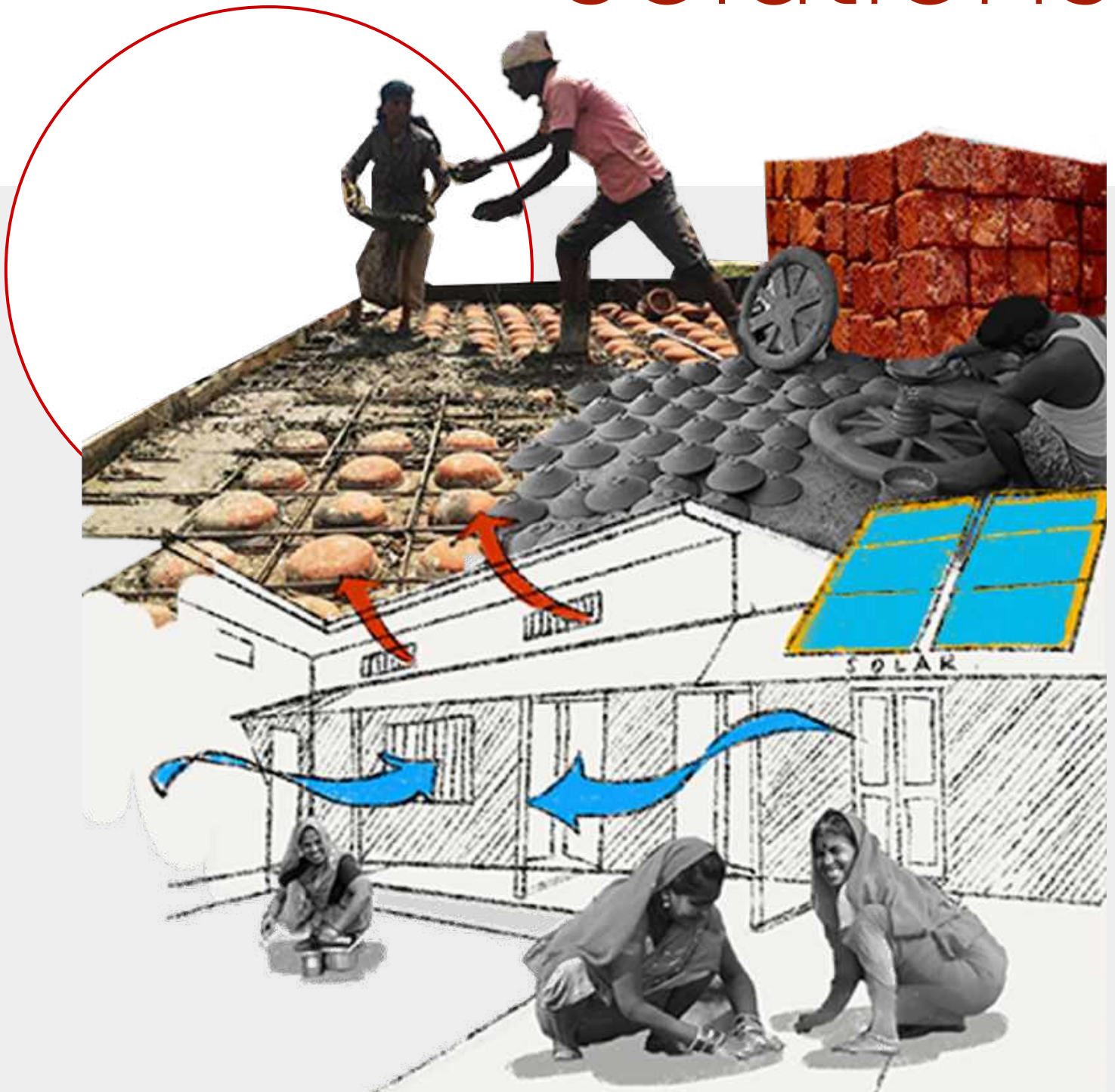


Cool Roofing Solutions



Passive integrated design strategies against heat stress



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- 01:** Global Context to Cooling and Built Environments
- 02:** The Built Environment Approach
- 03:** Solution Matrix for Cool Roofs
- 04:** Project Locations
- 05:** Solutions: 24 Selected Case Studies
- 06:** Ecosystem Needed to Scale Cool Roofing



Global Context to Cooling and Built Environments

The agenda of climate change, in the last decade, has moved from being a footnote to a primary heading. The IPCC report states that **climate-related risks to livelihoods, health, and human security** are projected to increase as the planet warms by 1.5 degrees. (IPCC 2022)

A study conducted across households in eight countries stated that **households spend between 35% and 42% more on electricity** when they adopt air conditioning (World Economic Forum 2020). As temperatures increase around the world, **cooling is emerging as a new, basic need** – even in countries that traditionally have not previously required such appliances. That puts an additional burden on families who might not be able to afford the most efficient appliances and could result in spending being diverted away from food or education towards cooling. Evidence from the ground through consultations for this report also point towards other indirect expenditures from the poor due to lack of appropriate, affordable and efficient cooling technologies. This has been in the form of **loss of productive hours, loss of efficiency** in livelihood, as well as long-term **impacts on health and well-being**.



The role of **passive cooling** is often underestimated in optimising the need for cooling solutions. The Economist Intelligence Unit on the Power of Efficient Cooling (The Economist 2020), illustrated through extensive modelling on the financial and environmental costs of energy supply that if electricity demand from space cooling is not reduced:

- Without the implementation of sustainable cooling solutions, countries aiming to meet **net zero emissions in 2050** are likely to **miss those targets by up to eight years.**
- **Efficient cooling can expedite the transition to net zero at a lower cost**, as well as providing benefits for all stakeholders, including governments, consumers and the power sector itself, given the right incentives

However, in the context of populations below poverty line, turning towards passive technologies for cooling solutions also results in reduced recurring expenditures on energy bills, productivity loss, income loss and health burden. Cooling solutions available today primarily respond to a society where supply of energy is not a constraint.

Low income communities are facing the impact of heat stress in multiple different ways and need cooling solutions today in order to adapt and overcome increasing challenges of food security, livelihood and health. If the existing cooling solutions are deployed in order to meet their urgent demands, it will not only result in future burden (due to unoptimised solutions), but also result in increased pressure on the planet due to increased emissions. There needs to be a greater understanding of the cooling needs, the factors that influence these needs and the **role of passive and active cooling solutions** to create a new spectrum of solutions.



Built Environment Approach

Alarmingly Rising Heat Stress

'Direct heat stress' cases account for about 10% of the total cases and up to 90% account for '**indirect heat stress**'. While direct heat stress affects people who are exposed to the sun during peak summer days, the striking fact about indirect heat stress is that it affects persons who remain indoors and are not directly exposed to the sun. These effects include circulatory overload, kidney failures, dehydration, etc. which causes hospitalisation and even deaths in some cases and yet they are almost never recorded as heat stroke effects.

Dependency on Active Cooling Techniques

Workspaces, houses, institutions characterised by heat trapping building materials, poorly ventilated spaces and those with an additional source of heat along with increasing external temperatures owing to climate change creates conditions for indirect heat stress. To cope with the extreme working and living conditions, the need and demand for active cooling techniques increase. And energy demand for the same is mostly met with **expensive and unsustainable sources of energy**. This reliance on energy sources increases the energy bills and thus **exacerbates the financial condition of the people**.



Broadly, the thermal quality of a habitat and the optimised use of the cooling source determines how much energy is needed to ensure the well-being of the household.

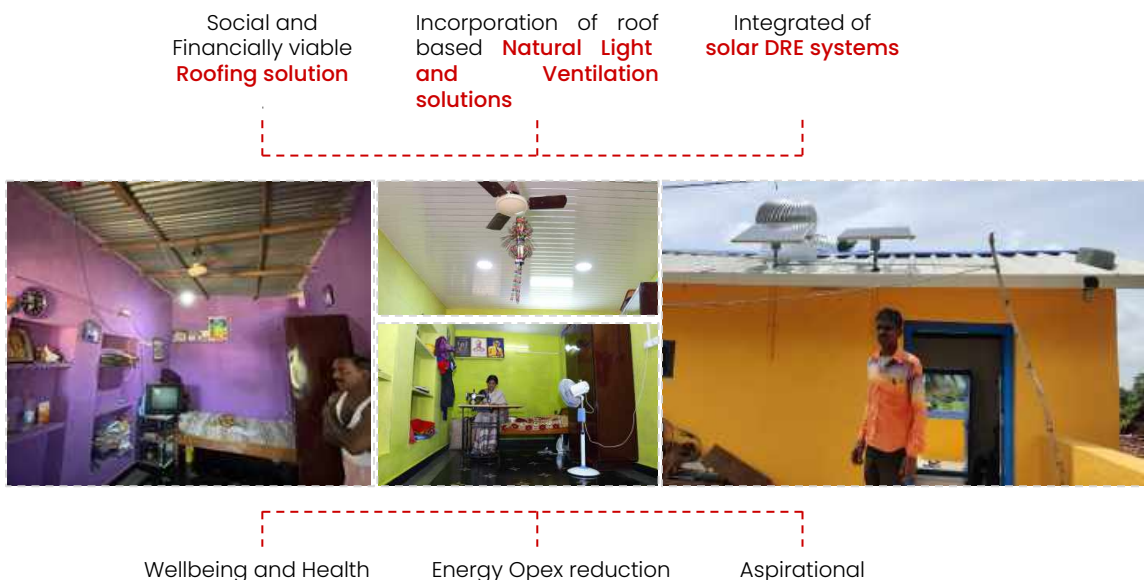
Factors that broadly affect the space cooling needs are as follows:

- **Climate, or the climatic zone** (dictating temperature, humidity, rainfall), can play a significant role in influencing the energy needs.
- **Roofing:** Roofing, in tropical habitats, constitutes 70% of the total heat gain. Most poorer habitats and institutions (in urban and rural geographies) use metal or asbestos sheet roofs which is a heat trapping material.
- **Activities:** Drudgery driven physical activities or use of active heat source as in forges, stoves etc also determines the heat stress and thus, the design of the intervention.

Key Intervention Areas

As mentioned earlier, low income households use their homes for livelihood activities. Cooling solutions in this case also need to include:

- Interventions that reduce the physical drudgery and improving productivity
- Interventions that extract heat from the heat generating sources



Simple interventions like careful selection of roofing materials, building technology, building layouts, increasing the building height, addition of roof fenestrations or openings, active cooling mechanisms using renewable energy solutions, etc. would be the ideal solutions in low resource settings.



Cool Pottery shed in Puri, Odisha for cyclone resilience

Solution Matrix for Cool Roofs

Temperature reduction	Upto $\Delta 4\text{ }^{\circ}\text{C}$				
Typology	Roof slabs (Structural covering)	Insulated roof panels (Roof covering)	Insulation layers (Intermediate Roofing layer)	Surface finishes (External Roofing layer)	False ceilings (Internal Roofing layer)
Type of construction	For infrastructure being constructed newly, slabs are the most ideal form of roofing with skilled workforce	For infrastructure newly constructed or renovated, roofing panels are ideal when structural load requires to be low with skilled workforce	For infrastructure, where structural load need to be low and low skill of the workforce is available for installation. Ideal for sheet roofing type.	For infrastructure, where structural load need to be low and medium to high skill of workforce is available for installation. Ideal for slab roofing type.	For infrastructure with both slab and sheet type roofing. Skilled workforce required for installation.
Example	Modular roof Hollow clay blocks	Puf panel Metahybrid	"Thermal wraps Glasswool/ Natural wools"	White tiles Cool roof paints	PVC Gypsum board
Cost per sqft (in USD) including framework and installation cost	\$5.8 - \$17	\$3.5 - \$8	\$0.6 - \$1	\$0.6 - \$5	\$2 - \$4
(In INR)	₹350 - ₹1300	₹270 - ₹600	₹45 - ₹70	₹45 - ₹360	₹150 - ₹300
	Sectors like Housing, Workspaces, Animal Shelters, School & other education facilities, Healthcare institutions				All use cases except Animal Shelters for rearing

Note 01: * For ΔT for above $4\text{ }^{\circ}\text{C}$
 Air conditioner (Active Cooling technology)
 Solar Powered Air Conditioner with thermal back up
 Solar Powered Air Conditioner with battery back up

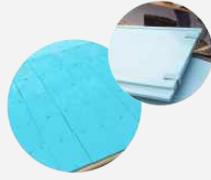
Note 02: *All cool roofs also incorporate insulated window frames and glass with low E value to prevent heat transfer
 Walls and windows are also shaded and protected to improve the range of cooling

Cool Roofing Solutions

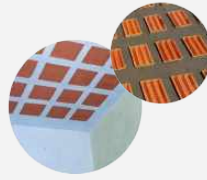
Roof slabs (Structural covering)



Hollow Clay Blocks



Modroof

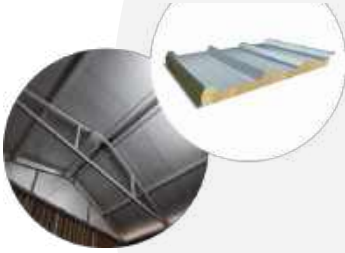


Filler Slab

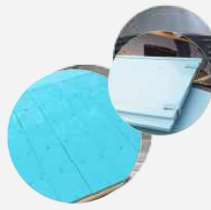


Madras Terrace

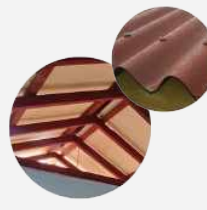
Insulated roof panels (Roof covering)



PUF Panel



Metahybrid



Onduline



Bamboo corrugated sheet with white surface finish

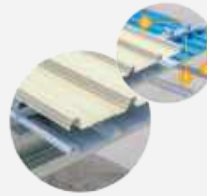
Insulation layers (Intermediate Roofing layer)



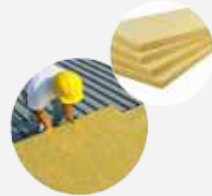
Thermal wraps



Glasswool



Double Panel Air Gaps



Rockwool

Surface finishes (External Roofing layer)



White Tiles



Cool Roof Paints



Clay Tiles



Brick Bat Coba

False ceilings (Internal Roofing layer)



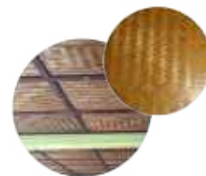
PVC Boards



Gypsum

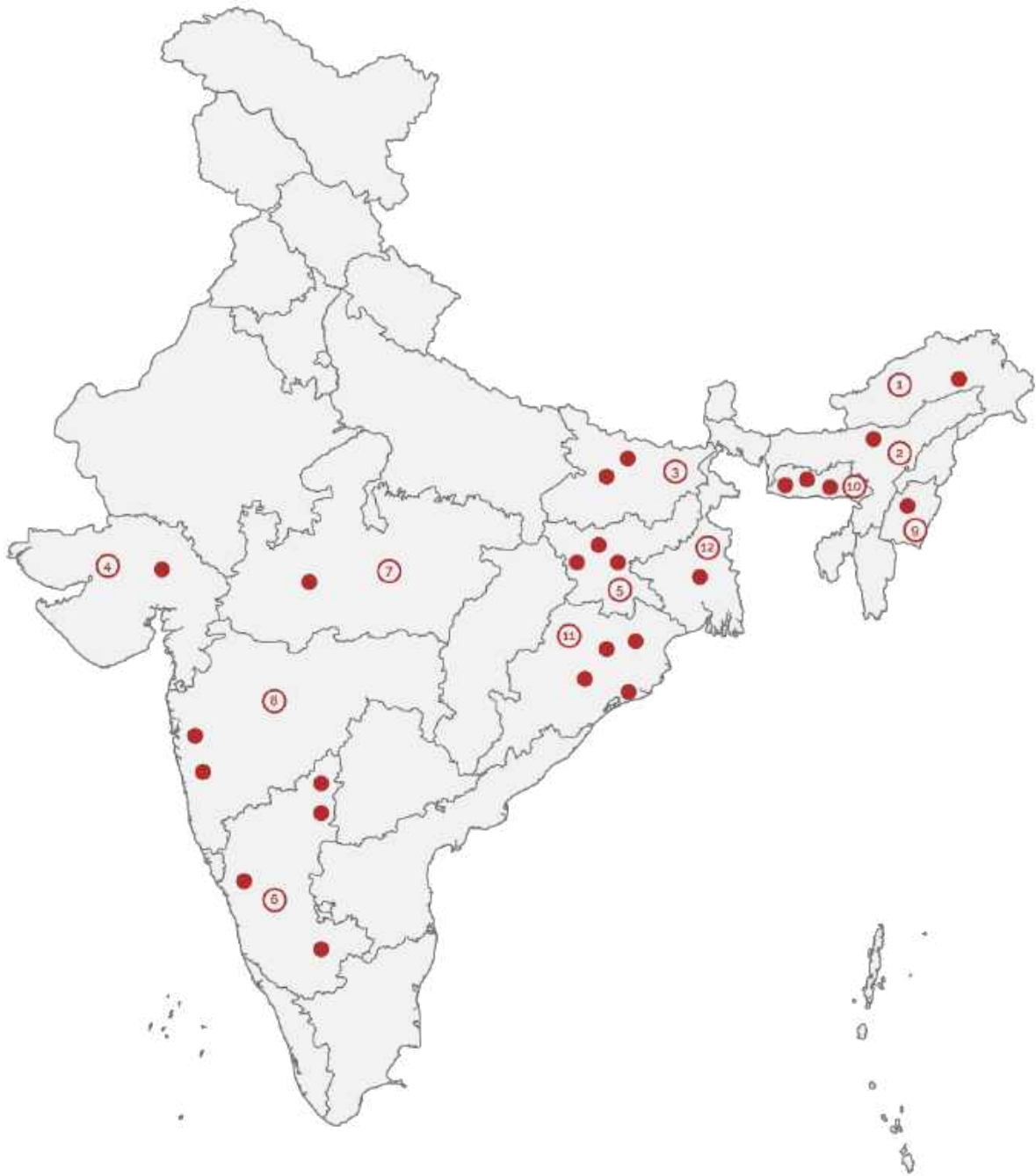


(EPS) Expanded Polystyrene



Bamboo Mats

Project locations



States:

- | | |
|-----------------------|--------------------|
| 01: Arunachal Pradesh | 07: Madhya Pradesh |
| 02: Assam | 08: Maharashtra |
| 03: Bihar | 09: Manipur |
| 04: Gujarat | 10: Meghalaya |
| 05: Jharkhand | 11: Odisha |
| 06: Karnataka | 12: West Bengal |



Solutions.

Case Studies



Name - Rabia

Address - Amalapur, Bidar

Occupation - Tailoring

Technology - Passive cooling technology

Monthly Income - INR 3,000 - INR 4,000

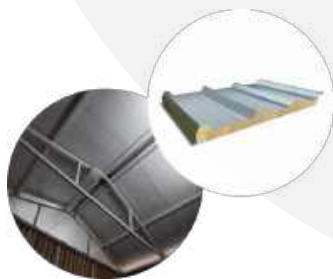
No. of Family Members - 8



Before

Insulated roof panel

Material - PUF Panel



After

Area of the house - 210 Sq. ft.

Recorded Temperature within the space:

Before

31°C

After

Δ 4°C
reduction



"With the previous roof, we weren't able to use the room during the afternoons. It used to get too hot. With this new roof, it's much cooler inside and we're able to use the space throughout the day"

~ Rabia Begum

Project done in partnership with **Samarasa**

Cool Roofing Solutions



Name: Hemalatha

Address: Amalapur, Bidar

Occupation: Tailoring

Technology: Passive cooling technology

Monthly Income: INR 3,000 – INR 5,000

No. of Family Members: 3



Before

False ceiling

Material – PPGI sheet + PVC False ceiling



Area of the house – 140 Sq. ft.

Recorded Temperature within the space:

Before

32°C

After

Δ 3°C
reduction



After



"It used to get really hot and uncomfortable before. Now, with the installation of the ceiling, it's very comfortable. I can work better and my daughter can study better because of the better environment."

~ Hemalatha

Project done in partnership with Samarasa

Cool Roofing Solutions



Name: Jasmin

Address: Valdodi, Bidar

Occupation: Cook

Technology: Passive cooling technology

Monthly Income: INR 8,000

No. of Family Members: 5



Before

After

Roof slab

Material - Hollow Clay Hourdi blocks



Area of the house - 200 Sq. ft.

Recorded Temperature within the space:

Before
31°C

After
Δ 5°C
reduction



"Installing the hourdi blocks for our roof has made our house really cool. Before, under our tin sheet roof, it used to be very hot. Now, it's so cool and comfortable inside that we don't even need to switch on the fan."

~ Jasmin

Name: Jagdevi

Address: Chimkod, Bidar

Occupation: Agriculture Labour

Technology: Passive cooling technology

Monthly Income: INR 4,000 - INR 6,000

No. of Family Members: 5

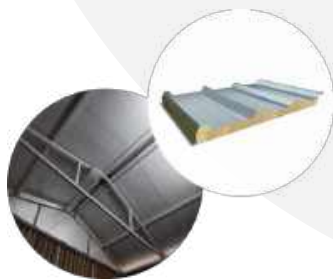


Before

After

Insulated roof panel

Material - PUF Panel



Area of the house - 140 Sq. ft.

Recorded Temperature within the space:

Before

35°C

After

Δ 4°C
reduction



"This roof has made it really comfortable in my house. During summers, it's cool inside and during winters, it's warm. This really helped when my daughter came back when she was pregnant. I was able to give her a place to stay comfortably."

~ Jagdevi

Project done in partnership with **Samarasa**

Cool Roofing Solutions



Name: *Nirmala*

Address: Mugad, Dharwad

Occupation: Roti making

Technology: Passive cooling technology

Monthly Income: INR 6,000 – INR 10,000

No. of Family Members: 3



Before

After

Roof slab

Material – Hollow Clay Hourdi blocks



Area of the house – 173 Sq. ft.

Recorded Temperature within the space:

Before
29°C

After
Δ 3°C
reduction



“It used to get very hot and smokey before. Working was difficult due to this. Getting the roof replaced and adding more windows has made the space very comfortable. We can work for longer now.”

~ *Nirmala*

Name: Vittala

Address: Mugad, Dharwad

Occupation: Roti making

Technology: Passive cooling technology

Monthly Income: INR 8,000

No. of Family Members: 4

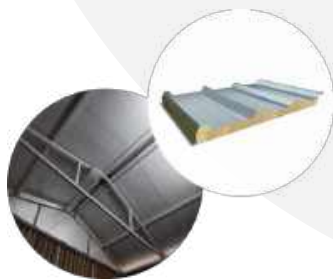


Before

After

Insulated roof panel

Material - PUF panel



Area of the house - 257 Sq. ft.

Recorded Temperature within the space:

Before

30°C

After

Δ 3-5°C
reduction



"The (cool) roof and the turbo ventilator has made my workspace very comfortable. I can work throughout the day. The skylight has made it bright and I don't need to switch on the lights during the day anymore."

~ Vittala

Name: Mahadevappa

Address: Garag, Dharwad

Occupation: Potter

Technology: Passive cooling technology

Monthly Income: INR 4,000 – INR 10,000

No. of Family Members: 5



Before

After

False ceiling

Material – PPGI sheet + Gypsum
False ceiling



Area of the house – 600 Sq. ft.

Recorded Temperature within
the space:

Before

32°C

After

Δ 2°C
reduction



“My workspace is more comfortable to work in now. It is cool and bright and I’m able to work for longer without getting very tired.”

~ Mahadevappa

Name: Mahadevi

Address: Kelgeri, Dharwad

Occupation: Home based petty shop

Technology: Passive cooling technology

Monthly Income: INR 5,000 – INR 8,000

No. of Family Members: 4


Highest temperature recorded in Dharwad in 2022 is 38°C



Before

Surface finish

Material - White Tiles



After

Area of the house - 520 Sq. ft.

Recorded Temperature within the space:

Before
30°C

After
Δ 3-5°C reduction



“When I was first introduced to this roof white tiling, I was skeptical on its benefits. Now, after it was completed, I have felt very comfortable inside the house. Days when it used to get very hot in the previous years are very comfortable and cool now.”
~ Mahadevi

Name: Parava

Address: Nigadi, Dharwad

Occupation: Roti making

Monthly Income: INR 8,000 -10,000

Technology: Passive cooling technology

No. of Family Members: 2

Area of the house - 1000 Sq. ft.

Temperature reduction within the space:

After
 $\Delta 5^{\circ}\text{C}$
reduction

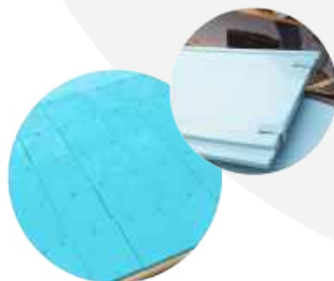


Before

After

Roof slab

Material - Modroof



"After the upgradation of my workspace, I am very comfortable working the long hours to run my business. This has allowed me to diversify and open my own Khanavali (eatery) as an extension to my home."

~ Parava

Project done in partnership with SKDRDP

Cool Roofing Solutions



Name: Gonen

Address: Tanal apal, East Garo Hills, Meghalaya

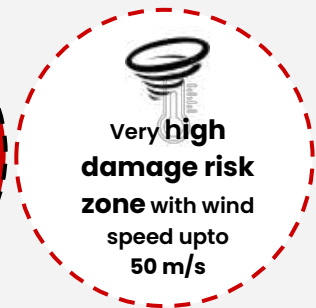
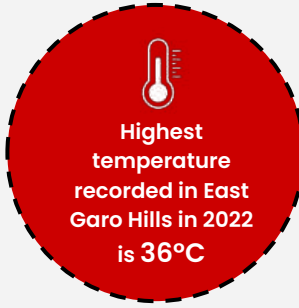
Occupation: Farmer

Monthly Income: INR 7,000

Technology: Cyclone resilient roofing

No. of Family Members: 4

Area of the house – 370 Sq. ft.



Before

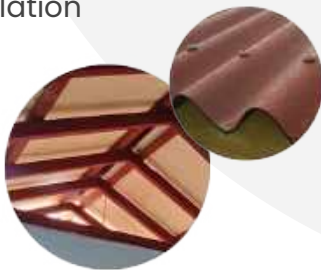
Cyclone Resilient Solution

After



False ceiling + Insulation layer

Material – Onduline roofing with marine plywood panels, air gap for insulation



Project done in partnership with **DC Office, East Garo Hills**

Cool Roofing Solutions



Name: Tansin

Address: Tanal apal, East Garo Hills, Meghalaya

Occupation: Farmer

Monthly Income: INR 7,000

Technology: Cyclone resilient roofing

No. of Family Members: 4

Area of the house - 370 Sq. ft.

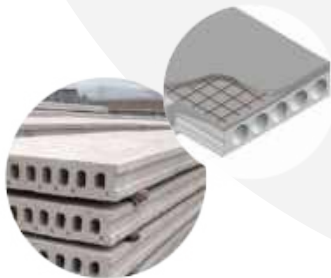


Before

After

Roof slab

Material -Precast slab and height increase



Project done in partnership with **DC Office, East Garo Hills**

Cool Roofing Solutions



Name: Pilseng

Address: Tanal apal, East Garo Hills, Meghalaya

Occupation: Farmer

Monthly Income: INR 7,000

Technology: Cyclone resilient roofing

No. of Family Members: 5

Area of the house - 520 Sq. ft.



Before

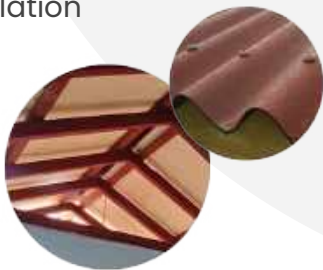
Cyclone Resilient Solution

After



False ceiling + Insulation layer

Material - Onduline roofing with marine plywood panels, air gap for insulation



Project done in partnership with **DC Office, East Garo Hills**

Cool Roofing Solutions



Name: Lakshmi

Address: Rajiv nagar, Ahmedabad

Space: Convenience store

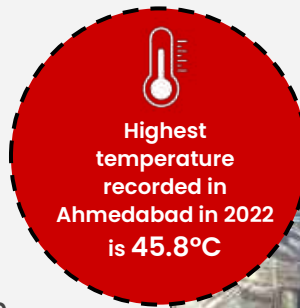
Monthly Income: INR 5,000 – 8,000

Technology: Bamboo corrugated sheet roofing

Area of the house – 100 Sq. ft.

Insulated roof panel

Material – Bamboo corrugated sheet



Name: Ashramshaala

Address: Gadat, Navsari, Gujarat

Space: Residential school

Technology: Passive cooling technology

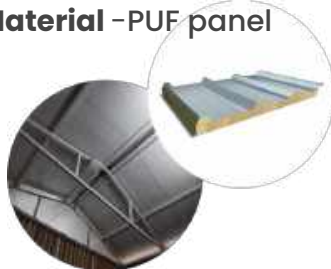
Area of the house – 800 Sq. ft.

After
 $\Delta 3^{\circ}\text{C}$
reduction



Insulated roof panel

Material – PUF panel



Projects done in partnership with **Mahila Housing Sewa Trust**

Cool Roofing Solutions



Name: Shilpa

Address: Mandya

Space: Dairy Farm

Technology: Passive cooling technology

Area of the house - 750 Sq. ft.

After

Δ 4°C
reduction



Before

After

Insulated roof panel

Material - Mangalore tile roofing and height increase



"With the new shed, my cows have a proper place to stay. They are more comfortable, safer and it has become easier to manage them."



Name: Alka

Address: Vangani

Space: House

Monthly Income: INR 6,000 – 8,000

Technology: Passive cooling technology

No. of Workers: 5

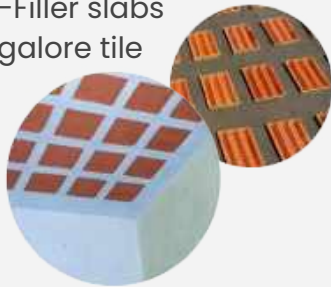
Area of the house – 437 Sq. ft.

After
 $\Delta 5^{\circ}\text{C}$
reduction



Insulated roof panel

Material – Filler slabs with Mangalore tile



Name: Punam

Address: Bhuiyan Toli, Ranchi

Occupation: Daily Wage Worker

Space: House

Monthly Income: INR 3,000

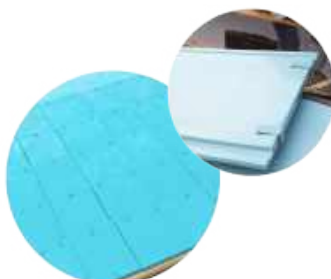
Technology: Passive cooling technology

No. of Workers: 4

Area of the house – 221 Sq. ft

Roof slab

Material – Modroof



- 1: Project done in partnership with **Habitat for Humanity**
- 2: Project done in partnership with **Mahila Housing Sewa Trust**

Name: Solar powered Delivery (Obstetrics) ward

Address: Yellapur

Space: Delivery ward

Monthly Income: INR 7,000

Technology: Passive & Active cooling technology

After
24-26°C



Before

After

Surface finish + Air conditioner

Material -Brick Bat Coba roof + Solar Air Conditioner with battery back up



Yellapur Labour rooms: A set temperature range (22.8°C-29.3°C) is required within the labour room for safe and comfortable delivery. To maintain this above temperature range, the installation of an energy-efficient Air Conditioner (AC) is done to cool the space during extreme heat situations.

Name: Rehana

Address: Amalapur. Bidar

Occupation: Tailoring

Technology: Passive cooling technology

Monthly Income: INR 20,000

No. of Workers: 9

Area of the space - 528 Sq. ft.

After
 $\Delta 5^{\circ}\text{C}$
reduction



Before

After

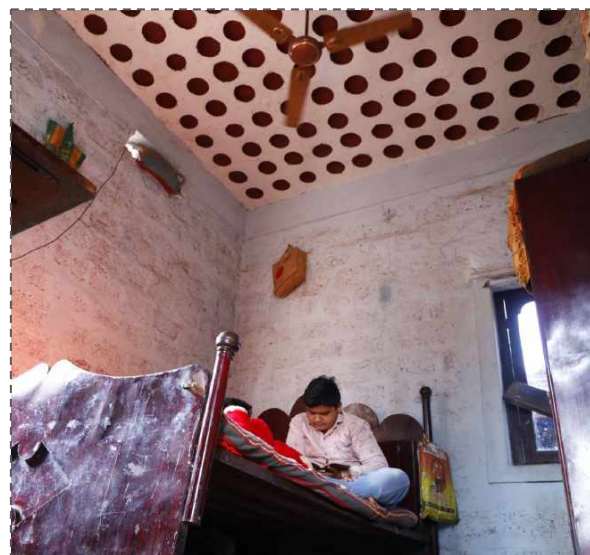
Roof slab

Material - Filler slab + Madras terrace



During COVID we were unable to live comfortably indoors which was very difficult for us before. Now it is nice and cool inside. We are able to open the windows also in the day. We are happy and comfortable enough even during the lockdown days.

~ Rehana



Project done in partnership with **Samarasa**

Cool Roofing Solutions



Name: Sangeetha

Address: Gadgi, Bidar

Occupation: Daily wage worker

Technology: Passive cooling technology

Monthly Income: INR 10,000

No. of Members: 4

Area of the space - 470 Sq. ft.

After
 $\Delta 5^{\circ}\text{C}$
reduction



After

Roof slab

Material - Madras terrace



Project done in partnership with **Samarasa**

Cool Roofing Solutions



Name: Bridge school

Address: Gillesugur, Raichur

Space: Educational Institution

Technology: Passive cooling technology

Area of the space - 752 Sq. ft.

After

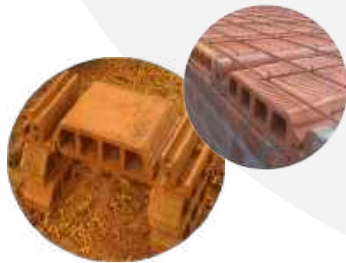
Δ 3-5°C
reduction



After

Roof slab

Material -Hollow Clay Hourdi blocks



Project done in partnership with **INGRID**

Cool Roofing Solutions



Name: Rairakhol PHC

Address: Rairakhol, Sambalpur

Space: Maternity ward

Technology: Active cooling technology

After
24-26°C



Air conditioner

Material - Solar Air Conditioner with thermal back up



Name: Bhadoti PHC

Address: Bhadoti PHC, Rajasthan

Space: Primary health centre

Technology: Active cooling technology

Area of the house - 511 Sq. ft.

After
24-26°C



Air conditioner

Material - Solar Air Conditioner with thermal back up



Projects done in partnership with **WISH Foundation**

Cool Roofing Solutions



Name: Navrachit Slum school

Address: Prahladnagar,
Ahmedabad

Space: Educational Institution (for
migrant children)

Technology: Passive & Active
cooling technology

Area of the space - 665 Sq. ft.

After
24-26°C



Before

After

**Insulated roof panel + Air
conditioner**

Material - PUF panel + Solar Air
Conditioner with thermal back up



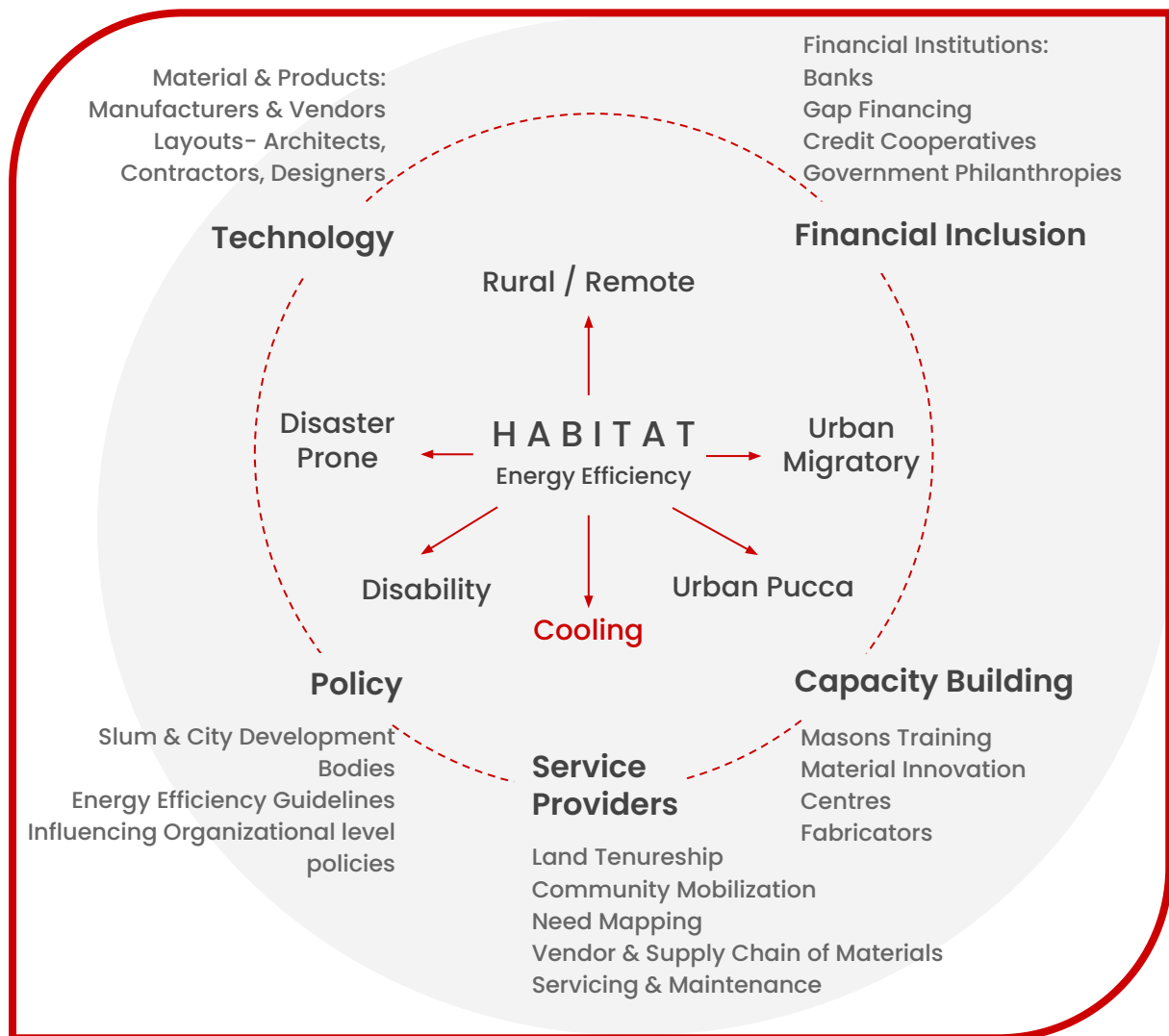
Project done in partnership with **Navrachit Trust and Mahila Housing Sewa Trust**

Cool Roofing Solutions





Aerial view of onduline roofing for a House in East Garo Hills, Meghalaya.
Project done in partnership with **DC Office, East Garo Hills**



Ecosystem needed to Scale Cool Roofing

When designing for cool roofing or any built environment solutions, customisation for end user needs, aspirations and access (or lack of) is extremely critical. The financial product models and recommendations for policy making would hence be ground up and appropriate to the needs of the community. Developing the ecosystem to scale cool roofing solutions would create larger impacts among communities in heat stressed geographies.

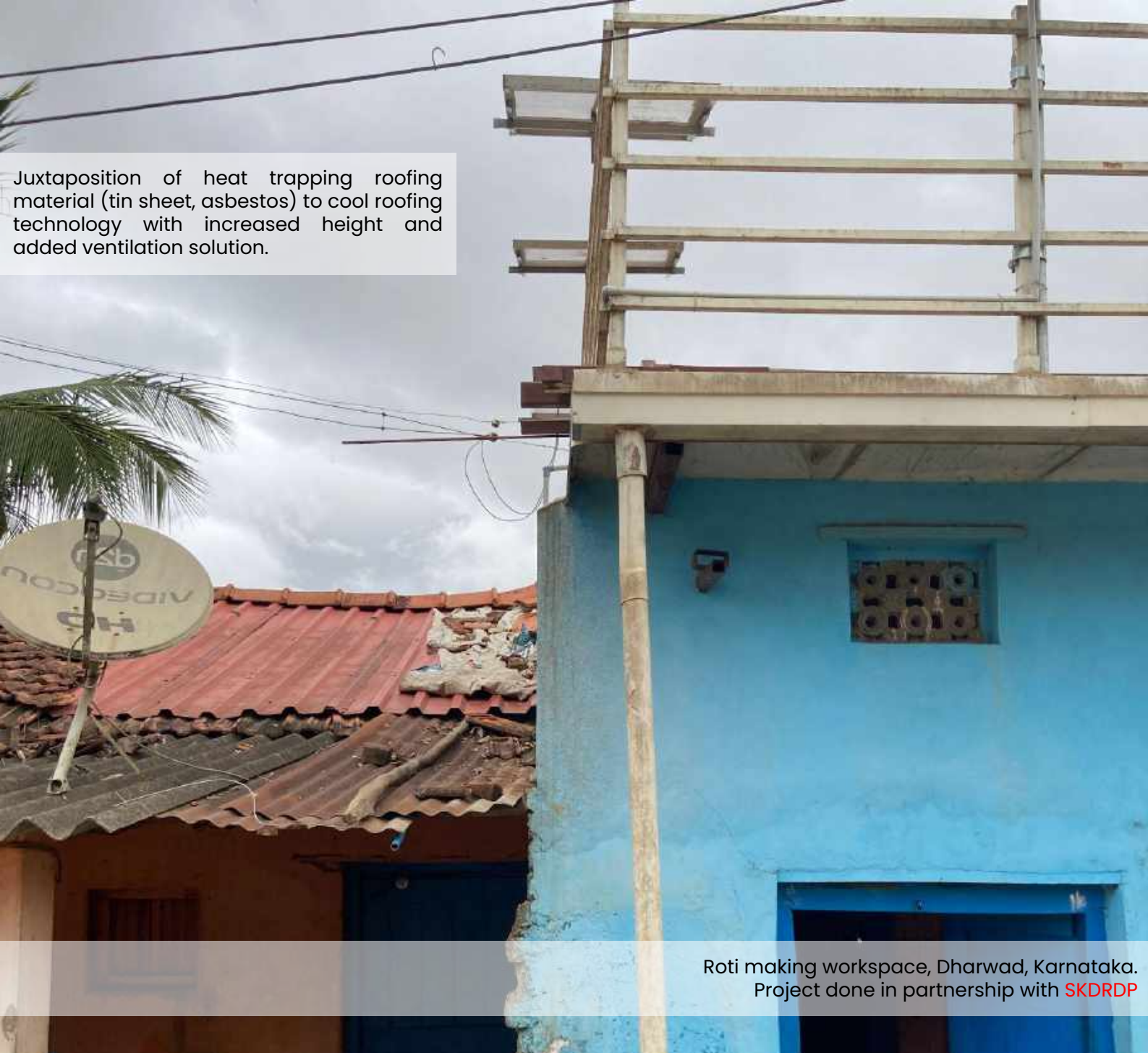
1. Financial inclusion

Sustainable building materials and construction technologies for cooling, can be productised and benchmarked with financial institutions like banks, MFIs as well as local institutions like credit cooperatives. This needs to be then supported with awareness building and financial products.

- Finance institutions need to extend loans for cooling solutions in tandem with government subsidies for cooling as well as other infrastructural schemes
- Investment needs to be sought to reduce interest rates for the marginalised communities for easy adoption of cool roofing solutions
- Philanthropic Institutions should allocate resources for innovations in the space of technology and delivery models as it is expensive and human resource intensive (which is one of the factors why private entities are slow to adapt).

This focus is especially required for creating sustainable solutions for the poor to get out of poverty.

Juxtaposition of heat trapping roofing material (tin sheet, asbestos) to cool roofing technology with increased height and added ventilation solution.



Roti making workspace, Dharwad, Karnataka.
Project done in partnership with SKDRDP

2. Capacity building and upskilling

Skilling building and incubation programmes/ incubators need to support capacity building of enterprises and individuals to innovate and market products for sustainability and passive cooling.

- Support innovations that create new benchmarks of technology development for the poor. Currently the appetite for innovation in the construction industry is high yet are focused on few solution types (ex sustainable walling material and construction methodology) - the need on the ground demands more innovation in the roofing industry.
- Build inclusive incubation programs that support innovation and entrepreneurship amongst local individuals like mason/ regional contractors, fabricators, carpenters, local manufacturers for products like cool roofing/ passive cooling construction to cater to the community.
- Provide mentorship in developing innovations on delivery models that let technical innovations reach the last mile.



Blacksmith workspace, Kolar, Bangalore.

3. Policy – Governance and Access

Governments at city, district, state and national levels will have to incentivise and promote a wide roster of solutions and technologies (most action plans are limited to cool roofing paints and green covers). Parallely, they need to create enabling policies encouraging grassroot focused environment friendly solutions for dissemination and adoption.

- Channel input subsidies towards affordable cool roofing solutions within the larger goal of reducing indoor heat stress, improving wellbeing of elderly, children, mothers, women and men alike and not affecting the environment at large
- Work closely with banks and local institutions like cooperatives and community based organisations to extend part loans for solutions or support interest subvention, alongside input subsidies
- Mandate and support climate friendly practices in convergence with existing government programs for disaster, health, community well-being, livelihoods, education etc.

As we are running out of time to combat the 1.5 degree increase, all stakeholders must take urgent actions. The report presents various solutions ready to be scaled and replicated across geographies. Doing so will result in new trajectories of development for the poor, which builds ownership at the grassroot and innovates for local systems to be more resilient. It can be done, but the window to do it is small.



Construction workers accommodation, Bangalore.
Project done in partnership with **Labournet**



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