Thermal Comfort in Informal Communities in Indian cities

COOLING DOWN THE FAIR WAY

The (F)air conditioning campaign was created by a confluence of consumers and associations protecting the planet's climate. Our program aims at reducing bills and greenouse gas emissions from the indoor cooling sector.

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PROBLEM STATEMENT

- 60% Indians live in informal settlements; yet their heat stress is largely ignored by 'cooling efficiency' programs:
  - ✓ only 5 to 10% of India's built-space is 'formal architecture'
  - ✓ 1 architect per 20,500 citizens in India; European ratio is 1:1,880.
  - ✓ **most of India 'builds itself' through 'self-constructed' housing**

- Housing forms poorly weatherized; roof temperatures > 50^0C @ air temperatures < 32^0C, too hot to sleep before Midnight

- Recurrent power outages and/or planned outages (load shedding) due to peak-demand from AC use by the affluent class; no backup power sources (diesel generators etc.) to even operate a ceiling or floor fan for basic comfort

- Heat stress disproportionately affects women; wake up much earlier to fetch water and cook - suffer the most from protracted sleep deprivation

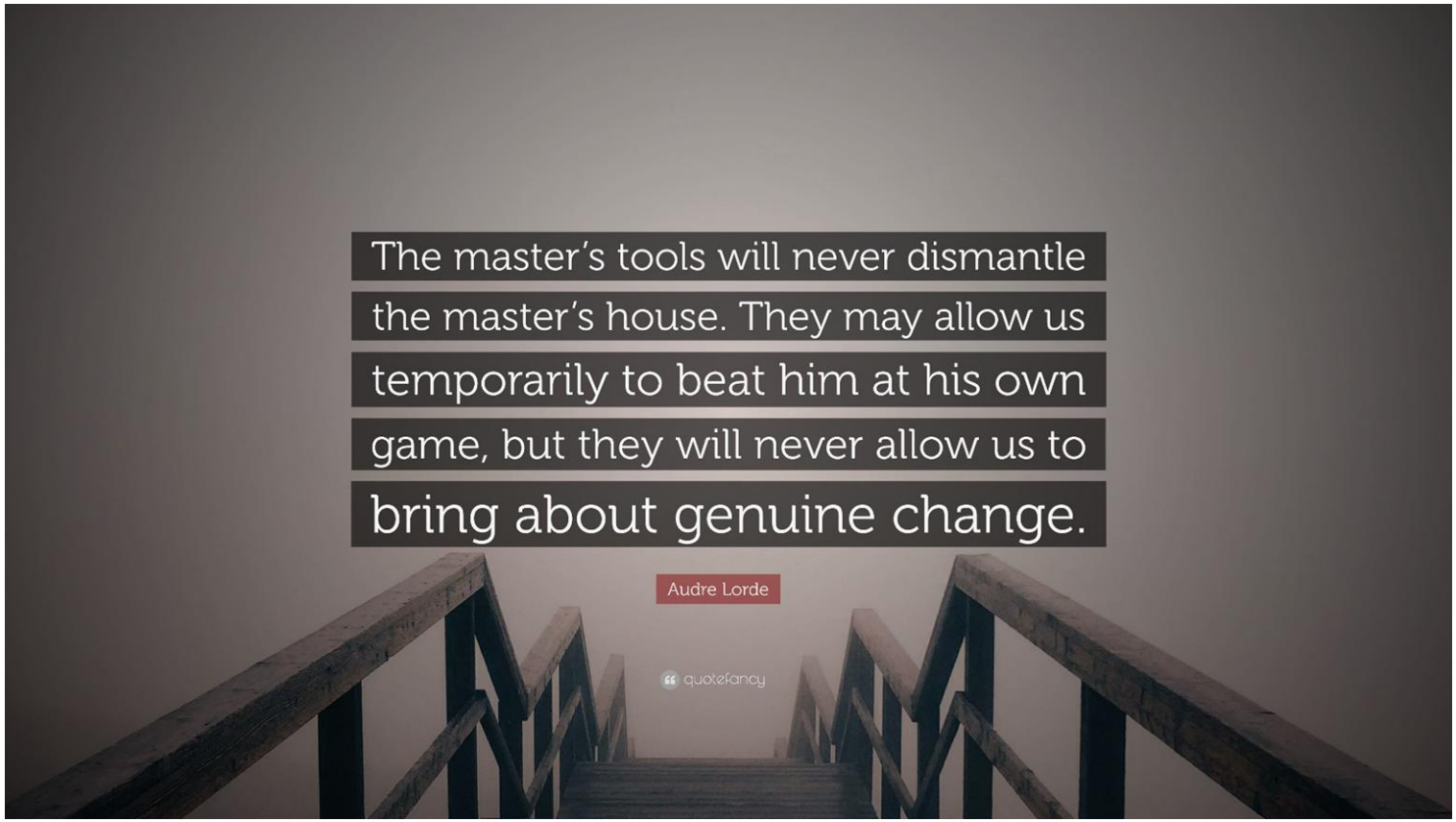
Heat Stress Conditions

Base Case	Type	City	Operative Temperature (°C)
1	Semi Kuccha House	Pune	42.1
2	Semi Pucca House	Pune	41.7
3	Pucca house	Pune	34.9
4	Semi Kuccha House	Bangalore	39.4
5	Semi Pucca House	Bangalore	39.3
6	Pucca house	Bangalore	33.2

PRAXIS OF HUMILITY

subversive idea:

can market mechanisms fix market failures?



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subversive idea:

no more ‘dreamed by the few’ for the ‘many’

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subversive idea:

'with' the people, not 'for' the people

It would be a false premise to believe that activism (which is not true action) is the road to revolution. People will be truly critical if they live the plenitude of the praxis, that is, if their action encompasses a critical reflection which increasingly organizes their thinking and thus leads them to move from a purely naive knowledge of reality to a higher level, one which enables them to perceive the causes of reality. If revolutionary leaders deny this right to the people, they impair their own capacity to think—or at least to think correctly. Revolutionary leaders cannot think without the people, nor for the people, but only with the people.

Dialogue with the people is neither a concession nor a gift, much less a tactic to be used for domination. Dialogue, as the encounter among people to "name" the world, is a fundamental precondition for their true humanization.

from: Pedagogy of the Oppressed, Paulo Friere

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Principles

- **Co-creation and Diversity of solutions: I**f all you have is a hammer, everything looks like a nail. ‘Paint your roof white’ smacks of elite condescension. A praxis embedded in community led co-creation of solutions.
- **Humility of praxis:** Doing ‘development’ only if the community reserves the right to say ‘thanks, but no thanks’. How open would we be to our own homes being part of ‘development’ experiments?
- **Health and Rights-Based approach:** If heat is a health issue, then the ‘legal status’ is immaterial e.g. COVID-19 vaccination.
- **Appropriate technology, resilience economy: L**ocal fabrication, maintenance without reliance on non-resilient corporate and global supply chains. AI, IOT, ML, next ‘fad’ please stay away.
- **Patience in an emergency:** Do we adopt ‘sustainable’ cooling solutions in our contexts? What makes us lurch towards large ‘scale’ in a hurry; after years of neglect?. Need ‘patience’ for decentralized autonomous ‘scaling’ models to flourish, with our initial structural support, but not ‘controlled’ by us through grand schemes.

Participatory Design

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Safety and Dignity of Life

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Women’s Coop-led Local Sustainable Economy

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Appropriate Technology

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Appropriate Technology (Rural)

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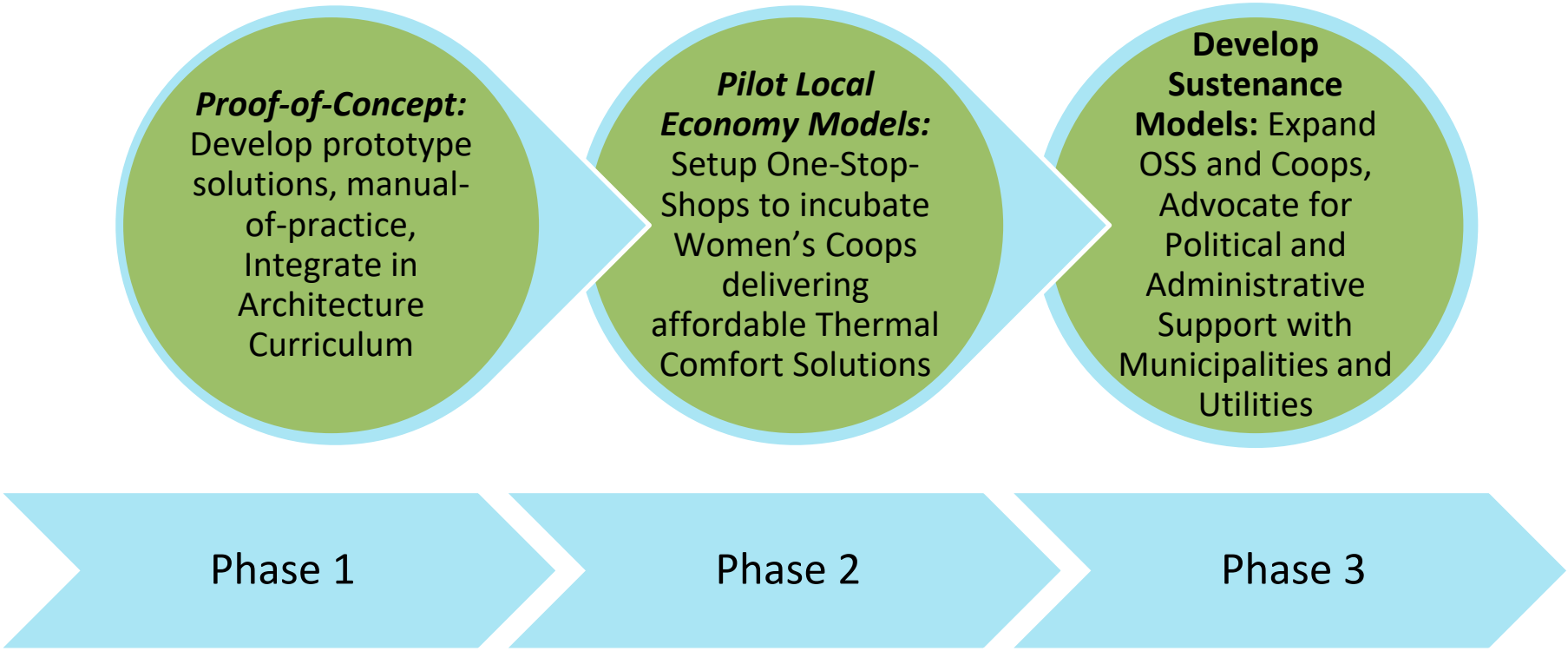
THEORY-OF-CHANGE

Framework Change: Foster Informal Housing Thermal Comfort & Women-Centric Political-Economy in India



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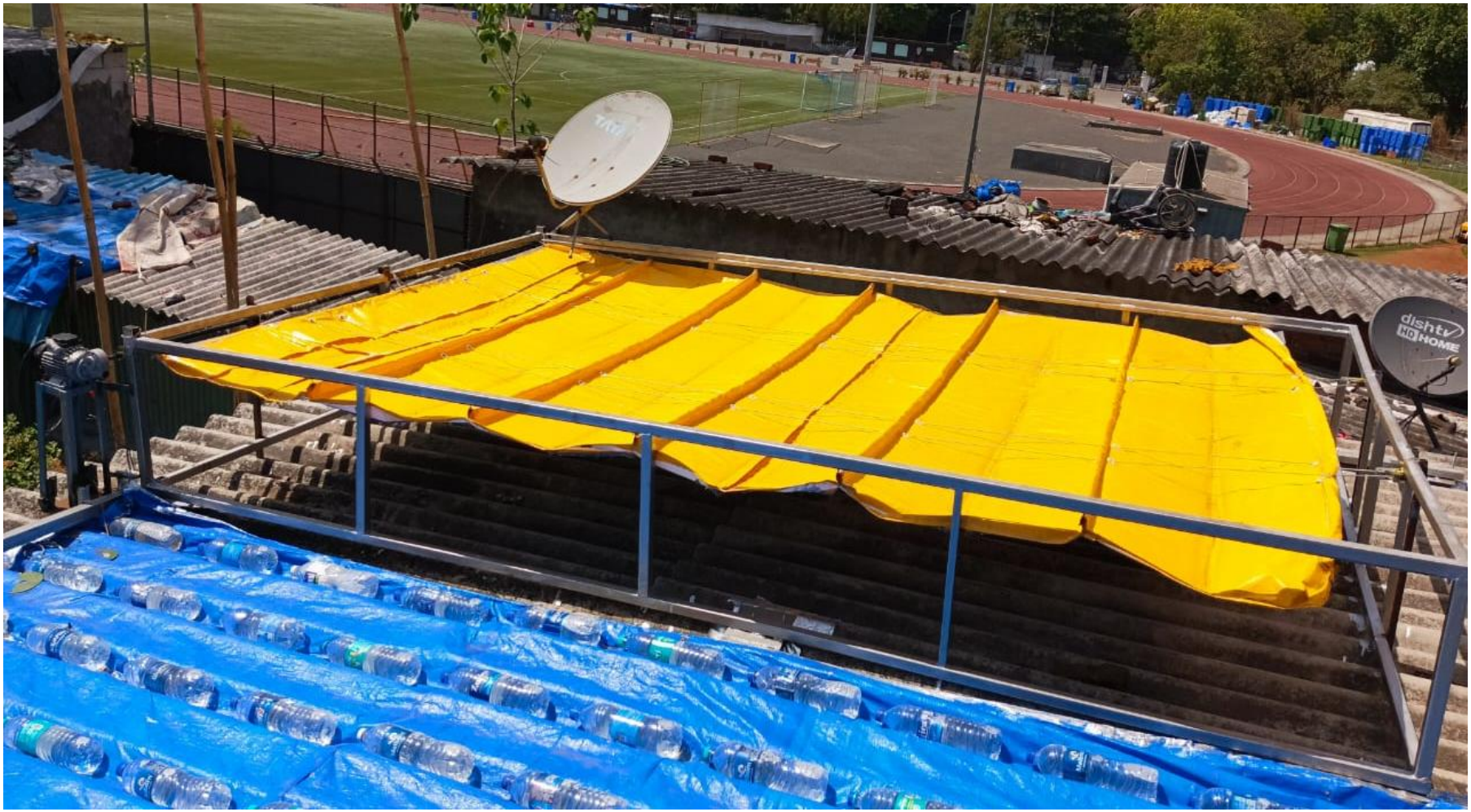
PILOT INSTALLATIONS

(Pune, Bangalore, Mumbai, Delhi, Chennai, Coimbatore)

Alufoil *(chain sprocket on tin sheet)*

Alufoil *(chain sprocket on concrete slab)*

Alufoil *(pipe motor on tin sheet)*



Alufoil *(pipe motor on concrete slab)*

Alufoil *(awning on tin sheet)*

Alufoil *(static, internal)*

Water-Filled PET Bottles

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Ecoboard *(chain sprocket on concrete slab)*

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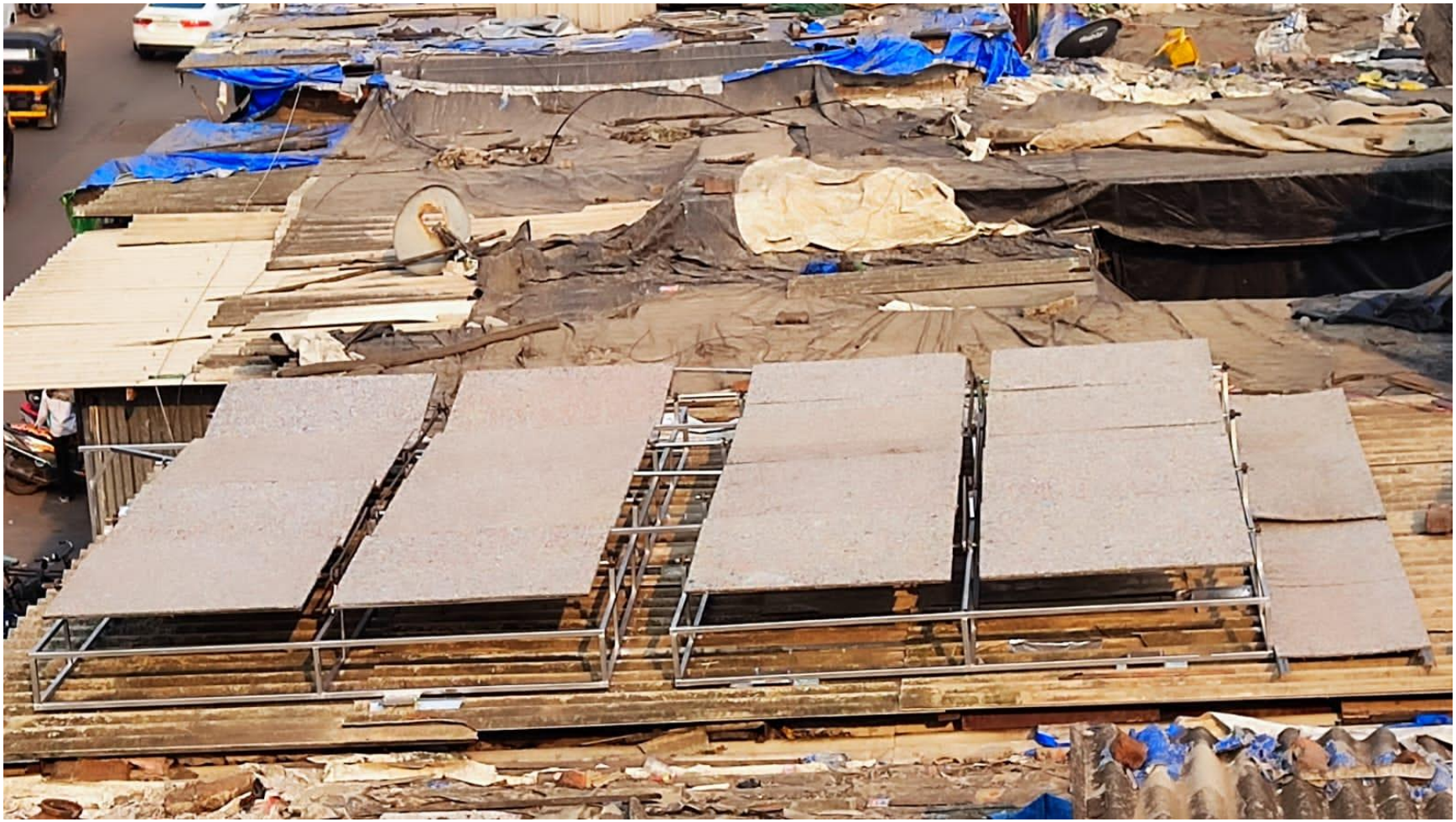
Ecoboard *(chain sprocket on tin sheet)*



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Rooftop Garden *(on tin sheet)*

Rooftop Garden *(on concrete slab)*

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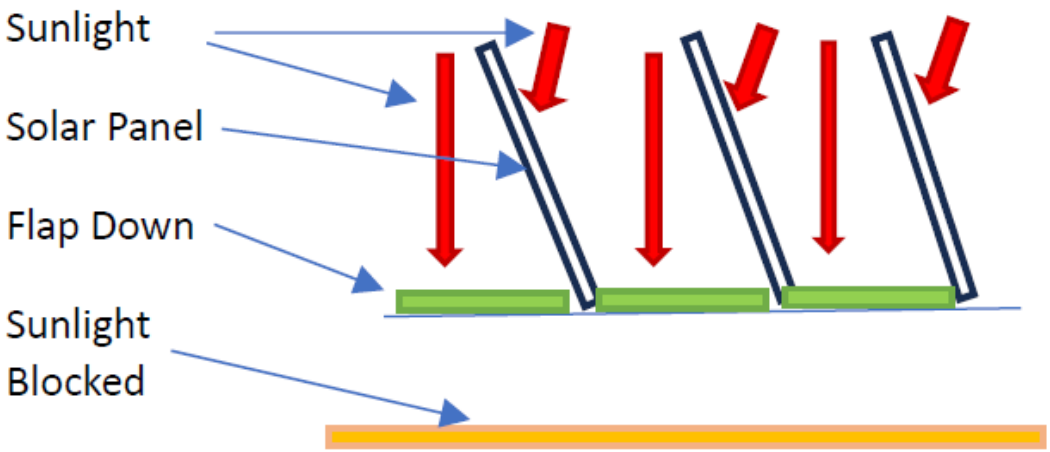
Dormer Window

Dormer Window

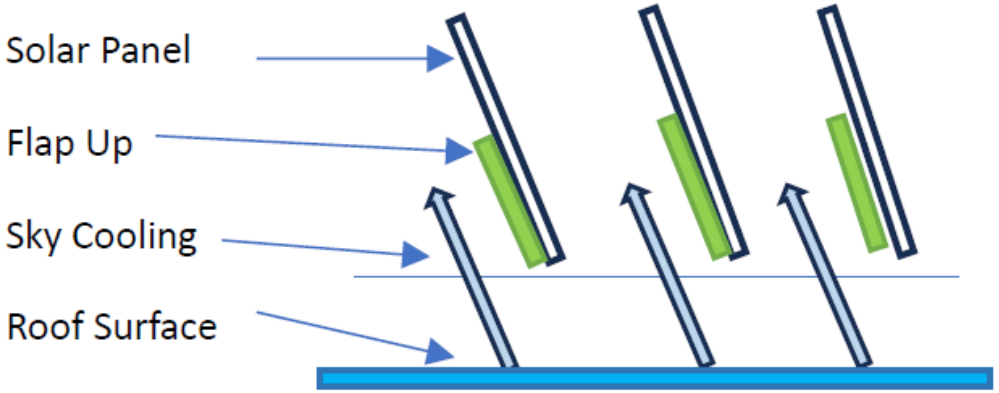
Wood-Wool Panel

Structure cooling

Solar PV + Radiant Barrier



Day Time



Night Time

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CURRENT STATUS

Building Physics Concepts & Terms

1. **Rooftop radiant temperature:** temperature at which the roof radiates downwards to occupants (the 'felt' temperature which can reach 52 degrees C in tin/cement asbestos sheet roofs during summers in Tropics)

2. **Mean radiant temperature:** average radiant temperature of all surfaces (walls, roof, floor) at which the roof radiates towards occupants (can reach 38 degrees in homes with tin/cement asbestos sheet roofs and single-layer brick walls)

3. Primary methods of thermal 'control' are: 1) ventillation, 2) insulation, 3) shading, 4) radiation barrier & night sky radiation, 5) thermal mass, and 6) reflection

4. Ventillation: limited by a) small windows, narrow alleys, b) 'packing' envelope with tarpaulins during monsoons, c) extremely low specific heat-capacity of air (i.e. need large flowrates to carry away heat)

5. Insulation: only 'delays' heat, once the heat has 'hit' the structure it will find a way into the indoor environment regardless

6. Reflection: requires intense maintenance to keep surfaces reflecting – to expect this in informal settlements demonstrates poor understanding of context.

7. Radiant barrier/night sky radiation and light-weight/locally available 'thermal mass' are relatively unexplored; our focal point.

Performance Assessment

1. Rooftop radiant temperature, not air temperature or DBT, is the most pertinent indicator of rooftop-retrofit thermal comfort solutions that address radiant heat gain from the roof.

2. Rooftop Garden caused roof radiant temperature, and mean radiant temperature to drop by approximately 8^0C and 3^0C respectively, at 6 pm within one week of sapling growth; performance will be augmented with greater foliage growth.

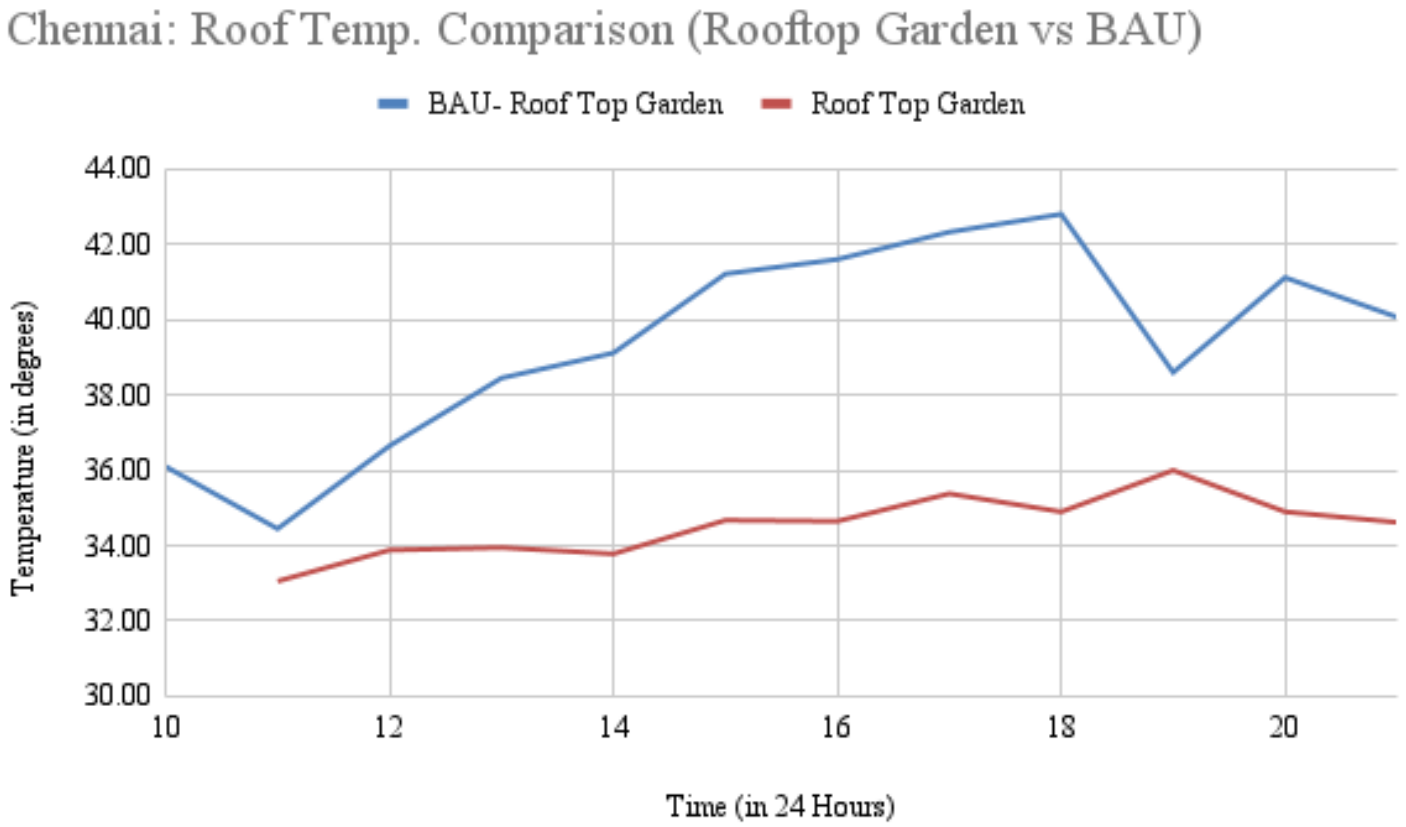
3. Alufoil Chain-Sprocket causes roof radiant temperature to drop by approximately 5^0C at 6 pm, and mean radiant temperature to drop by 4^0C at 12 noon.

4. Wood Wool Panels cause roof radiant temperature to drop by approximately 2^0C at 6 pm, and mean radiant temperature to drop by 1.5^0C at 5 pm.

5. Of the 4 solutions constituting the pilot testing, Rooftop Garden demonstrates the greatest thermal comfort impact, followed by Alufoil Chain-Sprocket Mechanism.

6. Wood Wool Panel and Water-filled PET Bottles seem to have had relatively minor impacts and require significant design modifications to enhance their performance.

Performance Assessment



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Pilot In-Situ Installations

- Proof-of-concept installations to test 9 passive design strategies/operating mechanisms.
- 50 informal settlement homes and 5 community buildings in refugee resettlement communities across 6 Indian cities (Mumbai, Pune, Bangalore, Delhi, Chennai and Coimbatore) over 2 years.
- 3 to 8 degrees

Academic Curricula Change

- July 2022: VTU Board of Studies (~ 49 architecture college campuses in Karnataka, India) accepted all recommendations to fundamentally integrate heatwave responsive design and informal settlement thermal stress related pedagogy, motivations, skills across all subject themes (humanities, theory, technical, design) across 5 years of the Bachelors of Architecture Curriculum.
- 'Climate Change' and ‘Informal Settlements’: 0 mentions in previous versions of curricula; ‘Climate Change’: 45 mentions, ‘Informal Settlements’: 67 mentions in new curriculum.
- Sept 2023: signing of an MoU with the University to establish a pedagogy training centre for all teachers (approx. 1000 teachers across the State) to be trained in teaching the revised curriculum

NEXT STEPS

Intersectional Ecological Design

- Combinations of passive cooling solutions (eg. Thermal mass and ventilation, insulation and radiant barrier)
- Radically cut groundwater temperature through Informal Settlement Rain Water Harvesting (never been attempted in India).
- Water-tenacity can enable organic ‘scaling’ of rooftop gardening in Informal Settlements.
- Local drainage canal revival through constructed wetlands/shaded green spaces on banks
- Low-cost modular active cooling solutions (eg. Modular structure cooling systems, highly insulated ice-box acs, silica-gel based low-tech dehumidification systems) coimbatore) over 2 years.
- Local fabrication through appropriate technology: substitute industrial materials with reused inorganic waste, biodegradable hand-crafted materials (eg. Khadi, sheep wool, rice-husk, areca nut leaf-based panels with reused inner reflective lining of MLP packets)
- Accelerated ‘weather-resistance’ testing and testing physical strains from aggressive human handling, stray animals, pests/rodents etc.

Policy Practice

- Diversity definition of Cool Roofs in Cool roof policy: needs to stop preoccupation with reflective coatings. There are other 'building physics' principles that are far more contextually relevant.
- Integrate cool roof designs into beneficiary-led-construction constituent of affordable housing programs in 4 states.
- Empirically ascertain reduced AC energy consumption in weatherized informal settlement homes vs. Norm; leverage outcomes into DSM programs of energy utilities. A key funder for OSS's could be Demand-Side-Management (DSM) Programs by Utilities (like Bachat Lamp Yojana). Energy-saved from future AC use by communities who'll need heavily subsidized electricity to operate ACs, can be sold to Industrial Consumers at significantly higher tariffs. This 'delta' per kWh can fund OSS's with seed-capital foy pay-as-you-go cooperative business models.
- Engage with heat-action-plan (HAP) apparatus to embed diverse pre-emptive cool-roof/green-roof program as safeguard against extreme heat-stress
- With HAPs, explore annual 'drives' similar to pre-monsoon malaria or flood control 'drives', to temporarily deploy solutions (eg. Placing of radiant barrier sheets on roofs) during heat waves.
- Work with Tamil Nadu department of environment's green school program to amend the scheme (pasumai pallikoodam thittam) to mandate green roofs/cool roofs for all government school buildings; the eventual goal to transpose across govt. Buildings in state.

Knowledge ‘Commoning’

- Devise training content for local fabricators (metal workers, mechanics, electrical and civil contractors, masons etc.).
- Devise training content for women’s cooperatives to foster capacity related to procurement, installation, and maintenance of thermal comfort solutions.

Co-operative Economics

- Co-create with microfinance institutions and local cooperative banks; ‘financial products’ for Women’s Heat Action Cooperatives (WEHACs) provisioning for appropriate-technology based thermal comfort solutions within their communities.
- Engage Tamil Nadu department of women and children to integrate cool roof solution fabrication, installation and maintenance related livelihood activities into the state’s national urban livelihood mission (NULM).
- Support ‘insertion’ of thermal comfort layer into the existing ‘service’ models already in operation by established housing-upgrade related CSO’s instead of launching new business models ourselves thus enabling organic ‘scaling’ without ourselves acquiring an inhuman scale.
- Recruit 8 to 12 member-owners in each city to form ‘experimental’ WEHACs, undertake formal registration with relevant government bodies, train, and financially support this self-governed women-owned small-scale cooperatives specialising in informal housing upgrades.
- Assist in operation of coop for 2 years to develop experiential knowledge
- Establish physical and online informal-housing thermal comfort one-stop-shop (OSS); a technical and finance assistance facility supporting registered WEHACs and an ‘incubator’ and ‘matchmaker’ between impact investment/micro-finance networks, utilities DSM programs, municipal and other government funds etc. And coops.

Water & Heat Nexus

- Heuristic studies in Informal Settlements (IS) in Mumbai and Bangalore have revealed that rainwater/floodwater ingress during monsoons is experienced as an acute existential threat; surpassing the risk/threat perception of heat stress in summers

- Water deprivation in IS (even during monsoons) exacerbates perceived and material inequities relative to affluent areas; domestic workers report grappling with flood waters in compounds of high-rise apartments where they work and return home to water cuts.

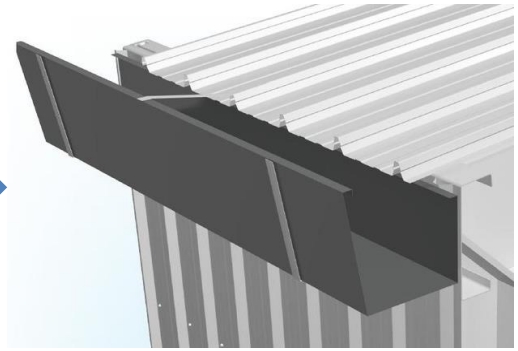
- Drastic reduction in underground moisture and ground water table in diminishes thermal mass, and the beneficial dampening effect, of the terrain which inflames the urban heat island effect.

- Water deprivation severely undermines the possibility of intense urban agriculture, and rooftop gardening atop IS homes; both are field-verified solutions to address extreme indoor heat stress and contributors to food resilience amongst marginalized communities.

System Design *(preliminary)*

MLP/Bamboo/Jute Rainwater Collection & Radiant Barrier Panel

Roof-runoff gutter



Rubber Water Storage Bag

Ringwell w/ Recharge Pit

Rooftop Garden w/ Drip Irrigation System

Indoor Water Storage Tank w/ Submersible Pump

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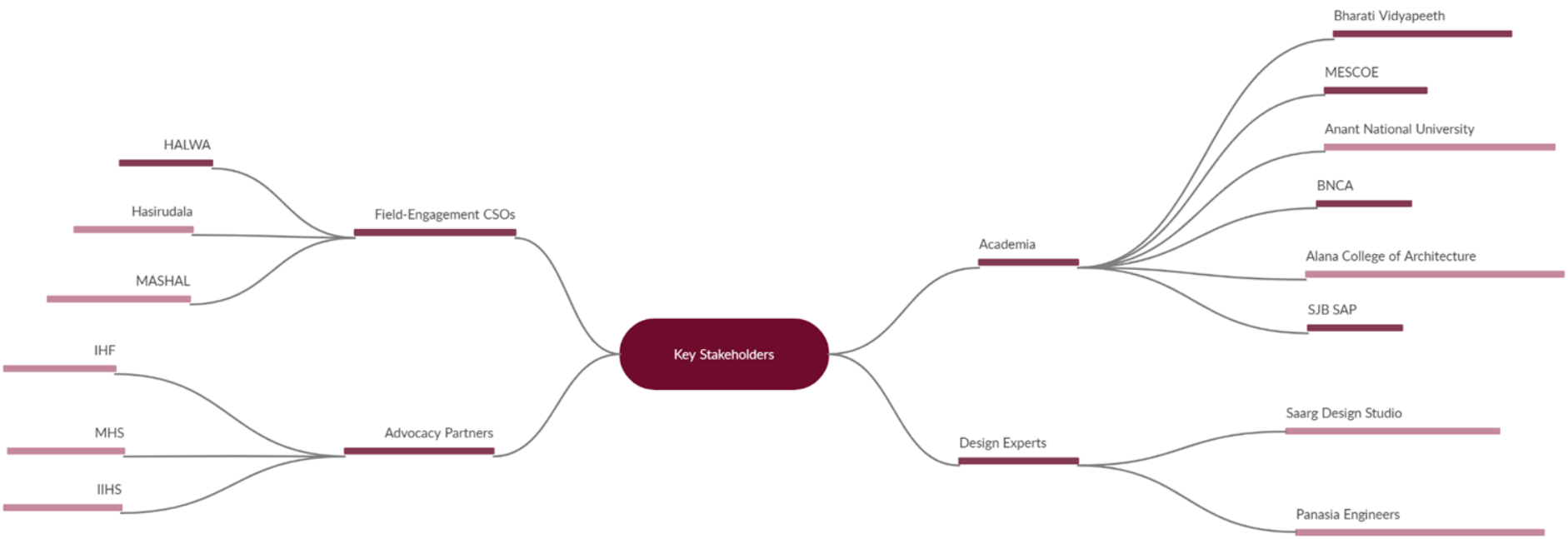
PARTNERS

Partnership Map



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Partners & Funders

noé 21
economy, energy, society

SIG

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

SHAKTI
SUSTAINABLE ENERGY FOUNDATION

REPUBLIC AND STATE OF GENEVA
POST TENEBRAS LUX

POLITECNICO DI MILANO

Ashden
Sustainable solutions, better lives

Panasia Engineers Pvt. Ltd.
Energy Efficient Cooling Technology

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Hasiru Dala

Maharashtra Social Housing and Action League
MASHAL

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IMPACT

- By October 2025, implementation of passive design solutions across 5-10% of informal housing dwellings in 4 typical Indian Metro Cities will be attempted, through government or city electric utility funded programmes and micro-business enterprises of women's cooperatives.
- This will avoid approx. 210 to 420 MW of power generation and mitigate approx. 0.5 to 1 Million Tonnes of CO2e per year and provide thermal comfort to approximately 1.5 to 3.0 million people.
- Approximately 16 architecture colleges, 2,560 architecture students, and 240 architecture professors will be engaged in learning and devising passive design solutions for the urban poor.