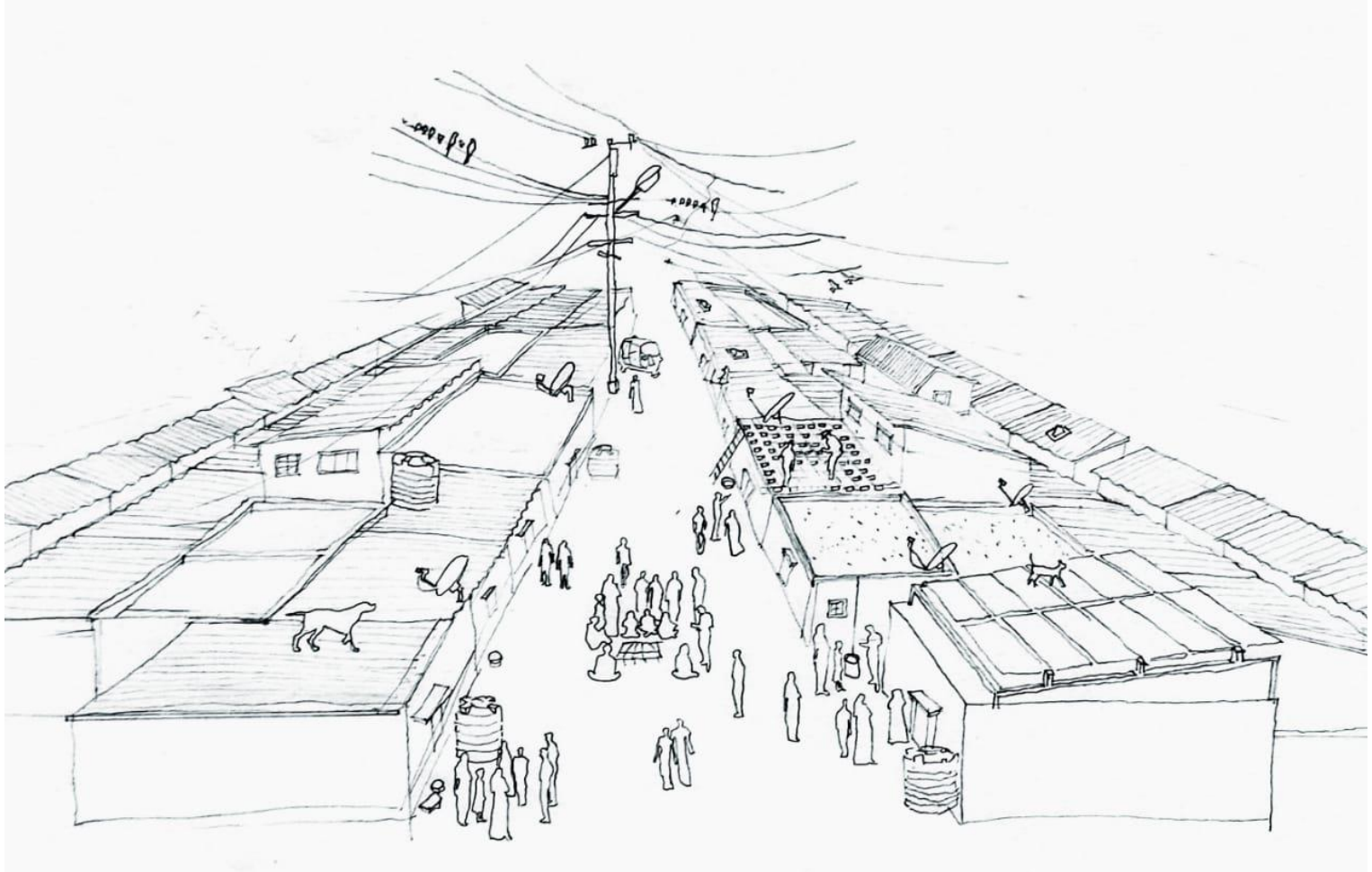

# THE INFORMAL HOUSING THERMAL COMFORT PROJECT (PILOT)

**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.

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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.

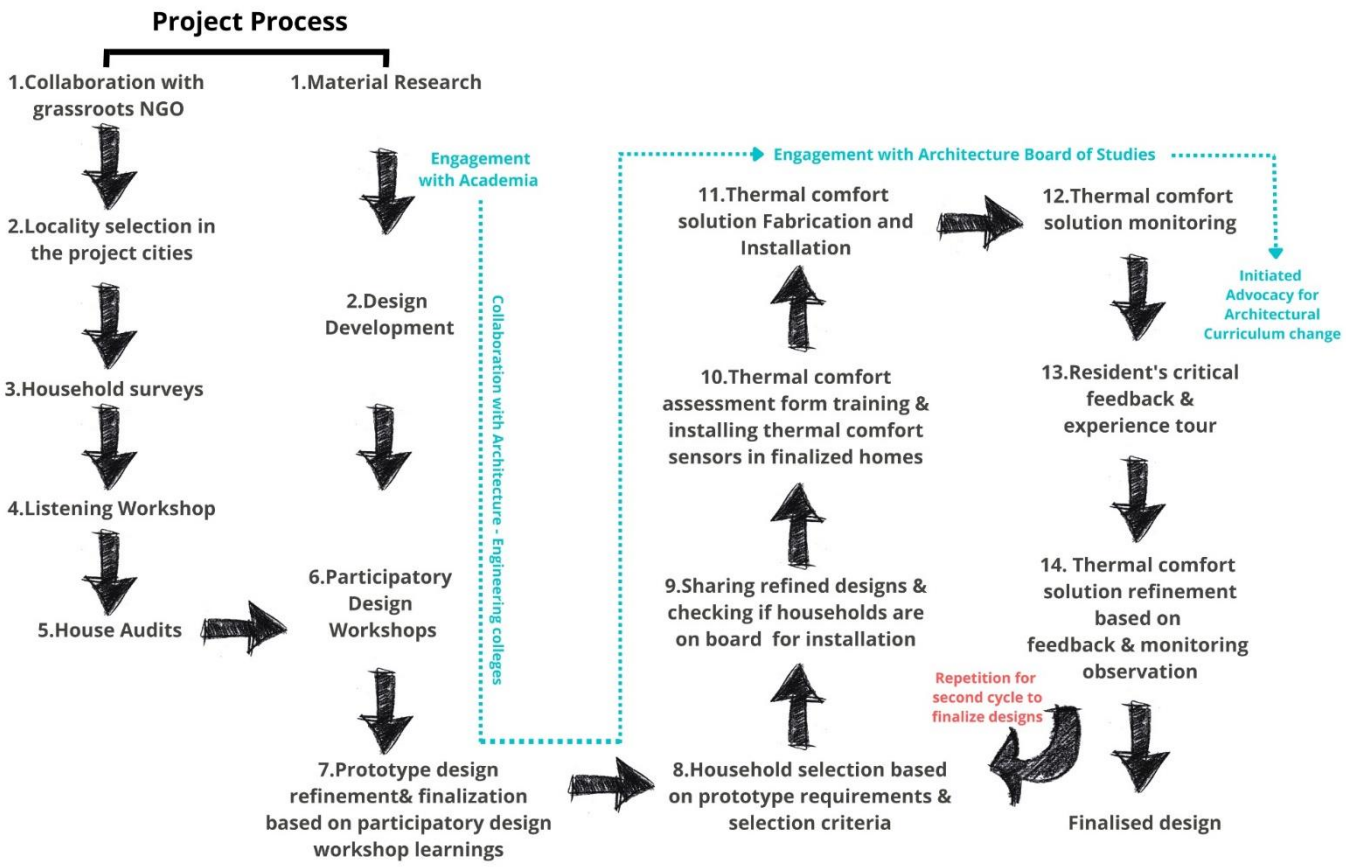
Therefore, in the current scenario of ballooning socio-economic and ecological injustices triggered by climate breakdown the phenomenon of architectural services being reserved for socio-economically privileged individuals demands transformation and architecture academia need to act now to spearhead 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<br>- Rooftop Garden (Pots)<br>- Rooftop Garden (Brick Bed)<br>- Rooftop Garden (Grow Bags)<br>- Alufoil (Static)<br>- Alufoil (Pipe Motor)<br>- Alufoil (Chain Sprocket)<br>- Alufoil (Curtain Mechanism)<br>- Wood Wool Panels<br>- Dormer Window | - Alufoil (Sliding)<br>- Alufoil (Static)<br>- Alufoil (Chain Sprocket)<br>- Ecoboard (Sliding)<br>- Ecoboard (Chain Sprocket)<br>- PET bottle<br>- 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 | Max. temp reduction by a solution | 7.6 deg C | 4.1 deg C |
| 14 | Avoided energy consumption, 'negawatts' generation per household. (estimated) | 320 kWh/yr | 420 kWh/yr |

| | | | |
|---|---|---|---|
| 15 | GHG emissions mitigation through reduced cooling energy demand and refrigerant per household (estimated) | 1,500 kgCO2e/yr | 2,000 kgCO2e/yr |
| 16 | Equivalent no. of trees planted per year per household (estimated) | 6 | 8 |
| 17 | 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.<br>- 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.<br>- After the installation of 'Ecoboard Chain Sprocket' the indoor temperature is comfortable enough to sit indoors even during power cuts. |
| 18 | Observed issues with installations (examples) | - There are issues with opening and closing the 'Alufoil Pipe Motor' installation<br>- The sunlight coming in through the 'Dormer Window' disturbs morning sleep | - The cats peeled off the 'Alufoil' layer and the installation is ineffective, now.<br>- The pulley mechanism for 'Ecoboard Sliding' is not working smoothly. Hence it cannot be opened & closed for night & day benefits, respectively. |
| **ENGAGEMENT WITH ACADEMIA** | | | |
| 19 | Colleges collaborated with for internships (in nos) | 2 | 1 |

| | | | |
|---|---|---|---|
| 20 | Architecture professors collaborated with for design support (in nos) | 5 | 1 |
| 21 | Board of Studies (BOS) engaged with to suggest curriculum change inputs for sensitization of students to sustainable architecture in informal settlements (nos) | 1 | 1 |
| 22 | Collaboration with Architecture Students for Internships (nos) | 5 | 1 |
| 23 | 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.

## 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

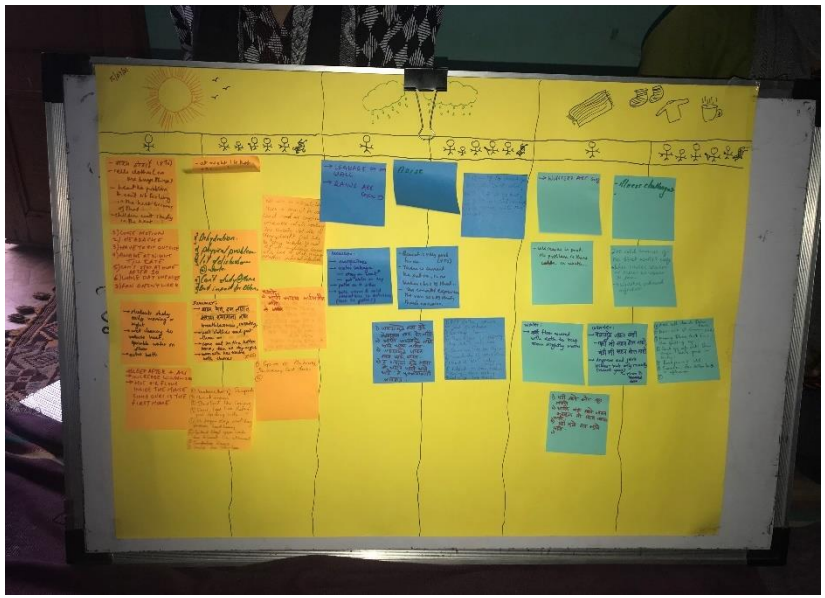


*Figure 1: Problem Diagnosis Chart - Listening Workshop*

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.

## 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.

*Thermal Sensor*

## 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.

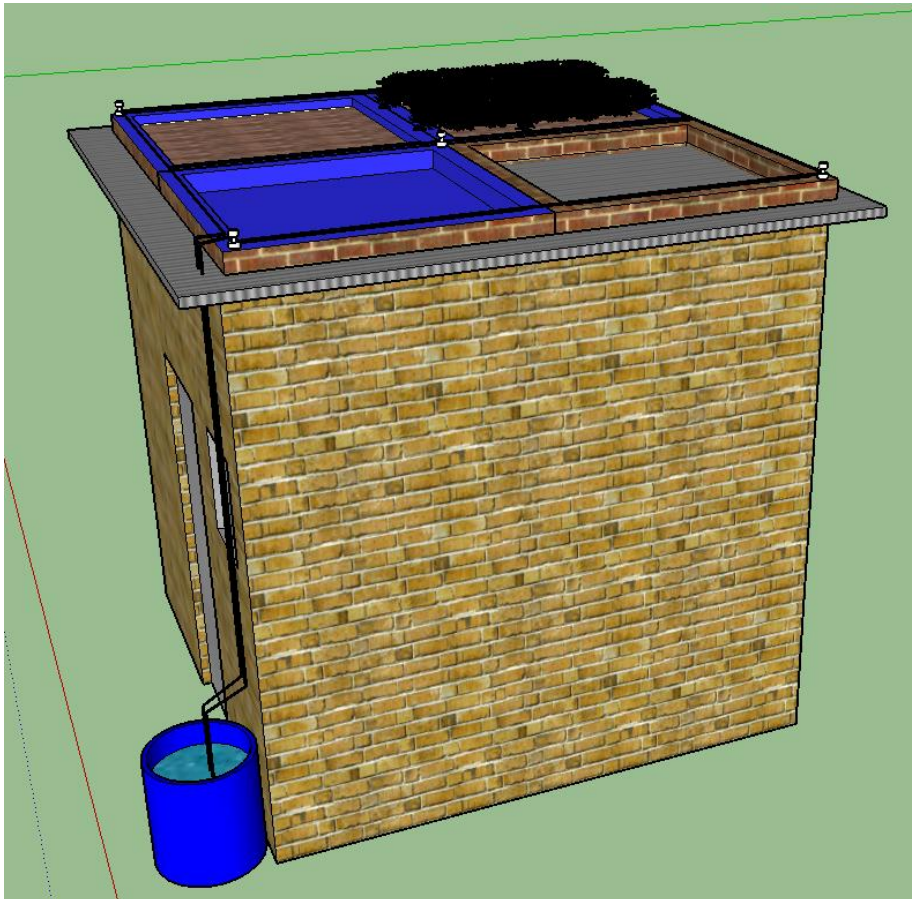
#### (II) A PEOPLE-ORIENTED EXPERIMENT CAN PROGRESS SMOOTHLY AND AUTHENTICALLY ONLY WITH PEOPLE'S SUPPORT

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<br>• 100% formaldehyde-free<br>• 100% durable – sustainable source<br>• 100% recyclable to equal product<br>• Fire resistant far better than MD<br>• Moisture resistant far better than MDF<br>• Density from 200 kg/m3 to 800 kg/m3 HD<br>• 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.<br>• 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<br>• The size of the panels needs to be optimum to ensure a trade-off between less framing metal usage and low wind resistance.<br>• 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<br>• Horizontal support should be given to the ecoboard sheet to prevent it from bending or breaking<br>• 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<br>• 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.<br>• The supports of the mechanism need to be sturdy and rigid. |
| HOMEOWNER FEEDBACK | **VijayaLakshmi, Bangalore -**<br>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 -**<br>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<br>• Non-porous<br>• Non-corrosive<br>• Non-abrasive<br>• Water resistant<br>• 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<br>• 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.<br>• 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<br>• The size of the panels needs to be optimum to ensure a trade-off between less framing metal usage and low wind resistance.<br>• Clearance of the mechanism needs to be such that it ensures maximum opening (minimum 5 degree) with minimum height of the mechanism.<br>• 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.<br><br>• 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.<br>• Rats might damage the material<br>• 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.<br>• 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.<br>• The supports of the mechanism need to be sturdy and rigid. |
| HOMEOWNER FEEDBACK | **Zubeida Kazi, Ibrahim, Pune -**<br>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 -**<br>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 -**<br>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 -**<br>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.<br>• 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.<br>• 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.<br>• Zero energy solution<br>• Does not generate waste<br>• Does not involve energy<br>• 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).<br>• 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.<br>• Chemicals can be mixed in water to prevent fungi but the disposal of that water will be a challenge.<br>• If the water bottle is filled fully then fungi can be prevented. |

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| | • 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.<br>• 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.<br>• 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.<br>• 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 -**<br>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.<br>**Mahjabeen, Pune -** |

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| | 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 |
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| MATERIAL | • 100% Biodegradable<br>• 100% Asbestos-free<br>• 100% Durable<br>• 100% Recyclable product<br>• The resistance against fire can reach up to two hundred forty minutes depending on the product's thickness and setup.<br>• Water vapor diffusion resistance factor: 4.7 m2k/w<br>• Density: 18mm - 626 Kg / m3<br>• 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<br>• 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** |

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| | 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.<br><br>**Muttamma, Bangalore**<br><br>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 |
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| MATERIAL | • Supports thermal comfort.<br>• Improves air quality.<br>• 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.<br>• The slope of the roof should be between 2-15 degrees.<br>• Minimum 4-inch soil depth is required to support the growth of any plant.<br>• In informal settlements there is high risk of snakes, hence scented flower plants should be avoided.<br>• Low weight, fast growing plants should be planned on rooftops to minimise the load on structure.<br>• Plant selection should be based on considering water availability during summer.<br>• Bean creepers have good foliage and needs minimal water and soil to grow.<br>• Pots should be supported with bricks to prevent the pots from falling off the roof.<br>• Soil should be replenished after every season (quarterly) with new soil, cocopeat and compost or manure.<br>• Plants with heavy fruits (eg. pumpkin) should be avoided.<br>• A drainage facility should be available to support the collection and reuse of drained water and soil.<br>• Green net or shade net should be installed to protect plants from succumbing to direct sunlight.<br>• 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.<br>• Mosquitoes will be attracted to the house due to the presence of water in the soil might spread diseases.<br>• Wet soil might corrode the roof.<br>• It might be difficult to climb up manually and water the plants everyday on the roof<br>• Plants could die due to excessive heat above the roof | | |

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| | • 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.<br>• Pots should have depth of at least 4 inches.<br>• GI thin wire can be used for growing of creepers.<br>• 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.<br>• Pot structure should be strengthened by regular dampening with water atleast for a day or two after construction of the structure.<br>• The potting mixture should contain a balance of soil, cocopeat and compost/manure. | • Lightweight Bio fibres or HDPE material growbags can support planting.<br>• 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.<br>• 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.<br>• Seeds/ plants be grown along the dripline of water.<br>• Some walking space to be at roof edges. | • Grow bags as per desired sizes and shapes should be installed depending on the roof characteristics.<br>• Some walking space to be left in between bags and at roof edges. |

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| | | • 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.<br>• Ensure the potting mixture is filled till 80% of the bed height to account for water drainage and to avoid soil erosion.<br>• 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.<br>• 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.<br>• Mulch the beds with grass, hay to ensure the soil retains its moisture. |
| HOMEOWNER FEEDBACK | **Ajit Kumar Yadav, Pune**<br><br>The resident found it difficult to give water to the plants on a regular basis, since he lives alone | **Jeera Lal Yadav, Pune**<br><br>The installation has provided relief to the residents' family by reducing the indoor heat. The elders of the | **Suman Yadav, Pune**<br><br>The installation has benefitted the family in multiple ways. They are able to sleep better and the |

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| | 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 |
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| MATERIAL | • Light weight and does not require additional structural components<br>• Low energy solution<br>• Low resources and waste solution<br>• The solution can be fabricated, installed and maintained by local people.<br>• 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.<br>• The opening of a Dormer Window needs to be facing leeward side for it to function appropriately.<br>• 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).<br>• The solution will be more useful if installed in an area of a house that does not receive sunlight.<br>• 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.<br>• A net is required to prevent insects from entering home.<br>• If the net size is too small dust may accumulate and stop air ventilation<br>• 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. |

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| 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**<br><br>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.<br><br>(Note : A revised version of the dormer window which addressed the water leakage issue was installed in the next resident's house.)<br><br>**Rukaiyya Sheikh, Pune**<br><br>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.<br><br>(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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