY CONFLATE INFORMAL SETTLMENTS ISSUES WITH THOSE OF LOW-INCOME HOUSING OR SOCIAL HOUSING; WARRANTING A STUDENT-LED PUBLIC CAMPAIGN TO UNDERSCORE THIS EXCLUSION AND APPLY ENOUGH PRESSURE UPON INSTITUTIONS THROUGH NON-VIOLENT MEANS TO DISMANTLE THE STRUCTURES OF THE STATUS QUO.

In a number significant of instances of engagement with Academic Deans and other Senior Management of Architecture Colleges in India, it was palpably clear that the systemic 're-inclusion' of the housing predicament of inhabitants of marginalised urban settlements in India was seen as an intrusion into the corridors of power and narrative control within Architecture Academia. Efforts to systemically integrate Informal Settlement related curriculum content across the 5-year syllabi was often denounced as 'prescriptive' and overstepping of their authority. This is verifiably contrary to the practice and protocols followed in the way the same curriculum deals with subjects that directly influence their ability to serve elite and bourgeois interests. For instance, almost all undergraduate architecture programs in India impart 'skills' and examine the issues related to design and construction of luxury resorts and bungalows through design studio projects precoccupied with these and similar subjects. Their dismissal as being 'mere coincidence' (despite it being a recurrent phenomenon in every college program surveyed by the cBalance team) by senior management personnel in architecture colleges is untenable and lacks intellectual rigor. The absence of informal settlement issues in these fora appears to be causally linked to the class-based indifferences that are prevalent in the upper ranks of academic 'business' interests. Incremental 'evolutionary' methods of change making are insufficient to address this lacuna and seems to warrant mobilizing of the concerns of architecture students who during their engagement with the informal housing project team, clearly underscored their discontent about never having being stimulated to think and 'see' the housing predicaments of the 'other' India as a legitimate location of the practice of their skill, as deserving of their competent, empathetic interrogation, in solidarity with the urban poor.

J) PARTNERSHIPS WITH ACADEMIA TO ENGAGE AUTHENTICALLY ON WHAT IS CURRENTLY A 'FRINGE' SUBJECT REQUIRES HIGH-LEVEL BUY IN WITH POSSIBLE FORMALIZATION THROUGH ACADEMIC CREDIT VIA ELECTIVES OR INCLUSION AS A DESIGN STUDIO SUBJECT ARE VITAL TO CATALYZE MEANINGFUL CHANGE

The experiment to engage with architecture students as design-interns, without their work being formally recognized as part of coursework (either as a design studio project, design assignment etc.), led to a situation where many interns abruptly terminated their contributions and participation at varying stages of the effort, well before their planned date of conclusion of the internship period. This indicated that formalizing student contributions through all authentic avenues of engagement, formally involving the academic institution as a whole instead of directly engaging with just the students, is likely to greatly enhance the rigor, diligence and mindfulness brought into practice by students.

K) PEOPLE CENTRIC EXPERIMENTAL ENDEAVOURS DEMAND COMMITMENT (FROM AN IMPLEMENTATION TEAM) THAT TRANSCENDS THE SCOPE AND DURATION OF A GRANT FUNDED PROGRAM

The fundamental experimental nature of a co-creation exercise, in solidarity with finite beings with finite capacities and frailties, with its mindful embrace of the unknown, are characterised by scant 'guarantees' of success or assurances of 'safe' interventions. Such interventions can sometimes disrupt stable situations and conditions both physically and/or socially. Mindfulness to evade as many disruptions as humanly possible in addition to committing to support households who might be impacted by unforeseen disruptions due to certain installations even if experienced after the duration of a project grant is warranted. For instance, based on the project teams experience it is likely that initial designs and installations might have latent, embedded lacunae which might only manifest over an extended time period well beyond the specific time horizon of a specific grant or project. Water leakage might emerge from unexpected intersections of the original roof and an installation that required cutting a part of the roof sheet and then re-establishing its integrity through adhesives, fasteners etc. Hence it is imperative that the engagement with residents who have displayed immense faith and courage in stepping up to participate in a real-world experiment and have surrendered generously to the process with a spirit of adventure, opening their homes and lives to external entities inclined to work with them, continues in a spirit of solidarity for as long as possible and that any further alterations, modifications or even un-doing of the intervention at a later stage are undertaken with empathy and without burdening homeowners with any costs for doing so.

L) 'AUTHENTIC DEVELOPMENT ENDEAVOURS' SHOULD BE CHARACTERIZED BY CONDITIONS OF EQUALITY OF POWER AMONGST PROJECT IMPLEMENTATION ENTITIES AND PARTICIPATING HOUSEHOLDS TO THE POINT THAT PARTNER HOUSEHOLDS CAN ASSERTIVELY AND CONFIDENTLY EXPRESS EVEN THE SEEMINGLY UNCOMFORTABLE SENTIMENT OF "I HAVE DECIDED TO NOT WORK ON THIS ENDEAVOUR WITH YOU"

Given the participatory nature of the thermal comfort endeavour, residents were encouraged to express their opinions and decisions uninhibitedly during interactions. For instance, when a given installation was proposed to a certain household they were given the option to 'accept' and also 'reject' the proposition. This was intended to create a sense of partnership, wherein there is space to share one's authentic feelings and thoughts with the other. This is essential to break away for 'top-down solution imposing' approaches to ensure that we recognize that the people we work with are just like us and have the right to 'reject' things they disagree with, given that the they are the ones who have a better understanding about their lives and their capacity to deal with any foreseen and unforeseen challenges that may come with new experimental interventions.

M) INTEGRATING THE ASPIRATION OF LOCAL ECONOMY REVITALIZATION (EG. THROUGH THE USE OF ONLY LOCALLY AVAILABLE MATERIALS AND SKILLS ETC), CAN PROVE TO BE A CHALLENGING CONDITION TO SATISFY AT THE PRELIMINARY STAGES OF AN EXPERIMENTAL HOUSING EFFORT. FOCUSING ON THE SOCIAL AND PHYSICAL SOLUTION DESIGN RESPONSE MIGHT BE A MORE REALISTIC APPROACH DURING EXPERIMENTATION WHICH CAN GRADUALLY MOVE TOWARDS LOCAL ECONOMY REVITALIZATION EFFORTS WITH TIME.

A key hypothesis of the 'Informal Housing Thermal Comfort' endeavour was examining the opportunities for local production of design solutions with insofar as possible locally devised, fabricated non-industrial materials, assembled locally and installed by local contractors; a barometer for 'success' in this context would be avoidance of long distance inter-city transport of persons and materials to informal settlements in Pune and Bangalore. The efforts to concomitantly experiment with harnessing of only local economic forces enmeshed with a host of other variables related to community engagement, academic engagement, solution design, material research etc. led to challenges and impediments which illuminated the possibility of considering local economic production as subsequent subject of interrogation and further experimenting after stability in the primary effort of devising community-based inclusive co-creation of durable contextually relevant solutions has been largely accomplished.

D. PROGRESS AT A GLANCE

The table below provides a glimpse into the projects progress, so far and also shares a few projected estimates (as applicable).

Sr. No	Subject	Project City	
		Pune	Bangalore
1	Settlement Name	Shinde Vasti	JyothiPura
2	NGO partner	MASHAL	Hasiru Dala
3	Highest Recorded Indoor Temperature	40.6 deg C	34.2 deg C
4	Households invited to be part of the experiment during household surveys (in nos)	25	23
5	Listening Workshops Facilitated (in nos)	4	4

6	Participatory Design Workshops Facilitated (in nos)	4	3
7	Critical Feedback Sessions Facilitated (Workshops/Household Visits)	4	2
8	Resident Experience Tours Facilitated (in nos)	3	3
9	Types of thermal comfort retrofits installed (in nos)	10	7
10	Types of thermal comfort retrofits installed (names)	- Water Filled Pet Bottles - Rooftop Garden (Pots) - Rooftop Garden (Brick Bed) - Rooftop Garden (Grow Bags) - Alufoil (Static) - Alufoil (Pipe Motor) - Alufoil (Chain Sprocket) - Alufoil (Curtain Mechanism) - Wood Wool Panels - Dormer Window	- Alufoil (Sliding) - Alufoil (Static) - Alufoil (Chain Sprocket) - Ecoboard (Sliding) - Ecoboard (Chain Sprocket) - PET bottle - Wood Wool Panels
11	Structures retrofitted between 2021-2022 (in nos)	19	10
12	Structures where retrofits were uninstalled at resident's request (in nos)	4	1
13	Avoided energy consumption, 'negawatts' generation per household. (estimated)	320 kWh/yr	420 kWh/yr
14	GHG emissions mitigation through reduced cooling energy demand and refrigerant per household (estimated)	1,500 kgCO2e/yr	2,000 kgCO2e/yr

15	Equivalent no. of trees planted per year per household (estimated)	6	8
16	Observed installation benefits (examples)	- After the installation of 'Wood Wool Panels', the floor of the house which used to be heated up between 10 am to 9pm during peak summers, stays cool throughout the day. - Children find it easier to focus on their studies between 1-4pm during peak summers, due to reduced indoor temperature after the 'Rooftop Garden Installation'.	- The use of fan has reduced after the 'Alufoil Chain Sprocket' installation. - After the installation of 'Ecoboard Chain Sprocket' the indoor temperature is comfortable enough to sit indoors even during power cuts.
17	Observed issues with installations (examples)	- There are issues with opening and closing the 'Alufoil Pipe Motor' installation - The sunlight coming in through the 'Dormer Window' disturbs morning sleep	- The cats peeled off the 'Alufoil' layer and the installation is ineffective, now. - The pulley mechanism for 'Ecoboard Sliding' is not working smoothly. Hence it cannot be opened & closed for night & day benefits, respectively.
ENGAGEMENT WITH ACADEMIA			
18	Colleges collaborated with for internships (in nos)	2	1
19	Architecture professors collaborated with for design support (in nos)	5	1

20	Board of Studies (BOS) engaged with to suggest curriculum change inputs for sensitization of students to sustainable architecture in informal settlements (nos)	1	1
21	Collaboration with Architecture Students for Internships (nos)	5	1
22	Collaboration with Mechanical Engineering Students for Internships (nos)	2	0

The sections that follow provide an overview of project sites in Pune and Bangalore, followed by detailed insights that emerged during different interactions and stages during the project.

Shindevasti, Pune, Maharashtra.

Nestled in the industrial area of Hadapsar in the city of Pune- 'Shindevasti' is an informal settlement of 693 households with a population of 2618 people. Most of its residents are migrants from different states across India such as Bihar, Uttar Pradesh etc. and also from different districts within the state of Maharashtra itself. Since Shindevasti is located in an industrial area, there are small factories around the settlement. Most residents work as truck drivers, watchpersons, helpers etc. in the factories. People also work as auto drivers, house help and some as daily wage labourers at construction sites and take up small projects within the community itself, too. Very few people are involved in homebased occupations such as tailoring. Principally, this is mixed community with people from different states, religions and engaged in different occupations coexisting with one another.

There is a human made water canal that runs through the settlement. The houses structures comprise of kuccha (both roofs and walls of tin sheets), semi-kuccha (brick walls and tin sheet roofs) and pucca houses (roofs and walls of concrete). Most houses have a single room, while some have two rooms. Very few houses have windows and the lanes between the houses are narrow in most cases, too. Overall most houses lack ventilation and are susceptible to heat stress on account of the house design, material and the spatial design of the settlement as a whole.

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Jyothipura, Bangalore, Karnataka.

Jyothipura, situated in the central region of Bangalore, is an informal settlement with around 200 households. The houses typically found here are semi-pucca (concrete walls and tin roofs), with a handful of 3-storeyed concrete structures. The settlement is edged with a railway track on one side whereas tall buildings stand on the other side. These contrasting realities in the immediate context, render the residents vulnerable and susceptible to evictions.

Most women work as cooks, domestic workers, waste pickers whereas men are more involved in construction work, carpentry, painting, electrical work and few into sales. The settlement, like its other counterparts, has interconnected narrow alleys across the locality, which are the most dynamic and lifeline of the locality with a range of outdoor activities occurring throughout the day. Most houses are adjoined with common walls on either side, leaving only two walls for ventilation. In few instances with presence of a window on the wall, they are not kept open due to privacy issues as they directly open to the narrow passage alleys. The interior environment of most of the houses are dingy and congested due to lack of ventilation. As temperatures rise up during summers, living inside these homes becomes unbearable affecting the residents with a multitude of issues like poor sleep, less productivity and potential health issues.

III. PROJECT INSIGHTS

This section shares detailed insights from the project and elaborates on three key processes:

A) 'Community Engagement' centred around 'participatory action' and 'co-creation'

B) 'Design and Installation' process embedded in local knowledge and participatory action facilitated in collaboration with architects, engineers, professors and students of architecture, fabrication and installation persons

C) 'Engagement with Academia' which focuses on efforts towards accessing, sensitizing and enhancing the existing knowledge repository of design in collaboration with architecture and engineering academic institutions, in addition to advocating for the seamless integration of sustainable design and informal housing in the architecture syllabus in collaboration with the Architectural Board of Studies (BOS) members.

(Note *- The 'Insights' under this section are 'subjective' and 'contextual' and are based on limited on-field observations which may or may not be applicable across all contexts.)*

A. COMMUNITY ENGAGEMENT

Listening Workshop(Bangalore)

The community engagement process was initiated by identifying and collaborating with grassroots NGO partners in Pune and Bangalore. Collaboration was followed by identifying a project locality in each city. This was followed by rapport building endeavours with community members through household surveys, followed by 'workshops' to 'listen to' and 'co-create' thermal comfort retrofit designs with the community. 'House audits' were conducted and preceded 'community meetings' to share refined designs with the households that had been modified based on their inputs during the participatory design workshop, proceeded the community workshops. The 'meetings' were also a space to share the criteria for household selection along with the list of households who were selected during the first and second cycle of the project, respectively. Consent was sought to proceed with installations and partner households were trained on filling thermal comfort assessment forms and thermal sensors were installed in their homes. This was followed by fabrication and installation of the thermal comfort retrofits. Critical feedback workshops and household visits were facilitated to harvest resident's feedback post installations, to learn about any refinements that could support enhancing the installations to support with finalizing the designs. The processes commencing 'community meetings' onwards were repeated for two cycles. Engagement with residents is still continuing to ensure that the thermal comfort endeavours spirit of working 'with' the community is alive and endures with time.

Specific insights from community engagement experiences are mentioned below.

1. NGO PARTNER ENGAGEMENT

A) PURPOSE

- To collaborate with grassroots NGOs partners to help facilitate rapport building with local communities in project locations
- To identify local communities that would be interested in and open to working on an experimental thermal comfort endeavour
- To identify contextually appropriate approaches to community engagement based on the NGO partners experience.

B) INSIGHTS

(I) GRASSROOTS NGO PARTNERS WHO HAVE A PRE-ESTABLISHED RELATIONSHIP WITH A COMMUNITY CAN ACCELERATE THE PROCESS OF RAPPORT BUILDING BETWEEN A NEW ORGANISATION AND THE COMMUNITY.

Collaborating with grassroots NGO partners. i.e., Hasiru Dala in Bangalore and MASHAL in Pune, proved instrumental in rapport building with the communities. These organisations have a well-established rapport with communities, due to their engagement as part of different development endeavours in the past. Their already established relationships accelerated the rapport building process which manifested through the community members smiles and their readiness to participate in the experimental thermal comfort endeavour, with an organisation they had hitherto not heard of.

(II) COLLABORATING WITH GRASSROOTS NGO PARTNERS WHO ARE WELL CONNECTED WITH A COMMUNITY CAN FACILITATE WORKING WITH CONTEXT APPROPRIATE COMMUNITY ENGAGEMENT APPROACHES

Grassroots NGO partner engagements provided insights on the communities' nature and practices, which supported with grounding community engagement to suit the local context. Additionally, the NGO partner's fluency with the local dialect, supported in connecting better with local communities even when faced with linguistic barriers. Additionally, in Bangalore, Hasiru Dala supported the process of connecting with the local community association and suggested ways to interact with its leaders.

2. LOCALITY SELECTION

A) PURPOSE

- To identify tenure secure informal settlements.
- To identify localities with predominantly tin roofed structures.
- To understand the overall context of a given community.

B) INSIGHTS

(I) TIN ROOFED HOUSES MIGHT NOT BE A COMMON OCCURENCE ACROSS INFORMAL SETTLEMENTS

In Pune, most houses were characterized by tin roofs and walls in some cases, too. Whereas, in Bangalore tin-roofed houses were rare in the initial project locations identified by Hasiru Dala. Narrowing down on the locality due to unavailability of tin roofed houses was a challenge. It was learned that since these houses were more susceptible to demolition, they were likely to be rebuilt by residents as soon as they can afford to build brick and concrete houses.

(II) PEOPLE FROM A GIVEN LOCALITY MIGHT NOT NECESSARILY BE FLUENT WITH THE LOCAL LANGUAGE

The migrant roots of the local community in Jyothipura in Bangalore were revealed when interactions with them indicated that most people were fluent in Tamil as opposed to Kannada (the local language in Bangalore).

3. ENGAGEMENT WITH LOCAL COMMUNITY ASSOCIATIONS

A) PURPOSE

- To work with local authorities and leaders to ensure the smooth implementation of the program in a given locality.

B) INSIGHTS

(I) ENGAGING WITH LOCAL COMMUNITY ASSOCIATIONS WITH TRANSPARENCY AND AUTHENTICITY MIGHT CREATE SPACE FOR MUTUAL UNDERSTANDING AND COOPERATION

In Bangalore, the local community association in the project area was approached for permission to work with a few houses in the community. When the association learned that the expenses for this endeavour would be borne by the project team, they shared that an arrangement where the project team could make a monetary contribution to the association to support the associations efforts would be advisable. However, when it was conveyed that the nature of the experimental endeavour is not based on a 'give and take' model and is rather based on working 'with' community members, the association understood the nature of the work and consented to the work progressing without any monetary contribution towards the association.

4. HOUSEHOLD SURVEYS

A) PURPOSE

- To build a one-on-one rapport with households.
- To understand the profile of households in a new community.
- To gauge whether heat stress as an issue is recognised by the community.
- To learn about community members' willingness to work on addressing the issue of heat stress with an organisation they are not familiar with.

B) INSIGHTS

(I) AN UNSPOKEN FEAR OF EVICTION LOOMS OVER THE MINDS OF RESIDENTS INHABITING INFORMAL SETTLEMENTS TRIGGERING SCEPTICISM TOWARDS ENGAGING WITH NEW ENTITIES INCLINED TO WORK WITH THEM.

In Pune, the households that were approached had worked with the grassroots NGO partner (MASHAL) on other projects in the past. This encouraged them to be open to speaking with the cBalance team during their initial interaction. However, there was a certain averseness to interaction, by households who were not associated with the NGO partner, which revealed the vitality of rapport building. For instance, when households who were not associated with MASHAL were approached, they were sceptical

and somehow misunderstood that the survey was being conducted by government entities. They expressed the unspoken fear of eviction that looms over informal settlements by excusing themselves from participating in the survey and saying that they had to go to their village for the next few months and wouldn't be present to participate in anything related to the survey. This was a pattern observed across row of houses in Shindevasti where an attempt was made to connect with households who were not associated with MASHAL.

(II) PEOPLE'S RESPONSIVENESS TO A SURVEY EXERCISE BY A NEW ENTITY MIGHT VARY DEPENDING ON THEIR EXPECTATIONS FROM THE SURVEY

While people in Pune who were not associated with MASHAL were sceptical to participate in the survey, community members in Bangalore were eager to be part of the initial survey because they learned through unknown channels that they would be receiving something 'free of cost'. Given the economically marginalized context they are part of they were eager to participate in the survey and benefit from it in any way they could.

(III) CASTE DISCRIMINATION CAN BE AN INFLUENTIAL FACTOR THAT DETERMINES PEOPLES BEHAVIOUR TOWARDS EACH OTHER IN A GIVEN LOCALITY

During the household surveys in Bangalore, it was observed that certain people disapproved of the project team interacting with community members from a certain section within the community. It was learned that this averseness was the result of caste discrimination wherein community members belonging to the waste picking community who belong to a societally determined 'lower caste' were looked down upon by people belonging to societally determined 'higher caste' who also held jobs that were considered 'more respectable' than the act of 'waste picking'.

(IV) TRANSPARENCY IS KEY IN INITIATING A RELATIONSHIP OF TRUST WITH A NEW COMMUNITY

Community members were curious about the project and expressed their concerns and questions, encouraging transparency about project motivations and also limitations during community interactions. Few questions by the community included: '*Do we need to pay for this*?', '*Will our roof get damaged if you climb on the tin sheet for your installation*?', '*For how long will the installation last?*'. Given that the community was being invited to participate in an experimental endeavour where certain things had no definite answer, anything that was uncertain at that point in time was rightfully communicated to the community. The authenticity of such responses was received gracefully by the community and promoted trust building.

5. LISTENING WORKSHOP

A) PURPOSE

- To create a space for people inhabiting informal settlements to share their experiences on issues they face across different seasons during the year.
- To understand already existing heat battling mechanisms and practices followed by the communities.
- To listen to community's discomforts, concerns and suggestions
- To emphasize the projects approach of 'co-creation' and 'participatory' action to community members to facilitate a spirit of 'partnership' and 'collaboration'

B) INSIGHTS

(I) SHARING INFORMATION THAT PEOPLE ARE CURIOUS ABOUT IS MORE EFFECTIVE THAN THRUSTING INFORMATION THAT MIGHT SEEM NECESSARY TO SHARE FROM A 'PRACTITIONERS' PERSPECTIVE

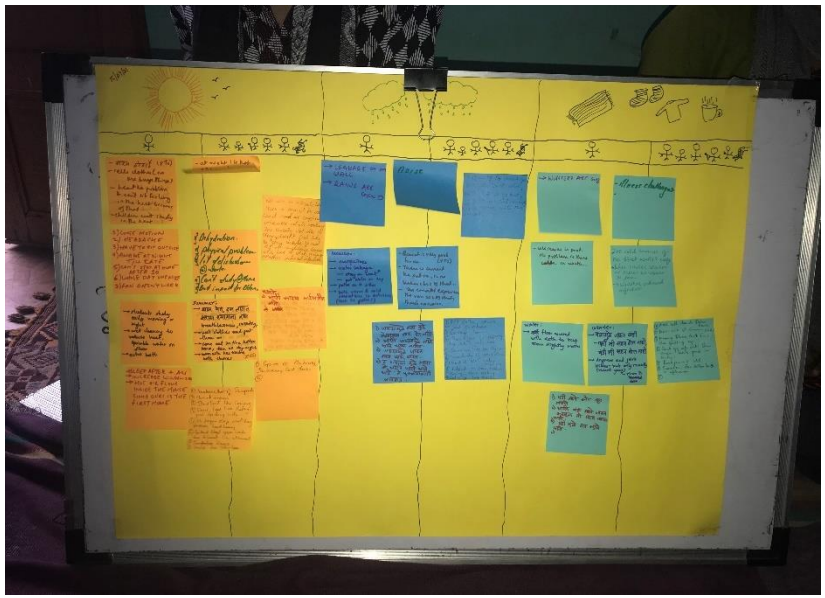


Figure 1: Problem Diagnosis Chart - Listening Workshop

The household survey experience triggered the project team to revisit and revise the initial facilitation plan for the listening workshop. For instance, it was planned that during the introductory part of the workshop there would be a section to explain the project story, discuss the impacts of climate change and the broader organisational thermal comfort story too. However, the flow of the listening workshop was revised, and the introductory parts were kept as optional to leave more space to share project-related information the community wanted, rather than thrusting the climate crisis-related information that were felt was important initially onto them. Efforts were made to listen to the residents involved, which ensured that the workshops satiated people's curiosity and progressed smoothly which also determined the nature of their future interactions with the cBalance team.

(II) THE USE OF RELATABLE DAY-TO-DAY EXAMPLES RATHER THAN TECHNICAL JARGON IS AN EFFECTIVE METHOD OF COMMUNICATING WITH COMMUNITIES WHO MIGHT HAVE NOT HAD THE OPPORTUNITY TO ENGAGE WITH THE TECHNICAL KNOW-HOW OF THERMAL COMFORT TECHNIQUES

Besides listening to the community, the listening workshop was a space to feed the communities curiosity about the nature of the experimental thermal comfort ideas they had been hearing about since the household surveys. Explaining the thought behind the thermal comfort retrofits that were to be suggested during the listening workshop through relatable examples helped the community understand things better. For instance, to explain the fact that some prototypes would function as a radiant barrier the

following analogical statement was used - "*to explain one of the things we are thinking about, think about how a cap helps you in summer. it creates a barrier between you and the sun protecting you from the sun's heat. Similarly, we thought, why not put a barrier that protects us from the sun on our roofs too?*". This helped the community understand the nature of the cooling techniques in an understandable manner compared to simply having technical terms such as 'emissivity' and 'radiant barrier' thrust onto them.

(III) EMPHASIZING THE VALUE OF COMMUNITY KNOWLEDGE SHARING CAN ENCOURAGE ACTIVE COMMUNITY PARTICIPATION DURING WORKSHOPS IN COMMUNITIES THAT HAVE BEEN CONDITIONED TO A TOP-DOWN APPROACH OF KNOWLEDGE SHARING

Many community members were hesitant to share their knowledge during the workshop and needed to be reassured of their agency to share knowledge that would support addressing their thermal comfort issues and other roof-related issues collectively. Few things that were constantly used to reinforce the necessity of knowledge sharing by the community during workshops were: "*We want to work 'with' you and don't want to impose our thoughts on you and tell you how you can address your own issues. We have only heard about the issues you face, but you are the ones who stay here and know your situation better than anyone else and this is why we want to hear your stories so that we can work together based on what you share. The ideas we are thinking of are not finalised and our intention is to work with you on modifying and contextualising them. We also want to hear about new suggestions you may have so that we can consider those and incorporate them if possible too. You shared a few things you do to address heat stress when we visited your homes, and we want to hear more about them and other things you may have thought of /are thinking of*". This affirmation encouraged community members to share their thoughts openly during the workshop as opposed to being present as passive participants.

(IV) HEAT STRESS HAS MULTIFACETED NEGATIVE IMPACTS ON THE LIVES OF COMMUNITIES INHABITING INFORMAL SETTLEMENTS

Few of the many heat-stress related issues revealed by resident during the workshop comprised of:

- Health issues: Headache, nausea, loss of appetite, prickly heat, get irritated, breathing issues, dizziness, skin gets swollen and burns, feeling suffocated, experience frequent headaches, dehydration, weakness, dry throat, skin irritation, breathlessness and irritation while urinating.
- Children and elderly related issues: Children can't sleep and focus on their studies due to the heat. Elderly people experience loss of appetite and have to spend time outdoors.
- Household chores: The heat inside the house plus heat from the stove makes it very uncomfortable for women to cook. Besides, cooked food gets spoiled easily during summers, increasing food-related chores.
- Increased Expenses: Expenses increase due to spending more money on electricity to run the fan and coolers, in addition to buying cold beverages and ice creams to relieve discomfort during summers.
- Sleep-related issues: Residents are able to sleep only after 4 am when in the morning during extreme summers, this impacts their mood making them irritated and angry influencing their ability to function mindfully throughout the day. In large families, the congested space makes it even more uncomfortable to sleep during summers.

(V) COMMUNITIES INHABITING INFORMAL SETTLEMENTS HAVE HEAT STRESS BATTLING MECHANISMS THAT CONSUME MINIMAL MATERIAL RESOURCES AND SUPPORT ADDRESSING THE ISSUE OF HEAT STRESS FOR A MINIMAL AMOUNT OF TIME IN MOST CASES EXCEPT FOR A FEW.

Few local heat stress battling mechanisms shared during the workshop comprised of:

- Sprinkling water on tin roofs
- Placing hay from cattle sheds on the roof
- Placing thermocol sheets/foam rolls on the underside of the roof
- Wiping the fan with a wet cloth to trigger cool air circulation
- Wiping the floor continuously with wet cloth
- During night time putting a wet cloth over legs to help sleep better
- Women adjusting the timings of their daily chores to ensure that they are not forced to work indoors when indoor heat is at its peak
- Children and the elderly spend more time outdoors rather than indoors during the peak summer

6. HOUSE AUDITS

A) PURPOSE

- To assess the house structures and understand any aspects the design and installation team need to be mindful of before finalizing the design and implementation processes for a given solution in a given household.

B) INSIGHTS

(I) A COMMUNITY BASED PARTICIPATORY AUDIT APPROACH CAN SUPPORT IN UNDERSTANDING THE INTRICACIES OF A GIVEN HOUSE STRUCTURE

During the house audits, community members provided insights on the age of their house structures, structural issues, water availability, their house maintenance habits, and other relevant external factors such as the occurrence of animals climbing on their roofs. This level of qualitative information would be impossible to harvest without consulting the community for lived experience-based knowledge during the audits.

(II) WORKING WITH HOUSES IN INFORMAL SETTLEMENTS WARRANTS AN APPROACH THAT IS SENSITIVE TO THE RESOURCES INVESTED BY THE COMMUNITY TO BUILD THESE STRUCTURES

The audits revealed that people had built their houses incrementally over the years. This emphasized the need to be mindful to secure the homes that had been built with love, hard-earned material resources and energy while embarking on an experimental thermal comfort journey with the homeowners of these houses.

House Audit

7. PARTICIPATORY DESIGN WORKSHOP

A) PURPOSE

- To harness information for the co-creation of context-specific thermal comfort solution designs with local communities.

B) INSIGHTS

Participatory Design Workshop, Pune.

(I) THE PREDOMINANCE OF DEVELOPMENTAL MODELS THAT ARE BASED ON 'SOLUTION-IMPOSING' PROCESSES, CAN MAKE MARGINALIZED INDIVIDUALS PASSIVE TO PARTICPATING IN MODELS GROUNDED IN CO-CREATION

Small-scale working models of solutions (Alufoil, Glasswool, Dormer Window, Rooftop Garden, Eco-board and PET bottles) were presented to the community as prompts during the participatory design workshops. The invitation to the community was to participate and co-create the roofing solutions. While few participants participated enthusiastically and gave feedback on the solutions, a few of them were passive. Efforts to overcome this barrier involved making conscious efforts to remind residents that their opinions matter and that the intention of this workshop is to facilitate a process of working 'with' them, since, nobody but they themselves know their context better.

(II) A PARTICPATORY DESIGN EXERCISE IS ESSENTIAL FOR THE CREATION OF 'CONTEXTUALIZED' AND 'PEOPLE CENTRIC' THERMAL COMFORT MECHANISMS

The participatory design exercise was extremely vital as it gave a whole new perspective on our designs, highlighting critical issues the project design team had hitherto not thought of e.g. Rodents that frequent homes could nest in and also damage certain solutions. Animals like cats, goats, and dogs walk on roofs and could damage solutions installed over the roof. There is a danger of solutions triggering fires if they get in touch with overhead electrical wires. What was most admirable was the communities honesty as they expressed their concerns and also rejected certain propositions. For instance, community members in Pune who work in factories knew that 'Glasswool insulation' is harmful if exposed to the human skin and voiced their dissent to the material outright. This is the crucial step of designs becoming more about the people and not just a mere research.

(III) PATRIARCHAL BEHAVIOUR CAN INFLUENCE WOMENS PARTICIPATION DURING GROUP DISCUSSIONS

Only 3 men showed up at the participatory design workshops in Bangalore. Despite the skewed representation of men and women at the workshops, it was observed that women were mostly silent in workshops where men were present. Men dominated most discussions at the workshops. However, at workshops where men were absent, women were more vocal about their opinions.

(IV) THE PRESENCE OF INDIVIDUALS FROM DIVERSE AGE GROUPS AT WORKSHOPS CAN ENCOURAGE DYNAMIC DISCUSSIONS CONTRIBUTING TO THE EMERGENCE OF DIVERSE DESIGN PERSPECTIVES

Based on observations during the participatory design workshops in Pune; there was an exchange of diverse design perspectives between individuals who agreed and also contradicted thoughts shared by participants from different age groups at the workshop. Workshops that were dominated by people who belonged to the same age group were relatively less animated and the perspectives that emerged were limited compared to workshops with a mixed group of participants.

8. HOUSEHOLD SELECTION DECISION SHARING

A) PURPOSE

- To share a list of households that were short-listed to be part of the experiment based on certain house structure-based criteria besides considering residents' preference for a given prototype as far as possible.
- To learn of their consonance and willingness to work with revised and co-created thermal comfort solutions to be retrofitted in their houses.

B) INSIGHTS

(I) A TRANSPARENT APPROACH OF SHARING DETAILS OF THE DECISION-MAKING PROCESS IN CASES WHERE THERE IS A LIMITATION TO WORKING WITH ALL COMMUNITY MEMBERS IS INSTRUMENTAL IN CREATING SPACE FOR EMPATHETIC INTERACTION BETWEEN COMMUNITY MEMBERS AND THE PROJECT TEAM.

Interactions with residents while sharing the list of shortlisted/selected households revealed the varying motivations and doubts that governed people's decisions to accept the suggested prototype retrofitted in their house structures. A transparent approach of sharing the household selection criteria which prioritized households that had weak structures and were structurally suitable for a given thermal comfort prototype, while considering residents' preferences as much as possible, was adopted. This ensured that community members were understanding, even if they were not considered for the first set of installations. Contrastingly, there were also instances where community members were sceptical about installing solutions in their house before anyone else and requested that they be part of installations later.

(II) THE WEATHER AT A GIVEN POINT IN TIME CAN INFLUENCE PEOPLES PREFERENCE FOR CERTAIN SOLUTIONS, EXHIBITING THE NEED TO CONSIDER OTHER ROOF RELATED ISSUES IN ADDITION TO HEAT STRESS WHILE DESIGNING ROOF RETROFITS, TO ENSURE A WHOLESOME EXPERIENCE WHICH CATERS TO PEOPLES COMFORT ACROSS DIFFERENT SEASONS ACROSS THE YEAR.

It was raining in Bangalore around the time of the first set of installations in October-November 2021. On account of this, residents were open only to sturdy and water-resistant solutions such as ecoboard and refused to experiment with other solutions. The rains seemed to be a bigger concern and solutions that could address leakage

issues, were prioritized by residents. Additionally, after the installation of the first set of thermal comfort retrofits in Pune residents requested that certain installations be uninstalled since they caused water leakage issues during a period of unprecedented rains which were not anticipated while designing the installations

(III) RESPECTING PEOPLES DECISION TO NOT WORK WITH A GIVEN SOLUTION CULMINATED WITH AN APPROACH OF EMPATHETIC LISTENING CAN SUPPORT WITH KEEPING THE SPIRIT OF PARTICIPATORY ACTION ALIVE.

A resident in Pune stated outright, 'This is a good solution. But I will not have this installed on my roof, because my house structure won't be able to support the water-filled PET bottles'. He was assured that any supporting structural enhancements that would be needed to address the issue he was concerned about would be looked into. He was still determined to not go ahead with the installation and his decision was respected. A woman who was approached for the same installation shared the concerns she had about a wooden beam that was broken in her house among other factors. An approach of 'listening' to her concerns and acknowledging them and ensuring her that her concerns would be kept in mind during the installation and efforts would be made to ensure that no damage is done to the house and its members due to the installation, was adopted. The experimental nature of the effort was emphasised to the resident and the fact that if successful the solution can be replicated by others living in similar contexts to minimize their heat stress-related issues, was shared. The woman empathised, reasoned and gave installation consent after a discussion with her family. Instances like these enunciated the need to listen, dialogue transparently and implement empathetically.

(IV) PATRIARCHAL DECISION-MAKING SYSTEMS CAN INFLUENCE THE DECISION OF A HOUSEHOLD TO PARTICIPATE IN EXPERIMENTAL THERMAL COMFORT ENDEAVORS WHICH MIGHT OTHERWISE BE EASILY ACCEPTED BY WOMEN WHO BEAR THE BRUNT OF HEAT STRESS IN TIN ROOFED HOUSES

There were also many instances where women were open to the installations, however, the men in the houses such as husband, sons who hadn't been part of the workshops refused to work with certain installations due to various reasons. There was an instance when a woman approached us and said that "*I am the one who stays at home all day. My husband doesn't. But he is adamant to have only wood wool installed and nothing else. Anything that helps me live comfortably indoors, works for me. But how do I convince my husband about this*?" Such experiences reflected the patriarchal underpinnings in the community. In another instance, a woman after installing the dormer window initially and facing issues with it during the monsoon refused to have the refined version of the dormer window installed again. While the woman who lived in the house was open to reinstalling it, her father who owns the house and supports her stated that he won't allow it since his daughter lives alone in the house with five of her daughters and cutting the roof of the house to install the dormer window would be inconvenient if the family faces issues with the installation again. He stated that since he supports his daughter, any unforeseen issue that might crop up due to the installation would be difficult for him to deal with given his age. He refused to reconsider his decision, even though efforts were made to assure him of the fact that responsibility for anything related to the installation would be borne by the organisation. His decision was respected and also demonstrated that some factors are non-negotiable.

(V) BOTH, ACCEPTANCE AND REJECTION BY COMMUNITY MEMBERS ARE A PART OF 'PEOPLE CENTRIC' EXPERIMENTAL ENDEAVOURS

While there were instances where some community members backed out due to various reasons, there were community members who supported this experimental endeavour till the end despite the challenges that were encountered along the way. And there were some, who came on board after hearing about the work from their relatives too. They exhibited patience and support towards unanticipated back and forth while commencing and during the installations. These experiences will be elaborated on in the sections that follow. Overall, approaching both acceptance and rejection by the community in the spirit of learning, helped keep the experimental nature of the thermal comfort endeavour alive, during the household selection decision sharing stage of the program.

9. FABRICATION

A) PURPOSE

- To manufacture the thermal comfort solutions based on the finalised designs.

B) INSIGHTS

(I) OFFSITE FABRICATION IS LESS INTRUSIVE TO RESIDENT'S DAILY ACTIVITIES AS COMPARED TO ONSITE FABRICATION

Fabrication for installations in first set of 5 houses was undertaken outside the houses itself. There were instances wherein figuring out how a certain prototype must be fabricated demanded extending the fabrication process beyond the initially anticipated timeline. Although residents were patient through the process when it was conveyed to them that the reason for unanticipated delays is because this is an experiment and new things are being learned on the field, the necessity to respect the residents time and space was realised. This learning was carried forward to the next set of fabrications where efforts were made to fabricate as many prototypes as possible at the fabricators workshop, which minimised the time spent in fabrication at the resident's household. For instance, in Bangalore it was observed that offsite fabrication reduced the time spent at households by 1-2 days.

Onsite fabrication of Alufoil Installation

(II) RESIDENTS MIGHT BE MORE COMFORTABLE WORKING WITH FABRICATORS FROM WITHIN THE COMMUNITY

The fabricators during the project have spanned people who are from the community, from outside the community but from the same city and people who came in from other cities as well. While the residents were welcoming to all the fabricators, they were more interactive with people from within the community. Additionally, residents were more open in expressing their views to known persons. A resident in Pune explicitly stated that he felt comfortable when a fabricator who was from his own village was involved in the fabrication and installation of the prototype in his house. However, a vital observation in Bangalore was that when an installation by a local fabricator did not meet the resident's expectations, they expressed resentment towards the fabricator during an installation feedback session, which was unpleasant experience from the fabricator's perspective. There is therefore a need to assess the overall context before determining a comfortable working arrangement for both the fabrication person and community.

10. INSTALLATION

A) PURPOSE

- To retrofit the manufactured thermal comfort solutions in resident's homes.

B) INSIGHTS

(I) INITIATING AN INSTALLATION MIGHT NOT NECESSARILY LEAD TO ITS COMPLETION

A resident in Pune who had initially agreed to have a refined version of the rooftop garden prototype installed at his house halted the work during the installation process. After witnessing the varying nature of installations that were worked on across different houses in Pune, the resident started demanding that more expenses be made to enhance the structure of his house before proceeding with installations. The engineers of the project team evaluated the situation and concluded that the installation planned for this house did not warrant as intense structural enhancements as the resident was demanding. Therefore, the installation process was halted after a series of empathetic dialogues with the resident to communicate the reasoning behind the decision to not provide structural enhancements and proceed with the installation as initially planned, which was not accepted by the resident. This conveyed the fact that initiating an installation might not always lead to the completion of the installation.

In another incident in Pune while the installation of wood wool panel was almost complete in one of the houses, a woman who hadn't been encountered by the team before entered the house and demanded that the work be discontinued. On inquiring about the reason for her demand it was learned that the homeowner we were working with had illegally secured ownership of the house structure without paying the rightful owners of the house their due. The woman who was the rightful owner of the house

therefore wanted the work to discontinue assuming that if the living conditions in the house structure improved, it might be more difficult to convince the people living in the house unjustly to vacate it at any point in time. An empathetic dialogue with both parties resulted in the work being discontinued and the installation to be removed from the house, to ensure that the discontent between the households was not aggravated further due to the installation.

(II) INFORMING HOMEOWNERS ABOUT DETAILS OF THE INSTALLATION WORK BEFORE COMMENCING THE SAME CAN SUPPORT MINDFULNESS TOWARDS RESIDENT'S CULTURAL NEEDS DURING INSTALLATIONS

In an incident in Pune during the time of an Alufoil installation, a site worker entered a resident's house for an installation related task and unknowingly walked into their prayer space with his safety shoes. The resident was discomforted by this and yelled at the site worker. A team member helped resolve the situation and calmed the resident and site worker. This incident was a learning step which indicated the necessity of briefing residents about the work involved and checking with them if workers must be mindful about particular places in the house that might be sensitive areas for residents and demand extra care during installations.

(III) INFORMING HOMEOWNERS ABOUT DETAILS OF THE INSTALLATION WORK BEFORE COMMENCING THE SAME CAN SUPPORT MINDFULNESS TOWARDS RESIDENT'S PHYSICAL NEEDS DURING INSTALLATIONS

In Pune, there are some houses that comprise of just one room that is used for resting, cooking and spending time with family members. Therefore, engaging in under the roof installations in such houses meant that the homeowners had to sit outside the house during the timespan of the installation. This meant that arrangements for temporary accommodation and food needed to be looked into before commencing an installation to ensure that residents needs are not compromised on during installation. This was a lesson that was learned after the first wood wool panel installation that was undertaken in a one room house in Pune. In addition to this there were some cases where residents requested that the work stop at 5 pm and continue the next day, while there were some who were okay with the work continuing until 7 pm. The installation schedule and arrangements therefore needed to be tweaked based on residents needs and requests.

(IV) SELF-INSTALLED SOLUTIONS CAN ENCOURAGE OWNERSHIP AND MAINTENANCE OF INSTALLATIONS BY RESIDENTS

The homeowner with the rooftop garden installation is a skilled worker who supported the installation process himself. He pro-actively participated in the planning, gave suggestions and even worked actively on monitoring the installation. He repurposed a green net that was installed below the roof as a shading tool to protect the seeds that were germinating from succumbing to the suns heat. He proactively communicates and even independently acts upon any issues he encounters on his thermal comfort and food growing journey, reflecting a sense of ownership towards the upkeep of the installation in his house.

11. THERMAL COMFORT MONITORING

A) PURPOSE

- To train residents to monitor the performance of the thermal comfort solutions installed in their homes based subjective parameters by filling a thermal comfort assessment form.
- To use thermal comfort sensors to monitor installations.

Thermal Sensor

B) INSIGHTS

(I) THE ACT OF INSTALLING A THERMAL COMFORT SENSOR BY ITSELF MIGHT NOT ALWAYS ENSURE CONSISTENT TEMPERATURE AND HUMIDITY READINGS. FOLLOW UPS WITH RESIDENTS MIGHT BE NECESSARY TO ENSURE CONSISTENT READINGS.

After the installation of thermal comfort sensors there were numerous instances where people switched the sensors off when they were visiting their village for a few days. In one instance on a cold winter night in January an elderly person removed the sensor and packed it in a bag assuming that the sensor was cooling the room down. These experiences indicated a lack of understanding about the purpose of the sensor by some household members. It was learned that installing the sensors alone was not enough, a series of follow up visits were needed to ensure that the sensor readings were consistent.

(II) PEOPLE DRIVEN MONITORING PRACTICES MIGHT NOT ALWAYS BE CONSISTENT AND MAY NEED CONSTANT FOLLOWUPS IF IT THE FIRST SELF-MONITORING ENDEAVOUR BY COMMUNITY MEMBERS

While people were responsive during the thermal comfort assessment form filling there were challenges with respect to consistency in form filling by the residents. There were instances where there were data gaps even after a series of follow ups. A few assumptions on why this challenge was encountered include that there were few people within the household who could read and write and the form filling was dependent on them, residents found it difficult to remember to fill the form amidst their busy schedules. Another assumption is that since the form filling was needed to be done for the timespan of 15 days, the activity might have seemed repetitive to some residents resulting in lack of interest manifesting in the form of inconsistent documentation of their thermal comfort experiences through the form. However, there were certain residents who were consistent with the form filling activity.

12. EXPERIENCE TOUR

A) PURPOSE

- To learn about community's general acceptance of the installed solutions and their willingness to invest in them.
- To understand community member's inclination to have the prototypes that have been piloted in a few homes in their vicinity, installed in their homes
- To understand the possibility of the community owning and facilitating the retrofitting solutions through local women cooperatives.
- To learn of any improvements that need to be made to the installation to suit the community's need and context, better.
- To aim of understanding the above mentioned aspects was gather insights on augmenting informal housing thermal comfort efforts in more informal settlements in the future, with support from women's cooperatives across different cities in India.

B) INSIGHTS

(I) SOLUTIONS THAT ARE VISUALLY VISIBLE (UNDER THE ROOF SOLUTIONS) AND HAVE AN AESTHETIC APPEAL MIGHT BE PREFERRED TO OVER-THE-ROOF SOLUTIONS.

During the first experience tour in Pune in the month of October it was observed that people preferred the wood wool panel installation. They mentioned that 'this looks nice like a false ceiling' and indicated their preference for this installation over others. The aesthetic value of the installation seemed to supersede its thermal comfort providing ability. This was a pattern that was observed across most residents, even though field team members observed certain other solutions performing better in the realm of thermal comfort.

(II) THE SEASON AND TIMING OF A TOUR CAN INFLUENCE PEOPLE'S FEEDBACK ON CERTAIN INSTALLATIONS

In Pune, while people preferred wood wool in the month of October (a time when the temperatures are bearable as compared to peak summer temperatures) they gave relatively good feedback for other prototypes such as alufoil and PET bottles as well during a second tour in the month of April during the peak summer. The season of the tour seemed to broaden people's perspective from solely aesthetics to sensorial thermal comfort benefits.

It was also noticed that time of the day influenced the sensory experience of the retrofits for e.g. in Pune, the solution with PET bottles on the roof was appreciated in the tour at 2-4 pm more whole heartedly than in the morning 11-1pm tour walk through of the solutions.

(III) INTRODUCING NEW COMMUNITY FEEDBACK METHODS THAT MAY BE UNHEARD OF BY THE COMMUNITY MIGHT RECEIVE MIXED REACTIONS RESULTING IN SOME PEOPLE DROPPING OFF IN BETWEEN THE FEEDBACK PROCESS. CONTRASTINGLY, IT MIGHT ALSO INTRIGUE PEOPLE AND CATALYSE THEM TO PARTICIPATE ENTHUSIASTICALLY IN THE PROCESS.

When people were invited to participate in the experience tours there were some who interpreted it as a meeting and were surprised when requested to visit a few houses with the project team on the day of the tour. Additionally, there were people who discontinued the tour after visiting a few houses and excused themselves by stating that they had to look into some other work. In some cases, however people were straightforward about the fact that they could not see how they would benefit from the tour when there was no probability of having any of the solutions installed in their houses in the immediate future. Contrastingly, there were people who were intrigued by the installations and shared their feedback enthusiastically and authentically, clearly stating their reasons for preferring and not preferring certain installations. They even invited friends to join them as they visited one house to the next during the tour.

(IV) CASTE DIFFERENCES CAN INFLUENCE RESIDENTS' DECISION TO VISIT CERTAIN HOUSEHOLDS AND EXPERIENCE THE IMPACT AND FUNCTIONING OF CERTAIN INSTALLATIONS

During the experience tour in Bangalore, there were a few instances where residents refused to enter certain homes during the experience tour. It was indicated by residents that since some people belonged to the so-called 'upper caste' households and they were not comfortable entering the homes of the so-called 'lower caste' households.

(V) PEOPLE MIGHT BE INCLINED TO PUT MORE EFFORT INTO LEARNING MORE ABOUT INSTALLATIONS THAT ARE CLOSER TO 'HOME'

Some people were hesitant or unable to climb ladders to look at over the roof solutions and had the option of looking at images/photographs that were available in such cases. However, it was observed that most people who were physically able to, eagerly climbed the ladder to look at the rooftop garden installation in Pune, since they had heard about the coriander, ladies' finger, spinach and other plants that were being cultivated on the roof of that house. The conversations they had were animated and revolved around how green and nice it looked in addition to the fact that it was a space to grow food as well- an activity that is closer to 'home' and that they usually

Resident climbing the ladder to look at the rood top garden during 'Experience Tour', Pune.

engage with in their villages. The homeowner himself mentioned that it was a good way to teach his children to stay connected with the soil, resonating with the thoughts of those who were eager to look at the installation in his house during the tour.

13. CRITICAL FEEDBACK

A) PURPOSE

- To create a space for residents who have thermal comfort solutions retrofitted in their houses to share their views and honest feedback on the issues, benefits of the installed prototype in their houses
- To receive inputs on a reasonable investment amount for the installation of a given solution in their homes.
- To receive inputs on ways to enhance the approach of working with communities for future reference.

B) INSIGHTS

(I) THE APPROACH TO HARVESTING FEEDBACK NEEDS TO BE FLEXIBLE TO ACCOMMODATE RESIDENTS NEEDS

Critical feedback was facilitated using a mixed formation of inviting people to a workshop and visiting them individually in their homes if they were unable to make it to the workshop. During the time of the first critical feedback session with 5 homes in Pune, the households were preparing for a festival and were unable to make it to the workshop at a common time. The project team therefore adopted an approach of visiting households individually at a time that worked best for the household members. During the second critical feedback workshop in the month of April most household members made it to the workshop, except for one who could not make it due to fasting for religious reasons and felt too tired to come to the workshop venue. An individual critical feedback session was facilitated for him at his house in this scenario. Working with residents to document their feedback might demand being flexible to different methods of facilitation to suit the needs of the community members.

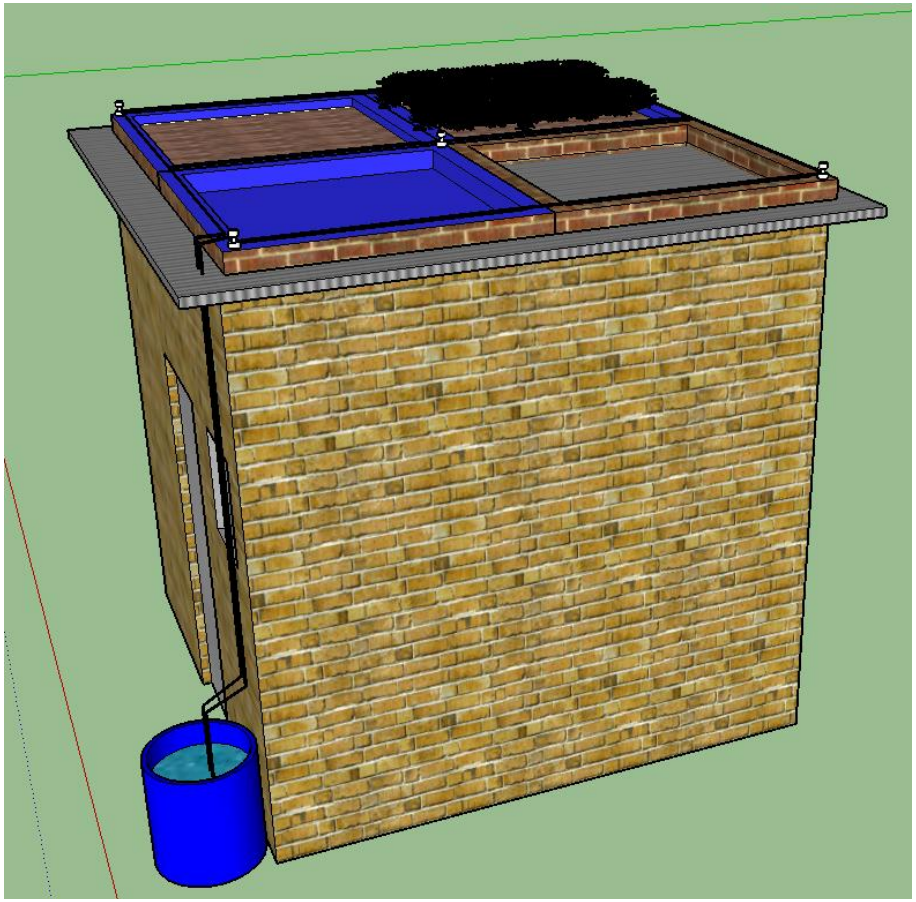
(II) A PEOPLE-ORIENTED EXPERIMENT CAN PROGRESS SMOOTHLY AND AUTHENTICALLY ONLY WITH PEOPLE'S SUPPORT

The critical feedback workshop was a space for reflecting on the challenges encountered and overcome together with the community. There were reflections on the issues people faced due to the installations which included leakage during the rains due to the installation of certain prototypes and other inconveniences people experienced during the installations and in terms of making it to workshops on certain days. At the same time there was gratitude for the efforts that were put into ensuring that inconveniences were looked after when they were encountered and shared at different points in time since the beginning. What emerged was a story of partnership, love, patience, endurance and hope which was made possible and will continue only with the people's support.

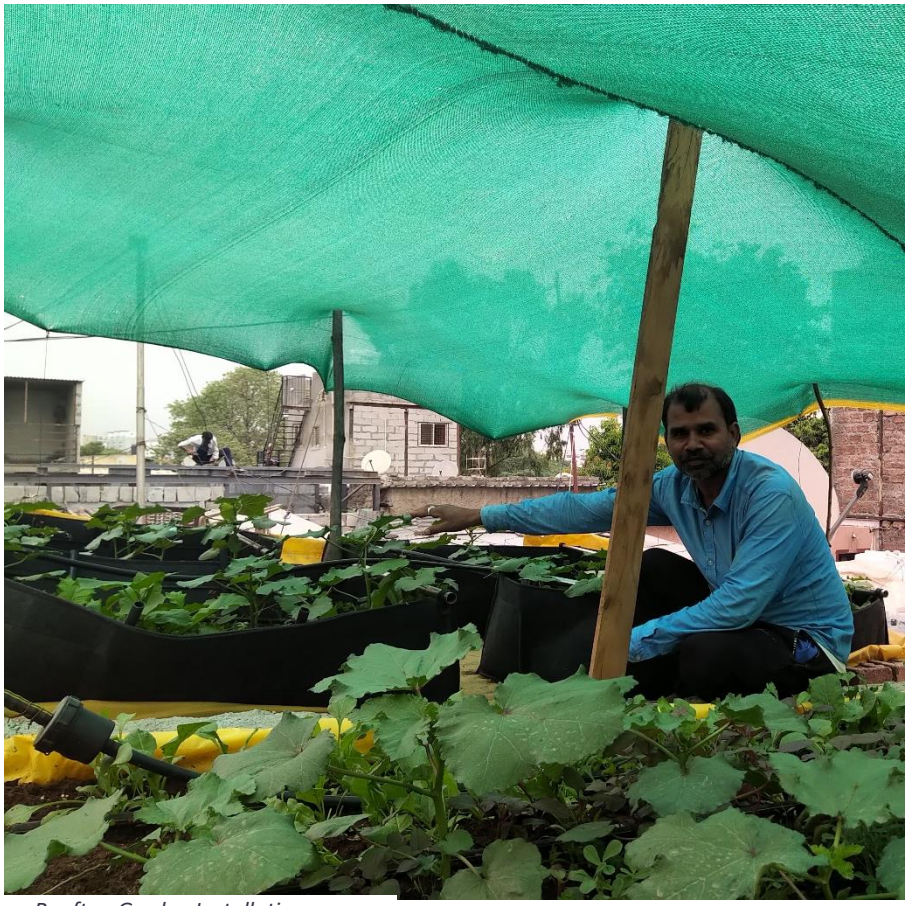
(III) BOTH POSITIVE AND NEGATIVE FEEDBACK SHOULD BE ACCEPTED GRACEFULLY AND EFFORTS MUST BE MADE TO ENSURE THAT PEOPLES LIVES ARE NOT DISRUPTED IN ANY CAPACITY IF AN EXPERIMENTAL INSTALLATION WORKS INEFFICIENTLY

The critical feedback workshop was a space for communities to share issues, benefits and recommendations on the installations. There were instances where participants shared that they were unhappy with an installation and if it couldn't be improved upon they would prefer that it be uninstalled eg. In Pune, in a house where the dormer window as installed during the second cycle, the resident was unhappy with the sunlight that had found a way inside the house due to the window which was disturbing her and her families sleep in the morning. However, she mentioned that the dormer was instrumental in cooling the house at night. Her concerns were acknowledged by the workshop facilitation team. Following this space was made to share recommendations on how the issue could be resolved. The resident and other participants at the workshop gave their suggestions which were noted down. The resident was assured that a quick fix would be made to assure that the issue would be resolved for immediate relief and that the projects design team would work on refining the installation based on recommendations received by the community so that the installation would be effective in the long run. The resident was understanding of the proposition and an agreement was made to continue working in the long term and an assurance was made to the resident that the project team is one call away and will be available to address any unanticipated issues that crop up due to the installation and if the resident decides that she wants the installation removed at any point in time, the project team would do the needful.

B. PROTOTYPE DESIGN AND INSTALLATION



Rooftop Garden Design



Rooftop Garden Installation

The design process occurred in 5 re-iterative stages which included material research and study, energy modelling, mechanism design, fabrication and installation. The material research was focused on deciphering which materials may be suitable for effective reflection and insulation from solar heat. During the material study phase, shortlisted materials were analysed and selected against a scoring sheet. The materials were studied in depth to understand certain physical properties like fire resistance, corrosion resistance, thermal conductivity, weight capacity, water absorption, etc. Thereafter, design base mechanisms were worked on to accommodate the material. The design process was facilitated by internal design team members and architecture and engineering interns, with guidance from academic design mentors. After the tentative finalization of selected designs, working models were fabricated and shared with community residents at 'Participatory Design Workshops' as design prompts to support co-creating and contextualizing the designs before finalizing them for installation. Inputs from the participatory workshops led to iterations in the initial designs. A structural audit was conducted across homes to decipher which solution may be appropriate for each household. Once the designs were finalized and suitable house structures were identified and residents' consent was sought for the installation, fabricators were brought onboard before the final stage of design for an integrative design-build process, leading up to the installation stage. After installation, readings from sensors were recorded along with the feedback from residents regarding their thermal comfort through 'thermal comfort assessment forms' to understand the performance of the solutions both quantitatively and qualitatively. This approach was continued for another cycle to work towards refined and final designs.

1. OVERARCHING INSIGHTS

A) MATERIAL RESEARCH & STUDY

(1) VERY FEW READYMADE THERMAL INSULATION SOLUTIONS AVAILABLE IN THE MARKET ARE SUITABLE FOR INFORMAL HOUSING DUE TO HIGH COST.

During material research, it was found that a lot of materials are available in the market for thermal comfort but most of them are expensive. Only 8 solutions which seemed most suitable to informal housing thermal comfort application, were narrowed down on.

(2) APART FROM COSTS, THERE ARE OTHER NON-NEGOTIABLE FACTORS THAT NEED TO BE CONSIDERED WHILE SELECTING SOLUTIONS.

Some factors that needed to be considered besides the cost of solutions were: the weight of the material, local availability, influence on the available space, end of life disposal, energy and water consumption as well as waste generation during manufacturing and operations etc.

(3) THERE IS IMMENSE POTENTIAL FOR ORGANISATIONS WORKING TOWARDS THE SAME GOAL TO LEARN FROM EACH OTHER

Research revealed that a few other organisations such as Mahila Housing Sewa Trust (MHT), are working on solving the issue of thermal comfort with the urban poor in India. MHT was consulted for suggestions on dormer window and rooftop garden, two solutions that had been successfully tried and

implemented by them. The organisations intelligence helped in designing solutions for implementation in Pune and Bangalore. For instance, the dormer window was initially fabricated by joining (screwing/bolting) separate parts. This design failed as there were a lot of leakages in it through all the joints when it rained. The issue was then discussed with MHT who suggested that the dormer window be fabricated in one-piece using the mould technique. This technique worked and leakage issue was negated.

B) ENERGY MODELLING

(1) SEMI KUCCHA AND SEMI PUCCA HOUSE STRUCTURES ARE MORE SUSCEPTIBLE TO HEAT STRESS THAN PUCCA HOUSE STRUCTURES.

Simulations showed that the semi kuccha and semi pucca houses are more susceptible to heat stress due to the structures being made up of metals, asbestos sheets etc

(2) ALUFOIL WOULD BE THE MOST EFFECTIVE MATERIAL IN MINIMIZING HEAT STRESS.

Simulations on design builder software suggested that alufoil would be the most effective material in minimizing heat stress in informal structures out of all the solutions that were tested on the software.

C) STRUCTURAL AUDIT

(1) EACH STRUCTURE POSES A SEPARATE CHALLENGE FOR RETROFITTING ROOFING SOLUTIONS.

During the structural audit, it was learned that general condition of most roofs in the settlements was poor. In some cases, the horizontal supports were rusted. In other cases, old wooden supports were present which weren't in a position to take on additional weight. In a few other houses, number of vertical columns to support the horizontal beams were also insufficient. Only few house structures were in a condition to take extra loads. These observations indicated that every house posed a separate challenge for retrofitting solutions. In some houses, horizontal beams were needed to give necessary support to the rooms to support certain installations, whereas in some others, both horizontal and vertical beams were needed to strengthen the roof adequately.

(2) SOLUTIONS SHOULD TARGET TO ACHIEVE AN ADDED BENEFIT OF WATERPROOFING TO OVERCOME LEAKAGE ISSUES.

Water leakage was a prominent issue in almost all the houses across both Pune and Bangalore. It needed to be ensured that retrofitting thermal comfort solutions did not make the issue of water ingress worse. Therefore, solution with an added benefit of waterproofing are necessary to address the communities roof structure related needs.

D) GENERAL INSIGHTS FROM RESIDENTS DURING PARTICIPATORY DESIGN WORKSHOP

(1) ISSUES WITH ANIMALS SUCH AS CATS AND RODENTS NEED TO BE CONSIDERED AND ADDRESSED THROUGH THE DESIGN.

One of the major issues which needed to be taken into consideration while designing was cats and rodents which are high in number in the community and they could damage the solutions. We had to make special arrangements for nets in case of dormer window and metal covering and chicken mesh in case of Alufoil on top to ensure that cats and rodents won't damage the solutions.

(2) MAKING ARRANGEMENTS TO PREVENT WATER ACCUMULATION ON THE ROOFTOP DUE TO SOLUTIONS IS A NON-NEGOTIABLE.

The residents were concerned about water being accumulated on the roof when PET bottles were placed in the valleys of the rooftop. They also thought that it would result in the tin getting rusted over a period of time. This was dealt with by placing a tarpaulin sheet in between the bottles and the roof and also in some cases by placing the bottles perpendicular to the valley and on the crests of the tin.

(3) THERE SHOULD BE NO COMPROMISE ON RESIDENTS' HEALTH BEING JEOPARDIZED THROUGH THE SOLUTIONS.

Residents had raised concerns about the health impacts of the Fibreglass insulation material which causes an itch on touching it during the participatory design workshops. Despite presenting a few suggestions on how the material could be completely sealed off to ensure that residents would not come in contact with it, residents were still sceptical about it. Ultimately, a decision was taken to discard the plan to work with the material since it would be inappropriate to go ahead with it even if there is a minutest chance of risking the health of residents.

E) GENERAL DESIGN INSIGHTS BY DESIGN TEAM

(1) DYNAMIC SOLUTIONS WITH OPEN AND CLOSE MECHANISMS ARE MOST EFFECTIVE.

Dynamic solutions such as alufoil chain sprocket, sliding, etc. when closed during the day act as a radiant barrier which delays the heat from entering the house. As the day passes, heat slowly starts to seep into the house so much so that when the surrounding temperature starts to drop during the evening, the temperature inside the house becomes higher. At this point when the dynamic solution is opened and exposed to the sky, the heat transfer gets reversed and the structure gets cooled fast during the

night. This radiant barrier + night sky radiation works in stark contrast to the static insulation system which can stop heat from entering the house during the day, but does not provide an outlet for the entrapped heat to pass during the nights resulting in discomfort.

(2) A VARIETY OF SOLUTIONS SPANNING ACROSS A DIVERSE PRICE RANGE NEED TO BE PREPARED TO MEET PEOPLES PAYING CAPACITY.

Dialogue with design mentors, other organizations and internal team discussions, summarized that the best way for a mass uptake of thermal comfort solutions in the future is to have a variety of solutions that cater to a range of prices, starting from the least expensive to not-so-cheap designs (which would overall still be less expensive than a cooler and definitely an AC). During a discussion with Mahila Housing Trust, it was learned that the most popular solution they are currently manufacturing in a locality in Ahmedabad costs 350 INR per sq. ft. This is more expensive than an AC, but the community is still willing to spend the money since they like the solution. This encouraged experimenting with more expensive mechanisms such as chain-sprocket based ecoboard, in the most recent stage of the project.

F. FABRICATION AND INSTALLATION

(1) IDENTIFYING FABRICATORS WHO ARE OPEN TO WORKING ON A SMALL SET OF EXPERIMENTAL SOLUTIONS CAN BE CHALLENGING.

Given the experimental nature of the project due to which the fabrication requirements were on a small scale, fabricators were hesitant to spend time on a short-term project. Finding fabricators who were willing to work on fabricating products they had hitherto unheard of was therefore challenging and time intensive. There were instances where fabricators committed to working on a given prototype and backed out at the last minute when they were invited to support a larger revenue generating endeavour by another entity.

(2) FOR A SMALL SET OF SOLUTIONS, COST PER SOLUTION INCREASES DRASTICALLY.

It was learnt that the overall cost of a solution increases drastically for a small set of solutions. For instance, the material cost, transportation cost, worker cost, etc. escalates for a small set of solutions vs a larger set. An overall cost difference of up to 60% per solution was calculated for a batch of 25 houses compared to a batch of 5 houses.

(3) IT IS CHALLENGING TO FABRICATE AND INSTALL THE FIRST INSTALLATION FOR OF ANY SOLUTION AND IT IS RELATIVELY EASIER AND LESS TIME CONSUMING TO REPLICATE THE DESIGN IN ANOTHER HOUSE.

The first fabrication of a solution generally took longer than anticipated in most cases. It was easier and less time consuming to replicate the design and installation. For e.g., the first house for Alufoil based chain-sprocket mechanism in Pune took 4 days to complete, but the next one took 2 days to complete including fabrication and installation.

(4) OFFSITE FABRICATION IS BETTER THAN ON SITE FABRICATION.

Offsite fabrication ensured that the solutions were manufactured at a faster pace in a fabricators workshop. The manufacturing time reduced drastically as compared to the off-site fabrication due to lesser disturbances and obstructions and workers being familiar with the working surroundings and machinery. For instance, alufoil curtain mechanism, which was manufactured on-site, took 8 days to get completed, whereas pipe-motor based Alufoil mechanism, an advanced and automated version of the curtain mechanism, took 5 days to complete.

(5) MODULAR & FRACTAL SOLUTIONS ARE THE WAY FORWARD FOR DYNAMIC MECHANISMS OF SHEET AND PANEL-BASED MATERIALS.

The best way forward for the uptake of dynamic mechanisms of sheet and panel type materials (ecoboard, alufoil, wool panels etc.), is to make modular mechanisms. The chain-sprocket and the sliding mechanism are representational examples of this idea, where the base material was the same and the material was changeable. This can create a space for residents to experiment with any other material that they might find helpful. Additionally, the designs being fractal can help with standardisation of the components of the mechanism. It can also help with the easy replacement of worn-out parts.

2. PROTOTYPE SPECIFIC INSIGHTS

A. ECOBOARD

MATERIAL DESCRIPTION:

Ecoboard is a multi-layer board made of compressed recycled material such tetra paks.

MECHANISM DESCRIPTION/S:

1. SLIDING

The sliding mechanism operates on the principles of sliding drawers, wherein channels and rollers help slide the boards to one end of the house to allow night sky radiation and thereby cooling within the house. A pulley mechanism is incorporated within the system to handle the sliding movement.

2. CHAIN AND SPROCKET

The chain-sprocket mechanism works on the principle of louvres, wherein all the panels of the louvres get opened and closed at the same time to allow radiant barrier and night-sky radiation as required. The movement is enabled with the help of chain and sprockets. It is operated with the help of a rope and pulley where the residents just have to pull and push up to a certain extent to enable the dynamic motion.

Ecoboard Sliding Installation (Closed)

Ecoboard Chain Sprocket (Closed and Open)

INSIGHTS:

	MECHANISM 1: SLIDING	MECHANISM 2: CHAIN AND SPROCKET
MATERIAL	• 100% biodegradable • 100% formaldehyde-free • 100% durable – sustainable source • 100% recyclable to equal product • Fire resistant far better than MD • Moisture resistant far better than MDF • Density from 200 kg/m3 to 800 kg/m3 HD • Insect free and insect repellent.	
DESIGN	• The solution can't be fixed directly on a tin roof and will need brick wall or vertical members to support. • To give full coverage to the roof it is important that the pre-existing roof structure be rectangular or square shaped.	• The size of the panels should be the same to ensure smooth interconnected panel movement • The size of the panels needs to be optimum to ensure a trade-off between less framing metal usage and low wind resistance. • Clearance of the mechanism needs to be such that it ensures maximum opening with minimum height of the mechanism.
PARTICIPATORY DESIGN WORKSHOP	• The ecoboard sheet should extend beyond the edge of the roof to make sure rainwater runs off easily • Horizontal support should be given to the ecoboard sheet to prevent it from bending or breaking • Installation of the solution shouldn’t hinder access to houses which have a terrace	

FABRICATION	• The pulley plane should be in one straight line to ensure the handling mechanism is smooth for the user	• The sprockets need to be aligned and welded perfectly in a straight line for smooth functioning of the chains • There should be no sagging in the pipe which supports rotation
INSTALLATION	• No part of the pulley assembly should be blocked by any structural elements of the house structure	• The fixing of chains for this mechanism needs skilled work persons. • The supports of the mechanism need to be sturdy and rigid.
HOMEOWNER FEEDBACK	**VijayaLakshmi, Bangalore -** The installation is not impactful. When there is no electricity the family has to sit outside the house. Opening and closing the installation is difficult. Additionally, the food gets spoiled due to the heat, just as it used to before the installation.	**Selvi, bangalore -** The installation is effective. There was a day when there was no electricity from 3:pm to 5pm. Everyone in the area was sitting outside the house but the residents were able to sit indoors since the temperature was comfortable.
PERFORMANCE MEASUREMENT	Average temperature reduction of 4 deg C was observed during day time	

B. ALUFOIL

MATERIAL DESCRIPTION:

Cross-linked polyethylene foam (also known as XLPE) is a closed-cell foam characterised by a compact feel and resistance to water. It is covered with a low-emissivity and high reflectivity aluminium coating on one side which ensures no heat is emitted inside the space.

MECHANISM DESCRIPTION/S:

1. STATIC: The static installation is an under the roof installation. The Alufoil, with its shiny side facing downwards, is stuck to the roof with the help of a strong adhesive. It supports insulation and ensures that the heat coming through the roof doesn't get transferred to the house as the shiny side facing down doesn't emit the heat absorbed by the foam.

2. SLIDING: The sliding mechanism operates on the principles of sliding drawers, wherein channels and rollers help slide the boards to one end of the house to allow radiant barrier and night sky radiation principles at play. A pulley mechanism is incorporated within the system to handle the sliding movement for the resident.

3. CHAIN SPROCKET: The chain-sprocket mechanism works on the principle of louvres, wherein all the panels of the louvres get opened and closed at the same time to allow radiant barrier and night-sky radiation as required. The movement is enabled with the help of chain and sprockets. It is operated with the help of a rope and pulley where the residents just have to pull and push up to a certain extent to enable the dynamic motion.

4. PIPE MOTOR: The pipe motor mechanism is like an automated curtain mechanism where the Alufoil sheet folds and unfolds as required to enable radiant barrier and night sky radiation principles. The Alufoil is supported on the rope which winds and unwinds enabling opening and closing of the alufoil that is resting on it. The rope is wound on the pipe which is being controlled by a motor. The residents have to just flip a switch to enable the opening and closing of the mechanism.

All dynamic mechanisms need to be closed during the day to stop the heat to the existing roof and opened in the evening to allow the tapped heat radiated back to the night sky.

Alufoil Pipe Motor (Closed)

Alufoil Chain Sprocket (Open)

Alufoil Static

Alufoil Sliding (Open)

INSIGHTS:

	MECHANISM 1: STATIC	MECHANISM 2: SLIDING	MECHANISM 3: PIPE MOTOR	MECHANISM 4: CHAIN AND SPROCKET
MATERIAL	• Excellent sound & heat barrier • Non-porous • Non-corrosive • Non-abrasive • Water resistant • Can be used as both a reflective outer surface and heat guard to maintain internal temperatures low/constant			
DESIGN	• It should be installed from the inside with the help of an adhesive • The alufoil layer should be facing downwards and not towards the sky.	• The span should not be too long or too wide as it will result in sagging of the material and the mechanism won't operate efficiently.	• The mechanism involves electricity usage (although minimal) but could be a deterrent during the times when there is power outage in the neighbourhood. • The span should not be too long or too wide as it will result in	• The size of the panels should be the same to ensure smooth interconnected panel movement • The size of the panels needs to be optimum to ensure a trade-off between less framing metal usage and low wind resistance. • Clearance of the mechanism needs to be such that it ensures maximum opening (minimum 5 degree) with minimum height of the mechanism. • The shiny side needs to face down and top of the foam needs to be covered with tin sheets to save it from getting spoilt during rains.

			sagging of the material and will create difficulty in operations. One module can cover maximum 12 ft by 12 ft area. • The silpaulin sheet on which the alufoil is fixed needs to be at least 120 GSM to ensure long life.	
PARTICIPATORY DESIGN WORKSHOP	• The gap between roof and sheet needs to be minimal. • Rats might damage the material • Make the solution such that the material in place could be changed and replaced whenever we want, the mounting mechanism could be the same and the panels could be of any material that residents like			
FABRICATION	• No fabrication required	• The plane of the pulley should be in one straight line to ensure the handling mechanism is	• The pipe which is going to rotate needs to be in one line with no sagging. • The sliding channels on the side should be vertical to the	• The sprockets need to be aligned and welded perfectly in a straight line for smooth functioning of the chains.

		smooth for the user.	silpaulin, i.e. silpaulin needs to be right beneath the channels. If not done this way, it will get dragged behind the channel.	• There should be no sagging in the pipe which is going to rotate.
INSTALLATION		• No part of the pulley assembly should be blocked by any structural elements of the building	• The rope needs to be tight to prevent sagging	• The fixing of chains for this mechanism needs skilled workpersons. • The supports of the mechanism need to be sturdy and rigid.
HOMEOWNER FEEDBACK	**Zubeida Kazi, Ibrahim, Pune -** The residents of both the houses have found the installation effective in reducing heat stress. They are pleased with the aesthetics of the solution. The residents are able to spend time inside the house during the day and can sit without the fan.	**Guna, Bangalore -** The resident experienced relief from heat after installing the solution. However, they have been facing an issue with cats scratching the alufoil sheet, which needs a little replacing and repair work.	**Atul Nanavare, Pune -** The resident has experienced the indoors being less hot than before and habitable during the daytime. He feels that the opening and closing mechanism can be swifter.	**Rayissa Sayyed -** The resident is experiencing thermal comfort and can sleep comfortably and for longer hours in the morning than before.

PERFORMANCE MEASUREMENT	Average temperature reduction of 2 deg C was observed during the day time in peak summer.	Average temperature reduction of 4 deg C was observed during the day time in peak summer

C. WATER FILLED PET BOTTLES

DESCRIPTION:

Discarded PET bottles filled with water and stuck on the roof.

Water filled PET bottle (Water Filling)

Water filled PET bottle- Installation

INSIGHTS

	WATER FILLED PET BOTTLES
MATERIAL	• Can be fabricated, installed and maintained by local people. • Water has the highest specific heat capacity than any liquid. Specific heat is defined as the amount of heat one gram of a substance must absorb or lose to change its temperature by one degree Celsius. For water, this amount is one calorie, or 4.184 joules. Thus, it can absorb heat before its temperature rises. This trait helps it to stabilize temperature in its surroundings. • This solution increases the thermal mass of the roof i.e., its ability to store heat, for a longer duration before letting it seep into the house through the day and reversing the heat transfer process of the water during the night, since the warmed water during the day gets cooled during the night due to the drop in ambient temperature, which in turn keeps the roof cool the next morning even when the sun starts to heat up. • Zero energy solution • Does not generate waste • Does not involve energy • Recycled material can be used.
DESIGN	• The roof structure should be good enough to take a uniform load of 1 kg per sq. ft (weight of 1 water filled bottle). • A motorised system to support the circulation of water across bottles can be challenging because the water required was too much and most communities face water scarcity in the summer months and additionally the chances of water leakage also high. • Chemicals can be mixed in water to prevent fungi but the disposal of that water will be a challenge. • If the water bottle is filled fully then fungi can be prevented.

	• The tarpaulin sheet and the bottles should be stuck on the roof to prevent it from cats and dogs.
PARTICIPATORY DESIGN WORKSHOP	• The existing roof condition needs to be considered while designing. • If the bottles are placed on corrugated roofs where the 'valley' width is low, there is a risk of impending storm water runoff (and hence inadvertently aiding water logging) from the roof during rainfall events. • Once the water gets heated the heat might eventually travel downwards through the roof through conduction processes (i.e., what if the thermal mass is insufficient to provide adequate time lag and decrement factor) - club this with an insulating layer below might help resolve this issue
FABRICATION	• The use of old PET bottles which are in good shape is recommended
INSTALLATION	• Horizontal support for the roofs should be installed from the inside in the roofs which lack the required strength to bear the load of the bottles. • The silpaulin sheet on which the bottles are to be stuck needs to be at least 120 GSM to ensure long life.
HOMEOWNER FEEDBACK	**Mangal Shinde, Pune -** The resident found the solution effective in providing thermal comfort. Her family can sit and sleep comfortably indoors compared to before. She found the solution easy to install and affordable and they are planning to install it themselves whenever they add another floor to their house. **Mahjabeen, Pune -**

	The residents family is experiencing reduced indoor temperature during the day and night,both. They are able to spend time inside the house during peak summers which was not the case before.
PERFORMANCE MEASUREMENT	Average reduction of 2 deg C was observed during day time in peak summer

D. WOOD WOOL PANELS

DESCRIPTION:

Wood Wool Panel is an environment-friendly, recyclable material made from wood wool, cement and water. It is installed under the roof.

Wood Wool Panel Installation

	WOOD WOOL PANELS
MATERIAL	• 100% Biodegradable • 100% Asbestos-free • 100% Durable • 100% Recyclable product • The resistance against fire can reach up to two hundred forty minutes depending on the product's thickness and setup. • Water vapor diffusion resistance factor: 4.7 m2k/w • Density: 18mm - 626 Kg / m3 • Insect free and insect repellent
DESIGN	This material should not be installed outside because the material can absorb water and dust.
PARTICIPATORY DESIGN WORKSHOP	This material was used as a replacement for the initially proposed 'glass wool' material that was rejected by residents at the participatory design workshops. Therefore, wood wool was not presented at the workshop.
FABRICATION	• As per the measurements make the entire frame with L-angles to hold the wood wool panels
INSTALLATION	• Take supports of the existing horizontal metal rods under the roof to fix the frame using GI wires. Enhance the strength by giving small metal pieces for support on all sides of the wall. Slide the panels through the fixed frame and position them • Weld L-angles as per the panel size and start fixing them from one corner of the house. Hold the panel and close the other sides with L-angles
HOMEOWNER FEEDBACK	**Balasaheb Chaure, Pune**

	The residents family is experiencing the thermal comfort benefits through this solution. Their house remains cool throughout the entire day, which was not the case before. They used to spend a lot of time outdoors due to extreme indoor temperatures, previously. They are able to sleep better now. They can even sit without the fan inside the house now. **Muttamma, Bangalore** The resident stated that the solution has not worked in anyway in their house. It is hotter than what it was before, without the wood wool panels. They feel hot even at 9 am in the morning. It gets hotter at night.
PERFORMANCE MEASUREMENT	Average temperature reduction of 2 deg C was observed during day time in peak summer

E. ROOFTOP GARDEN

DESCRIPTION:

This installation consists of a layer of vegetation that can be cultivated in diverse ways above the roof eg. In pots, brick beds, wooden crates, grow bags, etc.

DESCRIPTION OF TYPE OF INSTALLATIONS:

I. ROOFTOP GARDEN (POTS):

Plants grown in pots placed on the roof.

II. ROOFTOP GARDEN (BRICK BED)

A bed like structure using bricks/wooden crates in which plants can be grown.

III. ROOFTOP GARDEN (GROW BAGS):

Plants grown in Grow bags made of High-density polyethylene (HDPE) sheets. These bags are light in weight and can be moved around easily.

Roof top garden : Grow Bags and Brick bed

Rooftop Garden: Irrigation System

Rooftop Garden (Pots)

INSIGHTS:

	POTS	BRICK BED	GROW BAGS
MATERIAL	• Supports thermal comfort. • Improves air quality. • Can be fabricated, installed and maintained locally.		
DESIGN	• A sturdy framework of walls and roof which can withstand the weight of the installation is required. • The slope of the roof should be between 2-15 degrees. • Minimum 4-inch soil depth is required to support the growth of any plant. • In informal settlements there is high risk of snakes, hence scented flower plants should be avoided. • Low weight, fast growing plants should be planned on rooftops to minimise the load on structure. • Plant selection should be based on considering water availability during summer. • Bean creepers have good foliage and needs minimal water and soil to grow. • Pots should be supported with bricks to prevent the pots from falling off the roof. • Soil should be replenished after every season (quarterly) with new soil, cocopeat and compost or manure. • Plants with heavy fruits (eg. pumpkin) should be avoided. • A drainage facility should be available to support the collection and reuse of drained water and soil. • Green net or shade net should be installed to protect plants from succumbing to direct sunlight. • Frequent regular care and observation of plants, containers and roofs is a necessity.		
PARTICIPATORY DESIGN WORKSHOP	• Snakes and scorpions might come to reside in the soil. • Mosquitoes will be attracted to the house due to the presence of water in the soil might spread diseases. • Wet soil might corrode the roof. • It might be difficult to climb up manually and water the plants everyday on the roof • Plants could die due to excessive heat above the roof		

	• Lifting the planting surface off the roof with the help of a wooden blocks or some other method might help with weight issues.		
FABRICATION	• Lightweight good quality HDPE material pots should be used. • Pots should have depth of at least 4 inches. • GI thin wire can be used for growing of creepers. • The potting mixture should contain a balance of soil, cocopeat and compost/manure.	• 1 or 2 layers of rectangular bricks-cement pot like structure should be constructed as per the space available on roof. • Pot structure should be strengthened by regular dampening with water atleast for a day or two after construction of the structure. • The potting mixture should contain a balance of soil, cocopeat and compost/manure.	• Lightweight Bio fibres or HDPE material growbags can support planting. • The potting mixture should contain a balance of soil, cocopeat and compost/manure.
INSTALLATION	• Pots must be arranged on the roof at the front side of the house to enable ease of access to residents. • Ensure that the roof structure is strong and sturdy where pots are placed.	• Good quality double layered Tarpaulin sheet to be laid on the brick bed to avoid water leakage issues. • Seeds/ plants be grown along the dripline of water. • Some walking space to be at roof edges.	• Grow bags as per desired sizes and shapes should be installed depending on the roof characteristics. • Some walking space to be left in between bags and at roof edges.

		• Water Irrigation system be installed on the roof and provisions for the motor to be operated made from inside the house, to minimize frequent manual watering on roof. • Ensure the potting mixture is filled till 80% of the bed height to account for water drainage and to avoid soil erosion. • Ensure that the seeds, once sown are covered with green net at least during the initial 15-20 days to ensure they don't dry up due to excessive sunlight. • Mulch the beds with grass, hay to ensure the soil retains its moisture.	• Ensure the seeds once sown are covered with a green net at least during the initial 15-20 days to ensure they don't dry up due to excessive sunlight. • Mulch the beds with grass, hay to ensure the soil retains its moisture.
HOMEOWNER FEEDBACK	**Ajit Kumar Yadav, Pune** The resident found it difficult to give water to the plants on a regular basis, since he lives alone	**Jeera Lal Yadav, Pune** The installation has provided relief to the residents' family by reducing the indoor heat. The elders of the	**Suman Yadav, Pune** The installation has benefitted the family in multiple ways. They are able to sleep better and the

	and has to travel a lot for work. He found it inconvenient to water the plants when the pots were placed over the roof. He also noticed that the plants weren't receiving enough sunlight when placed in the lane outside his house.	family are glad that the children are getting a hands-on farming experience. They are concerned about soil erosion during the rains. Presently they are experiencing some issues with a cat that comes to reside on the roof at night damaging the plants.	children of the house are able to focus better on their studies which was difficult to do when indoor temperatures were unbearable, previously. The family is concerned about soil erosion during the rains.
PERFORMANCE MEASUREMENT	Average temperature reduction of 4 deg C was observed during day time in peak summer		

F. DORMER WINDOW

DESCRIPTION:

A dormer window[2] is made of fibreglass moulded into a hump that is retrofitted into existing corrugated steel/tin/cement roofs while the pane is made of translucent plastic to diffuse light and avoid glare. It works on the principle of convective ventilation where warm air rises up and vents out of the Dormer window. The plastic is moulded into a hump with an opening at the bottom to allow air to circulate. The gap is covered with a metal net to prevent insects and other animals from getting in the house.

Dormer Window: Indoor view

[2] *Ujasiyu* which literally means 'light' in gujarati language, is a simple dormer window devised as a prototype solution to be fitted in the roof. This solution was originally designed by an architectural firm footprints earth in collaboration with mahila sewa housing trust (mht) as the implementation partner for informal settlements with an objective of allowing light and ventilation in the otherwise dingy living spaces in the houses.

INSIGHTS

	DORMER WINDOW
MATERIAL	• Light weight and does not require additional structural components • Low energy solution • Low resources and waste solution • The solution can be fabricated, installed and maintained by local people. • Applicable in Kuccha and semi-pucca houses, with no or minimal source of light and ventilation
DESIGN	• The front part of a Dormer Window should be installed towards the slope of the roof to prevent the rainwater coming in the house. • The opening of a Dormer Window needs to be facing leeward side for it to function appropriately. • A Dormer Window will give better results if placed opposite to the door. Because the door will act as an inlet and the dormer window will act as an outlet (This will work as stack ventilation). • The solution will be more useful if installed in an area of a house that does not receive sunlight. • The solution should be installed away from the fan to avoid cross currents of air movement.
PARTICIPATORY DESIGN WORKSHOP	• Cutting of existing roof too much to fit the dormer window might weaken the structural strength of the existing roof. • A net is required to prevent insects from entering home. • If the net size is too small dust may accumulate and stop air ventilation • If a bigger jali/mesh is used then insects, rats can enter.
FABRICATION	• To avoid leakages, Dormer Window should to be manufactured as a one-piece solution using mould technique.

INSTALLATION	• The edges of the Dormer Window need to be fixed with a mixture of concrete and a waterproofing solution (e.g. Dr. Fixit) to avoid leakages.
HOMEOWNER FEEDBACK	**Anita Bhosale, Pune** The resident shared the dormer window gave a little relief in terms of ventilation and is a good day lighting solution. However, the resident requested that the dormer window be uninstalled from her house since the family faced water leakage issues during the rains. (Note : A revised version of the dormer window which addressed the water leakage issue was installed in the next resident's house.) **Rukaiyya Sheikh, Pune** The resident shared that the dormer window brings too much light into the room, due to which residents wake up earlier than before. They room feels hotter than before and they are unhappy with the dormer windows functioning during the day. However, the dormer window is effective in reducing the indoor temperature during summer nights and there is some relief at night because of it. (Note : Work to refine the installation and address the residents concerns is in progress. An alufoil piece has been used to create a barrier between the light that the dormer window brings into the house to address the residents immediate concerns and will be removed after a modified design is finalized)
PERFORMANCE MEASUREMENT	No difference was observed in the temperature as this is more of a lighting and ventilation solution.

C. ENGAGEMENT WITH ACADEMIA

Architecture student leading an experience tour in Pune

'Engagement with Academia' was part of the effort to catalyse the heads, hearts and hands of the architects of the future to work with people living in marginalized urban spaces. The engagement comprised the following approaches:

1) Collaboration with students of architecture and engineering as part of college 'internships' - A total of 8 interns initiated their engagement with the thermal comfort endeavour by working on material research and analysis. Post material research the students started work on the prototype design sketches and model. Once the sketches were ready, working models of the design were fabricated and used as design prompts in Participatory Design Workshops. Residents design suggestions and feedback were again incorporated into the design by the students and designs were finalised. A few students supported the fabrication and installation of these designs during the first cycle. In addition to engaging with students, architecture professors were invited to play the role of design mentors to guide and review students work on a frequent basis.

2) Advocating to architecture 'Board of Studies' (BOS) members for the seamless integration of sustainable architecture and informal housing perspectives architecture curriculum - The order of tasks as unfolded were a) Architecture Curriculum analysis and recommendations b) Identifying gaps and learnings from the first cycle of the 'Informal Housing Thermal Comfort Project' to initiate advocacy for the need and potential of integrating Informal housing perspectives in Architectural education that were presented to BOS members through a position paper c) Sharing the Position Paper and Curriculum Analysis and recommendations to initiate engagement with the Board of Studies to gather their perspectives and design the way forward to hand hold the universities in integrating the proposed changes. This effort has been undertaken with two universities, until now.

Detailed insights from these engagement processes are shared below.

1. COLLABORATION WITH ARCHITECTURE AND ENGINEERING COLLEGES

A. PURPOSE

- To create a space for architecture and mechanical engineering undergraduate students to develop their skills and manifest their academic knowledge in practice by working hands-on on the issue of heat stress with communities inhabiting informal settlements in a participatory manner.
- To sensitize professors of architecture to the issue of thermal comfort in informal settlements and create a space for them to contribute to the co-creation of solutions by playing the role of design mentors in the project.

B. INSIGHTS

(A) WORKING WITH ACADEMIA TO CREATE A SPACE TO WORK HANDS-ON WITH COMMUNITIES INHABITING INFORMAL SETTLEMENTS, IS AN EFFECTIVE PATHWAY TO SENSITIZE THE BUILT SPACE PROFESSIONALS OF THE FUTURE AND EQUIP THEM WITH SKILLS TO ADDRESS HEAT STRESS AND OTHER BUILT SPACE-RELATED INJUSTICES 'WITH 'COMMUNITIES INHABITING MARGINALIZED URBAN SETTLEMENTS.

Students who were associated with the project as part of their academic student internship programs shared that the program helped cultivate empathy towards heat stress and other injustices experienced by inhabitants in informal settlements. Few students who completed their entire internship were involved in community workshops, house audits, on-site installations and experience tour facilitation. It was shared by the students that the community engagement process was enriching and that they felt more grounded in the work they were engaging in as part of their internship. They expressed how this experience has helped them realise the importance of co-creating designs with communities and designing solutions that actually serve people's needs. They expressed how they have grown in empathy and humility through this process, besides enhancing their skill sets as architects and engineers.

(B) A LACK OF INTEREST BY STUDENTS IN COMPLETING THE COURSE OF AN INTERNSHIP THAT FOCUSES ON WORKING WITH INHABITANTS OF MARGINALIZED SETTLEMENTS IN URBAN AREAS IS THE REFLECTION OF AN EDUCATION SYSTEM THAT NEEDS TO ACCOMMODATE 'INFORMAL HOUSING' AS PART OF THE CURRICULUM TO ENABLE STUDENTS TO PARTICIPATE WHOLEHEARTEDLY TOWARDS WORKING WITH MARGINALIZED INDIVIDUALS

The experiment to engage with architecture students as design-interns, without their work being formally recognized as part of coursework (either as a design studio project, design assignment etc.), led to a situation where some interns abruptly terminated their contributions and participation at varying stages of the effort, well before their planned date of conclusion of the internship period. Such participation can be attributed to a deficient education system that fails to encourage students to participate in endeavours that can build their capacities to ensure a socio-ecologically just living spaces for marginalized individuals inhabiting informal settlements in urban areas. This indicated that formalizing student contributions through all authentic avenues of engagement, formally involving the academic institution as a whole instead of directly engaging with just the students, is likely to greatly enhance the rigor, diligence and mindfulness brought into practice by students.

(C) RETAINING REGULAR INTERACTIONS WITH ACADEMIC MENTORS CAN BE CHALLENGING AND INDICATES THE NEED TO REFLECT ON THE IMPORTANCE ATTRIBUTED TO INITIATIVES THAT ARE AIMED AT BUILDING STUDENTS CAPACITIES TO USE THEIR KNOWLEDGE AND SKILLS TO WORK TOWARDS ENSURING SOCIO-ECOLOGICALLY JUST LIVING CONDITIONS FOR INHABITANTS OF MARGINALIZED URBAN SPACES

It became increasingly difficult to have academic design mentors come together on monthly design review calls. Their other roles and responsibilities eventually seemed to take more precedence over the project. Keeping their interest and momentum going till the end was challenging, indicating the need to reflect on systemic changes that are needed to enable architecture academia to contribute to ensuring just living conditions for inhabitants of marginalized urban spaces.

D) SENIOR MANAGEMENT PERSONNEL IN ARCHITECTURE ACADEMIA IN INDIA WHO ARE EVASIVE ABOUT THEIR CURRICULUM'S SYSTEMIC NEGLECT OF INFORMAL HOUSING ISSUES, DEMAND A STUDENT-LED PUBLIC CAMPAIGN TO UNDERSCORE THIS EXCLUSION AND APPLY ENOUGH PRESSURE UPON INSTITUTIONS THROUGH NON-VIOLENT MEANS TO DISMANTLE THE STRUCTURES OF THE STATUS QUO AND MOVE TOWARDS A SYSTEM THAT IS JUSTICE-ORIENTED.

Senior management personnel from one of the universities that was collaborated with seemed to think that the current architecture system is not flawed and has no scope for improvement. He did not consider the lack of inclusion of informal housing perspectives in architecture education problematic and supported the existing elite-oriented system. Opposed to his views, students from the university expressed that they realise the lacuna in the system and see the need to advocate for curriculum change. A student-led advocacy approach therefore seems to be a vital pathway to ensure that the architecture academia is sensitized to built-space injustices and equipped with the skills to work towards addressing the same.

2. ENGAGEMENT WITH ARCHITECTURE BOARD OF STUDIES

A) PURPOSE

- To work on analysing and identifying architecture curriculum[3] gaps through the lens of exclusion of Informal Housing perspectives and sustainable architecture to make a case for the inclusion of these perspectives to Board of Studies members.
- To advocate for the integration of sustainable architecture design and informal housing perspectives in arch the architecture curriculum through engagement with Architecture Board of Studies members based on learnings from the Informal Housing Thermal Comfort Project.

B) INSIGHTS

(I) INSIGHTS FROM CURRICULUM ANALYSIS (EXAMPLES)

(A) THE ARCHITECTURE CURRICULUM EXCLUDES 'INFORMAL HOUSING', DEPRIVING STUDENTS AND ARCHITECTS OF THE FUTURE FROM CONTRIBUTING TOWARDS ENSURING JUSTICE IN MARGINALIZED URBAN SPACES.

The Architecture curriculum includes informal housing design in one semester as one of their design studios. This is an abrupt introduction to Informal housing owing to its complex and dynamic nature, which could be difficult to grasp in one semester. Additionally, site visits are either absent or designed as a separate elective. These factors

[3] Note: Insights based on 'curriculum observations' are based on the curriculum analysis of the two Architecture Universities mentioned in the report.

contribute to the lacuna in necessitating, sensitizing, motivating, and equipping students with the skills to unearth and address the socio-economic, cultural, ecological, and climatic complexities in informal settlements that are interlinked with the architectural design of these marginalized urban spaces.

(B) INTERCONNECTED SUBJECTS ARE COMPARTMENTALIZED IN THE SYLLABUS DEPRIVING STUDENTS OF A HOLISTIC PERSPECTIVE OF THE CONCEPTS THEY ENGAGE WITH AS PART OF THEIR FORMAL EDUCATION

Architecture is a convergence of multidisciplinary and sensory aspects of habitability of a space. It transcends the construction of walls and a roof and transforms a space into an experience. The distribution of five years of education in different design of building/space typologies has led to compartmentalization of concepts that needs to be viewed holistically. For e.g., Passive design is studied as part of climatology subject, but it is required to be integrated in respective designs, similarly Sustainable design or Vernacular architecture is designed as a separate subject or an elective with no parallels of its application in the design.

(C) AFFORDABLE HOUSING POLICY AND ENVIRONMENTAL SCIENCE TOPICS ARE LIMITED IN THE SYLLABUS AND NECESSITATE INDEPTH ENGAGEMENT TO CATALYSE THE ARCHITECTS OF THE FUTURE TO ENGAGE WITH THESE ELEMENTS THROUGH THEIR WORK

Subjects with respect to affordable housing and environmental science exist, but are limited to theory and are rarely engaged with through practical experience. Therefore, a future architect's knowledge and inclination to engage in-depth with affordable housing and environmentally sensitive design remains largely limited to post-graduation due to a lack of academic experience in these fields.

(II) INSIGHTS FROM INTERACTIONS WITH BOARD OF STUDIES MEMBERS

(A) THE SEAMLESS INTEGRATION OF INFORMAL HOUSING PERSPECTIVES AND SUSTAINABLE BUILDING TECHNIQUES IS ARCHITECTURE CURRICULUM IS A VITAL PATHWAY TO EQUIP THE HEARTS, HEADS AND HANDS OF BUILT SPACE PROFESSIONALS TO CONTRIBUTE TO JUSTICE-BASED ENDEAVOURS IN INFORMAL SETTLEMENTS

The curriculum of two architecture universities was analysed from the perspective of sustainable architecture and informal housing. Curriculum recommendations were worked on and shared with Board of Studies members from these universities. Engagement with one of the universities revealed that few of the board members aligned with thoughts on the vitality of integrating informal housing perspectives and sustainable architecture perspectives in the curriculum. They are currently in the process of navigating pathways to support and implement curriculum changes with the Informal Housing Thermal Comfort Team.

(B) THERE IS HOPE THAT BOARD MEMBERS MIGHT ALIGN WITH THE NECESSITY TO INTEGRATE INFORMAL HOUSING, THERMAL COMFORT AND CLIMATE CHANGE RELATED PERSPECTIVES IN ARCHITECTURE CURRICULUM

The curriculum changes caught the attention of the BoS about the missing elements of the present curriculum with regards to Thermal Comfort, heat transfer, passive design, climatology, sustainable cooling design, climate justice. The questions during the engagement were more on “How to” include these topics than “why to” include these. It was inferred that the BoS is open to the changes suggested and understands the need to study the architecture subjects in perspective to climate change and climate justice rather than isolating the architecture design discipline from these. The changes to the curriculum both across width and breadth of the subjects supported by activities was well-received by the Board of Studies members and has been taken up for review for its integration in curriculum.

(C) CURRICULUM CHANGE CAN BE A COMPLEX AND HIERARCHICAL PROCESS THAT DEMANDS PATIENCE FROM ENTITIES ADVOCATING FOR CURRICULUM CHANGE

The Board of Studies Members in one of the Architectural University's has been easily accessible and expressed keen interest and inclination to incorporate the proposed recommendations. In spite of this, it has taken a few months to accelerate the process of curriculum change, revealing that architecture curriculum change is a hierarchical and also complex process that may also warrant reaching out to the senate members of Engineering colleges, as the architecture board doesn’t have the sole authority to approve the changes.

(D) THERE IS A NEED TO BE MINDFUL OF THE TENURE OF BOARD OF STUDIES MEMBERS BEFORE INITIATING ENGAGEMENT FOR CURRICULUM CHANGE AND OTHER RECOMMENDATIONS WITH THEM.

It was learned that once the term of a given Board of Studies is completed the board is dissolved and new members are nominated. On account of this the response towards furthering curriculum change efforts with members from one of the two Board of Studies that were contacted, wasn’t encouraging as their tenure ends in August 2022. Though proposing curriculum changes was a possibility, completing the curriculum process wasn’t possible in the duration that was hoped for initially and hence the engagement with them has been paused until the election of the new board.

IV. WAY FORWARD

The Informal Housing Thermal Comfort (Pilot) endeavour has progressed through participatory co-creation with diverse stakeholders comprising of local communities, NGO partners, architecture academia, fabricators and installation persons, to spearhead the movement on battling heat stress-related injustices endured by people inhabiting marginalized settlements in urban areas.

This pilot endeavour is a stepping stone on a journey of making thermal comfort solutions available and easily accessible to communities inhabiting informal settlements firstly in Pune and Bangalore and across different contexts in India through a similar approach. Therefore, the immediate next steps are to monitor the performance of the pilot installations in Pune and Bangalore during peak summers and across different seasons. A culmination of learnings from performance measurement, design team observations and critical feedback from residents will contribute to the creation of more evolved prototype designs which will be modularized.

Considering that the work until now was part of the 'Research and development phase of the project' - installations were implemented on a small scale which contributed to increased intervention costs. Future endeavours will therefore focus on reducing the cost of finalized thermal comfort retrofits recognising that thermal comfort products should be affordable and accessible to marginalized individuals battling heat stress and poverty among other injustices. To contribute to this effort, mechanisms to facilitate the integration of affordable financial structure mechanisms for women cooperatives institutions and other stakeholders such as fabricators, installers, who are interested in and can provide thermal comfort retrofits in their own communities and across settlements, will be explored. Capacity building for financial, installation, maintenance and relevant soft skills will be provided to women cooperatives and other interested entities gradually through an 'Informal Housing Thermal Comfort One-Stop- Shop' piloted by cBalance.

The aim over the coming years is to collaborate with grassroots organisations and women's cooperatives across different heat stress battling cities in India to facilitate the implementation of informal housing thermal comfort pilot endeavours which can be scaled up once contextualized thermal comfort solutions are co-created with communities.

In the realm of architecture education, advocacy efforts with Board of Studies members will continue and handholding support will be provided to institutions willing to work towards the seamless integration of Informal housing and sustainable cooling perspectives in architecture education.

Overall, intention to progress with hope on this journey of co-creation, collaboration and meaningful imagination towards ensuring thermal comfort and justice to our marginalized human counterparts inhabiting informal settlements who are bearing the brunt of injustices that are being experienced on our climate collapsing planet.

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