Access to Sustainable Cooling

Innovation and Scale of Sustainable Energy, Energy Efficiency and
Green Built Environments in Cooling Solutions for Vulnerable Communities

SELCO Foundation
www.selcofoundation.org

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SELCO Foundation

Goal: SELCO Foundation seeks to inspire and implement socially, financially and environmentally inclusive solutions by improving access to sustainable energy.

Role of SELCO Foundation and its Partners: is to create benchmarks and replicable processes for achieving SDG 7 through all other SDGs by demonstrating inclusive and effective approached to poverty alleviation.

Global SDG 7 Hubs (Knowledge and Cross Learnings)

Innovation | **Incubation** | **Institutionalization**

Core Philosophies

Local ownership
Is built among stakeholders decentralization of sustainable assets for productive use where is maximum value capture and ownership is generated at end the user level

Need based innovation (technical, financial and social innovation)
designed and deployed keeping end-user at centre, end users as core owners of the problem, innovators, partners and investors

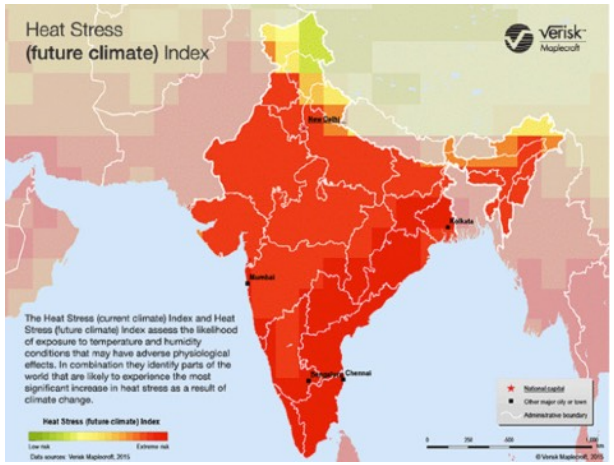
Systems Thinking
Creation of enabling conditions for innovations to scale is recognizing and building cross sectoral and interdisciplinary stakeholders at different levels

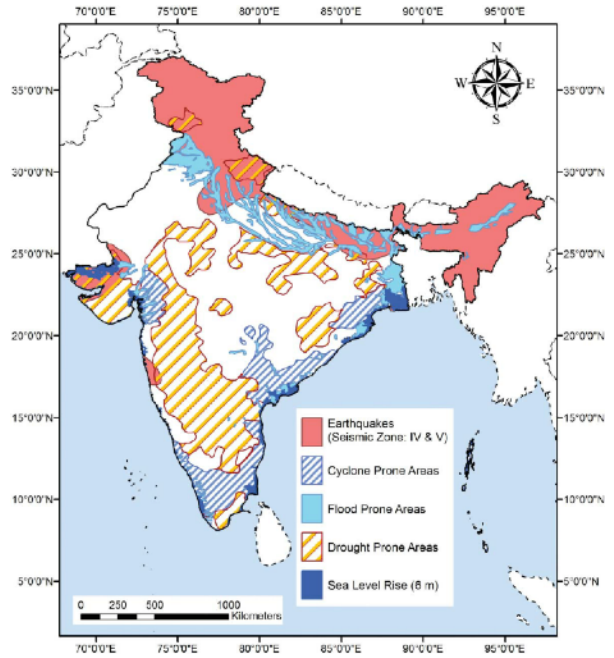
Implementation based
More emphasis on on-ground implementation driven learnings and evidence building than a prolonged theoretical and research phases

Process Replication
scaling of processes by contextualizing it to the needs

Why Cooling?

Cooling : The Next Big Inequality Challenge





Increased geographies impacted by Heat Stress (exasperated due to inefficient built environments): India's National Disaster Management Authority reported that the number of Indian states hit by heat waves had grown to 19 in 2018 from nine in 2015, and was expected to reach 23 in 2019.

Lack of Cooling Infrastructure for Immunisation: 2 million people die from preventable diseases due to damaged or degraded vaccines that were improperly refrigerated and did not follow protocols while in transit.

Reduced Productivity due to Inefficient Cooling and Increased Heat Stress: India is projected to lose 5.8 per cent of working hours in 2030, a productivity loss equivalent to 34 million full-time jobs, due to global warming, particularly impacting agriculture and construction sectors, a report by the UN labour agency said.

Inefficient Energy Needs for Informal Home-based workers: Poorly designed, multi-functional workspaces rely on incremental appliance based solutions for cooling - potential energy poverty trap

Shortage in Cold Storage resulting in Wastage and Loss of Income: India would need 3 million tonnes of additional cold storage and distribution hubs simply to catch up with current levels of food production and demand – never mind satisfy future growth.

Inequality in Cooling Access: More than 70% of existing capacity serves only potato produce, both in terms of capacity and specifications.

Infrastructure is primarily concentrated in few states, and that too near urban centers. This severely limits access to cold chain infrastructure for other produce, especially vegetables and fruits.

Need : Spectrum of Cooling

Passive Technology	Active Technology	Passive Technology

Space Cooling	Application Cooling

Heat Infiltration	Ventilation			Cooling						
Insulation, Wall, Shading	Fenestration	Exhaust (Room)	Exhaust (Spot)	Fans (Wind, Chill Effect)	Water Based Cooler	Radiant Cooling	AC (PCM Based or Ice Based)	AC (Cold storage or Cold room)	Freezer and Refrigerator	Portable Cooling Solutions

Health Well-being					Cooling for homes, health centres, schools etc	Heat exhaustion for cooking					Cooling for homes, health centres, schools etc - peak summers and heat stress zones **Combined with passive technologies to optimise cooling needs**	 **Health:** ILRs and Vaccine storage; Blood Storage and other medical samples Household Refrigeration	 **Health:** Active and Passive Vaccine Carriers
Livelihood												
Agriculture	Storage Units for cereals, and vegetables such as onions, potatoes							Cold Storage for Seed Storage, Aggregation and Processing	Retail Shops (including value-add: cut fruits and vegetables, juice etc)	Transportation of Fruits and Vegetables		
Animal Husbandry	Cooling/ Heating for animal sheds (dairy and poultry)				Cooling/ Heating for animal sheds (dairy and poultry)			Cold Storage for Meat, and Processed Food	Milk Chillers and Coolers Retail Shops	Transportation of Milk and Dairy Products, Meat etc		
Micro Businesses	Cooling for shops, home based businesses		Exhaust for businesses that use Kilns, furnaces, forges etc		Cooling for shops, home based businesses			Shared Cold Storage Units in Markets (flower, meat, fish, vegetable and fruits)	Restaurants, Retail, Mobile Vendors, Delivery Agents			

Designing Solutions for Improved Access to Cooling

Technology | Finance | Ownership

Combination of energy efficient appliances, decentralised renewable energy and sustainable built environments can lead to decentralised, sustainable and resilient models for optimised cooling solutions.

Energy Efficiency

Sustainable Energy

Sustainable Built Environments

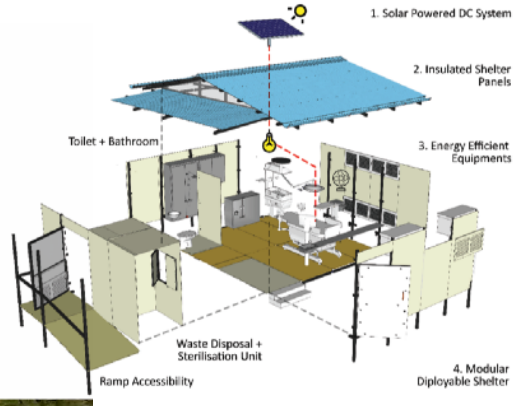
Health and Well-being

Productivity and Income Increase

Aspirational Livelihoods

Technology as a catalyst combined with appropriate finance, training, linkages and policy environment

Solutions | Health and Well-being



Cold Storage for Immunization

Optimised Space Cooling

Overall reduction in energy consumption for Cooling- 85%

Improved thermal comfort environment for both patients and health centre staff.

Improved productivity of health centre staff due to effective use of space.

Reduced dependency on energy for active cooling to maintain the required thermal comfort + Reduced Vaccine Wastage

Proving of models and processes with Karuna Trust

Replication and Adoption by multiple health partners

District wide Programs with Government Health Departments

State-wide program for strengthening of health system in Manipur and Meghalaya

Sharing Guidelines for National and Global Policy Stakeholders

20 health centres

500 health centres

Processes across State

1000 health centres (25+ million population)

Mapping Health Cooling Requirements
Health-Energy Audits
Critical Loads
Optimization of Cooling Needs
Efficiency of Equipments

Financing and Maintenance through local institutions- ARS
Procurement guidelines and building guidelines for energy efficiency

Influencing policies and guidelines with IRENA and WHO for developing nations
Training of government health staff
Procurement guidelines and building guidelines for energy efficiency

Challenge: The hot season lasts for 3.0 months, from **March 27 to June 26, with an average daily high temperature above 35°C.** The hottest day of the year is May 23, with an average high of 38°C with **relative humidity levels ranging from 45 to 60%. Sweltering conditions of high temperatures and high relative humidity resulted in heat stress in doctors and health professionals and lowered productivity levels. Additionally PPE suit utilisation and wastage increased 10 folds.**

Solutions | Health and Well-being

100% ECO friendly walling and flooring compressed Agri Fibre panels which is manufactured using the crop residue - **better insulation compared to conventional walling and flooring panels.**
Roofing panels additionally **insulated with reflective surface finishes** to further reduce indoor temperatures.
Ventilation systems and exhausts added to aid the ventilation




System	Efficient appliances with Green Building Design	In-Efficient appliances with Green Building Design	In-Efficient appliances with standard typical building designs
Total Load Connected	4290 W	5749 W	5749 W
Total Units Required	21.8 Units	30.63 Units	52.34 Units
Solar Panel Capacity	**12 kWp**	16.2 kWP	26 kWp
% of Savings (Energy)	28.82% (solution without energy efficient appliances and with green building design) **58.34%** **(savings with both- energy efficiency and green building design)**		

Solutions | Health and Well-being

Case Study: Improved Cooling Solutions for Last Mile Immunization

	Passive Vaccine Carriers	Active Vaccine Carriers
Temperature maintained for	4 hrs	11 hrs
Vaccine wastage	Based on the calculation per dosage, after the completion of the MHU the team used to discard vaccines approximately worth INR 500 every day (INR 13,000 per month)	No vaccine spoilage was observed. Unused vaccines could be used the following day
Outreach	Outreach in summer limited to a smaller geography	Outreach unaffected by seasons Improvement: from 30 to 50 children

Cold Storage Requirements

Bio Samples	-80 to -130°C
TB	-70°C
Vaccine	2 - 8°C
Blood	2 - 4°C
Platelet Storage	20 - 24°C
RBC / WBC Storage	2 - 4°C
Frozen Plasma, Cryodepleted plasma, Cryoprecipitate	-25°C

Active Cooling Solution for Agriculture and Animal Husbandry

SUSTAINABLE DEVELOPMENT GOALS + Cooling

Agriculture & Food Processing

Cold Storage
Horticulture, Floriculture, Meat and Fish

Refrigerator
Retail Storage of Beverages, Animal Products and Vegetables

Animal Husbandry

Vaccine Storage
Poultry, Goats and Cows

- Vaccine Carrier
- Portable Storage
- Stationary Storage

Dairy

- Milk Chillers
- Dairy Product Storage

Solutions | Livelihood: Agriculture

Solar Powered Decentralised Agri Cold Storage Solutions

Kunabi Community in North Karnataka

40 varieties of tubers grown

Increased demand but non-availability of the produce throughout the year

Cold Storage for 20 marginal farmers with around 2 acres each, designed to store for 3-4 months at 14-16°C temperature

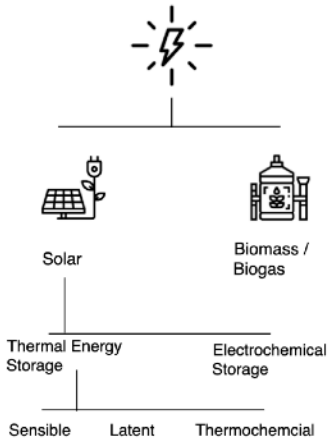
IMPACT:

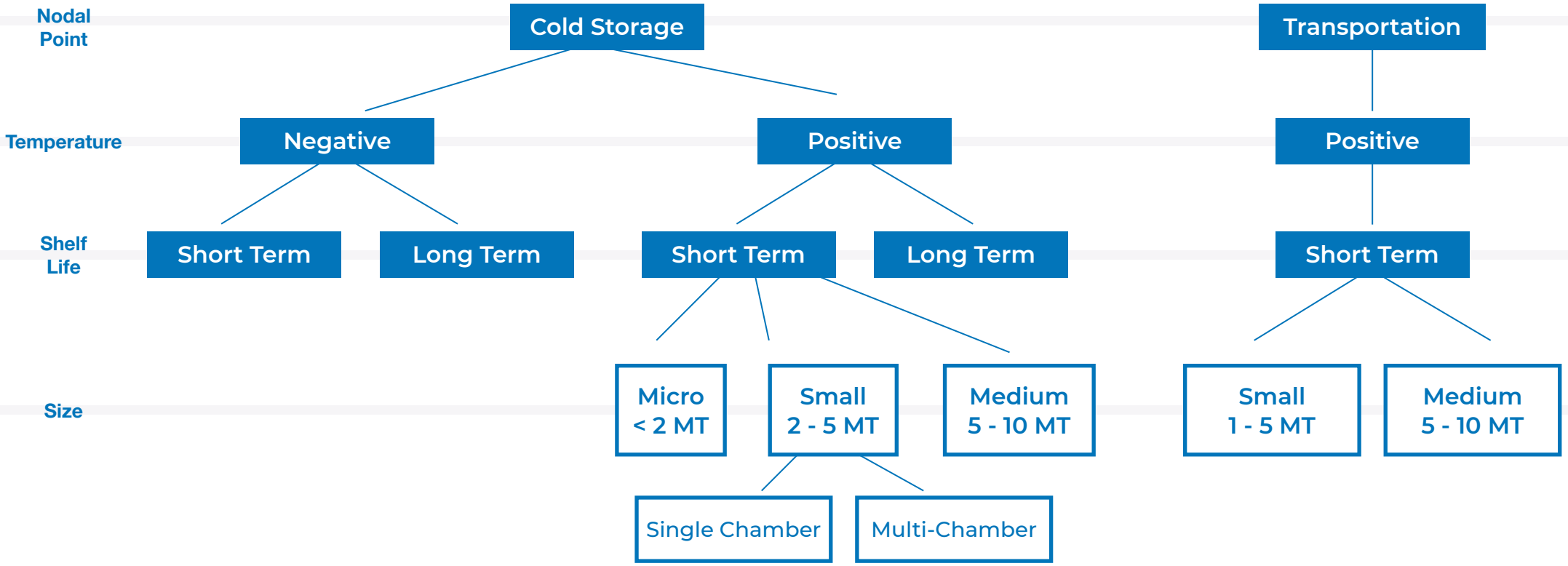
- After 2-3 months of storing, farmers were able fetch **3-5 times more price for tubers in the off-season.**
- **Wastage of tubers reduced from 35% to 5%**
- **Total increase in income was INR 100,000 per year**
- Opportunities to sell during **Tuber Mela** organized in the region every year

Agriculture | Solar Powered Cold Storage Units

Challenges:

- Voltage fluctuations,
- Unreliability,
- High diesel/ alternative fuel costs,
- Competitive with high commercial grid costs (3-8 years)
- COVID cases: Resilience building and criticality of decentralization





Agriculture | Commodity Specific Cooling Solutions

There are several factors that influence the choice of cooling solution and the energy requirements:

- **Temperature to be Maintained**: Each commodity has a specific shelf life and temperature requirement- not maintaining that can result in loss of produce, or chilling injuries (also resulting in loss)
- **Commodity Stored:** Decentralised cold storage units usually are used for multiple commodities- multiple chambers or treatment of vegetables and fruits may be required
- **Nodal Point in the Value Chain:** Farm Storage, Bulk Storage, Storage of processed food items- all have different cooling requirements
- **Relative Humidity:** This is an important feature to be maintained in addition to temperature for several commodities
- **Duration of Storage:** Primarily determines the energy requirement- influencing the number of door openings
- **Occupancy and Heating Load:** In some cases, heat generating appliances / activities, or heat generation due to number of humans occupying the space may also determine the cooling load

Custard Apple | Value Chain

Ripening Chamber

Temperature: 20 - 25°C

Hardener

Temperature: Negative 35°C

Deep Freezer

Temperature: Negative 22°C

Potato | Value Chain

Seed Potato

Temperature: 2 - 4°C
Relative Humidity: 90 - 95%
Shelf Life: 6 - 8 Months

Table Potato

Temperature: 18°C
Relative Humidity: 50 - 80%
Shelf Life: 45 days

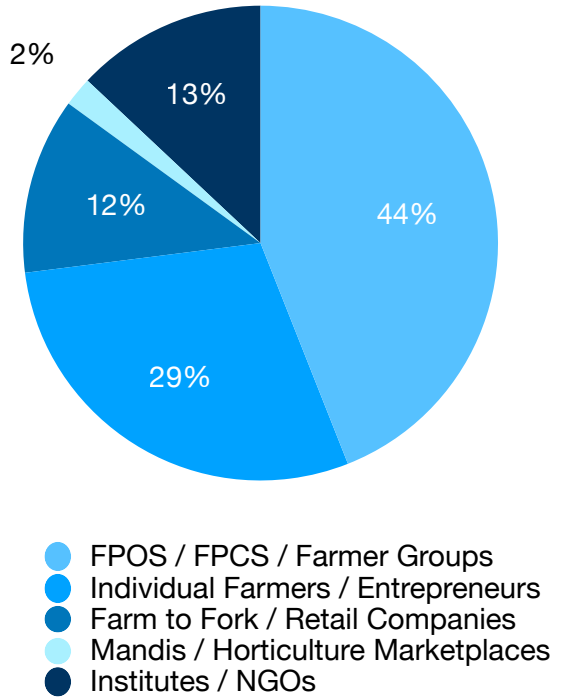
Table Potato

Temperature: 10 - 12°C
Relative Humidity: 90 - 95%
Shelf Life: 9 - 10 Months

Ownership and Financial Models

Snapshot of Solutions

End User	Financing Model	Technology Providers
FPOs / FPCs / SHGs Institutes Local Retail Businesses Local Government Private Companies Individual Farmer / Entrepreneur	**Sales Model** Lease to Own NGO finances/owned Long term bank financing Government financed Pvt Company owned Institution/FPO/Farmer Self financing **Service Model** Pay as you store or Cooling as a Service	CoolCrop Ecozen Pluss Inficold New Leaf Dynamics Solar Cool Tech Promethean Inspira Farms Cold Hubs Solar Freeze Black Stump



End user segmentation data across 340 units

Very Poor		Poor		Low Income	
Infrastructure support	**+ Finance**	**Infrastructure support**	**+ Finance**	**Infrastructure support**	**+ Finance**
100%	+ 1 year ops	30%-70%	8-10 yr	0%	5-8 yr
100%	op ex sust.	0%-30%	3-5 yr	0%	3-5 yr
70-80%	5 yr	0%	2 y mor, 5 yr	0%	Self

Decentralised Cold Storage in Odisha

Solution:
Farmer Producer Organization : Markoma Women Farmer Producer Company

Typical farm collection and storage systems, creating waste at all levels of the supply chain.

Availability of all vegetables in every season was also not possible because of **non-feasibility in producing crops round the year** in this area.

Storing and selling of vegetables were commercially **not feasible** because of **non-availability of cold storage** in Bissamcuttack area.

Traditional method of storing for highly perishable **commodities like vegetables is not suitable**.

Farmers **started selling their vegetables to farther markets** because of comparatively lower prices in the local markets. However, **sending vegetables to large markets of cities during the peak production time was a challenging task** for the local farmers.

Owned by a Women Led Farmer Producer Organization - 400 farmers

Decentralised Cold Storage- Savings in Transaction Costs for the Farmers

Established contracts with vendors for improved pricing

Unlocking Financing NABARD Infrastructure Fund, State Livelihood Mission

Practitioner Consortiums, Regulatory Mechanisms, Training Programs for Cold Storage Management

340 (30 Directly via SF) cold storage units- commodities, terrains, ownership models and financing models

Creating Consortiums for Sector wide Practitioner Representation and Advocacy

Solutions | Cooling for Productivity Improvement

Temperature across the Karnataka region has been increasing significantly at 95%. Increase in temperatures also have a profound effect on the living conditions of the poor and the related services administered to them. Small dwellings with tin sheets roofs increase the indoor temperature by more than 3-4 degrees. In hotter regions, when the outside temperature is 39-40 degrees Celsius the in-house temperature is at-least 43-44 degrees due to RH levels ranging in 30 to 60%. These conditions make it very dangerous of the poor to live or conduct any sort of livelihood activities.

The low-income group communities in Dharwad are generally observed **using tin or asbestos roofing sheets as their shed infrastructure for livelihood space**s due to easy availability and low capital costs for construction. These building materials especially in hot and arid climate zones, like North Karnataka, where the **max temperature recorded goes as high as 35°C, the the inner surface temperature of these metal sheets was observed to rise upto 50°C.**

Additionally, the communities were too **poor to invest in active measures of cooling**. The demands for energy were high yet unreliable with **livelihoods like snack making, flour milling and petty shops.**

Solutions | Cooling for Productivity Improvement

Cooling for Livelihoods which use Kilns, Furnaces and Forges:

- Blacksmithy
- Pottery
- Restaurants and Canteens
- Snack Making (Chips, Puffed Rice, Sweet Meat etc)
- Street Vendors

Optimization of Cooling also leads to:

- Improvement in Productivity
- Savings, Reduced energy consumption and future energy security
- Improvement in well-being - aspirational livelihoods

Cooling is one of the major concerns in building tropical houses. This problem is exacerbated by the **heat gain of the roof, which constitutes 70% of the total heat gain.***

**"Passive cooling techniques through reflective and radiative roofs in tropical houses in Southeast Asia: A literature review" (2014) Karam M.Al-Obaidi, Mazran Ismail, Abdul Malek Abdul Rahman*

This May, the temperature in Bidar peaked at 43°C.

At that time, due to the heat gain caused inside structures built using inefficient materials and design, **the temperature inside the house would be 49°C.** The felt temperature may be higher due to the high density in most of the low income households. **With adequate thermal insulation using passive technologies, this temperature can be reduced to 39°C.**

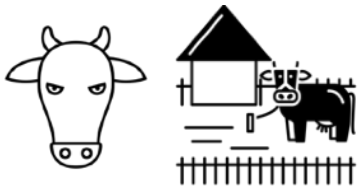
*BEFORE: Indoor Temperature was recorded **6°C higher** than outdoor temperature*

*AFTER: Indoor Temperature was recorded **4°C lower** than outdoor temperature. **This has resulted in an over 10°C difference in the indoor temperature for the family from the older house to the new house.***

Rehana's House in Bidar. The pictures were taken before the lockdown due to COVID-19

Solutions | Livelihood: Animal Husbandry

Gaps and Needs : Cooling for Dairy Farms



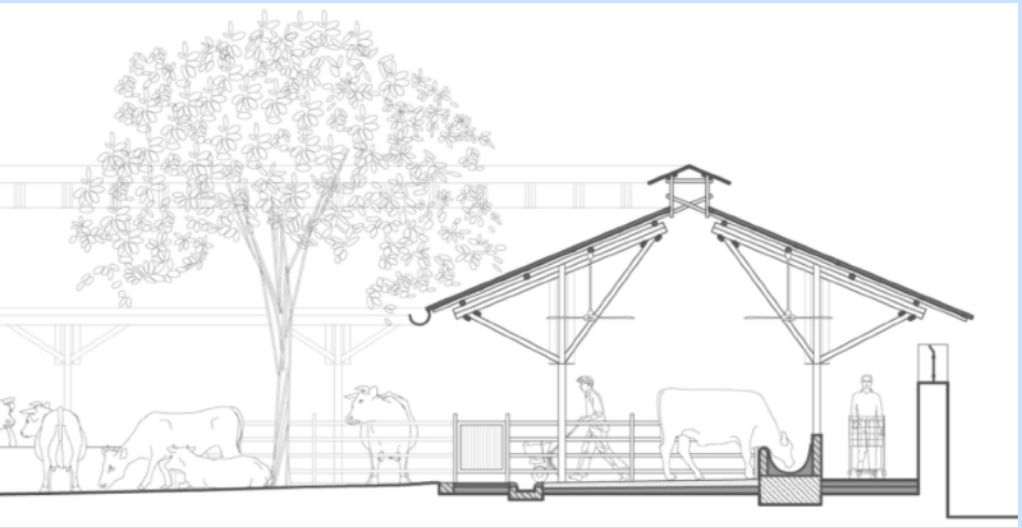
Behavioural restrictions associated with the use of tie-stall systems

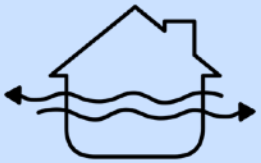
Heat stress affects cattle

- Reduction in fertility & calving rates
- Low milk components
- Susceptibility to infection

Limited access to water, quality feed and fodder leads to inappropriate consumption of feed and affects protein levels in the cows

Design Guidelines for Improved Cooling and Thermal Comfort





Orientation of the Building - Longer facades of the cow shed to face the North South direction to reduce heat gain.

Dominant wind direction to be used to allow maximum natural ventilation

All Roofing materials to be insulated to avoid heat build up during harsh summer days and nights
Overhangs and shading to be provided at 3-4ft outside the shed

Solutions | Livelihood: Animal Husbandry

Poultry Farms

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
28	32	37	41	43	38	32	31	32	31	30	28

High Mortality Rate and Poor FCR

Cooler	Turbo Ventilators	Cool roof paint, insulation and turbo ventilation	Full cool shed semi open	Full cool shed climate controlled
Incremental			**New- built from scratch**	

Improving Immunization

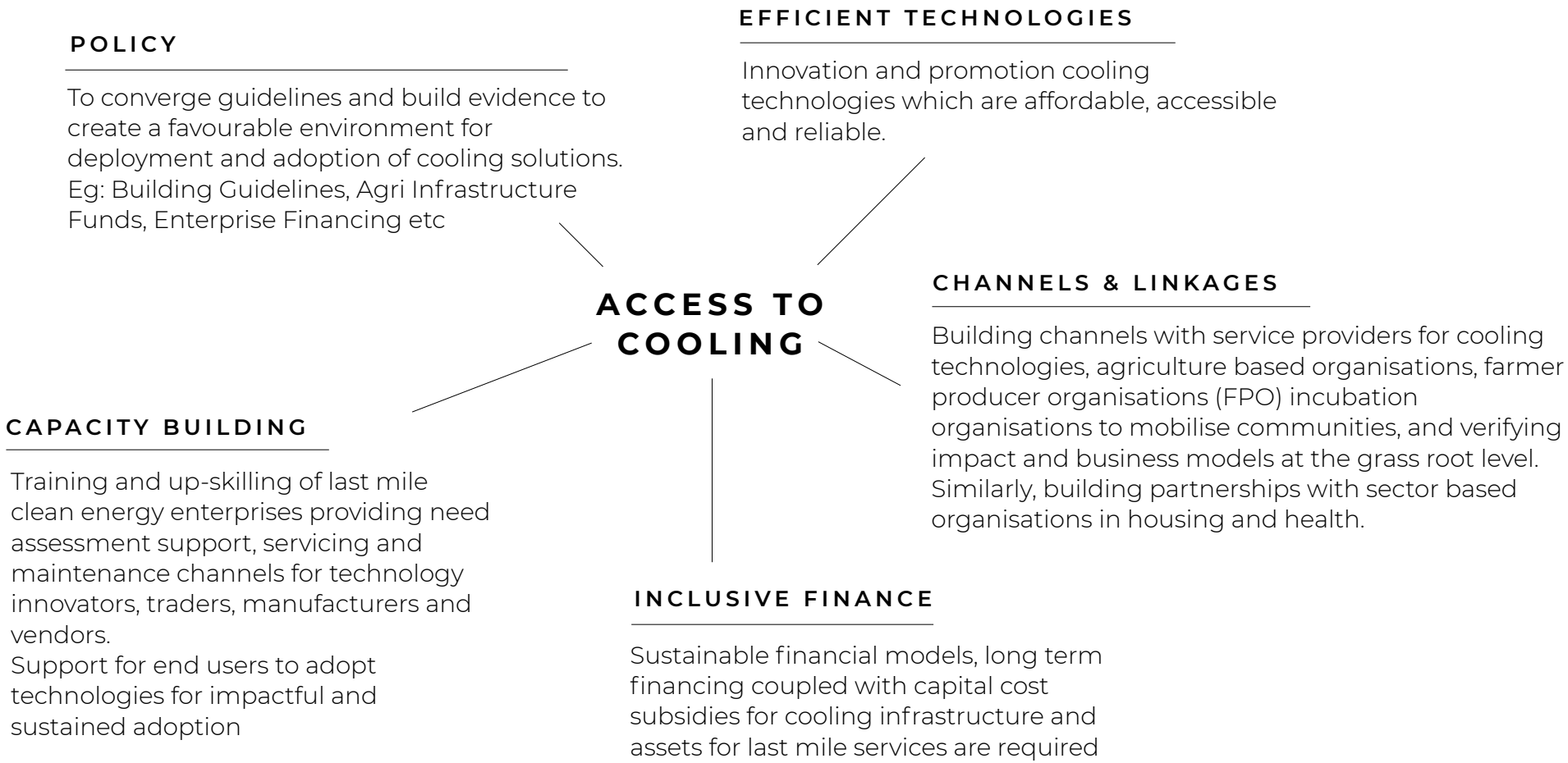
Ensuring the cold chain to prevent chick mortality due to vaccination failure.

Fully off grid model to ensure zero vaccination damage due to uninterrupted power supply.

Increasing efficiency and wide coverage of vaccination due to storage facility.

Ecosystem for Improved Cooling Solutions via SDG7

Poverty and the Burden of Cooling: Creating Sustainable Energy Ecosystems to Catalyse Innovations and Reduce Inequality



SELCO Foundation
Goal in 3 Years | **2021 - 2024**

Innovation and Scale of Sustainable Energy, Energy Efficiency and Green Built Environments in Cooling Solutions for Vulnerable Communities

- Map out the complete eco-system required for the poor and their related services that need cooling
- Implement in at least 10 typographies different cooling related applications (Impacting 6000+ families)
- To document delivery, finance and dissemination models for each of the above interventions
- To document and share learnings while providing capacity building on best practices
- To pursue and implement at least three policy level interventions with relevant stakeholders (e.g. local governments, housing departments, rural infrastructure schemes)
- To institutionalize cooling concepts in 15 organizations working in the fields of livelihoods, housing, energy and disaster

Access to Cooling, Climate Change and Energy Poverty

SDG 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 8 (Decent Work and Economic Growth):

- A smallholder farmer, will often lose at least 15% of his or her income due to food loss while harvesting and storing produce.
- Clean cold chains would strengthen the food supply by reducing post harvest food loss. This would reduce hunger and food insecurity by increasing the volume, quality and nutritional value of food reaching the market, and by reducing food prices and poverty.

SDG 3 (Good Health and Well-being):

- 2 million people die from preventable diseases due to damaged or degraded vaccines that were improperly refrigerated and did not follow protocols while in transit.
- India's National Disaster Management Authority reported that the number of Indian states hit by heat waves had grown to 19 in 2018 from nine in 2015, and was expected to reach 23 in 2019.[2]

SDG 9 (Industry, Innovation and Infrastructure):

- India would need to build 70,000 pack-houses, an additional 53,000 refrigerated vehicles – five times its current fleet
- India would need 3 million tonnes of additional cold storage and distribution hubs simply to catch up with current levels of food production and demand – never mind satisfy future growth.[6]

SDG 11 (Sustainable Cities and Communities):

- Efficiency benchmarks are not implemented or accessible to the poor or under-resourced regions.
- A lot of the infrastructure being built is done informally in cities, resulting in long term climate risks.

SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action):

- Cooling is already a major and growing emitter: one estimate suggests refrigeration and air conditioning cause 10% of global CO2 emissions[3]
- Cooling emissions currently account for 7% of the total, but are growing three times faster, so cooling's share will almost double to 13% by 2030.[5]

ACCESS TO COOLING

Access to cooling is linked to achievement of multiple Sustainable Development Goals (SDGs)

An inclusive approach, using Sustainable Energy (SDG 7: Affordable and Clean Energy) as a catalyst could also ensure that these goals are achieved to also ensure that two of the major threats of our times are tackled - Climate Change and Inequality.