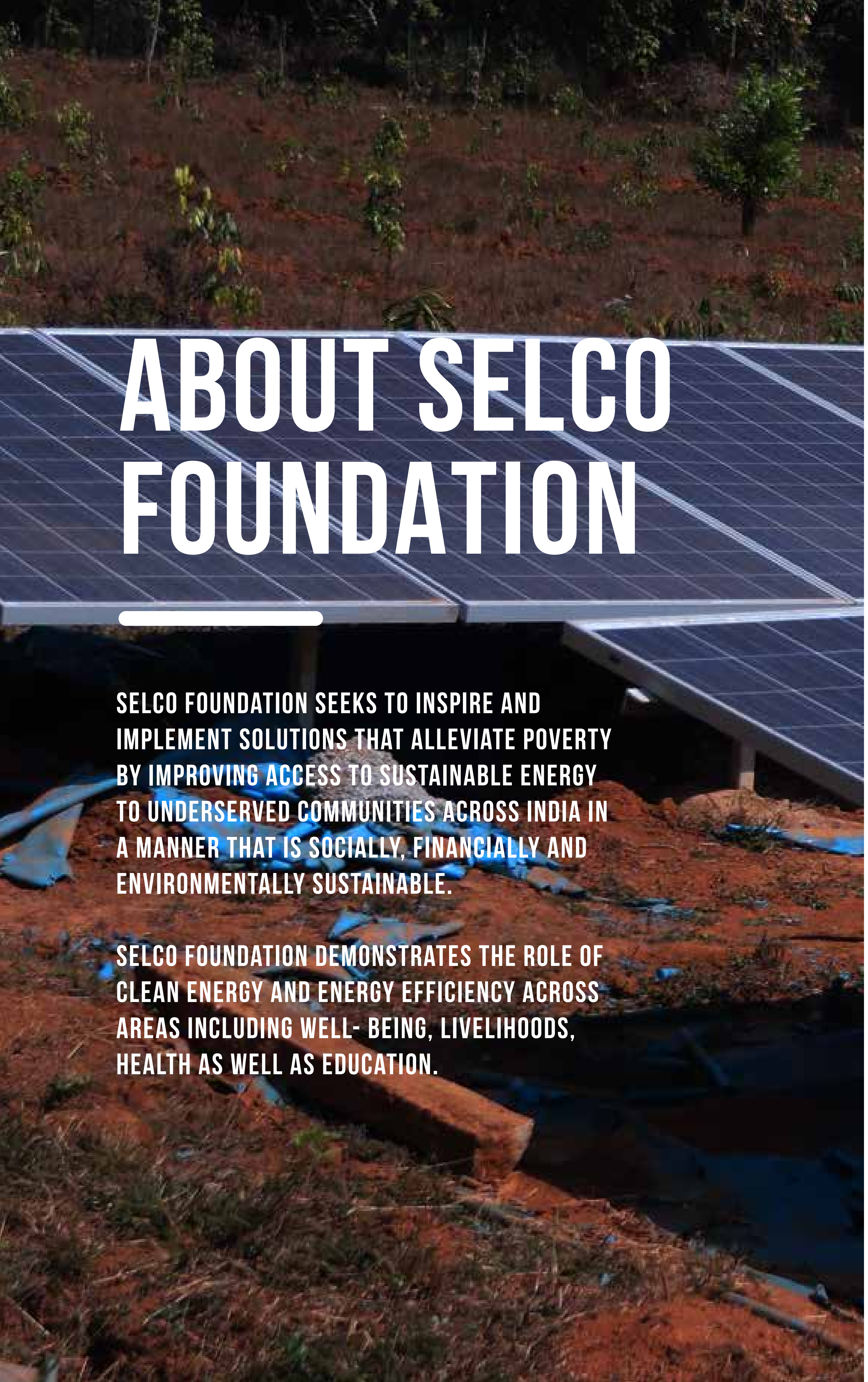
SELCAP
Sustainable Energy Led
Climate Action Program

SELCO
FOUNDATION



ABOUT SELCO FOUNDATION

SELCO FOUNDATION SEEKS TO INSPIRE AND IMPLEMENT SOLUTIONS THAT ALLEVIATE POVERTY BY IMPROVING ACCESS TO SUSTAINABLE ENERGY TO UNDERSERVED COMMUNITIES ACROSS INDIA IN A MANNER THAT IS SOCIALLY, FINANCIALLY AND ENVIRONMENTALLY SUSTAINABLE.

SELCO FOUNDATION DEMONSTRATES THE ROLE OF CLEAN ENERGY AND ENERGY EFFICIENCY ACROSS AREAS INCLUDING WELL- BEING, LIVELIHOODS, HEALTH AS WELL AS EDUCATION.

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*SELCAP is an Initiative by **SELCO Foundation***
This edition of the report is published in October, 2021

FOREWORD

GAURI SINGH

DEPUTY DIRECTOR GENERAL,
INTERNATIONAL RENEWABLE ENERGY AGENCY

The years leading up to 2030 are critical to the economic and environmental wellbeing of our planet. Sustainable Energy Led Climate Action Program (SELCAP), is a pragmatic and need based approach to providing decentralised energy solutions in rural India at both individual and community levels. Developed by SELCO Foundation, and supported by Lemelson Foundation, this Program has the potential of not just scaling up in India but also offers valuable learning for developing countries across the world.

SELCO Foundation has built a reputation for innovative applications of decentralized renewable energy, aimed at enhancing productivity across livelihoods. Their core philosophy of energy services as an enabler, has led them to work closely with practitioners in the development sector and with energy entrepreneurs to develop and commercialize energy efficient, renewable energy solutions. The ecosystem approach and deep understanding of the needs of clients has led to the development of sustainable business models for partners, new financial products to serve low-income consumers, and has informed government policies.

Climate change has added another layer of challenge to the livelihoods of the rural poor. SELCAP brings together small farmers and entrepreneurs with other key stakeholders in government, non-governmental organisations, investors and philanthropies, and incubators to match local efforts with national policies, to provide financial and technical support, and to offer innovative ideas. The cost and resource efficient energy solutions can mitigate climate threats while improving food production and processing, health care delivery, small business.

Unlike large-scale, capital-intensive plans, SELCAP focuses on communities and on lowering the transaction costs for the poor, with customized financial products, that understand their business cycle. Although SELCAP focuses on the needs of today while building the solution but elements for future resilience are embedded in the design, thereby advancing the idea that decentralised renewables, climate action and inclusive development can be synergistic.

SELCAP offers a comprehensive, compelling, practical way forward to advance development, adapt to climate change, and alleviate poverty in a holistic manner. As we enter the implementation stage of 2021-30 – in line with the UN goals – SELCO Foundation and SELCAP propose in these pages a rich set of solutions for governments, NGOs, financial organisations, incubators and the rural poor of India and the world.

FOREWORD

DAMILOLA OGUNBIYI

CEO AND SPECIAL REPRESENTATIVE
OF THE UN SECRETARY-GENERAL FOR SUSTAINABLE ENERGY FOR ALL

The science and evidence on the adverse effects of climate change are clearer today than they have ever been. And yet, we are nowhere near meeting the targets of the Paris Agreement.

Sustainable Development Goal 13 (SDG13) focuses on climate action and aims to strengthen resilience against natural disasters, integrate climate change measures into national policies and planning, and raise awareness and institutional capacity around climate change. But climate mitigation efforts must include vulnerable communities and emerging markets, and their development aspirations – with adequate financing to back these efforts.

And climate mitigation cannot ignore the huge energy access gap that still exists. For the 759 million people who live without access to electricity, and the 2.6 billion people who use unsafe cooking fuels, this is a matter of life and death. Without access to reliable and affordable electricity and clean cooking solutions, billions of people in developing countries rely on polluting sources of energy for their households, for businesses and livelihoods and even for education, health care and food security.

Providing access to sustainable energy can help save lives through improved healthcare and reduced exposure to indoor air pollution from firewood. It creates new jobs and supports income generating activities in local communities. And it accelerates the global effort to reduce the use of fossil fuels and limit carbon emissions. We must put people at the heart of our development and climate agenda, recognising that the energy transition will look different for different countries and regions. Billions of people in developing and emerging economies do not have the luxury of choice when it comes to powering their households or livelihoods. A realistic clean energy offer, one that addresses energy access gaps and development priorities, must be made available to them. Energy poverty is more than just the lack of access to electricity. It is not having enough electricity to live a modern, dignified, healthy and fulfilled life.

I'm pleased that the Sustainable Energy-led Climate Action Program (SELCAP) prioritises vulnerable populations, pushing for a need-based approach that empowers communities to adapt to climate change while also allowing for economic growth and development. And all of this is underpinned by access to sustainable energy. I hope that the solutions showcased in this report inspire action and replication at scale.

Achieving Sustainable Development Goal 7 SDG7), universal access to affordable and clean energy, will put us on a pathway achieve SDG13, as well as multiple other development goals.

FOREWORD

P V S SURYAKUMAR

DEPUTY MANAGING DIRECTOR,

NABARD

“Let food be thy medicine, and medicine be thy food - Hippocrates”

“You are the food you eat- Lord Mahavira”

Human survival is inextricably linked to the soil and water. In fact, Human Beings are a heap of walking soil, because the food we consume comes from the soil and we all go back to the soil eventually! Further, approximately 60% of our bodies is water! And still, how can we deny the effects of the ensuing climate change on our well-being and survival as these two essential ingredients of our lives are impacted by climate change?

The latest Intergovernmental Panel on Climate Change (IPCC) report published in August 2021, mentions the situation as ‘Code Red for Humanity’. It is therefore incumbent upon us to adapt to the climate change and also mitigate its effects. We should also accept and understand that its effects on the poor and vulnerable sections of the society are considerable, and it is a big development challenge both to the Governments and Civil Society Organizations.

The SELCAP – Sustainable Energy Led Climate Action Programme, initiated by the SELCO Foundation covers all the aspects of lives and livelihoods. Having productive lives and sustainable livelihoods is a manifestation of human well-being. It has successfully demonstrated the power of Sun (read solar power) to adapt and mitigate to many aspects of climate change. The Foundation has successfully established the importance of the nexus of SDG7 and other critical SDGs like health, gender and livelihoods. They have also added the SDG13 into the mix to make all their interventions very robust.

The 20 solutions identified through primary grassroot research have been proven on the field and the state governments and other stakeholders should take steps to replicate these examples and internalize such initiatives in their policies. I am very happy to note that many of these interventions are bankable and are financed by the Regional Rural Banks (RRBs). This clearly shows that banks are willing partners in this inclusive agenda against climate change. Sun is the ultimate life-giver and provider of universe, and many such development interventions are required to spread and mainstream these illustrious exemplars. I am sure that the efforts of the Foundation will lead to a sustained campaign by all the stakeholders for a sustainable climate action programme. I also wish that these exemplars attract the attention of many investors and Philanthropists.

I wish SELCO Foundation great success and pray the Almighty that their interventions will become the ‘gold standard’ so that they are emulated and replicated, and many lives and livelihoods are positively impacted.

Jai Hind

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EXECUTIVE SUMMARY

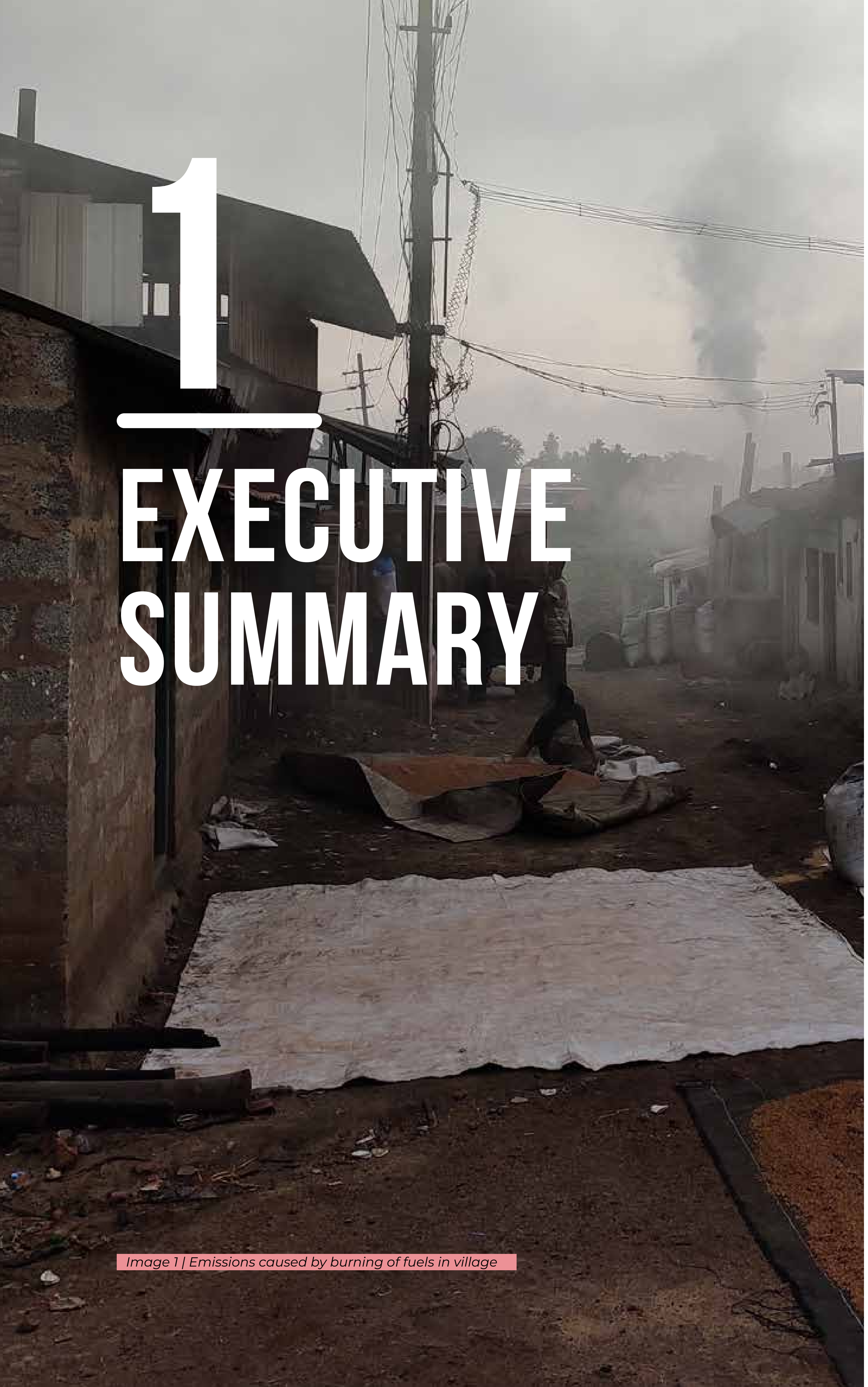


Image 1 | Emissions caused by burning of fuels in village

The agenda of climate change, in the last decade, has moved from being a footnote to a primary heading. It was actual physical climate change damages and no amount of studies or modelling that helped the world move in a pro-climate direction. Unfortunate weather-related large-scale disasters like repeated typhoons, mass flooding, multi-year droughts have forced governments, companies, policy makers and civil society to urgently develop environmentally focused narratives and strategies for their direct stakeholders. Many of the strategies underestimated the frequency and strengths of these disasters, thus bringing the urgency of tackling climate change issues to the front pages.

The IPCC report states that climate-related risks to livelihoods, food security, health, water supply and human security are projected to increase as the planet warms by 1.5 degrees. With a 2-degree rise, the risks will further intensify, resulting in increased poverty. Poor communities are especially at risk, since they have limited access to healthcare, education and livelihoods, things that can help them cope with the economic and social shocks that threaten to keep them in perpetual poverty. Additionally, many reside in climatically vulnerable regions, or have livelihoods which are extremely vulnerable to climate change.

As carbon emissions in the developing countries are rising, it is also leading to an increase in disparity in incomes. This emissions growth, with little choice, results primarily from energy use associated with economic development. For example, in India, Climate Change effects are now affecting all parts of the populations, with the poor being the hardest hit. Many parts of the population in the developing countries continue to have little or no access to clean and reliable energy, or are forced to rely on expensive dirty fuels for productive use. For this population to develop and meet their needs for well-being, health and livelihood, new energy pathways need to be designed.

Due to lack of energy driven innovation, the use of energy can result in un-optimised and inappropriate solutions which result in higher expenses and a larger burden on the poor. Current approaches to developmental needs, when not seen through an energy lens are becoming contributors to climate risks.

To be able to do this, it is important to note that for the poor, technological innovations are not just driven by energy efficiency (which implies reducing negative impacts of existing solutions) but also by sustainable energy transition as well as energy optimisation.

Sustainable Energy led Climate Action Program (SELCAP) calls for an approach that prioritises the need of vulnerable populations who are currently at the centre of the two greatest challenges that humankind is facing today – poverty and climate. It advocates for a need-based approach which prioritises minimising the current and future transaction costs of said communities. SELCAP does so by developing an array of solutions that empower the poor to adapt to climate change while also setting on a new trajectory of optimised development by transitioning to sustainable energy and mitigating future emissions.

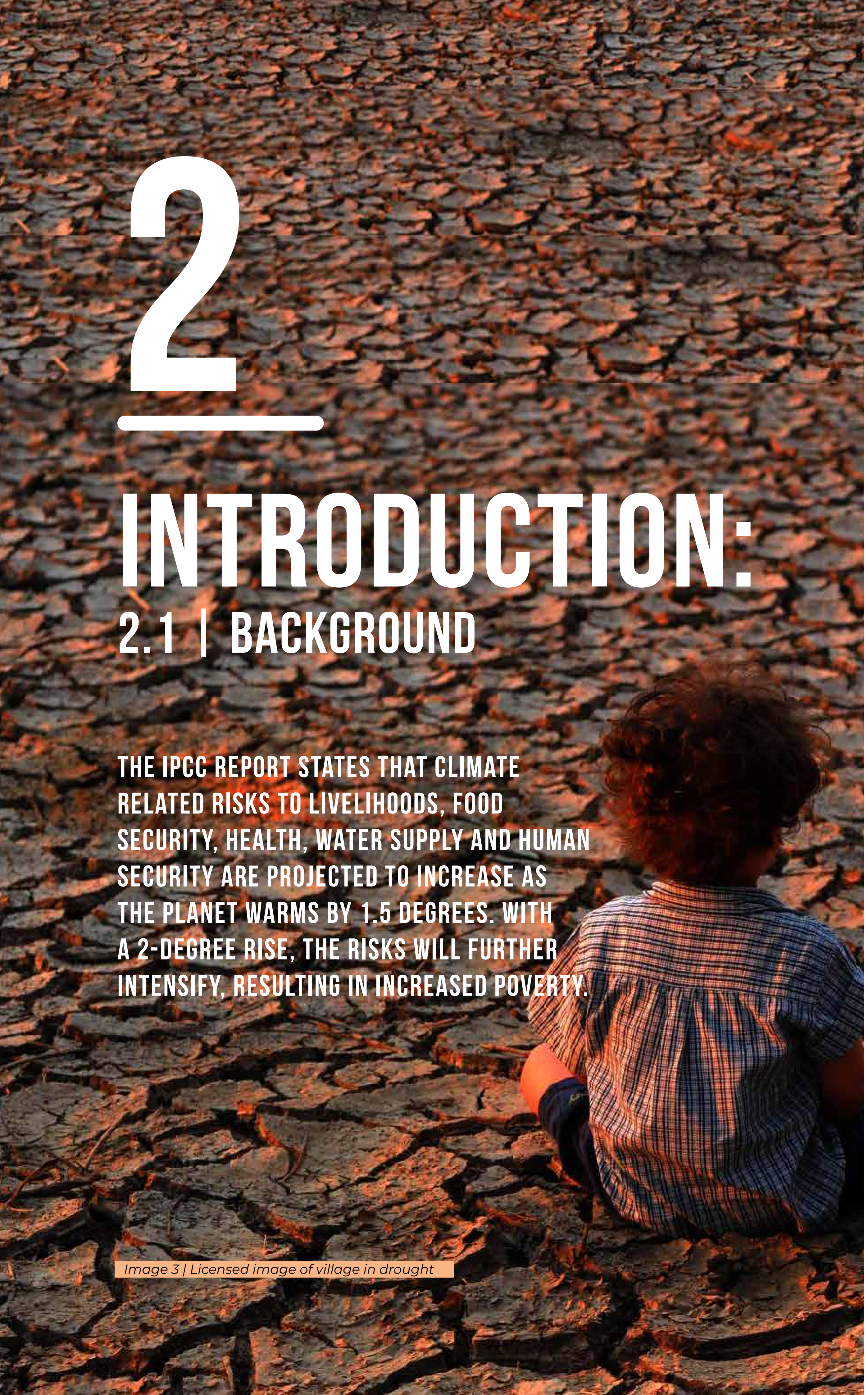
The 20 solutions identified through primary grassroot research, driven by sustainable energy have been proven on the field and should be replicated urgently. The solution designs showcased also bring about two key approaches:

- Decentralisation of solutions focusing on self-reliance and sustainability.
- Development of local systems which allow for local asset creation, improved ownership and decision making, resulting in larger and more sustainable developmental outcomes.

Both of these aspects pushes for re-design of technologies, delivery models, financing and community based institutions. It allows for development of local innovators and enterprises in order to build systems that adapt quickly to localised climate and poverty challenges.

The approach and solutions showcased in this document reinforce that decarbonization, climate resilience and poverty alleviation can be mutually reinforcing. Using the lens of Decentralised Renewable Energy, strategies for climate action and inclusive development can be delivered synergistically. But taking these solutions forward and building an enabling environment that allows for replication and scale up of these approaches will require incentivization of stakeholders to get away from business as usual practices and take bold steps.

Image 1 | Emissions caused by burning of fuels in village



2

INTRODUCTION:

2.1 | BACKGROUND

THE IPCC REPORT STATES THAT CLIMATE RELATED RISKS TO LIVELIHOODS, FOOD SECURITY, HEALTH, WATER SUPPLY AND HUMAN SECURITY ARE PROJECTED TO INCREASE AS THE PLANET WARMS BY 1.5 DEGREES. WITH A 2-DEGREE RISE, THE RISKS WILL FURTHER INTENSIFY, RESULTING IN INCREASED POVERTY.

Image 3 | Licensed image of village in drought

2.1 Background

Economic and socially poor communities, globally, are extremely vulnerable to numerous shocks from economic to social which keeps them in perpetual poverty. In the recent decades, vagaries of climate has further compounded the miseries of these communities. **The IPCC report states that climate-related risks to livelihoods, food security, health, water supply and human security are projected to increase as the planet warms by 1.5 degrees. With a 2-degree rise, the risks will further intensify, resulting in increased poverty.**

In India's case, most impoverished and under-served people live in the country's climate vulnerable regions. With limited access to healthcare, education and livelihoods, they are among the least equipped to cope with the climate change threats despite being over represented in climate vulnerable areas. The 2018 MPI Report (UNDP and OPHI) states that in addition to the 1.3 billion classed as poor, an additional 879 million are at risk of falling into multidimensional poverty, which could happen quickly if they suffer setbacks from conflict, sickness, drought, unemployment and more. In India, 8.5% of the population was identified as living in poverty, while additional 19% was at risk of falling into multidimensional poverty. This is because limited access to healthcare, education and livelihoods, and gaps in infrastructure have the poor adapt to climate risks.

For example, with primary occupations being impacted due to climate stresses, individuals and communities are forced to migrate looking for better opportunities. In the process, many sell their assets and skilled professionals from rural geographies are forced to take up manual and un-skilled work, i.e. working in factories, performing manual labour tasks, construction sites etc. In the long run, breaking the social fabric of our society, devaluing skills and pushing families into generational poverty. As per the Economic Survey of India 2016-17, there are over a hundred million migrant workers in India, of which most are circular migrants, working in multiple destinations during their lifetimes. (Mint 2019)

In India, an estimated 14 million people may have migrated this year (2020) due to slow onset climate change events. This number is expected to more than treble if current nationally determined contributions aren't enhanced and world heads for 3.2 degrees C warming over pre-industrial levels. (Hindustan Times 2020)

Individuals and communities' capacity to cope with climate variabilities is dependent on the services, opportunities and institutions available to them. If we use the analogy of the much beloved children's board game of Snakes and Ladders, snakes represent several shocks and stresses that negatively impact our health, well-being and livelihood. Ladders are opportunities available to us, such as the education system, health infrastructure, technology and knowledge systems, livelihood opportunities, financial ecosystem which allow for future investments, policies that account for externalities.

All these make it possible for us to better our lives. In a secure society, the aim is to reduce the 'snakes', or make the negative impact of the 'snake' smaller; and create more ladders. In reality, depending on where one lies in the poverty pyramid, the Snakes and Ladders Game Board changes.

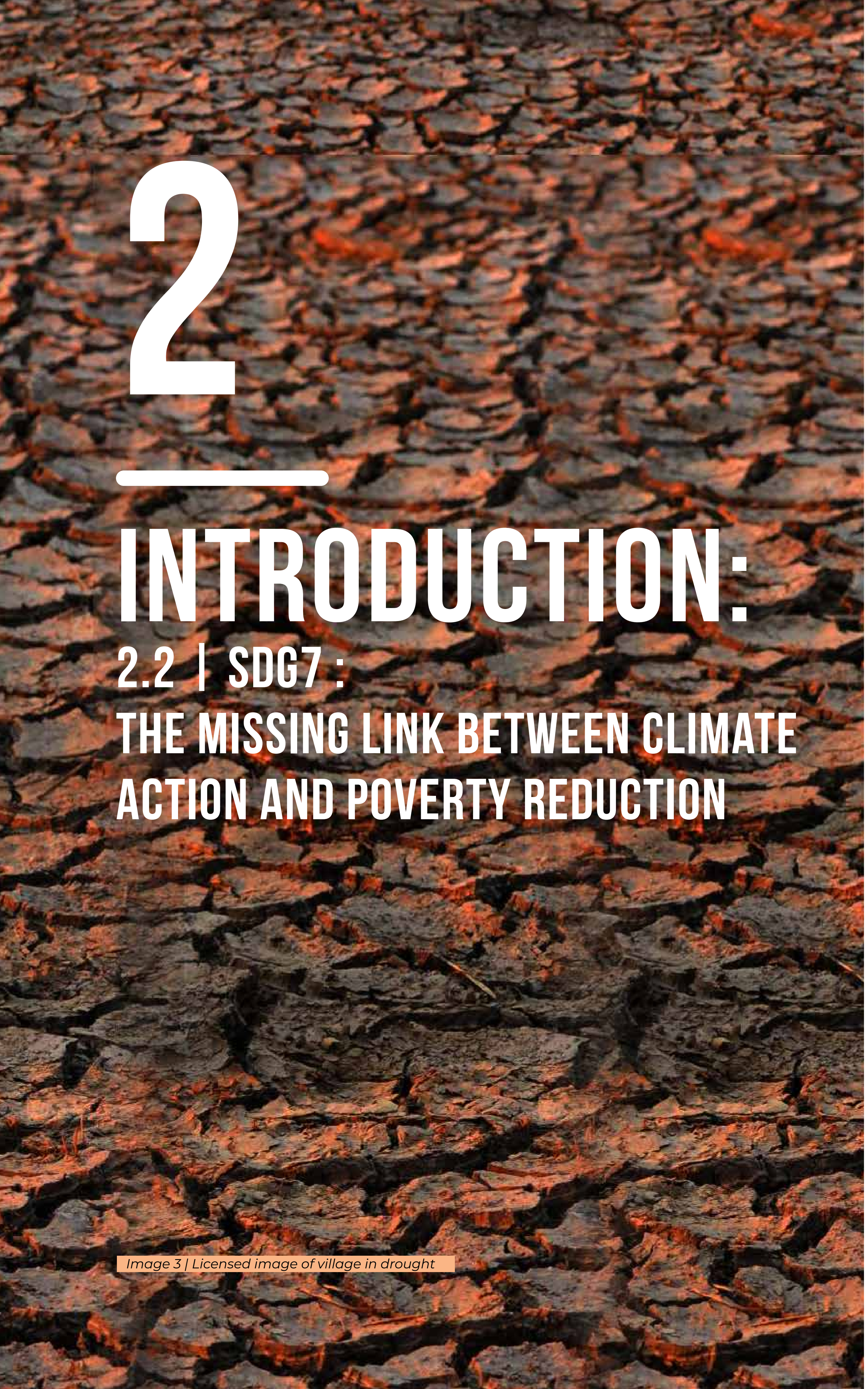
Over the past few decades, systems for innovation that allow for creation of more opportunities and safety nets have been skewed towards the more developed parts of the society.

However, for more insecure and vulnerable communities, the risks (or snakes) are being amplified due to climate change, and lesser and lesser systems are available for them to be able to bounce back. This implies that snakes are longer, with not many ladders.

Climate change is therefore, a serious threat to poverty eradication. **However, current development strategies tend to overlook climate risks.**

INDIA'S COUNTRY-LEVEL SOCIAL COST OF CARBON EMISSION WAS ESTIMATED TO BE THE HIGHEST AT USD 86 PER TONNE OF CO2. IT MEANS THE INDIAN ECONOMY WILL LOSE USD 86 BY EMITTING EACH ADDITIONAL TONNE OF CO2.

Image 4 | Representative image of Vegetable spoilage



2

INTRODUCTION:

2.2 | SDG7 :

THE MISSING LINK BETWEEN CLIMATE ACTION AND POVERTY REDUCTION

Image 3 | Licensed image of village in drought

2.2 SDG7: The missing link between climate action and poverty reduction

Energy is a key driver for development, as it can lead to increased productivity and incomes, reliable infrastructure for health, more interactive ways of information transfer and improved well-being. Today, 940 million (13% of the world) people do not have access to electricity (Ritchie and Roser 2020), and millions still lack access to affordable and reliable energy.

As the world focuses on lessening the developmental gap between the have and have-nots, energy demands are bound to grow. More importantly due to lack of energy driven innovations for development for resource constraint populations, the energy consumption patterns will grow in a manner that will lead to further burden on the underserved populations. This can already be seen in many developed countries as well, where lack of optimization in technology driven solutions for them have resulted in increased energy poverty (Euractiv, 2021).

Poverty eradication strategies, if not planned from energy lens,

- **Can result in economically poor communities using unoptimised and inappropriate solutions, resulting in higher expenses and energy debts**
- **Can add to GHG emissions and become a contributor to the climate burden caused by inefficient energy consumptions**

Thus, in order to meet the developmental needs of vulnerable communities and improve their adapting capacity to climate change, solution optimisation is critical. Current approaches to developmental needs, when not seen through an energy lens are themselves contributing to climate risks. This link between access to energy, climate change and poverty reduction has been illustrated in the examples below:

Inefficient Consumption of Energy by Productive Use Applications and Reliance on Dirty Fuels: Livelihoods can see disruptions, limit ability to mechanise and transform ways of production due to lack of affordable and reliable energy. Many also resort to dirty fuels such as diesel, kerosene, petrol to run generators, leading to higher expenses of energy and CO2 emissions. Small tailoring shops are not able to take larger orders due to lack of mechanisation and reliable energy. Farmers aren't able to process and manage produce due to lack of energy and appropriate solutions.

Inefficient Consumption of Energy by Productive Use Applications and Reliance on Dirty Fuels:

Livelihoods can see disruptions, limit ability to mechanise and transform ways of production due to lack of affordable and reliable energy. Many also resort to dirty fuels such as generators, leading to higher expenses of energy and CO2 emissions. Small tailoring shops are not able to take larger orders due to lack of mechanisation and reliable energy. Farmers are not able to process and manage their produce due to lack of energy and appropriate solutions.

Growing Disease Burden due to Climate Change and Inability to Strengthen Last Mile Health Infrastructure:

With growing climatic challenges, there has been an increase in the disease burden across the globe as well (especially air and vector borne diseases). Unreliability of energy at first point of care in the overall health infrastructure results in poor delivery of health services, long waiting time, and possibility of critical health services being made available at the last mile is also hampered. In order to strengthen reliability of services at the last mile, health centres continue to rely on dirty fuels for reliability. Additionally, ability of the health sector to extend critical services in remote geographies continues to be limited due to lack of innovations in appropriate technologies and reliable energy.

Increased Heat Stress resulting in High Energy Burden on the Poor, while furthering Emissions from Cooling Technologies:

Inefficient homes (which also serve as work spaces for many poorer households- home based food processing units, tailoring units or craft units, street vendors etc) capture heat and increase the temperature inside homes by 3-5˚C. In some cases, in addition to the building envelope capturing heat, heat producing activities such as heavy machineries, cooking or furnaces, further exaggerate the impact. With increasing heat stress across the globe, more and more workers have been losing their productive hours. This has resulted in increased dependence on technology and energy for relief, and thus is a future source for increased climate emissions.

STUDIES SHOW HOW THE POOREST PAY 'THREE TIMES MORE FOR ENERGY THAN THE RICHEST[1]. MANY OF THESE CALCULATIONS DON'T ACCOUNT FOR OPPORTUNITIES LOST OR INDIRECT COSTS OF EXPENSIVE AND UNRELIABLE ENERGY.

Image 5 | A solar powered storage unit at the village level

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[1] *(Energy Live News, 2020)*

LIMITING LIVELIHOOD OPPORTUNITIES

Low income and insecure livelihood

- Continued cycle of poverty
- Low profits
- High debt

Farmers manually process food grain for their own consumption and sell surpluses at low prices. They are stuck in a cycle of poverty, making low profits and incurring debt in times of shock and stress.

Farmers travel long distances to process their grain. Food grain is channelled through lengthy unnecessary channels. Large centralised mills make large profits leaving the farmer out of the bargain. Farmers fail to set up their own mill at the local level due to lack of energy or end up paying a large cost for procuring and purchasing diesel.

Centralised infrastructure catering to large farmers and those close to markets

- High transaction costs
- No solutions for small and marginal farmers
- High emissions from transportation

Small farmers invest in inappropriate technologies due to growing demand for mechanisation

- Inefficient fuel and machine usage
- Higher emissions and lower incomes
- Higher energy expenditures

NEED AT THE GRASSROOTS

- Improve productivity
- Upgrade livelihoods
- Diversify incomes & build capacity for value-add produce and higher profits

ALTERNATE REALITY

- Local energy efficient milling machines
- Lower transaction costs for milling and transportation
- Aggregation via farmer groups and higher returns

Farmers own their own energy efficient milling machines at the local level. They avoid spending transaction costs for milling and transportation. They create groups to aggregate their surplus produce, process and sell in markets for higher returns.

INCREASING COST OF ACCESSING HEALTH-CARE

For communities living in areas with variable rainfall and flood occurrences, stagnant water can lead to higher chances of water borne disease. These could also act as breeding grounds for insects such as mosquitos.

NEED AT THE GRASSROOTS

- Growing climatic challenges and disease burden
- Poor well-being of health staff and unreliable service for end users
- Unreliability of energy at health facilities
- Increasing expenditures on diesel for backup contributing to high emissions

Communities fall prey to diseases without having adequate shelter and access to clean water in times of emergencies. Access to healthcare in these times would be expensive considering remoteness and distances to equipped healthcare facilities. Healthcare facilities in turn would consume expensive diesel due to power cuts, leading to emissions.

CURRENT REALITY

- Technology innovations catering towards centralised hospitals and specialised care
- Healthcare infrastructure and human resources being deployed for extending health to last mile but not equipped with appropriate technology
- Un-optimised costs of delivering healthcare
- Poor well-being of health staff and end-users
- Increase in emissions from inefficient appliances

ALTERNATE REALITY

- Healthcare investments to strengthen systems and ownership at local, decentralised levels
- DRE ensures energy reliability and spurs innovations in Energy efficient appliances appropriate for decentralised usage
- Improved health seeking behaviour
- Solutions catering to local healthcare needs and disease burden
- Reliable and high-quality healthcare delivery at the last mile
- Reduced disease burden
- Reduced out-of-pocket expenditure for health seekers
- Reduced emissions from healthcare appliance powering
- Increased productivity of individuals and resilience from shock
- Reduced poverty

Disaster resilient homes and disaster shelters with access to water pumps and water filtering systems at decentralised levels would protect communities from diseases.
Decentralised, equipped and energy optimised health facilities at the last mile provide affordable and quality healthcare to communities.

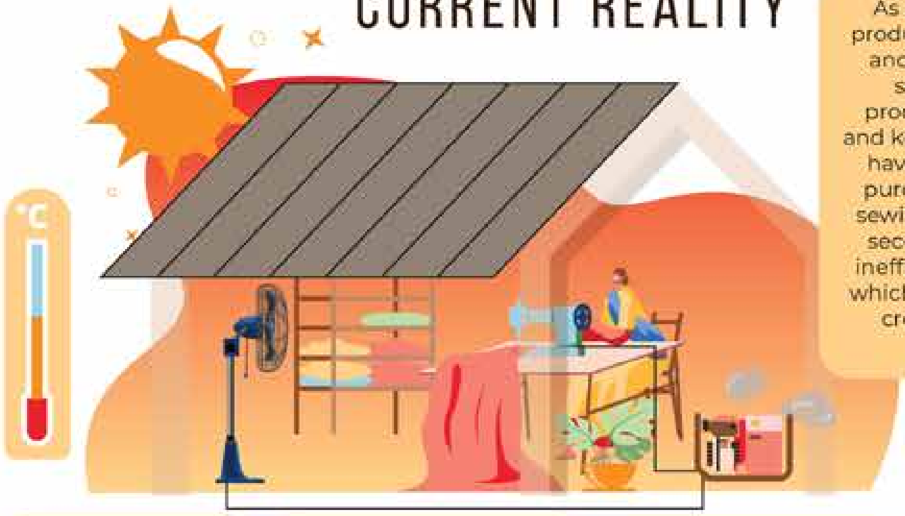
INCREASING HEAT-STRESS AND IMPACT ON PRODUCTIVITY

A single widowed mother takes a tailoring course and sets up a small tailoring business in her house. Her house, made of tin sheets in a dry country, reaches temperatures over 45-50 degree Celsius in-doors.

NEED AT THE GRASSROOTS

- Low access to financial capital for communities
- Low access to efficient technologies and services
- Inefficiently built homes
- Multi-purpose use of homes as work-places with heat producing activities
- Increased indoor heat capture by 3-5°C
- Reduced productivity and well-being of the inhabitants

CURRENT REALITY



As heat increases the woman's productivity lowers. The rising heat and drudgery from her manual sewing process lead to low productivity, cause health issues and keep her in poverty. She doesn't have any expendable income to purchase a fan and motorise her sewing machine. She purchases a second hand out-dated fan and inefficient sewing machine motor which shoots up her electricity bills creating a further dent in her pocket.

- Continued reliance on drudgery removing productive use appliances
- Increased investments on energy consuming cooling appliances
- Low financial capital access
- Increased and recurring expenditures on inefficient technologies
- Increasing need to combat heat-stress
- Energy burden
- Reduced productivity
- Reduced income
- Inefficient choices of appliances

ALTERNATE REALITY

- Increased access to longer term and affordable financial capital
- Availability & accessibility to energy efficient productive use appliances
- Availability of optimised cooling solutions (passive and active technologies)
- Reduced emissions from inefficient productive use and unnecessary cooling appliances
- Increased comfort and productivity and reduced energy burden
- Reduced indoor temperatures
- Increased incomes & well-being

The woman's training center connects her to a credible enterprise and a bank for her to be able to access a loan and purchase an improved roofing solution and an efficient motor with solar power for her manual sewing machine. The woman is able to steadily improve her productivity, increase her income and plan a growth strategy. She doesn't have to incur any additional cooling expenses as the roof, along with climate centric building design helps cut down indoor temperatures by 8 to 10 degrees.

In context of underserved populations, adaptation and mitigation strategies need to be interlinked. Strategies for adaptation- all those responses to climatic conditions that reduce vulnerability, are an integral and urgent part of overall poverty reduction strategies. Adaptation should not be approached as a separate activity, isolated from other environmental and socio-economic concerns that also bear an impact on the developmental opportunities for the marginalized. Mitigation is needed so countries can move swiftly to a sustainable society, and adaptation so that the poorer families, can avail alternate and more resilient livelihoods or wellbeing.

SUSTAINABLE ENERGIES LIKE SOLAR HAVE PLAYED A CRITICAL ROLE IN MAKING SOME OF THE VERY PRAGMATIC INTERVENTIONS IN ADAPTATION AND MITIGATION POSSIBLE, PAVING THE WAY FOR THE IMPORTANCE OF SDG7 IN ACHIEVING OTHER SDG TARGETS IN A CLIMATE RESILIENT MANNER.

Image 6 | Women Stacking Vegetable Crates in an efficient solar powered cold storage

3

UNDERSTANDING CLIMATE CHANGE

3.1 KEY STAKEHOLDERS

Image 7 | Climate Change causing drying of rivers

3.1 Key stakeholders

Sustained Climate Action which also results in new and inclusive development strategies for the most vulnerable, requires multiple stakeholders to converge their strategies.

The following section captures the existing adaptation and mitigation strategies taken up by four primary stakeholder categories:

- Non Governmental Organizations
- Incubators,
- Investors and Philanthropies
- Government Bodies or Institutions2.

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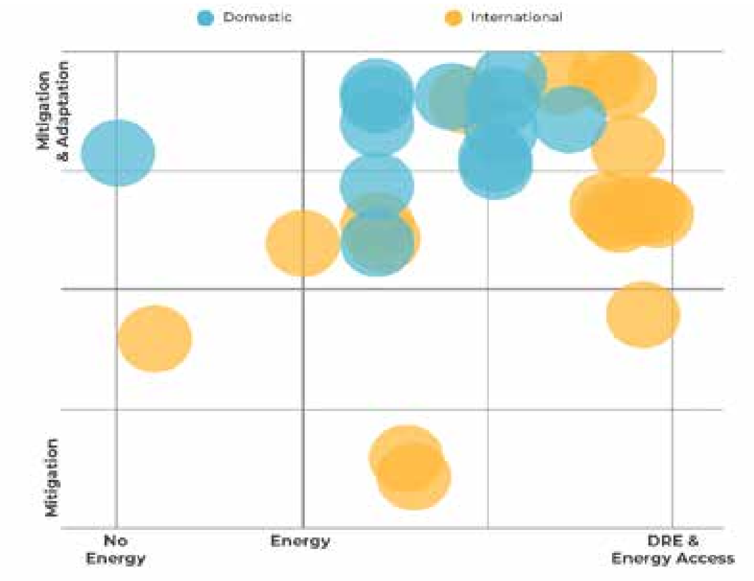
2 - The inferences shared on the strategies adopted by keys stakeholder categories towards climate adaptation and mitigation has been a result of a secondary research conducted by SELCO Foundation by mapping 100 entities

Non Governmental Organizations:

NGOs play a critical role in Climate Action, as they are the primary stakeholders representing the voices of the most vulnerable. They are also the first responders during climate disasters and play a significant role in building institutions for affected communities, and bridging the gaps in knowledge transfer, improving capacity and delivering critical services where neither the government, nor the private entities are able to reach.

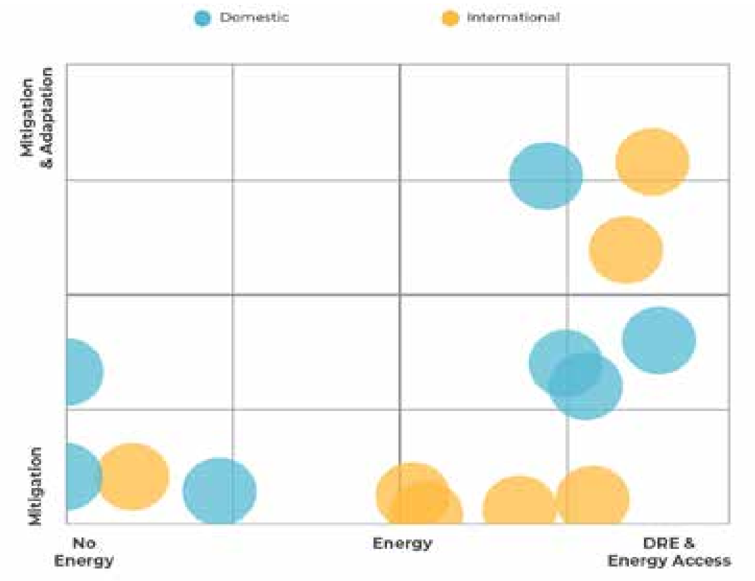


- Many of the NGOs that recognise their work under Climate Action (SDG13) or challenges around Climate Change, work on programs focussed on adaptation and resilience building.
- A large number of NGOs focused on Adaptation, have a concentrated thematic focus on agriculture, and capacity building on sustainable agricultural practices.
- In India particularly, there has been a shift in the conceptual thinking behind agriculture-based organizations. While in the 1960s, the focus was towards production enhancement, since the past decade, there has been a focus on Resilient Agriculture.
- While many of the larger NGOs with national footprint recognized energy as a need, they haven't necessarily adopted DRE solutions in a large way. Those that integrate DRE, tend to focus on solar and biogas primarily for irrigation, water pumping as well as basic lighting and cooking as part of their project or programme focus.
- Most small NGOs directly engaged in the agriculture space at the local level tend to focus on issues of water security and disaster management or disaster risk reduction when it comes to climate action.

Opportunities identified:

While the role of sustainable energy has been identified, further awareness and capacity building needs to be achieved. Showcasing more seamless ways of converging adaptation and mitigation portfolios via sustainable energy, could potentially transform the way solutions are being deployed currently. This report covers solutions which allow for DRE integration across various phases of programmes (For example in agriculture, at the input level, production, post production and market linkage levels).

Incubators



Solutions that use Sustainable Energy as a link towards fighting Climate Change and Poverty need to be developed.

Incubators can play a critical role in creating an ecosystem for innovation and entrepreneurship that encourages problem solving for climate action and poverty reduction.

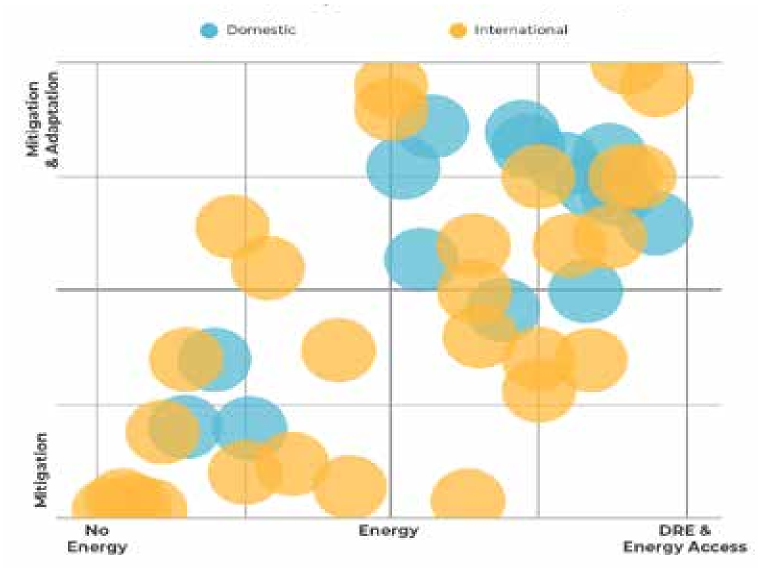
- Most of the incubators were found to be catering to technology needs from developed markets, and not looking at innovations for poor.
- Very few incubators were seen to be focused on Adaptation, and most looked at aligning their enterprises towards Mitigation activities. This might also be linked to concentration on GHG emissions in the Green Investment space.
- Majority of the incubator facilities which aligned their work towards SDG13, recognised the role of energy and had focussed themes and accelerator programs etc to incentivise and target the same. However, most of them were focused on core energy technologies (batteries, flexible panels, inverters etc), smart technology or renewable energy generation.
- But it is to be seen if specific incubators focussed on social innovations recognise the role of energy efficiency, sustainable energy as part of their portfolio, or are focused towards specific climate smart portfolios.
- Agriculture-focused incubators don't have strong portfolios on agri engineering despite need for small scale agricultural equipment to increase incomes and resilience on the ground.

Opportunities identified:

Incubators can nudge the sector by providing incentives and mentorship in a manner that allow for enterprises and innovators to build out their businesses to achieve adaptation and mitigation targets. There are a lot of opportunities for innovators and entrepreneurs to create solutions linking sustainable energies, climate change and poverty eradication. For example, agriculture-based incubators could build-out portfolios that allow for enterprises to engage with climate change issues and innovations for adaptation by small and marginal farmers. This would also require incubators to develop expertise and mentorship programs in a manner that is at the grassroot level and is able to mentor enterprises to capture grassroot issues.

Investors and Philantropies

It is important to note that these climate Adaptation and Mitigation Solutions are such that they require patient capital, as well as appropirate strategic investments which are not only purposed to spur innovation, but also to create an enabling environment which allows for, and catalyzes the replication and adoption of key learnings.

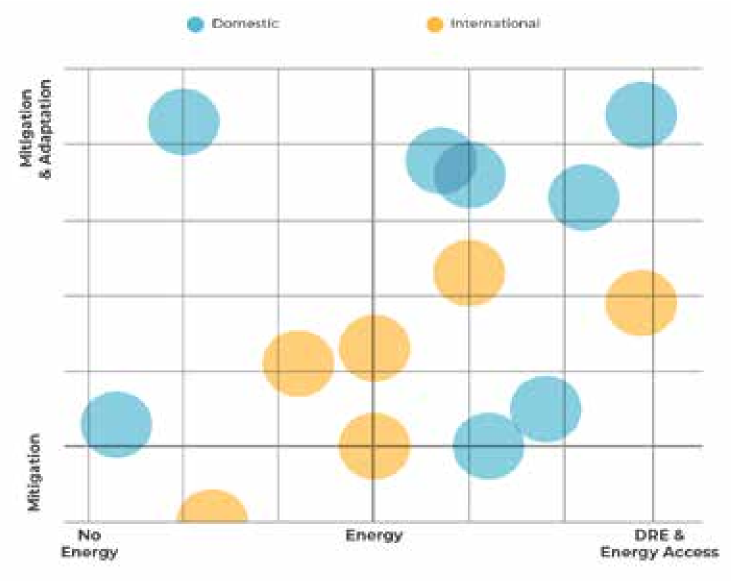


- Very few of the philanthropies have portfolios that recognise the linkage between development and Decentralised Renewable Energy (this is mainly true for foreign philanthropies).
- Most of the domestic funders mapped were focused towards specific sectoral issues and very few of them recognised the role of DRE or sustainable energy in furthering of the sector.
- The few philanthropies that had sustainable energy based programs, mostly looked at it from the lens of resilience building for vulnerable populations.
- Investors focusing on SDG13, were primarily aligned with Climate Mitigation.

Opportunities identified:

More investments are needed in decentralized energy as part of innovations to support climate adaptation and local resilience building (across health, agriculture, other livelihoods). Philanthropies need to see climate as a looming threat to all developmental activities. Not looking at climate sustainability, will risk people falling back into poverty. More philanthropies need to look at converging climate and developmental approaches. DRE could be a tool for the same.

Government Departments/ Institutions/ Bodies



Policy Makers are one of the biggest stakeholders in design and implementation of Climate Action and Poverty Reduction Strategies.

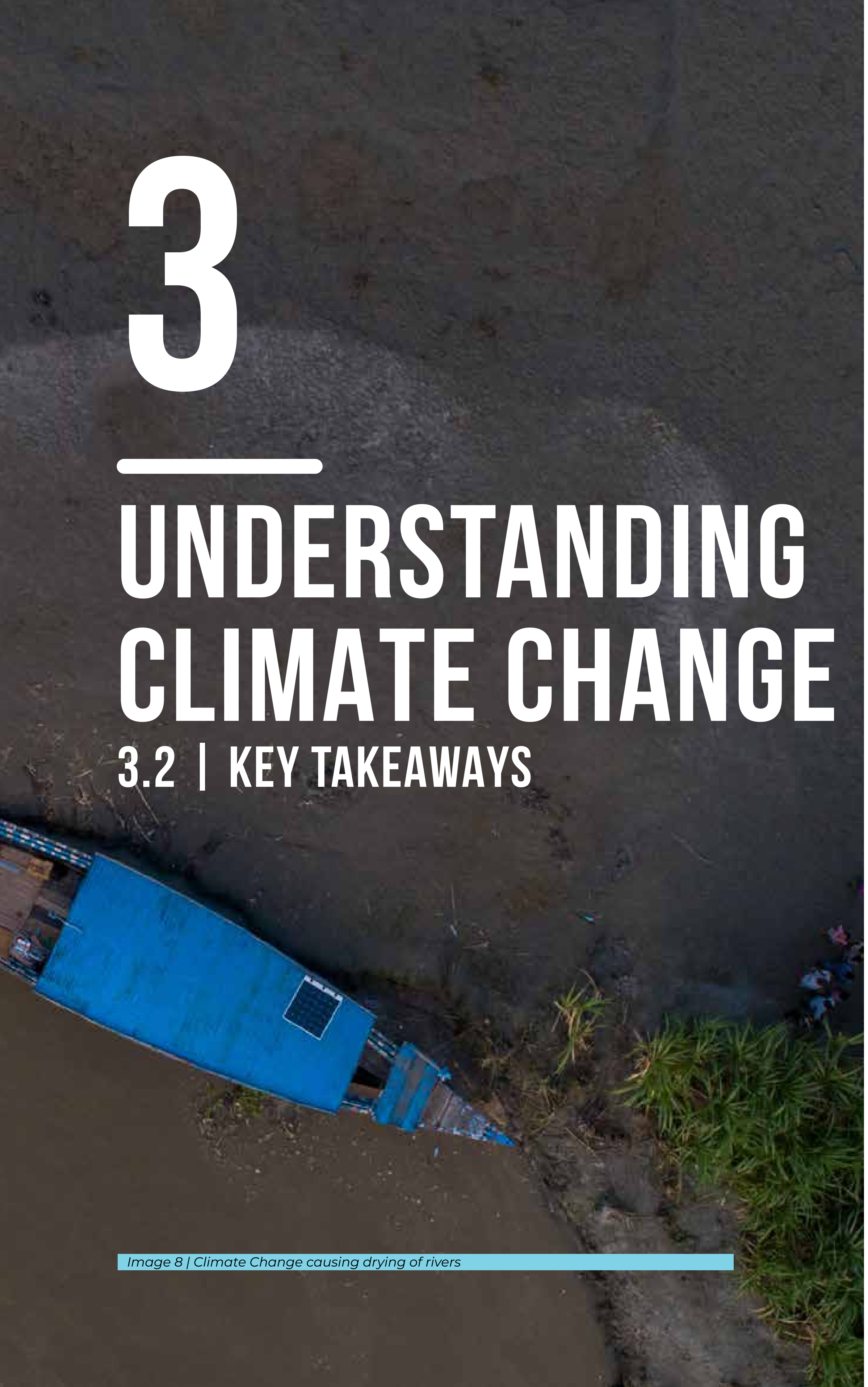
They can not only play a direct role in the deployment of critical programs, but also aid in creation of a supportive enabling environment for philanthropies, innovators, investments as well as NGOs to also channelise their resources for the same.

- All stakeholders analysed and mapped here were from India, and it was seen that all of the Climate specific departments, programs and institutions were focused on both mitigation and adaptation.
- It is also to be noted that the Government of India has announced specific time-bound missions, which are focused towards adaptation primarily and bring in a holistic view to achieving the SDGs.

Opportunities identified:

Policy makers often do not consider energy as a critical input while designing livelihood applications and health centers for under-served populations. Innovating and designing solutions through the sustainable energy lens, can potentially result in countries achieving mitigation targets, while ensuring that reliable and optimised solutions are made available to the most vulnerable.

There are existing flagship schemes on Rural Employment Guarantee, Organic Value Chains, Agriculture Infrastructure Development, MSME financing that are planned for at a district and sub-district level, and it would be fruitful to integrate DRE needs into these schemes to allow for better financial allocation and supporting services including training and capacity building, awareness creation etc.



3

UNDERSTANDING CLIMATE CHANGE

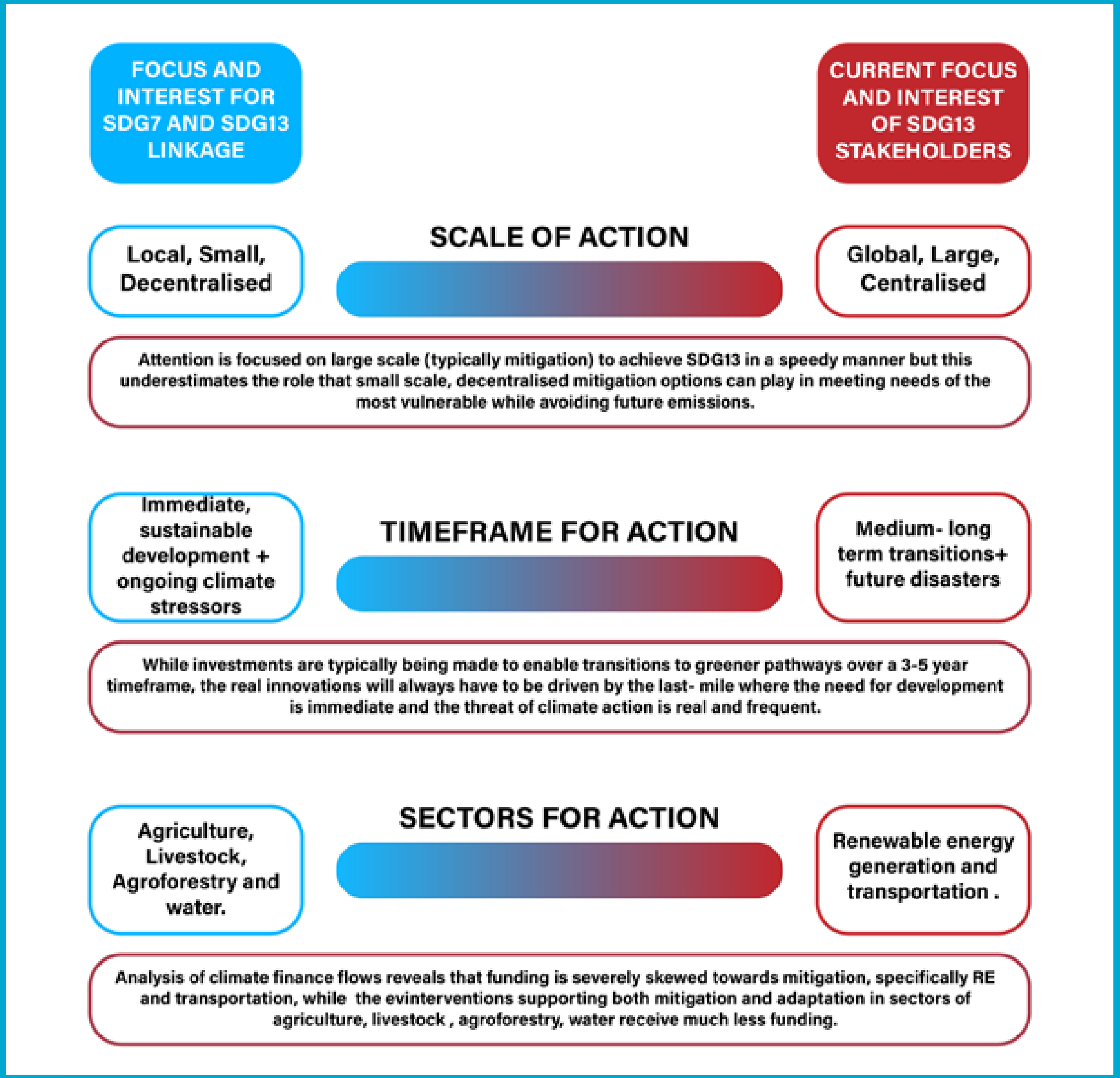
3.2 | KEY TAKEAWAYS

Image 8 | Climate Change causing drying of rivers

3.2 Key takeaways

Based on the analysis of government and intergovernmental plans, organization portfolios and field realities around climate action, there are certain key takeaways which have been summarised here. Frameworks, targets, narratives, innovations and finance flows are dispersed across a spectrum and can be mapped broadly across three indicators- their scale of action, their time frame of action and the sectors of action. Much of the effort on climate action (funds tracked, innovations being supported, policy targets and indicators) is currently focused on large scale, future timeframes, renewables and transportation focused, where the links to vulnerability are missing.

On the other hand, the needs of vulnerable communities lie on the other side of the spectrum where efforts need to be local, decentralized, addressing immediate stressors (albeit with sustainable solutions) with an interest in sectors such as agriculture, livestock, water where SDG7 is a catalyst.



FOCUS AND INTEREST FOR SDG7 AND SDG13 LINKAGE

CURRENT FOCUS AND INTEREST OF SDG13 STAKEHOLDERS

SCALE OF ACTION

Local, Small, Decentralised

Global, Large, Centralised

Attention is focused on large scale (typically mitigation) to achieve SDG13 in a speedy manner but this underestimates the role that small scale, decentralised mitigation options can play in meeting needs of the most vulnerable while avoiding future emissions.

TIMEFRAME FOR ACTION

Immediate, sustainable development + ongoing climate stressors

Medium- long term transitions+ future disasters

While investments are typically being made to enable transitions to greener pathways over a 3-5 year timeframe, the real innovations will always have to be driven by the last- mile where the need for development is immediate and the threat of climate action is real and frequent.

SECTORS FOR ACTION

Agriculture, Livestock, Agroforestry and water.

Renewable energy generation and transportation .

Analysis of climate finance flows reveals that funding is severely skewed towards mitigation, specifically RE and transportation, while the evinterventions supporting both mitigation and adaptation in sectors of agriculture, livestock , agroforestry, water receive much less funding.

Takeaway 1:
Supply Driven versus Demand Driven

Planning approaches have followed more of a MWs of generation (coal fired or solar), land requirements and supply rates. The primary assumptions to such an approach is that, other than estimating perceived shortage, reliable and stable supply will incentivize growth and entrepreneurship thus increasing the GDP of the country. While such an approach was valid in the earlier decades, when the supply was mostly catching up with the fast pace of industrialization, today that is not the case.

Emission reductions are expected to come from improving efficiency in energy generation, large industries, transport, building etc. While these are relevant in reducing and curbing emissions at a large global and national scale, they do not take note of the needs of communities most affected by climate change.

At the grassroots level, climate action needs to be intricately linked to local needs of poverty alleviation and creation of safety nets. Approaches and best practices that enable decentralized, scaled-down solutions play a critical role on the ground to address climate needs for agriculture, forestry, livelihood diversification and cooling. The growth has to be designed from an end-user's perspective and in a more holistic manner. The opportunities and needs have to be mapped out and the potential solutions have to be inclusive while being environmentally sustainable.

A demand driven approach to electricity, encourages the following:

a. **To view electricity or electrons as one of the many inputs to any interventions (wellbeing, livelihood, education, health etc.). The focus will always be on the sustainable delivery of the need and not on electricity.**

b. **Brings efficiency in technology design as the end-user would demand for affordable operational costs. Today, decisions are mostly made from a capital expenditure point of view and not on the combination of capital and operational expenditure.**

c. **Brings in efficiency of buildings and habitat, with logic similar to technology which perceives electricity as an input which has a bearing on the op-ex, the design of buildings will be innovative sustainable and energy efficient.**

d. **A demand driven approach will also democratize the choice of the end-user to design their own supply methodologies. With advancement in renewables in the decentralized space, end-users globally can plan the number of electrons.**

As one can see from the above points, a demand driven approach will automatically push for efficiency and sustainability.

Whether in terms of targets, financing available or innovations being undertaken, much of the focus within international frameworks and government missions is on a larger scale. Targets and indicators are presented in terms of GHG emission reductions on the mitigation side, and reductions in the number of disasters or damage from disasters on the adaptation side. It is important to note that it is critical to measure our progress towards mitigation by not measuring the number of renewable MWs being installed; but the number of millions of people living in a sustainable manner that will move the world to maintain a path towards restricting the temperatures from rising about 1.5 degrees.

Image 9 | Increasing Heat Stress among villagers

Takeaway 2:
Current Impact versus Future Stressors

Many climate strategies are focussed towards mitigation strategies, i.e. reducing climate change. Greenhouse Gas Emissions have been recognised as a key case for climate change, and therefore used as one of the main indicators for measurement of climate action strategies. The focus on this indicator as measurement of climate action, has shifted the focus to doing less bad (ie make previously inefficient technologies efficient), rather than doing more good (i.e. create new solutions benchmarks through need-based technology innovations).

Focus on future stressors, and mitigation makes stakeholders view adaptation and mitigation as siloed approaches. Inefficient solutions are implemented, which are then layered with a mitigation strategy to showcase high GHG emissions.

What is perceived as future stressors by the broader climate agenda, are seen by vulnerable communities as immediate threats; in fact many have already experienced those threats. With livelihoods being disrupted due to changing weather patterns, increasing disasters resulting in large scale migrations, built environments being unsustainable, healthcare demands increasing, well-being affected, there is a very critical need to create solutions that can address these issues today. It is critical for these solutions to have the foresight for adaptation but also contribute to future mitigations. Solutions today are typically designed for and by urban, higher economic strata, which needs to be reformed to ensure the needs of poor and vulnerable (which are significantly different and sometimes existential) are addressed at the earliest.

Image 10 | A school girl quenching her thirst to beat the heat

Example: A heatwave is defined differently for varying topographies. In the plains, the maximum temperature has to be 40˚C or above; in coastal areas 37˚C or more; and in hilly regions 30˚C or higher, according to the India Meteorological Department, which provides heat-wave forecasts for more than 300 cities (Business Standard 2020). However, in poorly designed homes with little ventilation and materials which capture heat, the delta felt temperature inside the building is +5˚C, i.e. a temperature of 35˚C, will be felt as 40˚C. Similarly, cramped spaces and heat producing technologies also result in increasing the burden of heat stress as felt by the inhabitants. All these factors significantly impacts the number of days in heat stress experienced by the poor, adding to the burden of cooling.

ACTUAL TEMPERATURE

JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT
28°C	32°C	37°C	41°C	43°C	38°C	32°C	31°C	32°C	31°C
33°C	37°C	42°C	46°C	48°C	43°C	37°C	36°C	37°C	36°C

FELT TEMPERATURE

Recognising space cooling as a key point of intervention, the Climate Action Stakeholders have been primarily supporting research and implementation to make Air Conditioners more efficient, reduce energy usage and thereby reduce carbon emissions. According to estimates, electricity demand for cooling is expected to grow almost twofold at an average annual rate of 6.1% to 2030. But such efforts on space cooling, assume sources of heat stress to be climate driven. In reality, for poorer communities, the climatic heat stress is exaggerated due to inefficient buildings and technologies which dissipate heat as well.

In such a scenario, cooling solutions need to follow a more holistic approach with the following features:

- Thermally comfortable homes which reflect heat
- Extraction of heat from heat generating appliances, and cook stoves
- Energy efficient cooling technologies
- Sustainable energy to curb future emissions

In the absence of such an approach which focuses on reducing the multiple factors impacting heat stress, the poor will be unjustly burdened with investing more in space cooling appliances. A recent Economist Intelligence Unit Report suggests that reducing electricity demand for cooling by 10-75% through wider measures such as improving building design and urban planning could allow for a quicker transition to net zero emissions by 2-8 years.

Takeaway 3:
Economic Viability- Technology versus Ecosystem Approach

As stated in the previous takeaway, the focus for technology innovation for Climate Action has been primarily driven by identifying key polluting practices and technical solutions to mitigate the same. This has resulted in programs being driven from the top, and to be focused on technology adoption. However, it was found that there was often little acknowledgement or assessment of where the gaps in the ecosystem lay, which inhibited the individual's capacity to invest in a sustainable solution.

These gaps could be in:

- Innovation of appropriate technologies
- Financing which allows for the poor to invest in technology driven solutions which are cheaper in the long run
- Capacity building and skilling on business models that allow for individuals to benefit from the impact of the technology driven solutions

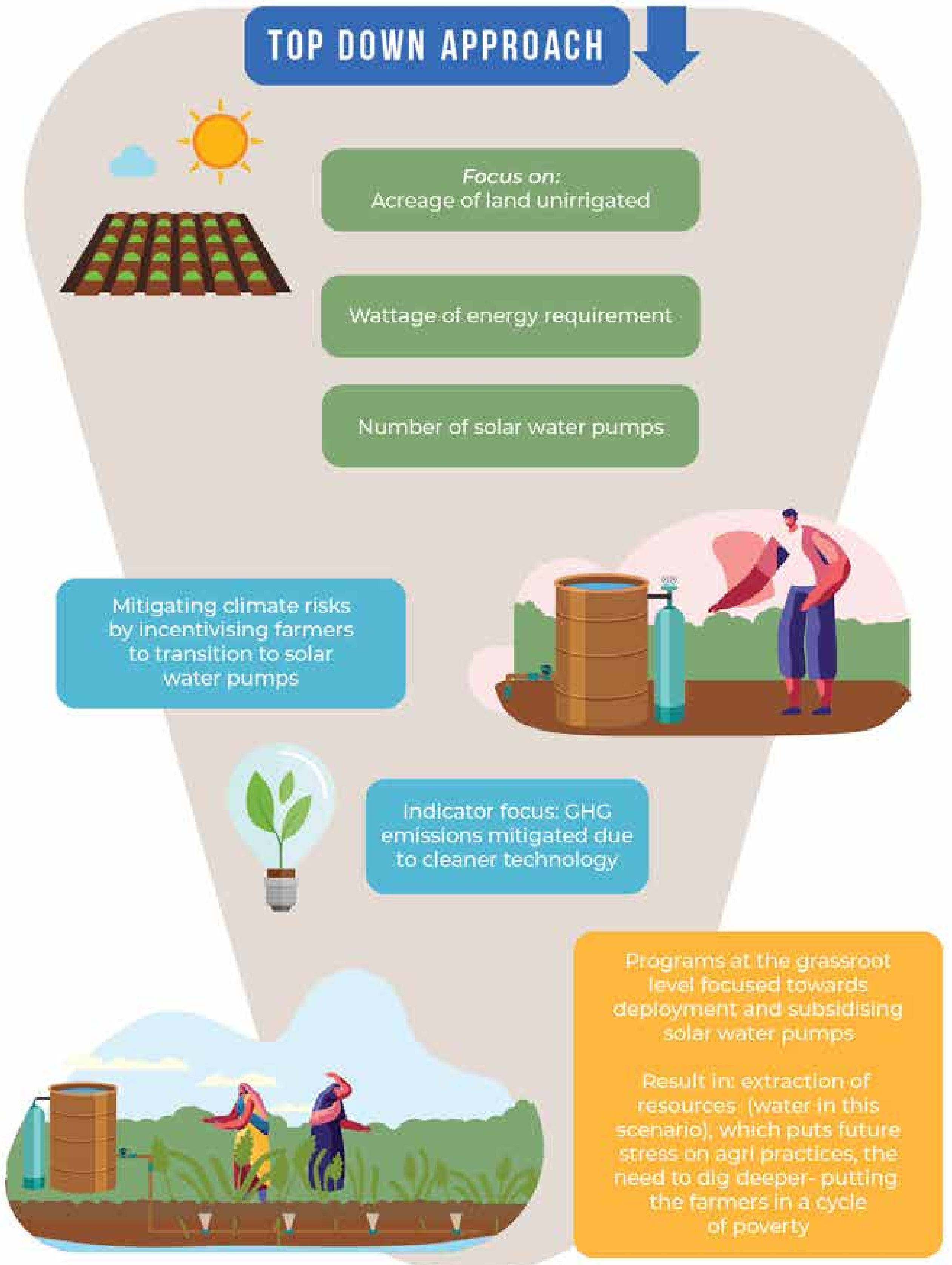
There is often a misnomer that communities are unwilling to invest in climate smart solutions. The reality is that the focus of monies and climate smart programs for the poor have been driven by inefficient technological solutions which result in future burdens on the poor, and less by a systems approach that pull them out of poverty in a sustainable manner. Such approaches have also resulted in poor communities being dependent on grants, and stuck in a system which is still vulnerable to future stresses and shocks.

Example: Irrigation has been identified as a key adaptation and mitigation strategy by many climate activities. However, a top down and technology driven approach has resulted in the key metric for the program at the ground level being deployment of a large number of water pumps. A lot of grant monies have also gone into financial modelling which prove that water pumps are only affordable if large subsidies are provided to the capital cost of the water pump. However, subsidies on the technology, have also resulted in over extraction of water which has depleted the water table, and resulted in need of higher capacity water pumps, and therefore higher input costs, and lower yield. Alternatively, if the grant monies were used to develop a stronger water infrastructure, training on cropping patterns and sustainable farming practices, along with efficient pumping and sprinkler technologies; the farmers would have a more sustained livelihood, better incomes, which could be then invested in sustainable technologies. Therefore, it is important to invest in an ecosystem that makes it viable for farmers to invest in technologies.

The solutions gathered in this document, map out the ecosystem that allows for technology innovations with a need-based approach, while also presenting financial models in a manner that prioritise supporting development of the ecosystem around a solution.

Image 11 | Floods, a direct consequence of climate change

TOP DOWN APPROACH



Focus on:
Acreage of land unirrigated

Wattage of energy requirement

Number of solar water pumps

Mitigating climate risks by incentivising farmers to transition to solar water pumps

Indicator focus: GHG emissions mitigated due to cleaner technology

Programs at the grassroot level focused towards deployment and subsidising solar water pumps

Result in: extraction of resources (water in this scenario), which puts future stress on agri practices, the need to dig deeper- putting the farmers in a cycle of poverty

TAKEAWAY 1
🟩 Supply vs Demand

TAKEAWAY 2
🟦 Current vs Future

TAKEAWAY 3
🟨 Tech vs Ecosystem

SDG7 DRIVEN BOTTOM UP APPROACH

High input costs, low yield, and seasonal agriculture Cropping patterns that nourish the soil, utilise less water- and reduce input costs

Implement solutions which strengthen backward and forward linkages, make agri services available and reduce future costs

Improved water management practices, and improvement in yield and production

Indicator used: Reduction in input costs and improvement in incomes

Subsidising the development of an ecosystem for sustainable and resilient agriculture- training on cropping patterns and infrastructure for ground water recharge

Results in: Optimisation of resources and future security of incomes, making it possible for farmers to invest in water pumps themselves

4

SELCAP:

SUSTAINABLE ENERGY LED CLIMATE ACTION PROGRAM

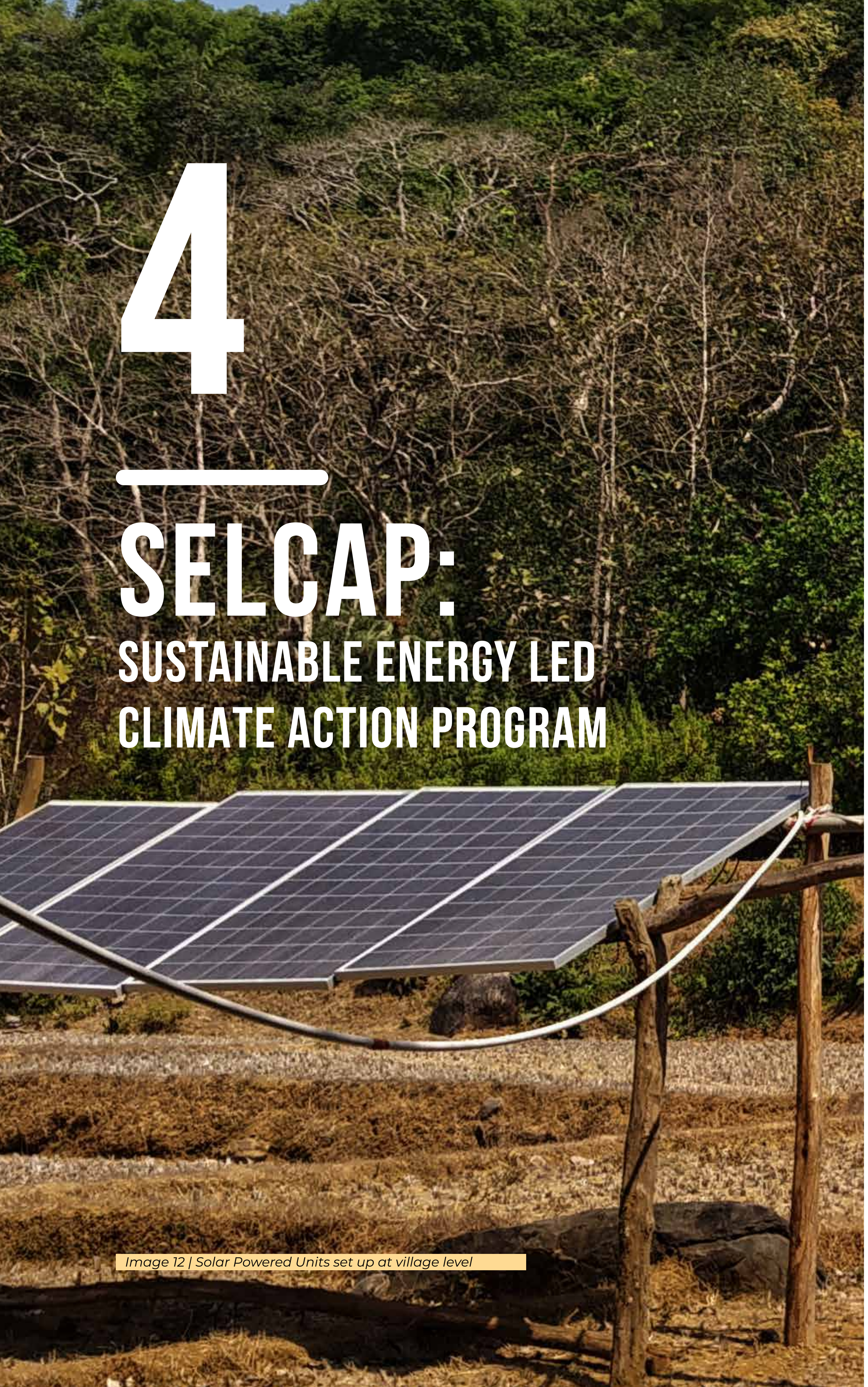


Image 12 | Solar Powered Units set up at village level

7 COAL-FIRED POWER PLANTS[3] CAN BE AVOIDED IF THE BOTTOM 40% OF THE INDIAN POPULATION MOVED TO DRE

Sustainable Energy led Climate Action Program (SELCAP) calls for an approach that prioritises the need of the poor- who are currently at the centre of the two greatest challenges that humankind is facing today- poverty and climate. It advocates for a need-based approach which prioritises minimising the current and future transaction costs of the poor. This approach which is focused on needs of today, while also builds systems which allow for resilience in the future is critical to ensure that the poor move out of poverty in a sustainable manner. SELCAP does so by developing an array of solutions that empower the poor to adapt to climate change while also setting on a new trajectory of optimised development.

This translates into solution design in two key ways:

- **Decentralisation of Solutions:** In the context of poverty and climate change a focus on decentralisation is critical for the following reasons:
    - Decentralising focuses on shortening of supply chains and self-reliance: this is specifically important in the context of climate change. Disruptions due to sudden climate shocks can pose additional burden on poor in accessing services related to health, livelihood and well-being. In many cases the poor aren't able to bare these additional costs resulting in loss of life, livelihood, critical assets and debt. All of these can result in generational poverty.
    - Local systems allow for local asset creation, improved ownership and decision making: decentralisation in a manner that allows for local ownership from the affected communities themselves, does so by creating local systems that result in larger and more sustainable developmental outcomes. Local ownership as part of solutions design pushes for re-design of technologies, delivery models, financing and community based institutions. Climate change affects geographies and people in varying ways- and solutions cannot be centralised or standardised. Decentralising solutions that allow for development of local innovators and enterprises is critical in order to build systems that adapt quickly to localised climate and poverty challenges.
- **Optimisation for Poverty Reduction and Climate Change:** Access to energy and technology have been one of the factors in reduced capacity of the underserved in adapting to climate change. Many of the world's poorest populations, also the ones most vulnerable to climate change, do not have access to reliable energy. They are in dire need of solutions that help them adapt, but also in a manner that does not contribute to future emissions.

3.This assumes that the bottom 40% of households are accessing between Tier 2 and Tier 3 levels of energy access. Tiers of Access- assumed as per ESMAP-WB (2015) Beyond Connections.

4.1 Sustainable Energy drives for decentralisation and optimisation

SELCAP identifies the role of sustainable energy, specifically decentralised renewable energy (DRE) in driving for decentralisation of solutions and optimising for consumption within planetary boundaries. Following are some of the ways DRE pushes for an approach that keeps climate and poverty at the forefront:

New way of understanding energy economics for solutions:

In the current scenario, capital cost and operating cost for solutions are viewed separately. Especially in the case of technology, the ownership for capital and operational costs usually lie with different stakeholders. The manufacturers and innovators of technologies primarily focus on capital cost or features of technologies, but there are little or no incentives in bringing down operational costs of the technology. In the context of underserved communities, the energy burden of running and maintaining a technology can itself be a factor in them not being able to adopt technical solutions. For example:

- In agriculture many technologies are designed for centralised processing, catering to larger quantums of produce. Most farming communities are not able to own and run such centralised processing units because of high operational costs in the form of electricity bills and expenditure on diesel for back-up power.
- In health, many technologies are designed for specialised health care delivery or larger hospitals. These technologies need to be operated and maintained in specific environmental conditions, requiring high energy consuming HVAC systems. Studies across developed countries showcase energy consumption on HVAC to be the highest contribution to energy bills. This flaw in overall solution design for healthcare, itself makes many services and technology provision inaccessible to many first point of care and referral in the health system in a developing country.

Innovations in DRE based solutions drive for further attention on operational costs of energy as well, and drives for innovations which set new benchmarks for energy consumption. These benchmarks help technology driven solutions become more accessible to the low-resourced and poorer populations, and also drive for new consumption trajectories for the more developed and richer populations.

Image 13 | A solar vegetable dryer

Image 14 | A solar dryer tray

Optimisation of Technology: Scale of Use, Usability and Need-based Features:

Many features that are critical in technologies when designed for a centralised use, may not be needed when being used and owned in a decentralised manner.

Additionally, decentralising a technology driven solution does not mean down-scaling the technology. It means re-designing the technology as per local, more heterogeneous needs. For example: Crops (vegetables, fruits, cereals, spices etc) are extremely heterogeneous and change over geographies.

Geography specific crop varieties offer specific features which allow for biodiversity benefits, nutritional value, and also need specified climatic conditions for growth.

For example, short staple cotton, local to many parts in India can grow even in drought conditions, whereas BT cotton gives higher yield, but is high resource consuming, while also draining the soil of nutrients and lowering water tables in the long run. Similarly, special varieties of rice grown in North Eastern parts of India can grow as high as seven feet, so as to counter the floods in the region.[4] But these crop varieties have not been encouraged over time due to centralized and large aggregation and processing services.

Currently, processing units cater to single crop varieties only. Even in the case of agricultural cold storage units, they are set up for single vegetable type for easier management as per crop seasons and temperature requirements. DRE led innovations, focused on needs of end user, can result in new problem identification and decentralising of both technology and ownership models for processing.

Examples showcased in this report bring out models that have gained traction with individual nano and micro enterprises, self help groups and cooperatives. More importantly, the solutions also bring out key technology features that have been innovated upon when ownership decentralises.

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4 - Consultations with farmer organizations in Tamil Nadu, Karnataka and Assam. These were done as part of stakeholder consultations for this report.

4.2 An Ecosystem for Innovation:

An ecosystem approach to innovation takes a systemic approach which brings together: technology innovation, financing, delivery model and incubation, human resource, and policy. All of these require significant focus and convergence in order to deliver solutions in a sustainable manner.

Most of the targets or indicators in Climate Action Programs (SDG13) focus on financing, policy and human resource. However, the key gaps in the ecosystem that have been identified from the bottom-up approach in the report were in technology innovation, financial innovations and innovations in delivery models and incubation.

The following sections analyse four key sectors, and elaborate on the ecosystem gaps, as well as point towards certain benchmark solutions which need to be taken forward—both as approached to solutions design and to inspire further innovations, as well as to replicate across geographies and vulnerable populations. The four sectors identified were observed to be critical for populations living in poverty - Two sectors in livelihoods (Agriculture and Animal Husbandry), Health and Cooling. With a grassroot lens, the sections highlight critical challenges from a climate and poverty lens and introduces solutions which have been implemented on the ground and need support from multiple stakeholders for replications. Each of the four sectors have been detailed in the following pages. Through grassroot consultations, key climate and poverty challenges we've identified and chosen 20 solutions have been showcased.

Sustainable Energy nexus solutions have been mapped for four sections: Agriculture, Animal Husbandry, Health and Cooling. These have been identified and explained on the basis of the following four factors:

Vulnerability:

The sectors chosen employ or impact some of the most vulnerable populations across globally. Further, they also impact populations which currently live in poverty, and if solutions are not designed keeping in both adaptation and mitigation.

Energy:

These sectors have been recognised as very high consumers of energy.

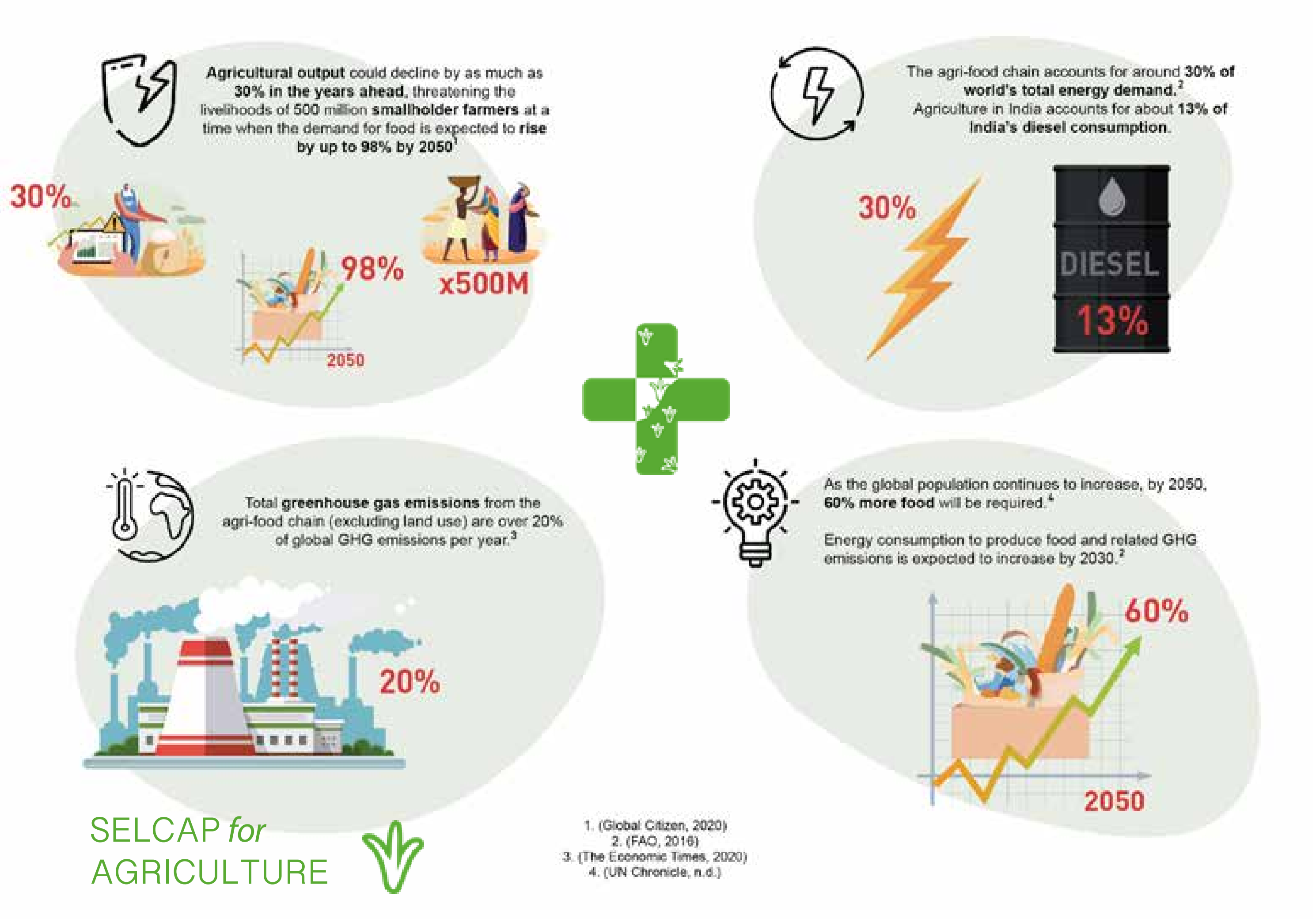
Additionally, because of the growing needs of the planet, there are several studies that highlight the growing energy demands in these sectors too.

Climate Mitigation Opportunity:

The sector accounts for high GHG emissions, and a large percentage of it may be linked directly to energy or any technological as we as any systemic breakthroughs needed in the said sector.

Need for Innovating within Planetary Boundaries:

Recognising earth system processes have environmental boundaries, the report recognises need to highlight solutions that look at optimisation of solutions and transforming existing practices. The chosen sectors specifically pose this challenge.



Agricultural output could decline by as much as **30% in the years ahead**, threatening the livelihoods of 500 million **smallholder farmers** at a time when the demand for food is expected to **rise by up to 98% by 2050**[1]

The agri-food chain accounts for around **30% of world's total energy demand.**[2]
Agriculture in India accounts for about **13% of India's diesel consumption.**

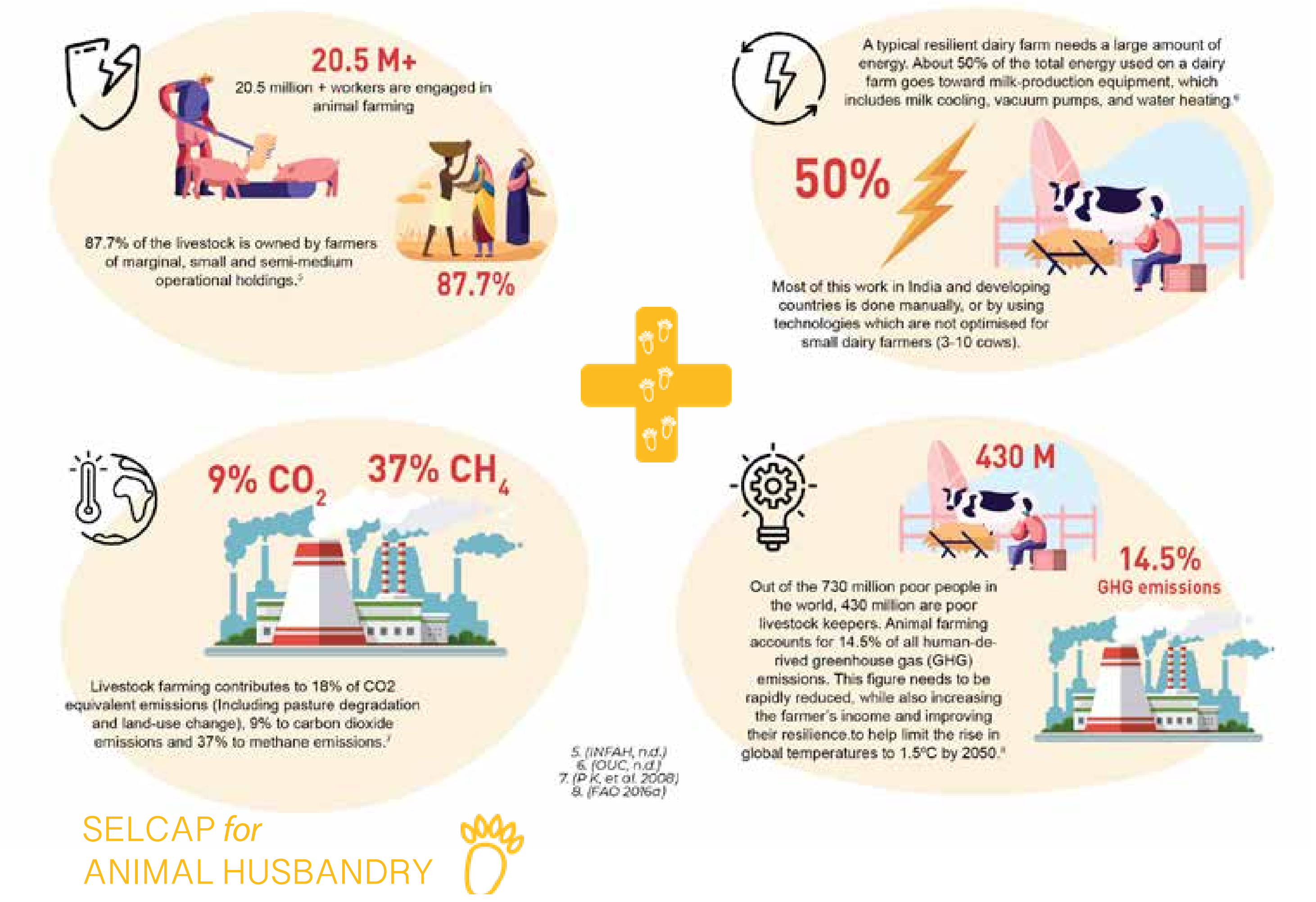
Total **greenhouse gas emissions** from the agri-food chain (excluding land use) are over 20% of global GHG emissions per year.[3]

As the global population continues to increase, by 2050, **60% more food** will be required.[4]

Energy consumption to produce food and related GHG emissions is expected to increase by 2030.[2]

SELCAP *for*
AGRICULTURE

1. (Global Citizen, 2020)
2. (FAO, 2016)
3. (The Economic Times, 2020)
4. (UN Chronicle, n.d.)



20.5 million + workers are engaged in animal farming

87.7% of the livestock is owned by farmers of marginal, small and semi-medium operational holdings.[5]

A typical resilient dairy farm needs a large amount of energy. About 50% of the total energy used on a dairy farm goes toward milk-production equipment, which includes milk cooling, vacuum pumps, and water heating.[6]

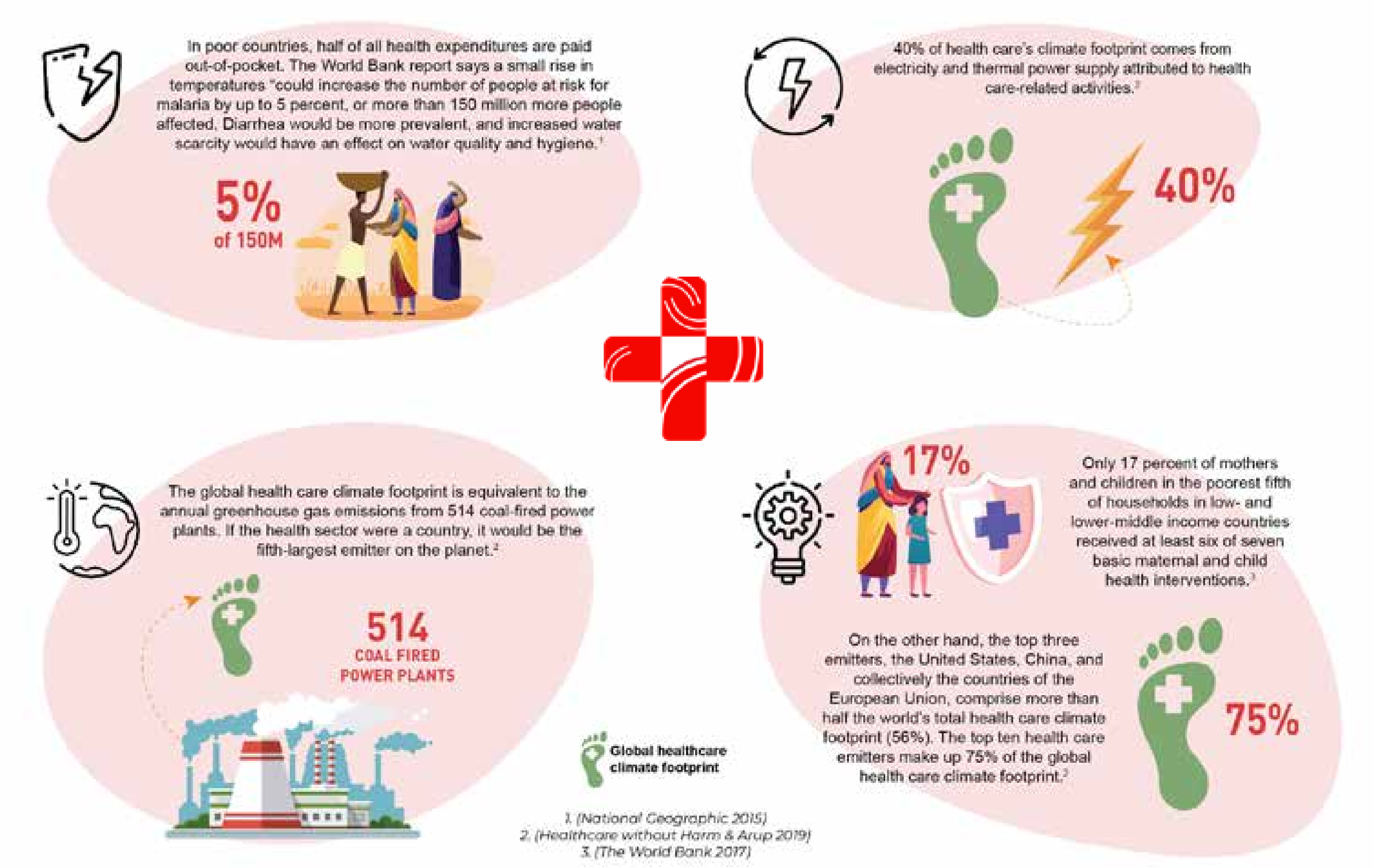
Most of this work in India and developing countries is done manually, or by using technologies which are not optimised for small dairy farmers (3-10 cows).

Livestock farming contributes to 18% of CO2 equivalent emissions (Including pasture degradation and land-use change), 9% to carbon dioxide emissions and 37% to methane emissions.[7]

Out of the 730 million poor people in the world, 430 million are poor livestock keepers. Animal farming accounts for 14.5% of all human-derived greenhouse gas (GHG) emissions. This figure needs to be rapidly reduced, while also increasing the farmer's income and improving their resilience.to help limit the rise in global temperatures to 1.5°C by 2050.[8]

5. (INFAH, n.d.)
6. (OUC, n.d.)
7. (P K, et al. 2008)
8. (FAO 2016a)

SELCAP *for*
ANIMAL HUSBANDRY



In poor countries, half of all health expenditures are paid out-of-pocket. The World Bank report says a small rise in temperatures "could increase the number of people at risk for malaria by up to 5 percent, or more than 150 million more people affected. Diarrhea would be more prevalent, and increased water scarcity would have an effect on water quality and hygiene.[1]

40% of health care's climate footprint comes from electricity and thermal power supply attributed to health care-related activities.[2]

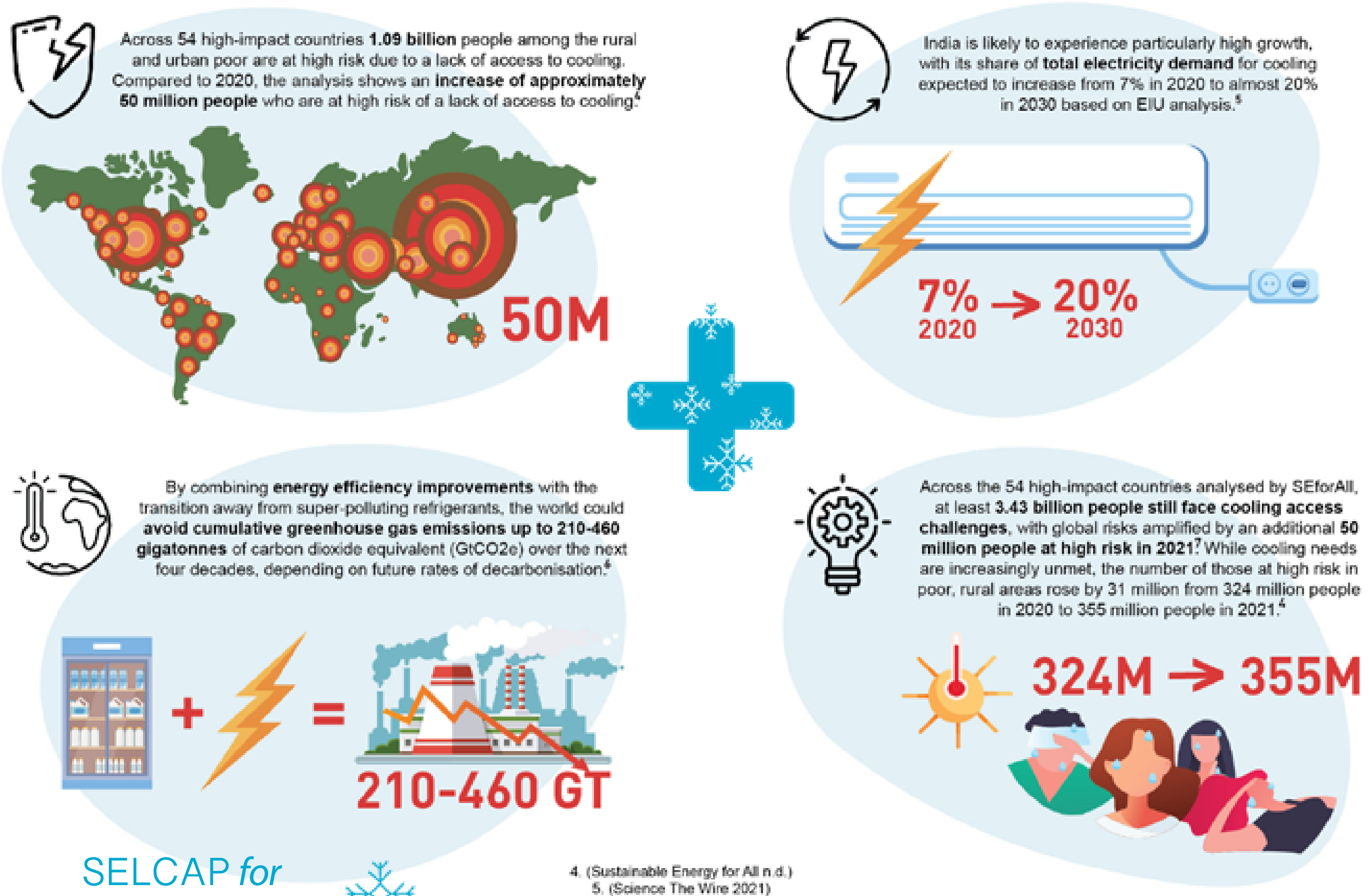
The global health care climate footprint is equivalent to the annual greenhouse gas emissions from 514 coal-fired power plants. If the health sector were a country, it would be the fifth-largest emitter on the planet.[2]

Only 17 percent of mothers and children in the poorest fifth of households in low- and lower-middle income countries received at least six of seven basic maternal and child health interventions.[3]

On the other hand, the top three emitters, the United States, China, and collectively the countries of the European Union, comprise more than half the world's total health care climate footprint (56%). The top ten health care emitters make up 75% of the global health care climate footprint.[2]

1. (National Geographic 2015)
2. (Healthcare without Harm & Arup 2019)
3. (The World Bank 2017)

SELCAP *for*
HEALTH



Across 54 high-impact countries **1.09 billion** people among the rural and urban poor are at high risk due to a lack of access to cooling. Compared to 2020, the analysis shows an **increase of approximately 50 million people** who are at high risk of a lack of access to cooling.[4]

India is likely to experience particularly high growth, with its share of **total electricity demand** for cooling expected to increase from 7% in 2020 to almost 20% in 2030 based on EIU analysis.[5]

By combining **energy efficiency improvements** with the transition away from super-polluting refrigerants, the world could **avoid cumulative greenhouse gas emissions up to 210-460 gigatonnes** of carbon dioxide equivalent (GtCO2e) over the next four decades, depending on future rates of decarbonisation.[6]

Across the 54 high-impact countries analysed by SEforAll, at least **3.43 billion people still face cooling access challenges**, with global risks amplified by an additional **50 million people at high risk in 2021**.[7] While cooling needs are increasingly unmet, the number of those at high risk in poor, rural areas rose by 31 million from 324 million people in 2020 to 355 million people in 2021.[4]

SELCAP *for*
COOLING

4. (Sustainable Energy for All n.d.)
5. (Science The Wire 2021)
6. (UNEP 2020)
7. (Sustainable Energy for All n.d.)

Additionally, for the purpose of this report, a solution is characterised of innovations in the following three categories:

Technical Model: Driven by a need-based approach, the technical model keeps in mind the following features:

1. **Appliance:**
    - Appropriateness of the Technology: All technologies keep the end-user's need at the centre and therefore the appropriateness has been defined by understanding the scale of use and the functionality of the technology.
    - Energy Efficiency: Optimising on energy efficiency measures, reduces the burden of operational costs, the burden of sourcing and generating additional energy, as well as reducing future emissions.
2. **Built Environment**: Appropriately designed built environments incorporating passive design techniques, in order to optimise the need for active energy needs and provide comfortable working and living environments.
3. **Source of Energy**: As discussed before, use of Decentralised Renewable Energy ensures innovations to be resource-efficient, and also mitigate future emissions
    - By offsetting carbon emissions by transitioning to cleaner fuels.
    - By creating new benchmarks on energy consumption and pushing for innovation on the first two components described above.

Financial Model: The solutions captured recognise innovations in financial models which allow for end users living in poverty to invest in technology driven assets that reduce future burdens on their cash-flows by:

- Increasing productivity or well-being
- Optimising overall costs on energy- capital expenditure and recurring costs on energy

Social Model: The innovations in social models drive ownership of assets or technology driven solutions to the last mile end users. The models showcased range from entrepreneurship models, service delivery models, group owned models or cooperative owned models.

Image 15 | Solar panels at the grassroots level.

5

Image 16 | Representative image of soil

SELCAP *for*
AGRICULTURE

5

SELCAP *for* AGRICULTURE

A NEED-BASED AGRICULTURAL SOLUTION WOULD PRIORITISE THE DEMANDS OF THE FARMER (IN CONTEXT OF RESOURCES AVAILABLE) AND NOT JUST THE FOOD PRODUCTION DEMAND. HOW DO I GROW MORE RICE? VS IF I HAVE 1 ACRE OF LAND, AND A WATER TABLE OF 1000 FEET DEPTH, WHAT AGRICULTURAL PRACTICES WOULD BE MOST VIABLE FOR ME?

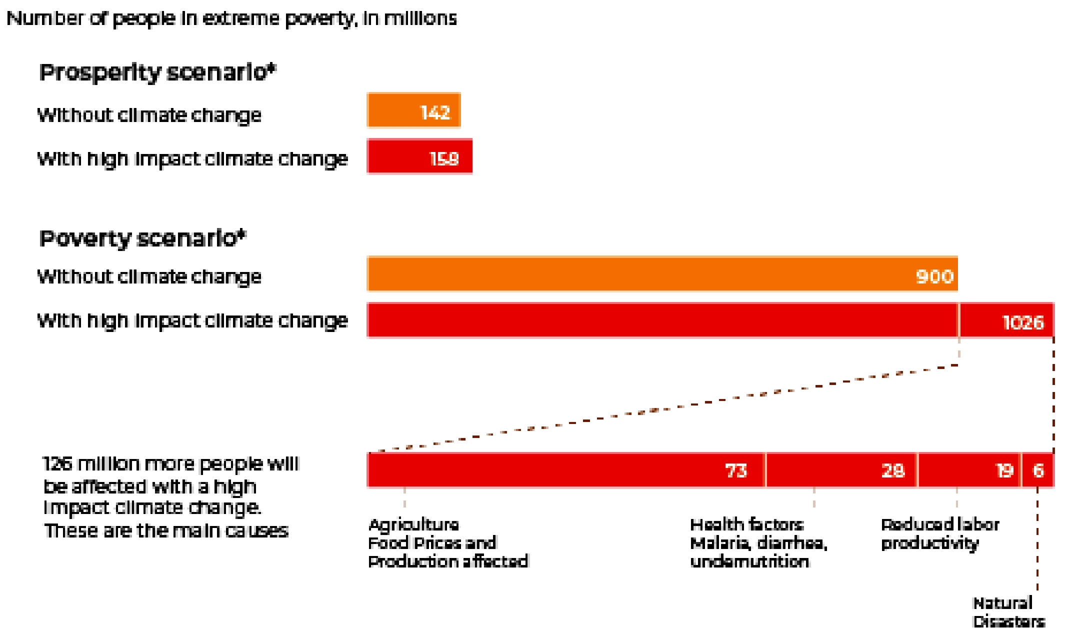
5.1 Agriculture, Poverty and Climate

Agriculture is one of the key economic sectors for the poor globally, particularly in developing countries, making it one of the most powerful tools to end extreme poverty. Growth in the agriculture sector is two to four times more effective in raising incomes among the poorest compared to other sectors. **Analysis in 2016 found that 65 percent of poor working adults made a living through agriculture (The World Bank, 2020).**

Current challenges in agriculture are exacerbated by climate change driven by increased heat stress, variable precipitation led shifting rainfall patterns, droughts, floods, cyclones, agroecosystem boundaries, increasing pest attacks etc. Climate change is causing catastrophic economic and social losses to farmers. **They are most vulnerable to climate change due to reliance on already stretched thin and rapidly depleting natural resources like soil and water. Inputs aside, without appropriate links to markets or having bargaining power, farmers are exploitable in these fragile unequal systems.**

The agricultural landscape of developing countries is composed of small fragmented land holdings. **Small and marginal farmers with land holdings less than 2 hectares are ill-protected from the vagaries of climate change and other systemic problems .** The current narrative lays focus on farmers having to produce enough food to feed the teeming billions with increasing demand, which is of critical concern. However, what also requires focus is what resources farmers have, and how we can optimize production using said resources and increase their incomes to build their resilience. **For example, the shift from how does a farmer with one acre of land produce x kgs of rice to meet the demand to how does a farmer with one acre of land improve their income in a flood prone area is essential.** This is a critical question for innovations required in agriculture from a climate-energy nexus perspective.

By 2030. effects of climate change on agriculture key to driving people into poverty



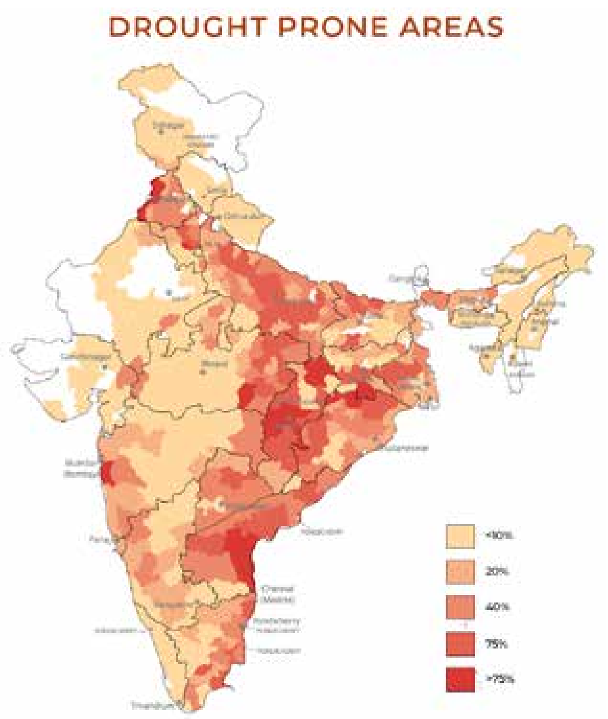
Source: adapted from (National Geographic 2015)

Image 17 | Women in villages have to travel great distances to fetch water

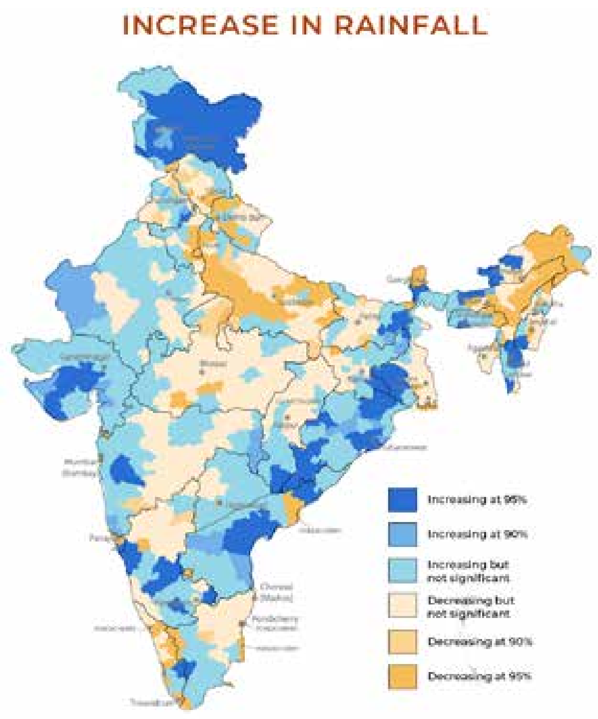
5.1a Agriculture in India: Plight of the Small Farmer

Indian farmers are considered the most vulnerable with 86.2% being small and marginal farmers (Provisional Agri Census of India 2015-16). Marginal farmers have land ownership of less than 1 hectare and small farmers with less than 1-2 hectares. Apart from these farmers, a large population engage as tenant farmers with no land ownership, performing tasks as farm labourers earning a daily wage income of upto INR 350 (according to labour ministry, 2017). These labourers engage in on farm and post harvest activities which are the most drudgery prone activities. According to the first Climate Vulnerability Assessment of India (2019-20), these farmers are unable to make adequate decisions about when to sow, what to grow, and how-to time inputs. (Sathyan, et. al., 2018). They also find it difficult to cope with the high food price and the fluctuations in the same.

Climate change caused disasters have become increasingly common in many regions across India's diverse climatic zones. Worryingly, some flood-prone districts are becoming drought-prone or vice-versa in a short period. The situation in the rest of the country is also not very promising. **As many as 86 districts all over the country are now staring at a severe water crisis as their deficit rainfall percentages are greater than 40 per cent (Climate Vulnerability Assessment, India, 2019-20).** There were 26 major droughts from 1870 to 2018, with rainfed agriculture dominating the agricultural makeup of the country with 68% of the total net sown area occupying 177 districts. Extreme floods are an increasingly common occurrence with 14 states in India having been flood affected in the last two years. **These climatic extreme events affect small and marginal farmers affecting their livelihoods leaving them with only a single crop per year.** This also makes them highly vulnerable which reduces their risk taking ability or their ability to make investments and low incomes.



Adapted from (Kannan, Paliwal, & Sparks, 2017)

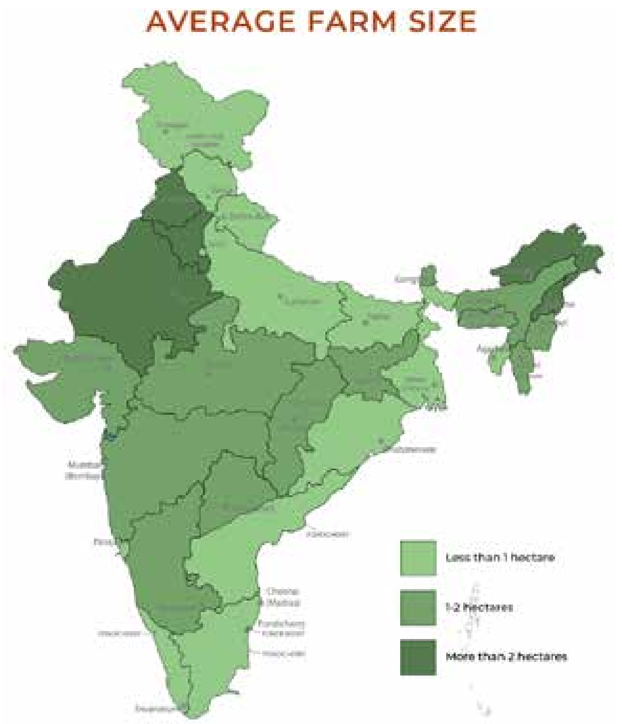


Adapted from (India Climate Dialogue, 2018)

5.1b Climate Change and its Exponential Impact on Small and Marginal Farmers

As established above, climate change is further exacerbating poverty in farmers. With arable lands being considered fallow, salinated or producing low yields, farmers claim continuing down the path of farming is like gambling. Land, a generational asset, is one of the key assets for small and marginal farmers which they are either resorting to selling or holding on to which is creating further debt due to the current state of agriculture. In the absence of appropriate financing, farmers resort to taking crop and personal loans from money lenders and informal sources with abysmally high interests leading to cyclical debts. Despite the government constantly trying to improve agricultural credit (with nationalising commercial banks, setting up of regional rural banks), nearly 44% of rural debt is held by non-institutional agencies. **Nearly four in ten of 8,007 Indian farmers who committed suicide in 2015 were in debt, compared to two in ten in 2014; more rural households went into debt over 11 years; and the average rural household had borrowed Rs 1.03 lakh, according to an IndiaSpend analysis of government data (IndiaSpend, 2018).**

Communities are moving to larger and tier 2, 3 cities in search of livelihoods working in factories, performing manual labour tasks, construction sites etc. As per the Economic Survey of India 2016-17, there are over a hundred million migrant workers in India, of which most are circular migrants. **This also results in loss of skill sets or criminal underuse of skill sets which have been passed down generations and are invaluable. These multi-pronged effects lead to creating intergenerational poverty furthering disparity.** There is a very critical need in boosting agricultural practices in a climate smart manner with appropriate technologies making it productive for farmers at a per acre yield level.



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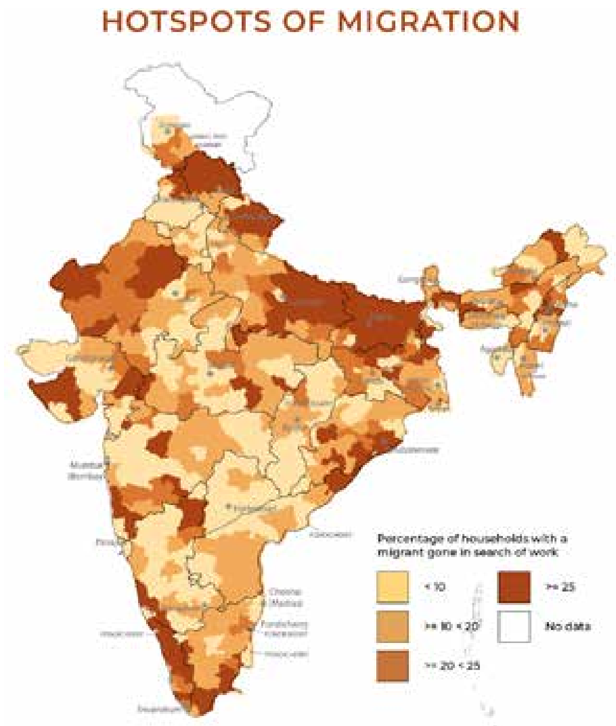


Adapted from (Mint, 2019)

There are gaps across the chain from inputs all the way to outputs leading to low productivity:

- **At an input stage**- with no access to climate smart seeds, water, appropriate technological and knowledge support for cropping and on- farm production resulting in low yields

  At an output stage - with no access to storage, transport and poor market linkages leading to further losses in income

The approach needs to consider the amount of resources that farmers are working with, the scope to further productivity with climate smart techniques, appropriate technologies and support them at the output stage to make farming profitable, sustainable and adaptive.

As opposed to how much demand lies in the market and for farmers to meet those demands without any support or safety nets.

Image 18 | Representative image of fallow land after a crop harvest.

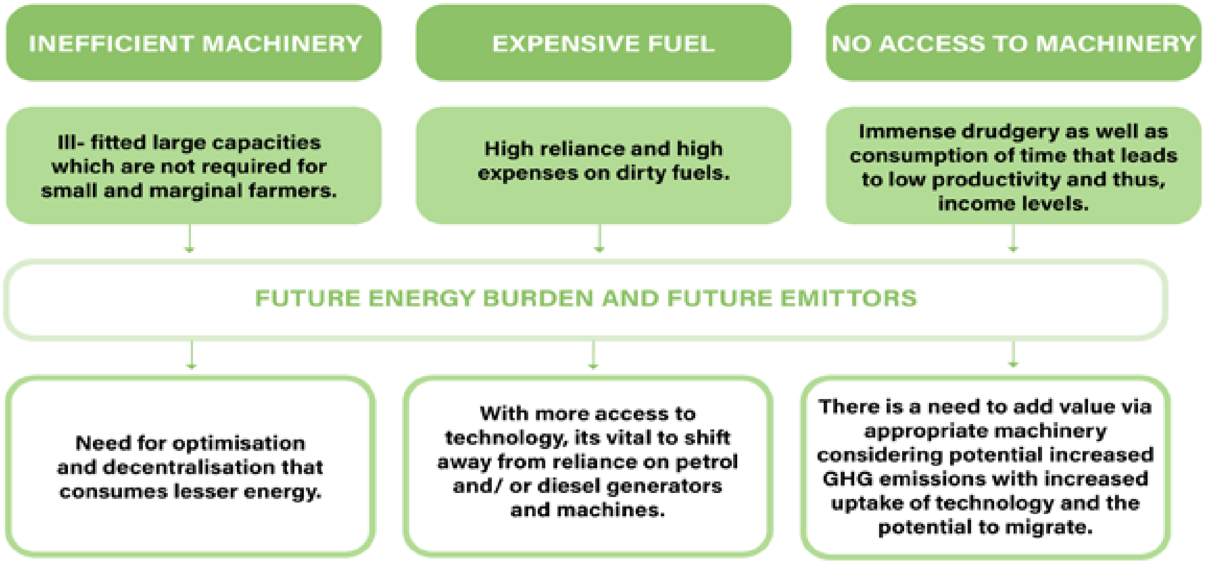
Image 19 | River normally used for irrigation water now dry due to climate change.

5.2 Innovation Gaps: Poverty and Future Climate Stresses

For increasing production while reducing input costs and furthering gains at a price realisation level, technological interventions are critical.

However, presently markets are dominated by large scale, ill-fitted agricultural machinery which are inefficient, use dirty fuels and are unaffordable for small and marginal farmers. Innovations in the agricultural sector do not consider the needs of small and marginal farmers who have limited access to capital, require only smaller capacities of machines and cannot take on increased energy burdens. With most farmers lacking access to machinery, increased access to inefficient machinery would result in increased GHG emissions.

Take a look at the current scenario:



INEFFICIENT MACHINERY

Ill- fitted large capacities which are not required for small and marginal farmers.

EXPENSIVE FUEL

High reliance and high expenses on dirty fuels.

NO ACCESS TO MACHINERY

Immense drudgery as well as consumption of time that leads to low productivity and thus, income levels.

FUTURE ENERGY BURDEN AND FUTURE EMITTORS

Need for optimisation and decentralisation that consumes lesser energy.

With more access to technology, its vital to shift away from reliance on petrol and/ or diesel generators and machines.

There is a need to add value via appropriate machinery considering potential increased GHG emissions with increased uptake of technology and the potential to migrate.

Adoption of inefficient machinery leading to extractive practices leading to natural resource depletion.

For example, over the years with increasing heat stress and variable precipitation driven droughts and deficit in rainfalls, ground water tables in Andhra Pradesh have dipped down to 1200 ft with levels at 800 ft a few years ago. With the state government supplying free electricity for pumping, most farmers in the region including small farmers invested in inefficient high capacity pumps and over pumped water through deep borewells as tomato crops are water intensive.

Farmers and Farmer Producer Organization presidents in the region claim that the groundwater depletion over the years could also have been caused due to over-pumping of water. There is an urgent need to address these issues through better, more efficient technologies, decentralised renewable energy coupled with sustainable practices like drip irrigation, groundwater recharge, resuscitating farm ponds.

5.2a Agricultural Value Chains: Inappropriate Solution Designs Resulting in Cyclical Poverty

Farming practices are composed of a series of complex practices which are steeped in tradition but are also rapidly evolving. Many of these evolved practices are counteractive on the natural ecosystem but are their forms of adapting to rapidly changing climatic conditions. For example, farmers use GMO seeds to combat pests and because they are cheaply available. Over time, with pests becoming resistant to these seeds leads to over use of pesticides as they cannot afford low crop yields considering erratic rainfall patterns and other climatic factors too. However, pesticides also lead to a significant increase in input costs, overuse of which can have long term, often irreversible impacts on soil health. However, it is important to note that any environmentally extractive or environmentally unfriendly decisions practiced by small and marginal farmers are made due to the economic and social costs that have to be borne by them. While soil health will degrade in the very near future, farmers struggle with regaining input costs made in a single cycle. However, there is opportunity here for both mitigation and adaptation where farmers could be given the right knowledge and awareness through soil testing centres, better seed varieties from seed banks, bio-inputs in place of fertilizers which they could produce using DRE powered decentralised machinery, better cropping practices like multi-cropping, low tillage etc resulting in low input costs, better yields, better incomes as well as better soil health resulting in carbon sequestration.

Any agricultural practice if looked at through the lens of the value chain approach helps determine the gaps and requirements at every stage. Any solution looked at in a silo ignores the holistic nature of the problem at hand. In agriculture - pre-production, production, post harvest management, post harvest processing are broad stages of any value chain require to be studied for mapping gaps and the interconnectedness of issues. The value of each stage of the value chain adds to the final output. From a climate perspective, each step offers an opportunity in mitigation and adaptation, a sustainable practice which results in a sustainable outcome. With increased need for mechanization, the energy burden will also increase. There is potential to mitigate and off-set energy from traditional fuels with renewable energy.

From a climate perspective, each stage and nodal points in the value chain are affected by climate change and in turn also act as causes for further deterioration of natural resources. For example - The pre-production stage of the value chain includes seed management, soil health management, input management and nursery management. Increasing precipitation and heat stress affects the soil moisture and quality, conditions under which seeds are not able to perform well. Temperature variations and unseasonal monsoons lead to increased pest attacks leading farmers to use chemical pesticides (as mentioned in the section above) which again affect the soil and water quality of the region. Lack of information and knowledge of climate smart or adaptive techniques and appropriate technologies lead to degradation at the first stage of the value chain itself.

If we take the example of the green revolution in India with respect to the supportive institutions that were set up, agriculture institutes, seed banks were set up locally. Similarly this approach will need to be taken from a decentralisation approach to enable sustainable practices by providing affordable climate friendly inputs to farmers locally. Input and output linkages in close proximities are present but in very small pockets.

Image 20 | Representative image of a farmer harvesting brinjals

Image 21 | Woman with a village level mill

If we look at soil testing centres which are a critical first step with respect to inputs, it would be required at a block level as opposed to it mostly being at a district level which it currently is at. (information through stakeholder engagements). Soil testing centres require efficient equipments, decentralised energy to be able to function through the year. Expansion of infrastructure should take into account this decentralisation approach to be able to reach communities at the last mile and enable access.

This approach reduces transaction costs for end users, brings inputs and outputs closer, energy access closer. The production stage of the value chain includes irrigation and groundwater management and on farm activities. Heat stress reduces surface water levels, depletes groundwater aquifers. Variable precipitation affects water security affecting soil quality, reduced yields and crop failures. Due to this, farmers use highly extractive high capacity pumps often powered by diesel and other dirty fuels. These consume a lot of electricity and are highly inefficient in turn further depleting water sources. Similarly, inefficient large-scale on- farm technologies that consume a lot of dirty fuels are adopted by farmers for tilling, harvesting, threshing etc.

Decentralised machinery is often not found in markets which results in farmers paying labourers which increases their input costs significantly. For example, rice, a water intensive crop, is grown predominantly during the kharif season. It is also a labour intensive crop where most farm labourers engage in rice cultivation at the same time of the year in all the rice growing regions of the country. Shortage of labour becomes a key issue which showcases a need for decentralised on-farm implements which could allow farmers to have unabated growth and production.

The post harvest stage of the value chain includes storage of perishables and fresh produce, preservation of perishables and agricultural waste management. Globally, vegetables and fruits account for 41% of Global Food Waste. 55% of Global Food Wastage occurs at the Agricultural Production and Post Harvest Handling and Storage stages (FAO 2011). In regions where farmers could earlier use traditional practices of on-farm storage like making heaps of their produce and covering it with hay can no longer employ these methods given the increasing heat stress and precipitation variation. Year on year we see painful images of farmers dumping their precious fresh produce on roads and landfills due to fluctuating market rates and unavailability of cold storage infrastructure.

There is a critical need for this infrastructure at decentralised levels given that there is a major shortage of cold storages in India with 92% of them being used for potato storage. Currently, centralised cold storages are also large emitters of carbon. Along with cold storage infrastructure, there also lies opportunities in using this waste to generate biogas and slurry which can be used as farm manure. It links back to the production stage of the value chain where fertilizers can be replaced with this organic matter, leading to better soil health.

The post harvest processing stage of the agricultural value chain includes primary and secondary processing, food processing and storage of processed items. This links the previous stage i.e. processing machinery can enable reduction of agri-wastage. For example, within horticultural crops there are grades A, B and C based on the quality of the produce. This process of grading itself is done manually in most regions in India which can be replaced with efficient grading and primary processing technology. In absence of food processing machinery, grade C produce is discarded or sold for close to nothing. This produce, if processed and packaged, can allow farmers to gain a significantly higher value, not just regaining their input costs, but also leading to profits

CHALLENGES: AGRICULTURE-PRE PRODUCTION

Seed Management and Availability

High yield varieties of seeds may negatively impact soil health, moisture content and in turn the climate

Increasing variations in water availability call for climate resilient seeds that don't have longer term effects on soil or climate

Soil Health Management

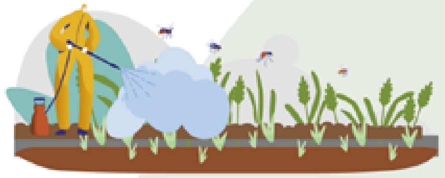
Lack of information may cause indiscriminate use of pesticides and fertilisers negatively impacting soil health and the climate

Heat reduces moisture content of the soil, and further impedes water + nutrient uptake to the plant

Increasing risks of drought with reducing soil moisture and fertility. Floods and cyclones cause soil erosion and increased salinity

Farmers lack access to soil testing centres as they are often located at district levels, reducing accessibility. There is a need for **decentralised soil testing centres** for farmers to gain knowledge on methods to regenerate soil quality while planting appropriate crops.

Input Management



Use of chemical pesticides and fertilisers have long and irreversible impacts on soil health and ground water tables

Increasing heat adds further pressure on farming with growth in pests and weeds, as well as reduces yields which require healthier alternatives

Increasing variability in precipitation reduces farm yields & lack of updated information, forces farmers to overuse pesticides, calling for more sustainable alternatives. Use of petrol powered sprayers increases emissions and costs

Presently farmers lack access to bio-inputs like herbicides and fungicides which can replace fertilizers and reduce input costs. Lack of **decentralised sustainable machinery to produce bio-inputs** at a farm or local level exists

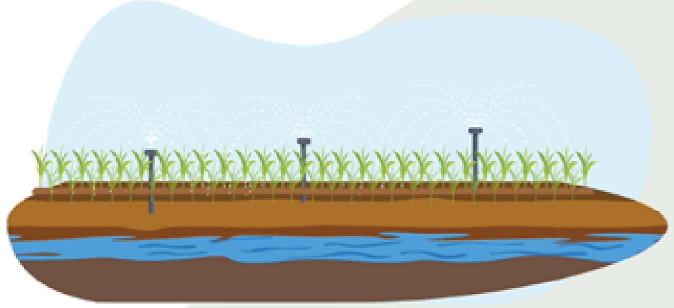
Nursery Management

Lack of efficient sapling management in the absence of nurseries, causes inefficient use of water and land.

Extreme heat can damage saplings, requiring efficient methods of sapling management
Nursery usage along with efficient natural resource management until transplantation would help farmers to adapt to precipitation variability

Usage of optimized pumps and climate smart practices like **rainwater harvesting, drip irrigation with efficient pumps** can offset use of in-efficient high capacity pumps powered by dirty fuels.

CHALLENGES: AGRICULTURE-PRODUCTION



Irrigation and Groundwater Management

Overuse or inefficient use of water, extractive practices lead to depleting water tables

There is a critical need for creating access to **need based efficient pumps** along with best practices like creation and r**egeneration of farm ponds, groundwater recharge,** using drip irrigation to conserve water etc.

Reduces surface water and depleted aquifers, calling for sustainable practices for water storage and conservation

Variability in precipitation decreases water security for farmers, causes loss in arable land and crop failures. This leads to farmers using high capacity pumps increasing costs and energy consumption

On Farm Technologies

Inefficient farming methods have a negative impact on the climate. Large scale machinery has high carbon emissions due to usage of dirty fuels.

Increasing heat reduces production, calling for more efficient harvesting technologies which minimise farm level waste

Due to variable precipitation and resultant decrease in soil quality would require additional demand and usage of farming machinery calling for more sustainable technologies.

Most small and marginal farmers lack access to on-farm machinery which are drudgerous, time consuming and often expensive (labour costs).
Farmers otherwise adopt or rent large scale machinery which is very expensive, consumes dirty fuels.
There is a need for **decentralised on-farm technologies coupled with climate smart agri techniques.**

🟧 **Problems**

🟩 **How is something here contributing to Climate Change**

🟩 **How are they affected by Climate Change**

🟩 **Technological Gaps**

CHALLENGES: AGRICULTURE-POST HARVEST MANAGEMENT

Inefficiencies of natural resource utilisation (land and water use) due to wastage down the agricultural value chain. Current storage practices are high emitters of carbon.

Storage of Perishables and Fresh Produce

Shortening shelf life of perishable commodities due to increased heat

Variable precipitation may cause damages to standing crops or breakages in supply chains, calling for emergency food storage needs

Farmers lack access to **cold storage facilities** which lead to a lot of wastage of produce. The current state of cold storage infrastructure is large scale, centralised, consuming a lot of electricity as well as diesel through generators as they need to be powered constantly to avoid spoilage. Farmers often have to travel long distances to access these storages increasing costs or through traders increasing transport emissions.

Preservation of Perishables

Food wastage caused due to increasing heat calls for better preservation techniques

Variable precipitation may cause damages to standing crops risking profits, calling for critical value addition

Farmers lack access to decentralised value add machinery like **driers.** The ones available are usually large scale and centralised, owned by large food processing companies who have benefits of capital, infrastructure and linkages.

Agricultural Waste Management

Higher rates of waste produced due to climate emergencies and broken supply chains calling for better utilisation of waste produced

The tonnes of horticultural waste sees zero to minimal value at the farm and market level. Farmers lack knowledge on waste to value propositions available like **biodigesters.**

CHALLENGES: AGRICULTURE-POST HARVEST PROCESSING

Primary and Secondary Processing

Centralised processing units are high emitters of carbon and lengthen supply chains causing high transport emissions (Input and output supply + Byproduct supply). They take away essential profits from farmers which may inhibit usage of climate friendly crops and practices or increase unfriendly practices like fertiliser usage in hope for higher yields to meet profit needs.

Variable precipitation may cause damages to standing crops, or breakages in supply chains, calling for emergency value addition to maintain food security. Increasing droughts call for more climate resilient crops which would need to be incentivised directly with increase in farm incomes

Centralised processing units dominate and control markets leaving farmers with little to no bargaining power or profits. In India centralised processing of cereals like millets are concentrated in a single region with produce and it's by-products traveling 1000s of kilometers leading to huge transport emissions. These machines are of extremely high capacity, are large consumers of energy as well as are emitters. At a local level, farmers travel kilometers to access mills not just incurring transportation costs but losing their daily wages in the process as well due to time spent. Farmers lack access to decentralised processing machinery which is very critical at this stage of the value chain

Storage

Centralised storage units are high emitters of carbon as well lengthen supply chains causing high transport emissions (Input and output supply + Byproduct supply).

Increasing heat calls for improved storage practices as traditional techniques may not be suitable anymore.

Variable precipitation may cause damages to standing crops or breakages in supply chains, calling for emergency food storage needs

Decentralised cold storage units and fridges can help communities store perishable processed value added products, reduce wastage, reduce transport emissions and increase incomes significantly

🟧 **Problems**

🟩 **How is something here contributing to Climate Change**

🟩 **How are they affected by Climate Change**

🟩 **Technological Gaps**

5.3 Agricultural Solutions for Climate Smart and Equitable Future

The section below illustrates some examples of solutions which have been captured from the ground. These solutions use renewable energy as a bridge to meet the developmental needs of farmers in a manner that optimizes energy usage while limiting negative climate impacts. While eight solutions have been identified, two have been showcased in greater detail below which illustrate technology models that are need based, optimize energy consumption and are decentralised while keeping the farmer at the centre. Multiple finance and ownership models which are critical for adoption of technologies at local levels have also been showcased.

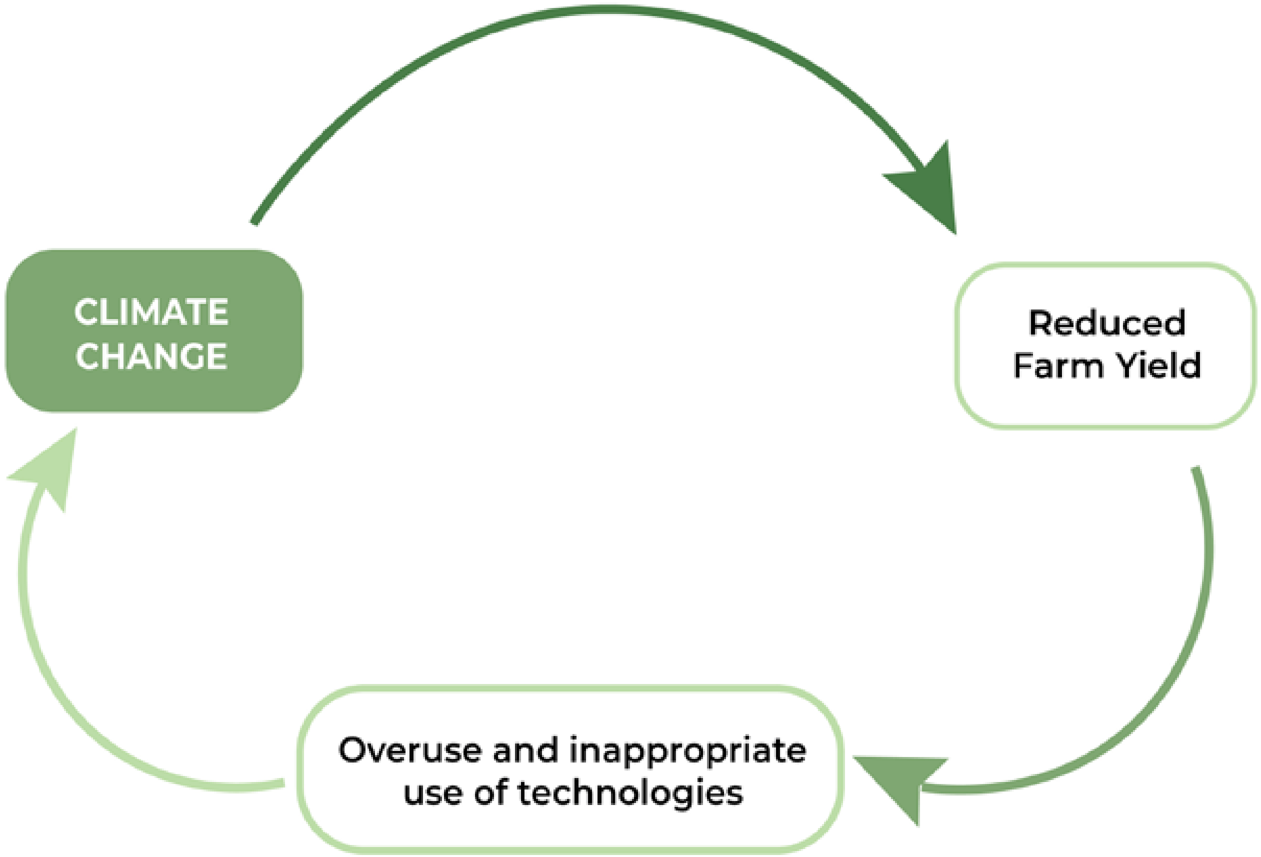


Image 22 | A decentralised solar powered millet processing machine

POINTS OF INTERVENTION: AGRICULTURE

De- Centralised Solar Powered Soil Testing Centers

Better adaptive capacities
With better knowledge and awareness on the quality of soil, farmers can make better decisions on cropping, efficient input use resulting in better yields and savings.

Reduced emissions from fertilisers: A 2013 report by WWF, India states that better management practices can reduce fertiliser needs and resultant emission by more than 50%

Reduced emissions from transportation: Reduced distance travelled by farmers to access soil testing centres, will further contribute to lower transport emissions.

Optimised energy usage and avoiding emissions through sustainable energy: The number of soil testing centres need to be expanded 10 times (approximately 700 districts versus 7000 blocks).

Better soil quality and increasing carbon sequestration: With bio inputs, degraded or decomposed soils can be resuscitated, increasing yields, producing healthier crops leading to increased carbon sequestration.

Decentralised Solar Powered Production of Bio Inputs and Solar Charging Station for Sprayers

Reduced input costs for farmers: It is estimated that application of bio organic yield has brought down input costs by 20%

Reviving land fertility and increasing yield: Bio fertilizers have claimed to increase yields by 20% once the land is made completely organic which takes about 3-4 years

Reduced emissions due to transition to bio-inputs: Fertilizer applications are estimated to represent about 1.5 % of global GHG emissions. With rising climate change, there is a need to deploy decentralised bio-input units

Better soil quality and increasing carbon sequestration: With bio inputs, degraded or decomposed soils can be resuscitated, increasing yields, producing healthier crops and leading to increased carbon sequestration

Integrated Irrigation Solution (Water Pumps, Ground Water Recharge and Farm Ponds)

Contributing to improved groundwater levels: Farm ponds and rainwater harvesting techniques like borewell recharge cause a rise in ground water levels restoring the flow of water even in borewells that have fully dried up. Farm ponds help store water for critical irrigation post monsoons and can also be a way to reclaim and reuse fallow lands and reduce soil erosion. They also facilitate percolation of water, acting as a water recharge mechanism.

Reduced water usage: Efficient irrigation practices like drip, sprinkler, etc. reduce water usage and fertilizer wastage, delivering water and required nutrients directly to roots, helping the soil retain moisture longer.

Conuting to improvements in health: Regions with extremely low groundwater levels also see an increase in fluoride content in the water. The fluoride content in drinking water and water used for irrigation can be reduced by rejuvenating these water sources.

Improved income security and potential to raise income: An integrated solution can enable dryland farmers to undertake irrigation to improve crop yield. Access to pumps and sustainable water sources can potentially increase the area under irrigation or add another cropping season to the farmer's yield and income

Improved water access and efficient water usage: Contribute to longer term benefits for the farmland and rejuvenate the land for future yields

Reduced expenditure on irrigation in the medium-long run: Reduction in operational expenses of fuel costs and maintenance of diesel-run pumps; Shared or rental models for solar water pumps reduce capital expenditure incurred by each farmer on irrigation per cropping season.

Decentralised Solar Powered Technologies for Non-Timber Forest Products (Lac)

Improved efficiency in harvesting of lac:
With climate change affecting quantity of lac production, mechanised lac pruning technology allow for farmers to achieve improved efficiency in lac extraction.

Reduced emissions from optimised and decentralised lac processing units:
Aiding forest dwellers in improving their margins per unit lac harvested through decentralised lac processing units. With restrictions in expanding the grid into forested regions, communities tend to rely on dirty fuels or have to travel long distances for accessing processing units.

🟩 Points of Intervention

🟩 Adaption

🟩 Mitigation

POINTS OF INTERVENTION: AGRICULTURE

Decentralised Solar Powered Agricultural Cold Storage Units

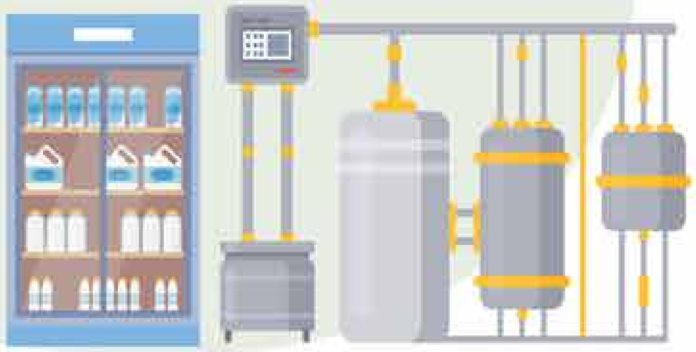
In Jharkhand, a Farmer Producer Organisation using a solar powered 5 MT cold storage, has saved on 150 MT of wastage per year amounting to USD 5000 - resulting in USD 145 of savings per farmer per year

Food Security
Natural resources should be efficiently used and with food wastage lower in the supply chain mitigated

Reduced Transaction Costs for Farmers
Farmer incomes can be positively impacted by climate friendly cold storages which would help reduce transportation costs

Energy efficient cold storage systems powered by decentralised sources of energy can help save upto 73,54,75,00 Mwh of energy every year in India

Reduced energy consumption with efficient cold storage systems.



Decentralised Solar Powered Processing Units for Millets (Aspirator, Huller, Destoner, Pulverizer, Polisher)

Food security: With decentralised processing, farmers can get better price realisation at the markets. Centralised processing affects the bran layer which contains the most nutritious part of millets leading to lower nutritional content in the millets. With processing locally available, it will also be affordable for farmers to consume their own produce which will have maximum nutritional impact.

Reduced Transaction Costs and Time Saved for Farmers: Farmers in remote regions often travel 5-10 kilometers by bikes, cycles and foot to process their produce in the absence of public transport infrastructure. They spend a whole day traveling and waiting for milling and in the process lose out on a day's income/daily wages in the range of INR 300-400.

Reduced transport emissions due to decentralisation: Nashik in Maharashtra is a central hub for millet processing for all millet producing states which are 1000s of kms away resulting in very high transport emissions. After the millets are transported, the waste which is 40% of the crop is then again transported elsewhere adding to the emissions.

Reduced energy consumption: If decentralised processing units are to scale, the reliance on electricity and other dirty fuels like diesel will be eliminated with the use of solar power.

De- Centralised Solar Powered Processing Units for Cotton (Ginning and Spinning)

Transport emissions
With decentralised units, the transportation emissions caused by moving cotton to centralised units and the waste being transported separately will be reduced. Additionally emissions from transport of fertilizers could also be avoided with short staple cotton.

Less emissions by growing short staple cotton
Studies suggest that short staple cotton has lesser emissions from pesticide use and reduced natural resources like water than BT cotton i.e. long staple cotton.

Short staple cotton, a climate friendly alternative: Short staple cotton is more suitable to rainfed conditions, it is more tolerant to moderate saline ground water and water logging conditions. With decreasing quality of ground water and soil impacting crop yields, this variety is a climate smart crop fit for adaptation.

Replacing BT cotton, the dirtiest crop: Studies have shown that there is a direct correlation between BT cotton and farmer suicides as it is a crop that is very input cost heavy which leads to cyclical debts. It is also grown in rain fed areas with the crop requiring irrigation leading to crop failures. With short staple indigenous cotton, the extractive practices of growing BT cotton would also be slashed resulting in better soil and water health

Decentralised Solar Powered Processing Units for Horticulture

Improved income generating opportunities from horticulture for farmers; horticulture in itself is also meant to increase farmer resilience to climate variability

Reduced Emissions from Food Wastage: Lower methane and other emissions (including from water and energy use for growing) from fruits and vegetables that would otherwise have created wastage

Optimised Decentralised Processing Units: Avoided emissions from diesel and electricity that would otherwise be used for powering decentralized processing machinery.

🟩 **Points of Intervention**

🟩 **Adaption**

🟩 **Mitigation**

These are examples of a few nodal points, in a value chain of a crop which could easily have up to 30 nodal points. It's critical to examine and consider interventions in every part of crop value chain which both contributes to climate change as well as has potential for better practices leading to adaptation and mitigation efforts in a holistic manner.

This begs for reforms in the approach to the agriculture sector while aiding farmers economically. There is humongous scope for stakeholders of all at every level to contribute, invest, design, innovate, finance and support implementation through this approach.

Image 23 | Solar panels powering a village level millet processing unit

'Labour burden on women millet producers must be reduced'

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Families separated by the search for fodder

Source: (PARI 2019a)

Source: (DownToEarth 2018a)

SEPARATING THE CHAFF FROM ODISHA'S RAGI REVIVAL

Source: (PARI 2019d)

Source: (IndiaSpend 2019)

42% INDIA'S LAND AREA UNDER DROUGHT, WORSENING FARM DISTRESS IN ELECTION YEAR

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'THE SOIL DOES NOT NEED ANY POISON FOR KILLING PESTS'

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Source: (PARI 2019c)

Source: (PARI 2019b)

PRAHLAD'S PAINFUL CHOICE: COWS OR GUAVAS?

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SOLUTION 1

5.3A: DECENTRALISED SOLAR POWERED MILLET PROCESSING UNITS

INCREASING CLIMATE RESILIENCE THROUGH MILLET CULTIVATION AND INCREASING FARMER INCOMES THROUGH PROCESSING IN HEAT STRESSED AND DROUGHT PRONE AREAS

Lack of accessible Millet Processing

Millet processing involves pre-cleaning, destoning, hulling and processing, which in the absence of processing machinery take days to do manually. This activity is wholly undertaken by women. Millet processing machinery is critical to reduce drudgery and increase the uptake of millet production; as millets do not provide good returns at the farm gate and have a much higher value after processing.

Image 24 | Traditional processing method

SOLUTION:
SOLAR POWERED MILLET PROCESSING UNITS

For all post harvest processes, a decentralised millet processing unit with grader, destoner, dehuller, polisher (optional) and flour milling machines would serve all of the farmer's post-harvest processing needs.

Decentralised small-scale units can be hugely beneficial to farmers and in boosting the rural economy. Farmers could consume their own produce, sell for higher values and also use every part of the crop within their farms itself.

Even the post processed waste (20% of the crop) can be turned into animal feed. Value added products can also be made locally through collectivization seeing higher returns for farmers.

0.4 coal fired plants can be avoided if moved from centralised to decentralised millet processing units. This has a GHG mitigation potential of 2052.92 kgCO2e/unit/year

India's millet production in a year is 16140000 tones which if replaced with decentralised solar powered energy efficient milling units, can reduce 513,737,376.0 kWh energy units per year.

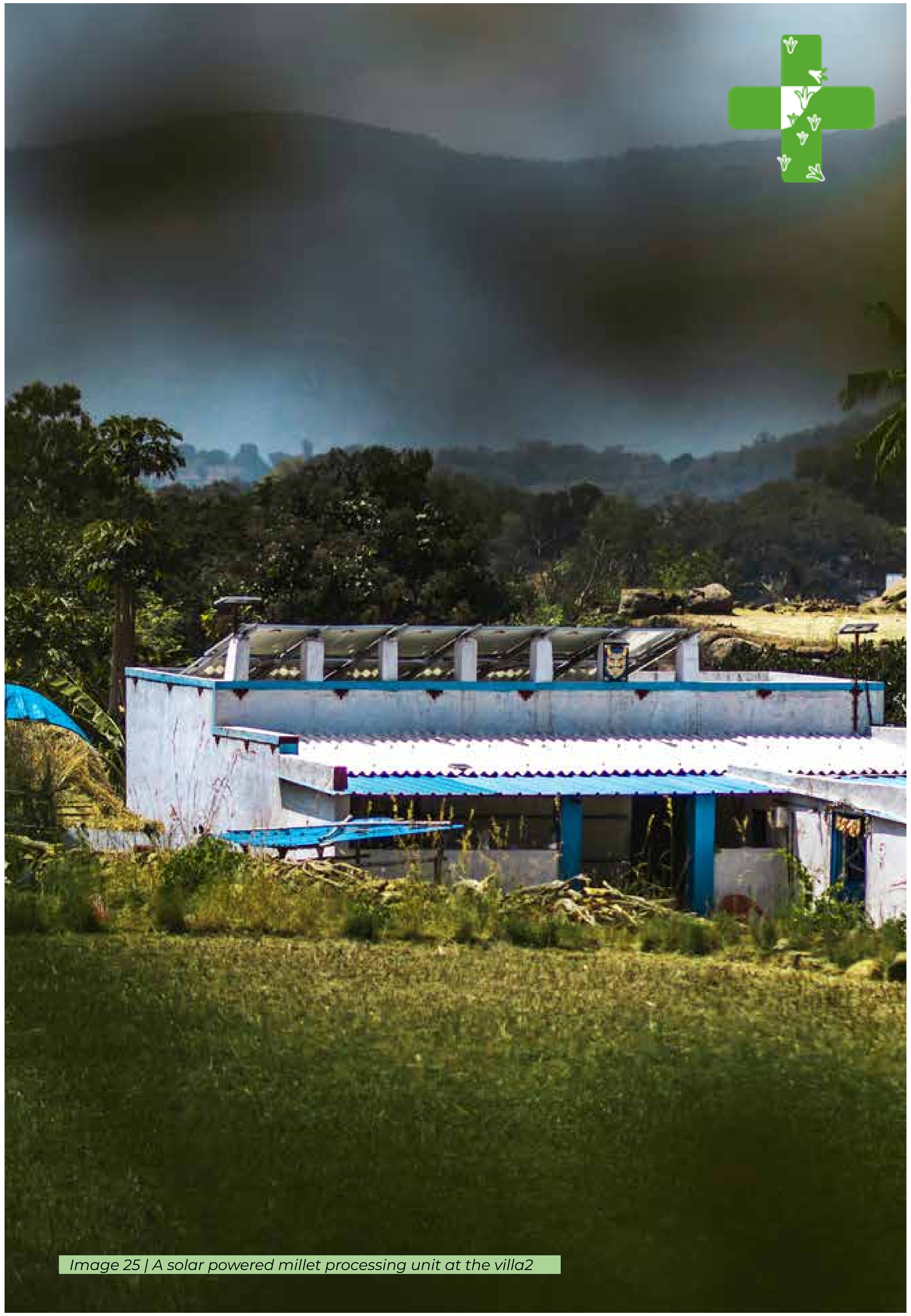

Image 25 | A solar powered millet processing unit at the villa2

Image 26 | A woman working the milling machine

TECHNOLOGY: INEFFICIENT CENTRALISED MILLET PROCESSING VS EFFICIENT DECENTRALISED SOLAR POWERED MILLET PROCESSING

Gaps in Millet Processing:

Millet processing is one of the most critical gaps in the millet value chain which is often addressed as one of the reasons farmers do not uptake growing the crop.

a. Millet processing that is done in mills like other cereal processing, is centralised, large scale, far from villages and smaller towns, increasing transaction costs for farmers, consumes times and wages for those days

b. Nashik, a hub for millet processing in India has large scale mills 1000s of kilometers away from millet growing regions. It crowds out local consumption, and makes it less affordable for farmers to grow the crop

c. Decentralised modernized millet processing machines are inaccessible to farmers from an ownership and and usage perspective

Technologies that make up millet processing:

a. Threshers

a. Graders, destoners and aspirators

b. Dehullers and polishers

c. Pulverizers

Local context and business models:

The types of crops and their processing requirements informs the machine selection. For example, jowar or sorghum doesn't require to be polished as it is a naked millet. At a centralised scale, there is a need to account for all varieties grown in the region as they are located at a larger geographic scale. Millet varieties change from location to location based on their resources as with most other cereals. Often, the infrastructure is incentivising one variety and in the process homogenization of the crop takes place. As a result centralised machineries also tend to cater to the homogenized variety. It is important to design and select machinery which can support the various varieties in the local regions. Since millets are predominantly grown in tribal regions which are remote and forested, energy is highly unreliable or there is no access. Design considerations on portability, energy designs with complete autonomy is critical.

Local context and models also tell us about the size andscale of operations and the energy scenario. For example, at a decentralised scale, Self Help Groups might only need a flour mill as it caters to local self consumption needs where processing volumes and batches are very small. As opposed to a Farmer Producer Organization which would be able to run all the machines from a scale and business modeling perspective.

The scale of operations:

This identifies the capacity of the machines and the level of automation for millet processing

- For example - centralised units have a complete assembly line and are hyper automated. Decentralisation doesn't require that kind of automation as the outputs per day are lower, the cost benefit of minimal labour which allows human activity. Ergonomics still need to be kept in mind.
- The capacity of the machines tells us about the energy requirements, system designs and the optimization of the energy design. For example - from the biz model defining what is needed to be done on a given day.

Energy optimized designs :

- For example, the speed of the milling machine is one of the factors influencing the machine selection as well as the hours of operation which define the solar system design. Based on the processes, speed and scale, the actual operational flow of milling, energy requirements can be established.

Firstly, decentralised millet processing machines are not scaled down versions of centralised machines but are designed differently in more ways than one. They are designed keeping needs and requirements of communities in a localised geography which are starkly different in the ways larger machines and their business models are set. While both have economic gains, decentralised models keep social benefits at the centre while centralised models keep capital gains as the focal point. Some State Governments in India have started formation of Millet Missions to encourage farmes to continue growing millets. With an increase in millet production, the need for processing units locally for farmers is bound to grow. Hence, it is critical to consider decentralised efficient milling units to reduce emissions and increase sustainability.

Image 27 | Life growing around solar powered millet processing unit

Image 28 | Millet Processing by small, marginal farmers for local consumption

OWNERSHIP AND DELIVERY MODEL 1

Individual small and marginal farmers owned, service model:

Who own the machine (providing additional income) and charge a small servicing fee for small and marginal farmers locally for processing their produce

Shivamma, Tulsikere village, Chamrajnagar district, Karnataka, South India

Climate Risk:

- Drought-prone region
- Erratic rainfall
- Depleting Ground Water Tables

Main sources of income:

- Agriculture- typically single rainfed cropping season, has 2 acres of land where they cultivate ragi, turmeric with other horticulture produce, and such is the case of most households in the region.
- Migrant labour work in other districts during drought season

Problem and Solution:

In the absence of millet processing units, community members including Shivamma had to travel to the town area 8 kms away to access the mill. This coupled with poor accessible roads, poor modes of transport to cover this distance, they often had to travel by foot to mill their ragi. They spent about INR 50 to cover this distance via shared vans. With the solar powered millet processing unit, they are able to avoid transaction costs and time spent with the service available locally and in an affordable manner.

OWNERSHIP AND DELIVERY MODEL 2

Self Help Groups and Farmer Producer Organizations owned, trader and self-consumption model:

For self-consumption, the FPO/SHG charges a minimal fee (INR 2-5 per kg) which could be utilized as a service. Within the trader model, farmers sell their produce to the FPO (incurring a minimal servicing fee) who in turn sell the processed millets to a trader/enterprise. Alternatively, the FPO/SHG process the millets, package it and sell it under their own brand with potential to make value added products

Sittilingi Organic Farmers Association, Dharmapuri district, Tamil Nadu, South India

Climate Risk:

- Dry land region
- Low and erratic rainfall

Main sources of income:

- Aggregation of millets from FPO farmer members and selling them wholesale
- Selling millet grains through their own retail outlets
- Making processed food items like biscuits and selling them in their retail outlets

Problem and Solution:

Farmers in this region moved to organic cultivation of millets and other crops led by the Sittilingi Organic Farmer Producer Organization. Being situated in a remote valley, erratic power supply and extended power cuts in the monsoons would completely disrupt their processing functions. This would increase their diesel consumption, expenses as well as not being able to meet demands. With solar powering their processing units, they are able to meet demands through the year with no disruptions.

Image 29 | Millet processing through a Farmer Producer Organization model

Image 30 | Self Help group working as a small scale packing unti

OWNERSHIP AND DELIVERY MODEL 3

Self Help Group owned, linked to anganwadis (local government day care):

The SHG procures millets from local farmers, processes and sells it to local day care (government run) that includes millets in diets for increasing nutrition for children.

Mother care Self Help Group, Bissamcuttack, Rayagada District, Odisha

Climate Risk

- Heat stress
- Flood prone,
- Cyclone prone

Main sources of income:

- Community members are engaged in millet farming and cattle rearing as their primary occupation, on lean seasons they migrate for daily wage labour.
- Aggregation of millets and processing for self consumption of local farmers
- Surplus quantities among the farmers in region is purchased by the SHG and further sold to Anganwadis in the village as part of Odisha Millet Mission programme.

Problem and Solution:

Mothercare is a Self Help group which was organized to address the nutrition needs of the Kankubadi village. Flour milling was carried out manually within the village or a processing center away from the village was accessed for the service. Due to manual flour milling being carried out, the drudgery caused was immense particular for the women in the community who performed this task.

With the solar powered flour mill being owned and run by the SHG, it has made milling services easily accessible within the community. It has also given rise to self consumption quantities, which otherwise would have been sold off to markets. The SHG also provides millet millets through the Odisha Millet Mission to public anganwadis which provide free nutritional meals to children and pregnant women.

It's about food, nutrition and livelihood security

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Source: (DownToEarth 2018b)

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POOR POST- HARVEST STORAGE, TRANSPORTATION FACILITIES TO COST FARMERS DEARLY

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Source: (The New Indian Express 2021)

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TOMATO FARMERS IN THE RED HURT BY PROBLEM OF PLENTY

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Source: (The Hindu 2020)


Source: (The Times of India 2020)

LACK OF COLD STORAGE FACILITIES HITS TELANGANA FARMERS

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HOW MUCH OF INDIA'S AGRICULTURAL PRODUCE IS WASTED ANNUALLY?

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Source: (The Wire 2021)

SOLUTION 2

5.3B: DECENTRALISED SOLAR POWERED AGRICULTURAL COLD STORAGE UNITS

DECREASING FARM WASTE AND CARBON EMISSIONS AND AIDING FARM INCOMES BY INCREASING ACCESS TO EFFICIENT DECENTRALISED COLD STORAGES POWERED BY RENEWABLE ENERGY

Lack of Decentralized Cold Storages

Farmers lack access to cold storage facilities which lead to a lot of wastage of produce. The current state of cold storage infrastructure are large scale, centralised (in terms of ownership and capacities), consuming a lot of electricity as well as diesel through generators as they need to be powered constantly to avoid spoilage. Farmers often have to travel long distances to access these storages increasing costs or through traders increasing transport emissions.

Image 31 | Representative image of Traditional Storing Method of harvest

SOLUTION: SOLAR POWERED AGRICULTURAL COLD STORAGE

- The off-grid cold storage unit showcases complete elimination of diesel generators in locations with as high as 15 hours of daily power outages.
- The advantage of the solution is that the off-grid solar integration and universal thermal energy storage can seamlessly be integrated to any cold chain application without changing the cooling hardware.
- Energy storage systems are exactly the same for milk chillers and cold storage, which translates to replicability and scalability of the technology.

India's total cold storage requirement is 62,000,000 MT which if centralised is replaced with decentralised cold storages, can reduce 33,945,000,000 kWh energy units per year. 29 coal fired plants can be avoided if moved from centralised to decentralised cold storage units.

Image 32 | Solar Powered cold storage unit for villages by SELCO

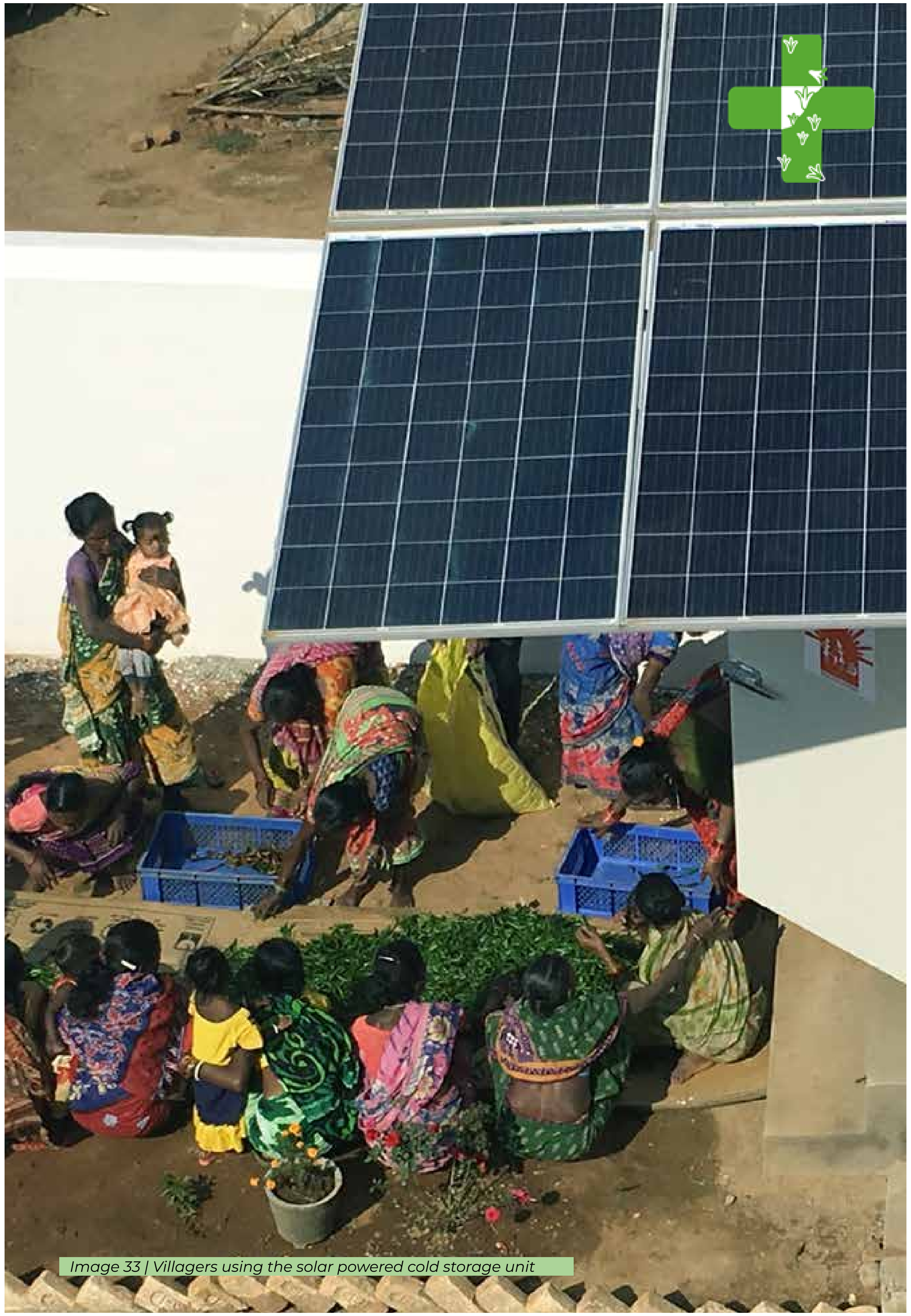


Image 33 | Villagers using the solar powered cold storage unit

TECHNOLOGY: INEFFICIENT CENTRALISED COLD STORAGE VS EFFICIENT DECENTRALISED SOLAR POWERED COLD STORAGE

Gaps in post harvest management:

- With increasing heat stress and market volatility, lack of cold storage is resulting in wastage of tonnes of produce with farmers incurring losses
- Centralised cold rooms dominate the cold chain make up of the country with most cold storages used for single commodities like potatoes
- There is a critical need for last mile decentralised cold storages at a farmer level increasing their linkages and thereby incomes.

CENTRALISED VS DECENTRALISED

Local context and business models:

- A key difference in centralised and decentralised cold storages is based on economic gains i.e. with centralised systems, large business owners or the government is using it as a stock point at large quantums. However, with decentralised systems, it is for farmers wanting to protect their price.
- Centralised cold storages are cold rooms where large batches of n number of commodities can be stored. They are predominantly based on a renter model which multiple parties lease and use at varying points in time. It works with the principle of infinite supply of energy and is not optimized for anything. Decentralisation is needed based on the local crops and farmers are storing surplus which in this context could be a whole batch due to volatility as they want to sell as soon as possible. This requires design to consider chambers and segregators to accommodate the needs of various perishables.

The scale of operations:

- A key feature of decentralised cold storages is pre-cooling which works for smaller scales of operations. Pre-cooling capacity is essentially the temperature variation from the ambient temperature (which could be 30 degrees) to a cold storage which is at 7 degrees. It is using optimum temperature everyday so one is maintaining reliability of energy access through a solar system (days of autonomy). If this design principle is not followed, the system would consume a lot more energy. This best practice is done at a decentralised level to maintain energy efficiency. Centralised systems don't need to consider this as it works with the assumption of unlimited uninterrupted energy. Which is why they build them at such huge scales (compressors sized a certain way) that temperature variance is irrelevant. .

Energy optimized designs :

- Decentralised cold storages are primarily for post harvest/post processing while centralised cold storages are for wholesale or retail. To capture value addition through post harvest processing, energy is required. The energy scenario is most rural regions close to farmers are sparse and unreliable while cold storages need to operate for 24 hrs, as they store perishables.

Image 34 | Fresh produce being stacked in the cold storage unit

Image 35 | FPO Members explain the trader model to farmers

OWNERSHIP AND DELIVERY MODEL 1

FPO owned, trader model:

Who own the machine, function as traders, purchase vegetables and fruits locally, store them for higher value and selling produce in larger markets, to gain profits.

Murhu Nari Shakti Kisan Producer Company Ltd, CiNi Jharkhand

Climate Risk:

- Increasing summer days
- Reduced monsoons

Main sources of income:

- Agriculture- cereal and horticulture crops like tomatoes, cucumbers and chilli

Problem and Solution:

In the absence of a cold storage, farmers were selling their perishables at whatever rates the market would offer which was volatile. The burden of predicting prices and returns would lie with every individual farmer, inhibiting adoption of the technology. With the help of CINI, Farmers in Khunti carry out a cold storage business. A solar micro cold storage unit which is a small scale 5 MT, solar powered cold room meant to store fresh fruits, vegetable, flowers, processed food and other perishable commodities. The unit enables both pre-cooling and storage of perishables to preserve their freshness and maximise shelf life. Through a trader model they can gain higher value in the markets. In this context, trader models work more effectively to ensure higher capacity utilisations.

Savings from avoiding wastage - INR 3,71,500

Income on rental - INR 60,000

150 MT per year saved amounting to INR 3,71,500 resulting in INR 10,614 of savings

OWNERSHIP AND DELIVERY MODEL 2

FPO owned service and trader model:

For farmers, vendors and trader, the FPO/SHG charges a minimal fee (INR 2 per kg) which could be utilized as a service.

Markama Agri Producer Company Ltd, Harsha Trust, Bissamcuttack, Rayagada, Odisha

Climate Risk:

- High risk zone for wind, cyclones and droughts

Main sources of income:

- Agriculture for small and marginal farmers - horticulture crops such as tomatoes, brinjal, bitter gourd, cucumber, water melon, beans
- FPO - Selling of inputs like fertilizers, seeds to farmer members and running the cold storage as a business

Problem and Solution:

The key issues facing farmers was the volatility of prices in the markets affecting their incomes. Wastage was another issue as farmers would not have the option to store leading them to either selling at low rates or letting the produce go to waste. The 5 MT solar powered decentralized cold storage, was installed in September, 2018. Due to cropping pattern changes introduced by the NGO, productivity has increased and due to the cold storage wastage has reduced. Per farmer who harvests 100 kg, 40% loss was happening out of which 20% was wastage/glut. The remaining 20 kgs was due to price fluctuation. This 40% loss has been minimized. Due to establishing working deals with vendors and traders, it has allowed for farmers to receive a fixed (and agreed upon) price for their produce throughout the year, remaining unaffected by any externalities to do with climate or markets.

Image 36 | Farmers segregating produce

Image 37 | Vegerables stored in owned cold storage

OWNERSHIP AND DELIVERY MODEL 3

Temple owned cold storage for providing free food to visitors:

The management owns and runs the cold storage to preserve perishables which is then used to prepare food for visitors.

Samsthana Shree Mahabaleshwar Temple, Gokarna, Karnataka

Climate Risk

- Heat stress
- Heavy winds
- High rainfall
- High humidity

Problem and Solution:

Samsthana Shree Mahabaleshwar Temple, Gokarna is well known temple where devotees from all over India visit.The temple has undertaken Amrutanna Prasad Bhojan section for preparing free food for lunch & dinner for more than 2000 devotees daily. The temple lacked a cold storage unit for preserving Vegetables, Milk & Coconuts due to which they incurred huge losses. The temple uses a 6 MT solar powered cold storage room facility post which the wastage of produce has reduced drastically. Pre intervention, 800 kg of vegetables and 500 pieces of coconut was decaying due to the warm and humid climate. The temple management is now buying vegetables and fruits in bulk which in turn saves the investment on commodities when purchased in smaller volumes and separately.

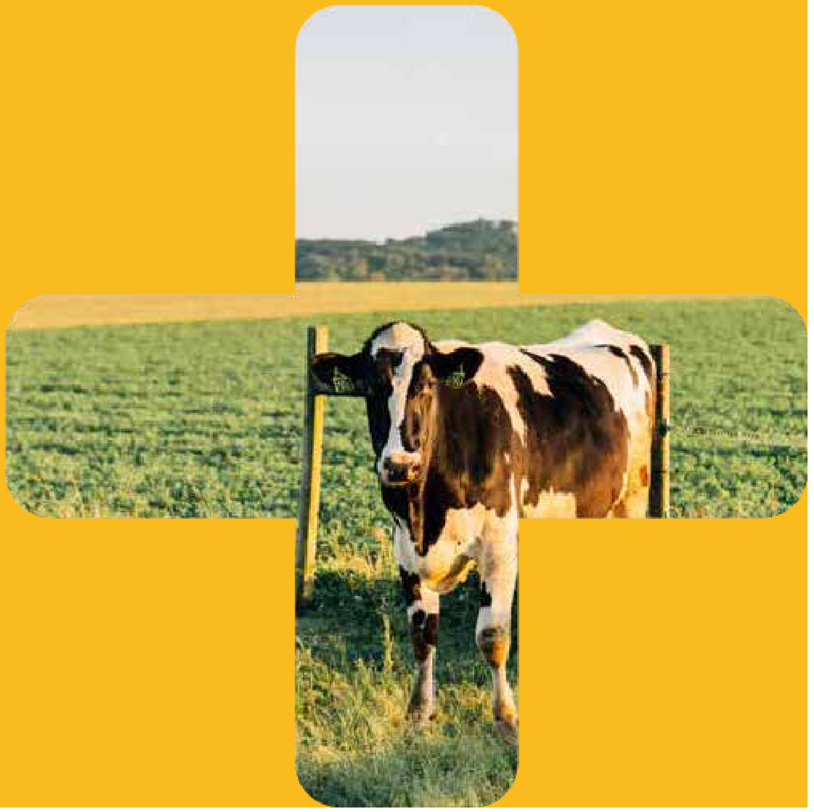
Image 38 | Representative image of cow at village level

SELCAP *for*
ANIMAL HUSBANDRY

6

SELCAP *for* ANIMAL HUSBANDRY

INDIAN LIVESTOCK FARMERS DO NOT HAVE ACCESS TO EFFICIENT DECENTRALISED TECHNOLOGICAL SOLUTIONS WHICH COULD HELP THEM ADAPT TO CLIMATIC VARIATIONS MAKING THEM VERY VULNERABLE



6.1 Animal Husbandry, Poverty and Climate Change

Smallholder livestock keepers, fisherfolks and pastoralists are among the most vulnerable to climate change. Climate change impacts both farmers and livestock directly. With increasing heat stress and variable precipitation, livestock mortality rates, natural resources, feed, production are impacted as a result of which farmers incomes are hit. At the same time, the livestock sector contributes significantly to climate change. In fact, 14.5 percent of all human-caused greenhouse gas (GHG) emissions come from live-stock supply chains. They amount to 7.1 gigatonnes (GT) of carbon dioxide equivalent (CO2-eq) per year. The main sources of emissions are feed production and processing, and methane from ruminants' digestion. The good news is that wider adoption of existing best practices and technologies in animal feeding, health and husbandry, and manure management could help the global livestock sector be more resilient and cut its emissions of greenhouse gases by as much as 30 percent (FAO, 2016).

Globally, 430 million people are poor livestock farmers. A shift in the lens of animal husbandry being a key emitter to supporting small and marginal livestock farmers is critical, as they are highly vulnerable to climate change.

While developed countries have adopted industrialised large scale production practices, developing countries still have small and marginal livestock farmers in rural regions relying most on livestock for food, income and livelihoods having a direct correlation to nutrition and food security. These traditional systems have been defined on the basis of local natural resource base and availability.

Image 39 | Heard of Cows being escorted for grazing

6.1a Animal Husbandry in India

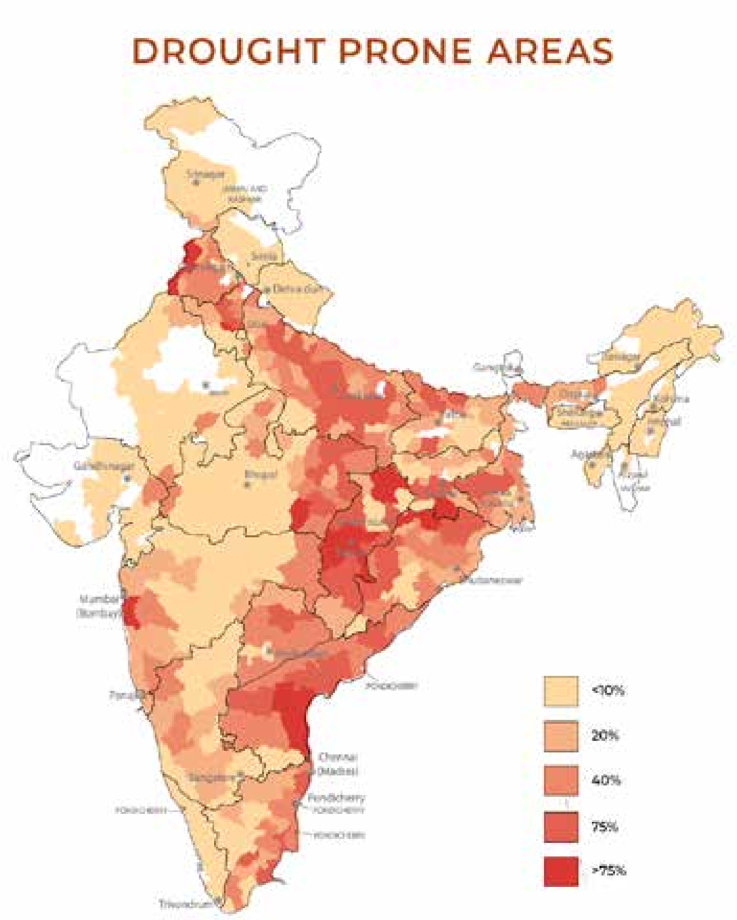
Animal husbandry in India is made up by small, marginal and landless farmers. With only 2.29 per cent of the land area of the world, India is maintaining about 10.71 per cent of the world's livestock. On an average, a farmer in India has two cows across the country, with a cattle population of 302,340,000 according to the 20th livestock census. Poultry is the most potent source for subsidiary incomes for landless and poor farmers. **22.9 percent of the landless and 9.6 percent of marginal and small farmers (up to 2 hectares) depend on livestock as a major income source.** For such farmers, animal farming integrates well with the family's economic crusade against unemployment, poverty and uncertain income flows from main activity (Business Line, 2018).

At all-India level, out of the 100 income of a small/marginal farmer, 70 comes from crop agriculture and 30 comes from livestock. However, in some of the States like Gujarat, Haryana, Goa, and Jharkhand, the income from livestock for small/marginal farmers could be in the range of 50-60 out of the total income of 100 (Business Line, 2021).

In farms with livestock, animals are used on the field for production activities, their dung goes into the field or is used as a cooking fuel along with firewood. **Livestock are the biggest safety net for farmers during a time of crisis acting as the asset or collateral for credit. Livestock is the insurance of the poor.** A major social role of livestock is as gender equaliser since the sector generates maximum earning opportunities for women (India Water Portal, n.d.)

However, with shifting climatic patterns, increasing heat stress, livestock farmers are left in the lurch. Even for the resource deficient for whom livestock plays an important income source, climate change makes them far more vulnerable. Let us take the example of a nomadic pastoralist community called Van Gujjars in India. They are historically a forest dwelling community spread across the northern states of Uttarakhand, Uttar Pradesh, Himachal Pradesh and Kashmir.

A part of the community still resides in the Uttar Pradesh-Uttarakhand border region of the Shivalik mountain range where they live with their buffaloes and have lived in forests to have an unending supply of feed for their livestock.



Adapted from (Kannan, Paliwal, & Sparks, 2017)

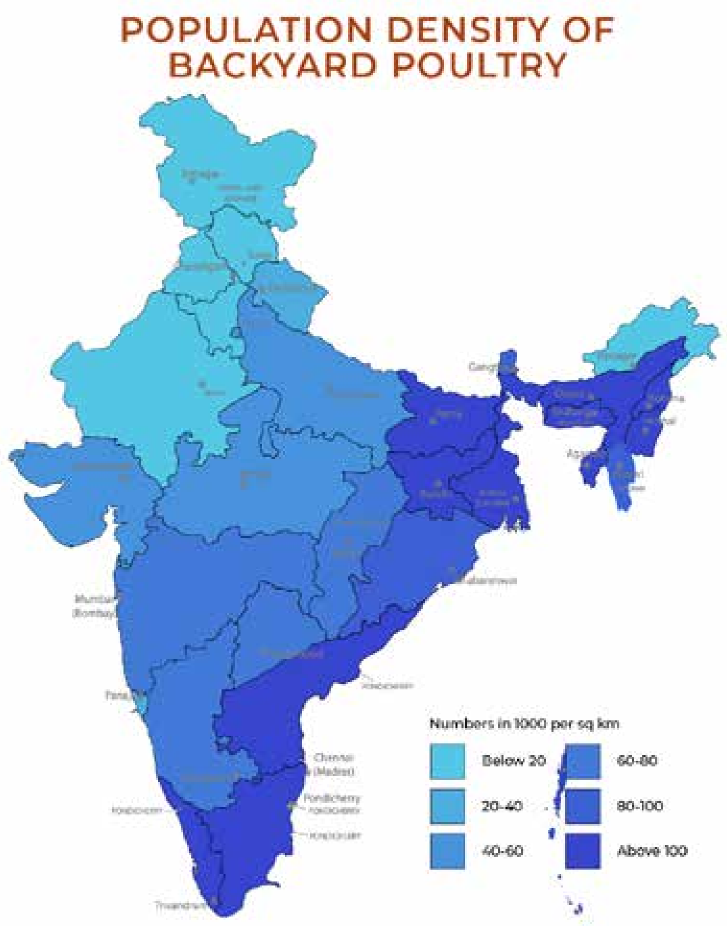
Due to living within the confines of forests, they do not have access to energy, health care, education or other basic systems. However, over the years with the growth of invasive species, increasing temperatures leading to the forests drying up for longer months, the community now needs to spend their incomes on buying fodder from towns to sustain their livestock. They now also spend summer months in cooler regions of Uttarakhand working in apple orchards as daily wage labourers to be able to buy fodder for their cattle. With pressure on forest systems and natural resources, the community and their cattle are bearing the brunt of unequal systems with no alternative solutions being provided to them to support their livelihoods.

Similarly, cattle camps have become a constant in the lives of farmers in drought prone regions. Cattle camps or chara chhaonis have had a long history in Maharashtra and Karnataka as a short-term drought measure, apparently starting from Shivaji's reign in the 17th century. Since 2011, they have become a part of the summer landscape in Maharashtra, particularly in its dry central and western belts (PARI, 2016).

Due to fodder and feed deficiency which they could earlier find in their fields, farm-ers now need to temporarily move to cattle camps to keep their livestock alive during these crucial months.

Now, with increasing droughts as well as lands becoming uncultivable, livestock are becoming the lifeline for farmers.

On the other hand, the changing temperatures are impacting livestock mortality, raising the number of diseases and reducing productivity, which, in turn suggests the need for appropriate technological solutions and best practices to be promoted and adopted.



Adapted from (South Asia Pro-Poor Livestock Policy Programme 2014)

6.2a Animal Husbandry Value Chains: Inappropriate Solution Designs Resulting in Cycle of Poverty

In India, Operation Flood that led to the White Revolution in the 1970s led to decentralisation of aggregation and giving milk producers agency. Systems and infrastructure was also brought to the last mile for animal husbandry i.e. collection centres, chilling, immunization, veterinary dispensaries, distribution of feed and fodder (production is still centralised) etc. However, all of these are being challenged by cli-mate change with gaps widening. A similar approach needs to be taken with respect to technological uptake by livestock farmers and strengthen existing supportive structures to adapt to increasing heat stress and variable precipitation related climate stressors.

Indian livestock farmers do not have access to efficient decentralised technological solutions which could help them adapt to climatic variations making them very vulnerable. Technologies at every part of the value chain can act as opportunities in building the resilience of farmers, opportunities in both adaptation and mitigation. Interventions across the value chains can result in holistic outcomes, increased yields and incomes.

In the pre-production stage, there is feed and fodder management, farm management, veterinary services, shed management etc. There is scope for efficiency in every part of this value chain with technological interventions. Let's take an example of fodder production which is a critical part of input management. As mentioned in the above sections, **with increasing heat stress and reducing rain falls, in regions where grazing on farm was a possibility, farmers now spend their precious incomes on buying fodder to sustain their livestock.** Feed is also critical which is centralised in it's production and travels to remote regions, contributing to emissions. With decentralised technologies such as hydroponics units which consume a fourth of water, barely any land as it is vertical farming, resulting in producing highly nutritious feed. Gopal Poojary, a farmer in Karnataka who is associated with the Karnataka Milk Federation adopted a hydroponics unit and grows maize in it. This is resulting in savings and increased quality of milk production (by three litres) and has also observed the milk to have better fat content.[5]

Similarly, sheds which house livestock also need to be adaptive to increasing heat and precipitation variations. For example, poultry sheds are usually open with mesh walls on the longer sides of the shed for passive ventilation. When it rains, for water to not enter, farmers tie tarpaulin sheets to the side and keep it closed through the monsoons. This leads to an increase in humidity which increases disease spread. With erratic monsoons, this technique is dated and requires improved technological interventions. Improved shed designs, along with active solutions like a dehumidifier and passive solutions like curtain winching are critical.

In the production stage of the value chain, lighting, storage and by-product management play important roles. Efficiency improvement per unit yield in poultry is important as the Feed Conversion Rate is lower, emissions per unit are higher. From a climate perspective, efficiency in production is important for emissions to be reduced and from a developmental perspective, reducing input costs. Efficient lighting for poultry can reduce feeding days, produce a live bird of two kgs within 45 days leading to reduced input costs and emissions worth five to ten days. With coolers and efficient sheds, the increase in efficiency will be much higher.

Similarly, producing biogas using farmyard manure can meet domestic fuel demands and replacing firewood and LPG which are both unsustainable sources of fuel. On-farm production of bio gas in India is easily achievable as families have a minimum of two cows which produce enough biogas to meet cooking demands of a household for one year. However, this technology does not reach people and improving accessibility and delivery models are of utmost importance.

In the post production processing stage, storage, milk processing and poultry processing make up the key activities. Earlier, cows would be brought to collection centres to be milked, the milk would be weighed and tested by the aggregator. However, with supply chain lengths increasing, farmers milk their cows in farms and bring the milk to the aggregation point. **With increasing temperatures, the milk is prone to spoilage which leads to losses and emissions which meet no demand. Cooling solutions like milk chillers need to be brought to the source now to secure farmers and reduce wastage.** In order to use surplus milk and poor quality milk, post processing technologies can aid farmers in producing value-added products which can be very profitable for them.

In order to use surplus milk and poor quality milk, post processing technologies can aid farmers in producing value- added products which can be very profitable for them.

Image 40 | A goat herder

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[5] *- Mr Gopal Poojary was part of stakeholder consultations to understand the impact of climate change on dairy farming*

CHALLENGES: ANIMAL HUSBANDRY- PRE PRODUCTION

Accessibility to Feed and Fodder

Feed and fodder are both transported over long distances to meet nutrition needs of cattle especially to areas which are already drought prone. Centralised feed processing and transportation would contribute significantly to GHG emissions.

With increasing heat stress and extended dry spells, grazing has become an issue for milching animals and other livestock. Farmers spend a lot of their incomes buying fodder and feed for their animals which is a centralised industry. Decentralised feed production needs to be addressed for small and marginal farmers.

Farm Management with increased temperature and rainfall

Due to increasing heat stress, there is a stark reduction in productivity and in milk production. Poorly designed poultry sheds and dairy sheds can increase diseases with increasing variable precipitation. Sustainable designs and construction of appropriate sheds and living spaces are important to keep the livestock healthy, more productive for farmers to increase their incomes and reduce input costs.

Last mile Veterinary Services

With varying temperatures and climate, livestock are now more prone to diseases than ever. With varying temperatures and climate, livestock are now more prone to diseases than ever. Change in weather pattern, increased moisture and rainfall leads to this. There is an increasing need for vaccinations and immunization services at the last mile which is presently absent.

CHALLENGES: ANIMAL HUSBANDRY- PRODUCTION

Increased emissions from usage of inefficient lights whose demand will only continue to grow

For poultry farmers, lighting plays a very critical role in the production cycle as chicks require this during their growth stage to produce appropriate yield. Small and marginal farmers lack efficient poultry lighting as well as with scare energy, farmers cannot use poultry lights efficiently

Lighting for farms

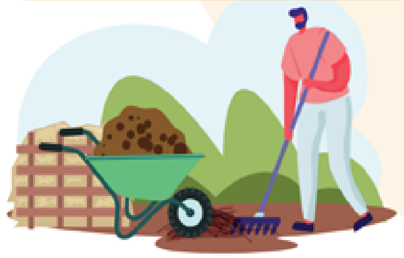
Cooling at farm level for reduced wastage and microbial growth

Increased emissions from energy consumption for cold storage needs to satisfy growing demand

With increasing heat stress, moisture due to variable precipitation and longer supply chains, the need for chilling of milk is required at the source itself. Earlier chilling at the aggregation centre was sufficient but with longer distances and higher temperatures, wastage of milk is a huge issue which needs to be addressed.

Emissions from animal waste generation - Methane and Carbon dioxide

By Product Management

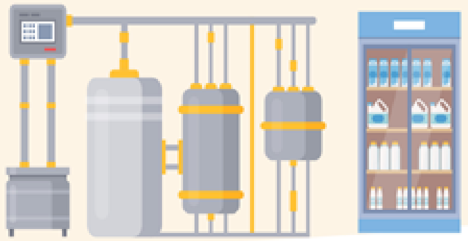


Dairy farmers have constant access to a fuel source i.e. manure which is not converted to an energy source like for cooking as they lack the means. Often, the use is in a mix of manure and fire wood which is increasingly a depleting source due to variable precipitation and increased heat stress. Reusing animal waste can meet domestic fuel demands using the right technologies

CHALLENGES: ANIMAL HUSBANDRY- POST PRODUCTION

Milk Processing Storage and Fresh Produce

Poultry Processing and Storage



Increased emissions from energy consumption for processing needs to satisfy growing demand

Animal Husbandry outputs can be used to process and create value added products as well as in curbing waste. Farmers lack post processing equipment or have inefficient equipment. To store the value added post process products, cold storage and fridges are required at decentralised scales as these are perishables that are highly prone to wastage.

■ **Problems**

■ **How is something here contributing to Climate Change**

■ **Opportunities Identified**

6.3. Animal Husbandry as a solution for climate smart and equitable future

The section below illustrates some examples of solutions which have been captured from the ground. These solutions use efficient technologies, sustainable designs and renewable energy to meet the requirements of livestock farmers while limiting climate impacts. Small and marginal farmers lack complete access and knowledge of these solutions which with increasing climate burdens are imperative for productivity and in reducing emissions for the sector. While four solutions have been identified, two have been showcased in greater detail below which illustrate technology models that are need based, optimize energy consumption and are decentralised while keeping the farmer at the centre. Multiple finance and ownership models which are critical for adoption of technologies at local levels have also been showcased.

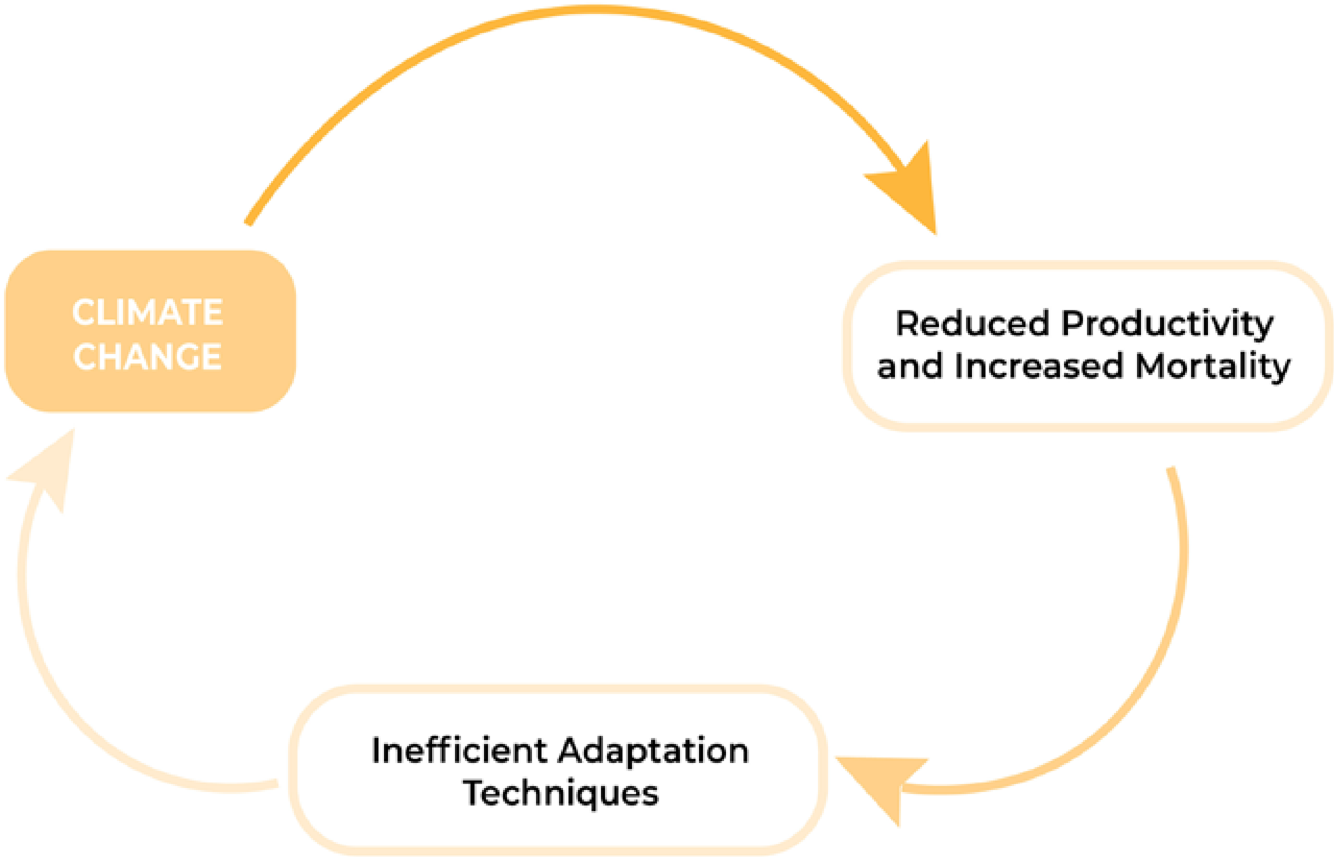


Image 41 | Milking in progress. using solar powered milking machine

POINTS OF INTERVENTION: ANIMAL HUSBANDRY

Solar Powered Hydroponics at Farm level for improved resiliency of farmers in accessing fodder

Increase in Income: Income increase for small and marginal farmers owning 2-4 cattle can be between INR. 23,800 ($308) and INR. 46,000 ($615) per annum. This is a consequence of two aspects: Reduced feed expenditure: the production of green fodder from hydroponics reduces the expenditure on externally purchased feed, leading to savings of between INR. 7,800 ($104) and INR. 15,000 ($200) per annum

Increased production and quality of milk (increase in fat percentage): Milk production typically increases by about 1 liter per cattle and could be upto 4 liters for each small farmer household, an increase in income of approximately between INR. 15,000 ($200) and INR. 31,000 ($415) per annum.

Savings in time and increased convenience: Growing fodder in hydroponics units requires roughly 6-7 days. This reduces the time and effort involved in accessing green fodder from common lands or irrigated lands of other farmers. Much of this benefit is seen by women who are primarily responsible for dairy farming activities within the farming household.

Reduced water usage: Hydroponics requires less water. Given the water content in the fodder produced through hydroponics, the quantity of drinking water can also be reduced. Estimates suggest that 1 kg of hydroponics fodder requires about 3-4 liters of water to grow, while traditional fodder of the same quantity would require about 15-20 liters of water.

Reduced land requirements: Government estimates suggest that the area under fodder cultivation has remained static for the last 4 decades, while the lands available for grazing are reducing or have been degraded.

Avoided land use change and preservation of carbon sinks: In the absence of adequate green fodder, changes in land use are often observed with conversion of forest lands into grazing pastures if left unchecked. Hydroponics for fodder production at a decentralized level can contribute to preserving existing carbon sinks, and avoid the release of emissions from land use change.

Reduced emission intensity: Increased milk production per cow reduces the emission intensity per liter. Estimates suggest there can be upto 35% methane reduction from livestock using hydroponics-produced fodder.

Solar Powered Vaccine Refrigerator for Last Mile Immunization and Reduced Mortality

Reduced mortality risk: With increasing disease burdens due to climate stresses, livestock require more frequent vaccinations. With decentralised vaccine refrigerators, last mile delivery of vaccinations through worker like pashu sakhis can be carried out

Increased incomes and savings: Farmers input costs and emissions from rearing livestock can be utilized by increasing mortality rates of livestock.

Reducing emissions from transport: With vaccine refrigerators placed closer to communities, the transportation of people and vaccinations can be reduced drastically leading to reduced emissions.

Reducing emissions from increased vaccine refrigerators: With decentralised solar powered vaccine fridges, emissions can be displaced.

Bio Digesters

Savings in time and reduction in drudgery: Avoiding the need (usually for women) to spend hours or a whole day gathering firewood- especially in areas where deforestation has already been rampant. At the very minimum, a whole day lost in firewood gathering contributes to an opportunity cost of roughly INR. 250-300 a day of daily wages.

Reduced indoor air pollution: By using clean fuel for cooking, burning that causes smoke and particulate matter are avoided, reducing indoor air pollution and associated conditions such as breathing issues, burning of eyes and so on.

Provides an organic agricultural input to improve field yield: The bio slurry production as a by-product of the biogas solution can contribute to creating local entrepreneurship opportunities for the manufacture and sale of organic slurry as fertilizers to local farmers.

Reduced deforestation: With the availability of improved, cleaner cooking fuels the use of firewood would be minimised or eliminated.

Reduced emission intensity of livestock: Better manure management reduces emissions and the emission intensity of each individual livestock.

Avoided burning of firewood: Reduced emissions of carbon and other particulate matter

Cool Sheds for reduced stress amongst animals

Increase in savings and farmer incomes: With cool sheds, there will be a reduced cost for farmers and an increased productive cohort of livestock

Reduced mortality risk: With increase disease incidences due to moisture in sheds and soil, improved sheds can offset mortality rates and increase efficiency in resource utilisation

Reduced GHG emissions through improved health: Poor health management of livestock leads to higher mortality rates which in turn doubles the investment of resources for the same yield/ production and therefore increases GHG emissions. Poor health can also affect bodily functions of certain livestock and increase their production of specific emissions that contribute to global warming.

Energy efficient appliances lead to energy savings and reduce pollution: Energy efficient appliances like lighting, dehumidifiers can reduce emissions at a per shed level

■ **Solution**
■ **Adaptation**
■ **Mitigation**

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Focus much needed on India's fodder shortage.


Source: (Scroll 2017)

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WHAT COW-LOVING NATION INDIA SHOULD ACTUALLY FOCUS ON: MAKING MORE FODDER AVAILABLE TO STARVING CATTLE

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Source: (PARI 2019)

CHIMNABAI GETS TO EAT FINALLY, WITH 8,000 OTHERS

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Sources: (PARI, 2016), (Business Line, 2020), (PARI, 2019), (The Print, 2020), (Scroll, 2017)

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Source: (Business Line 2020)

'AN ANIMAL SAVED TODAY IS AN ANIMAL EARNED TOMORROW'


Source: (PARI 2016)

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THE SHORTAGE OF FODDER IN INDIA IS THE PRIMARY CAUSE OF RISE OF MILK COST, SAYS GOVT. INSTITUTE

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SOLUTION 2

6.3A: DECENTRALISED SOLAR POWERED HYDROPONICS

PROLONGED SEASONS OF DROUGHT AND REDUCED WATER AVAILABILITY AFFECTS SMALL AND MARGINAL FARMERS' ACCESS TO GREEN FODDER FOR CATTLE FEEDING, AN IMPORTANT SOURCE OF SUPPLEMENTARY INCOME

Image 42 | Lack of feed

Lack of feed production and appropriate technologies

- India is facing an extreme animal feed shortage, which is a major factor behind the recent rise in costs of milk production. According to the report, there is a deficit of 23.4 per cent in the availability of dry fodder, 11.24 per cent in that of green fodder, and 28.9 per cent for concentrates.
- Procuring feed and fodder comprises large of input costs for livestock farmers which can be offset with on-farm production of the same.
- Feed and fodder travels long distances due to centralised production increasing emissions.

SOLUTION: SOLAR POWERED HYDROPONICS UNITS

1. In terms of feed and fodder, cattle typically require a combination of dry fodder (straw), green fodder (grass, typically through open grazing), concentrates and mineral mixtures for nutrition (oil cakes, pellets etc) and water.

2. Hydroponics fodder production units with timed sprinkler systems and powered by solar water pumping solutions for each individual farmer or for collectives can help address the need for green fodder with higher nutrition and water content, particularly in dry months, alongside:
    - reduced water requirements
    - no land requirements
    - no added chemicals
    - no dependence on grid or erratic power supply

3. This solution helps provide more nutrition for cattle, improving health and increasing dairy yield by more than one liter per day per cattle. It also contributes to increased fat content in milk resulting in higher income levels per liter. The larger impacts and benefits of the system are outlined in the section below.

4. This is done by growing seeds without soil and with minimal water over a period of seven days where seeds sprout seedlings that grow upto a height of about 1.2ft. In advanced hydroponics, specific quantities are sprayed through nozzles/ sprinklers in a timely manner. In some cases this water may include organic nutrients to substitute those provided by the soil in traditional farming. (through consultations with hydroponics manufacturers).

Image 43 | Solar powered hydroponics unit by SELCO

Image 44 | Solar powered hydroponics unit by SELCO

TECHNOLOGY: INEFFICIENT CENTRALISED FEED PRODUCTION VS EFFICIENT DECENTRALISED SOLAR POWERED HYDROPONICS UNITS

1. **Technologies that make up a hydroponics unit:**
   - a. Unit size: 7 racks/ levels of 4 trays each (i.e. 28 trays)
   - b. Sprinkler system with timer
   - c. Input seeds: Typically Maize; Input requirement is between 750gm- 1kg per tray
   - d. Water requirements: Roughly 7-10 liters of water per day
   - e. Space requirements: 13-14 sq ft floor space and height of 7 feet.

2. **Solar water pumping solution:**
   - f. Solar panel module of 40W
   - g. Battery capacity of 40Ah
   - h. Diaphragm pump of about 50-60W
   - i. Timer for the sprinkler system

CENTRALISED VS DECENTRALISED

Local Context and Business Models:

- The type of livestock that farmers have would have certain feed and fodder requirements. The climate risks that various regions have also determine how much fodder can be grown and with remoteness, procuring feed also is a challenge. Local contexts can tell us about the size and scale of operations and the energy scenario will determine the system design.
- For example, individual small and marginal farmers who own the hydroponics unit would require a system to grow adequate green fodder to meet the requirements for the two to four numbers of cattle they own. Dairy cooperatives and collection centers whose primary activity is typically the collection, treatment and sale of milk and dairy products would need larger systems to provide input linkage like feed to farmers.

The scale of operations: This is the fundamental difference between centralised and decentralised feed production. The size of hydroponics unit is also determined by the livestock size

- Hydroponics challenges the source of nutrition of the cow. Centralised units produce processed feed which increases milk yield in cows. However, hydroponics provides the same nutrition in a very different way which is through micro greens (70% maize). Centralised feed is of poor quality as it does not have as much nutrition and they mix other things to produce a mixture.

A total quantity of 80,000,000 MT of feed is required per year to feed India's cattle which if replaced with decentralised solar powered hydroponics units, can reduce 14,310,495,733.333 kWh of energy units per year. This has a GHG mitigation potential of 344.45 kgCO2e/unit/year.

Image 45 | Fodder harvesting in progress

Image 46 | Hydroponics fodder in different growth stages

OWNERSHIP AND DELIVERY MODEL 1

Rural, small and marginal dairy farmers:

Who own the hydroponics unit and have reduced input costs of procuring feed from distances.

Ms. Rathnamma of G. Kothapalli village, Anantapur district, Andhra Pradesh, South India

Climate Risk:

- Drought prone region,
- Low and erratic rainfall
- Depleting water levels

Main sources of income:

- Agriculture- typically single rainfed cropping season, growing groundnut, redgram, some fruits (as part of a multi-cropping sustainable agriculture programme)
- Dairy farming (2-4 cows/ buffaloes)

Problem and Solution:

In the absence of open grazing in pastures, and inability to purchase expensive green fodder, the hydroponics unit has given individual farmers the option of growing fodder at home using maize seeds, with minimal water inputs.

OWNERSHIP AND DELIVERY MODEL 2

Dairy cooperatives and collection centers in drought prone regions

Running it as a service model, they can charge local farmers a small fee and provide linkage to good quality nutritious feed locally

YH Dairy (owned by Mr. Srinivas), Chitradurga district, Karnataka, South India

Climate Risk:

- Drought prone region,
- Low and erratic rainfall

Main sources of income:

- Collection, treatment and sale of milk and dairy products
- Production and sale of green fodder (using hydroponics)
- Revenue from contract farming on parts of the land

Problem and Solution:

Like other drought prone regions, farmers in this region face shortages of green fodder, particularly in the dry months. By leveraging the network of dairy farmers that sell their milk at this collection center on a daily basis, this collection center has diversified their portfolio to include the sale of fodder inputs to farmers.

Image 47 | Sowing in progress at a collection centre

7,000 a litre: milking donkeys now a breeder's dream?

Source: (PARI 2020)

Source: (DownToEarth 2021)

Source: (WION 2021)

INTRANASAL COVID VACCINE PROTECTS ANIMALS FROM SICKNESS AND VIRUS

REDUCING HUMAN- CAUSED METHANE EMISSIONS BY 45% KEY IN AVOIDING THE WORST OF CLIMATE CHANGE: UN

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OVER 10,600 PIGS DIE OF AFRICAN SWINE FEVER IN THE STATE OF MIZORAM.

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Source: (The Tribune 2021)

Source: (PARI 2016)

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'AN ANIMAL SAVED TODAY IS AN ANIMAL EARNED TOMORROW'

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SOLUTION 2

6.3A: DECENTRALISED SOLAR POWERED VACCINE REFRIGERATORS FOR LIVESTOCK

IMPROVING THE HEALTH OF RUMINANTS TO CREATE CLIMATE RESILIENT LIVELIHOODS IN THE LIVESTOCK SECTOR AS WELL AS REDUCE THE SECTOR'S IMPACT ON THE ENVIRONMENT

Lack of timely vaccinations at last mile

- Effects of climate change can be felt in terms of poor health and disease susceptibility of livestock. This, combined with inaccessible vaccination services adversely affects the health and reproduction efficiency of the livestock and ruminants, reducing productive cohort of livestock causing resource wastage and increasing farmers' carbon footprint.
- Climate risks such as heat stress affects the health of livestock (eg. metabolic rate, endocrine status, oxidative status, glucose, protein and lipid metabolism, liver functionality) reducing their reproductive efficiency. Also, the changes in rainfall patterns and increase in water stress increase the spread of vector-borne diseases , food-borne diseases and the susceptibility of livestock to such diseases .
- Poor health management of livestock leads to higher mortality rates which in turn doubles the investment of resources for the same yield/ production and therefore increases GHG emissions. Poor health can also affect bodily functions of certain livestock and increase their production of specific emissions that contribute to global warming. Evaluating disease dynamics and health management is therefore critical for both mitigation of the effects of climate change as well as adaptation of livestock to climate change.

SOLUTION: SOLAR POWERED VACCINATION UNITS

1. One of the most critical aspects of livestock health management is timely and periodic vaccinations being administered to the livestock. Accessible vaccination services are very critical for the rural and small holder farmers especially in areas where the climate change impact already exists (drought/heat stress) or where there is such impending climate risk.

2. To address this, solar powered vaccine cold storage and cold vaccine carriers are designed and deployed through different decentralized delivery channels to provide last mile delivery of vaccination services. Portable vaccine cold carriers are critical for transporting vaccines from health facilities with refrigeration to reach areas where refrigeration and ice are not available.

Image 48 | A solar powered vaccination unit by SELCO

Image 49 | Medicine being adminitered to poultry

TECHNOLOGY: INEFFICIENT CENTRALISED VACCINATION UNITS VS EFFICIENT DECENTRALISED SOLAR POWERED VACCINATION UNITS AND CARRIERS

CENTRALISED VS DECENTRALISED

Local context and business models:

1. Based on the climate variations, the disease burden, the need for frequency of vaccinations would differ. Earlier with fewer diseases, vaccination units at a block or district level would be sufficient, however now that chain needs to be shortened. With last mile workers in India for livestock such as pashu sakhis, they can play an important role in decentralisation of vaccination services for communities. Based on the type of ownership model, the terrain, the number of carriers would be determined as well as the vaccination units.

The scale of operation: The fundamental difference between centralised and decentralised vaccination units are the types of technologies.

2. The efficient solar powered units relook at the type of cooling because huge centralised units are deep freezers. This in a decentralised manner while going to the last mile which as process itself is not efficient but is also expensive and prone to wastage. Both the decentralised efficient vaccine fridges and carriers use PCM based technology which is far more efficient and removes the need for ice packs completely. They charge when required as opposed to constantly which is the case with inefficient fridges.

A total quantity of 223,872,938 vials of vaccination are required per year to meet vaccination demands which if replaced with decentralised solar powered vaccination units, can reduce 31,051,176.501 kWh of energy units per year. This has a GHG mitigation potential of 3582.29 kgCO2e/unit/year

Image 50 | Chicken Coop in an Indian Village

Image 51 | Medicine administered to poultry by NGO personnel

OWNERSHIP AND DELIVERY MODEL 1

NGO or Farmer Producer Organization/ Company (FPO/ FPC) service model

Here, the asset is owned by the FPO/ FPC but placed with the village level cadre who are trained for last mile delivery of vaccination services by the FPO or the supporting local NGO. Nominal service charges paid by farmers for these services which are retained as commission by the village level cadre. Similar models can be implemented through farmer groups or local institutions/ organizations that work with local farmers.

Vikalpa NGO, Khaprakhol tehsil in Balangir district in Odisha

Climate Risk:

- Extreme sub-humid tropical climate
- Drought prone

Main sources of income:

- Works towards livelihood promotion by forming Farmer Producer Groups, Self Help Groups for horticulture, agriculture and livestock.

Problem and Solution:

Earlier, the NGO would procure vaccinations from the district headquarter which is 75 kms away from this region and some remote villages which are 20-30 kms further in. This resulted in irregular vaccination practices leading to mortality.
The solar powered 25 litre vaccine refrigerator owned by one of the producer groups is run in the form of a service model where the producer group procures the vaccines from the district headquarter, stores the vaccines and the community purchases it from them for very nominal rates i.e. INR 1 for a vaccine for chicks and INR 10 for a vaccine for goats. This resulted in increased vaccinations facilitating set up of solar powered micro enterprises offering more services to poultry farmers.

OWNERSHIP AND DELIVERY MODEL 2

Government promoted Entrepreneur Service model:

In this model, the asset is owned by the individual local entrepreneur who is also a village level Government trainee for livestock extension services ("Pashu Sakhi"). The entrepreneur then provides these vaccination services to the local farmers in the village for a nominal fee. This model may also be implemented with a Government partner through their local trainees as part of the Government veterinary service program

Morzina Khatun, Dhubri, Assam

Climate Risk:

- Flooding
- Intermittent droughts

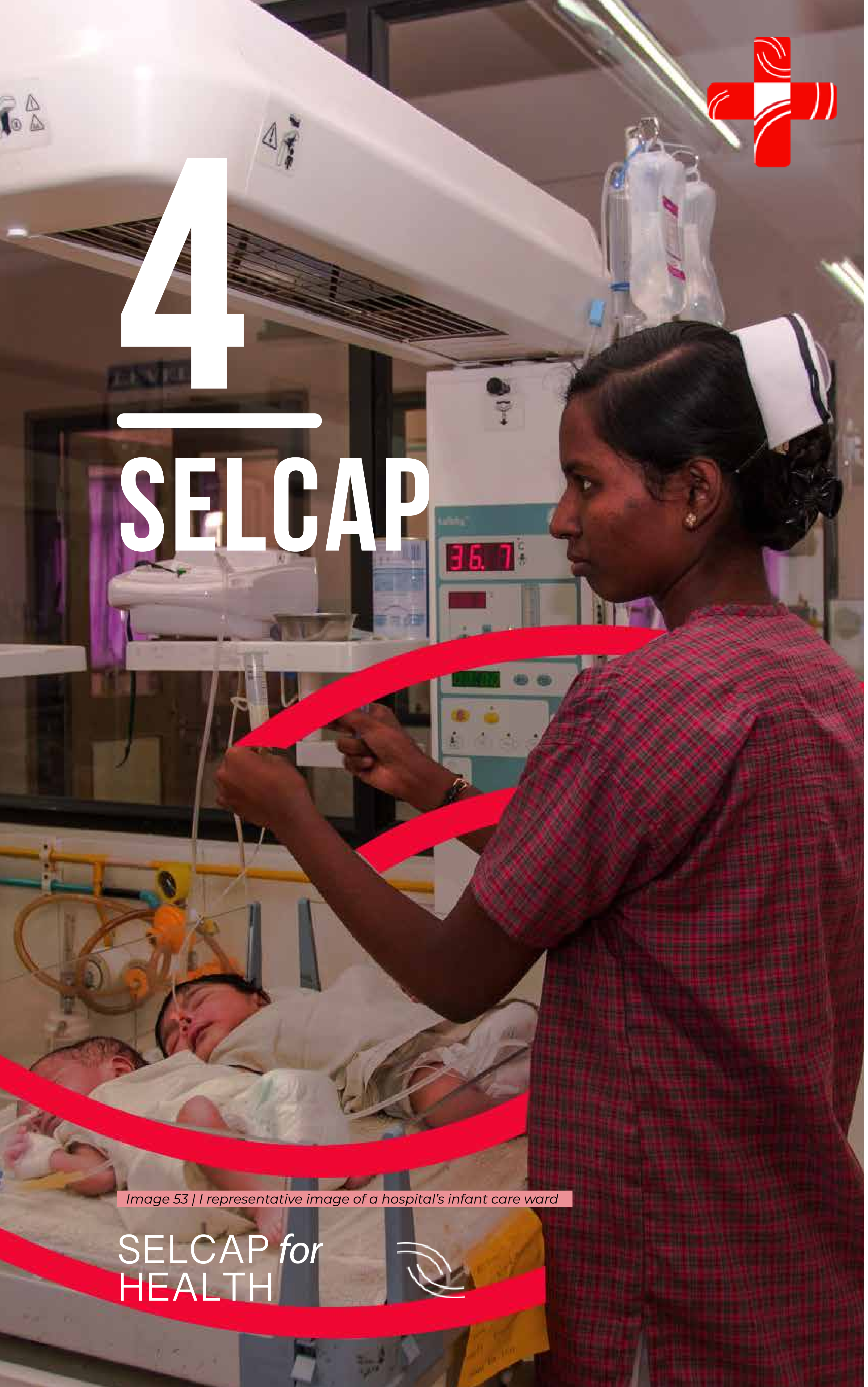
Main sources of income:

- Entrepreneur who has 2000 chickens, 500 ducks
- Works as a Pashu Sakhi at the Panchayat level for the Assam Rural Livelihood Mission. She takes care of vaccinations for livestock in her cluster, where there are approximately 5000 poultry birds.

Problem and Solution:

Morzina purchases vaccinations regularly from the nearby town to administer them to the livestock she supervises in the cluster. However, storing sufficient vaccinations has always been an issue. Post installation of the vaccine storage, she was able to vaccinate 2000 chickens, 100 goats and 500 cows. She is able to provide vaccines to the livestock in a timely manner which has resulted in reduced mortality among livestock. She is also able to store additional vaccines for PPR, FMD, Duck Cholera, Duck Pelag, Lasota etc., and provides door step services to communities.

Image 52 | Vaccines stored in solar powered refrigerator



4

SELCAP

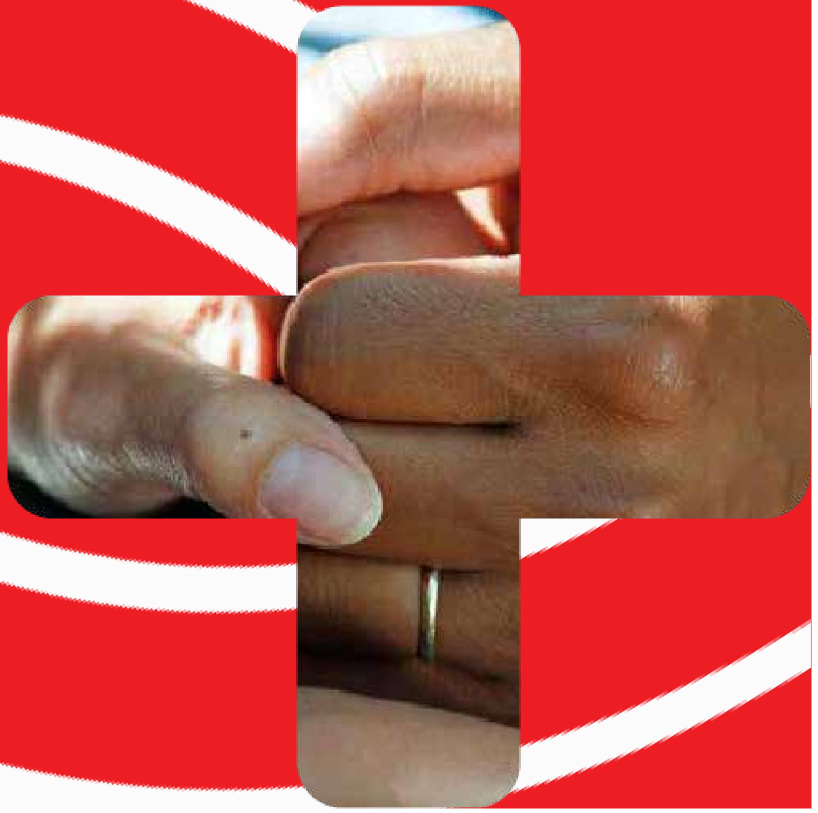
Image 53 | I representative image of a hospital's infant care ward

SELCAP *for*
HEALTH

7

SELCAP *for* HEALTH

IN ADDITION TO BEING MORE EXPOSED TO THE IMPACTS OF CLIMATE CHANGE, VULNERABLE COMMUNITIES ALSO FACE A DISPROPORTIONATE BURDEN OF THE HEALTH IMPACTS DUE TO THE INABILITY OF THE HEALTH INFRASTRUCTURE TO CATER TO THEIR NEEDS.



7.1 Health, Poverty and Climate Change

The World Health Organization recognises that rapid demographic, environmental, social, technological changes are likely to accelerate the spread of several infectious diseases. Combined with the health impacts of extremes in temperature, and in climatic and weather events, they have the potential to cause a severe strain on the health care system, particularly in growing economies with adverse implications for the poor (WHO n.d.).

The Lancet has called Climate Change as the "biggest global health threat of the 21st century (Wang and Horton, 2015)."

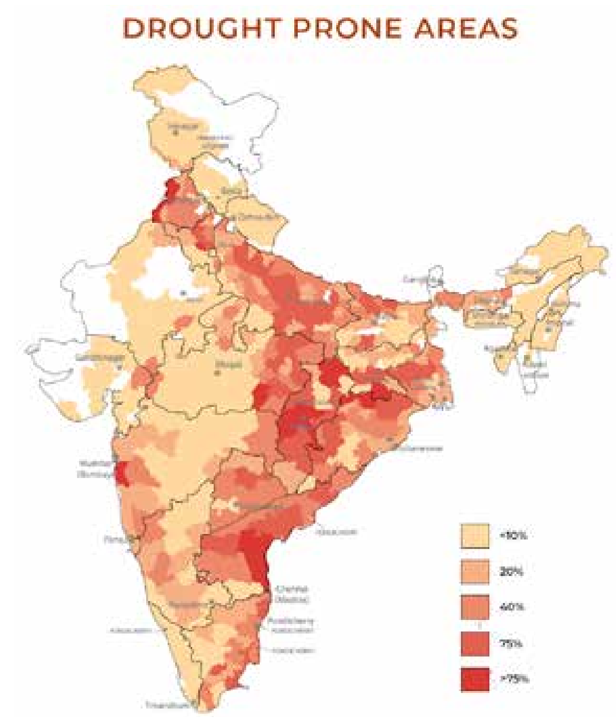
Climate change affects human health in two main ways:

- first, by changing the severity or frequency of health problems that are already affected by climate or weather factors;
- second, by creating unprecedented or unanticipated health problems or health threats in places where they have not previously occurred (USGCRP, 2016).

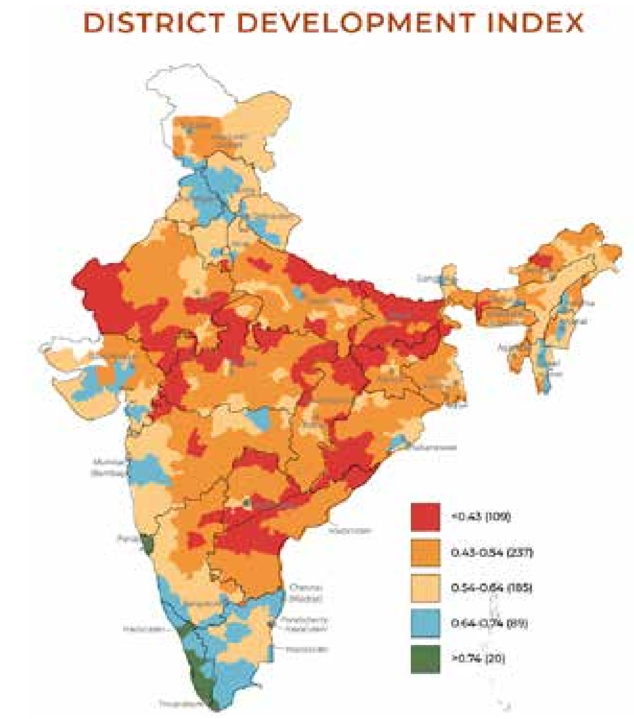
Image 54 | Representative image of Villagers waiting at a local health camp

Image 55 | Village woman trained as a PHC worker attending to patients

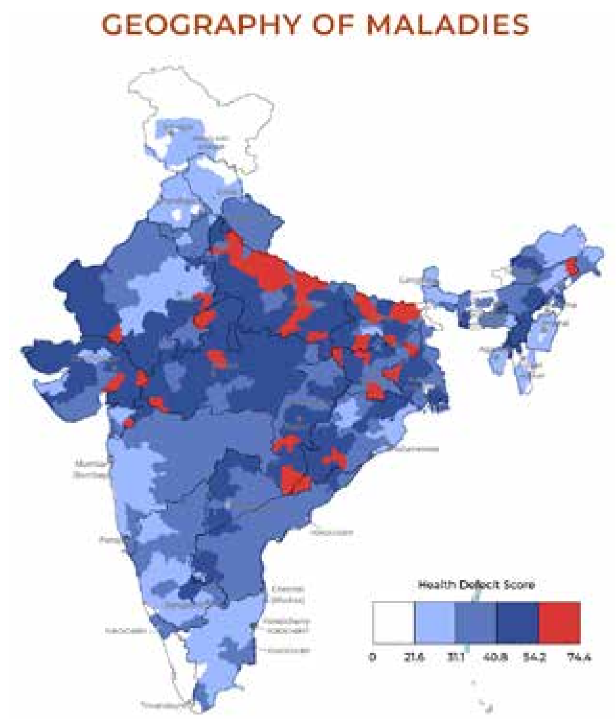
7.1a Climate Change Increasing Health Burden for the Poor



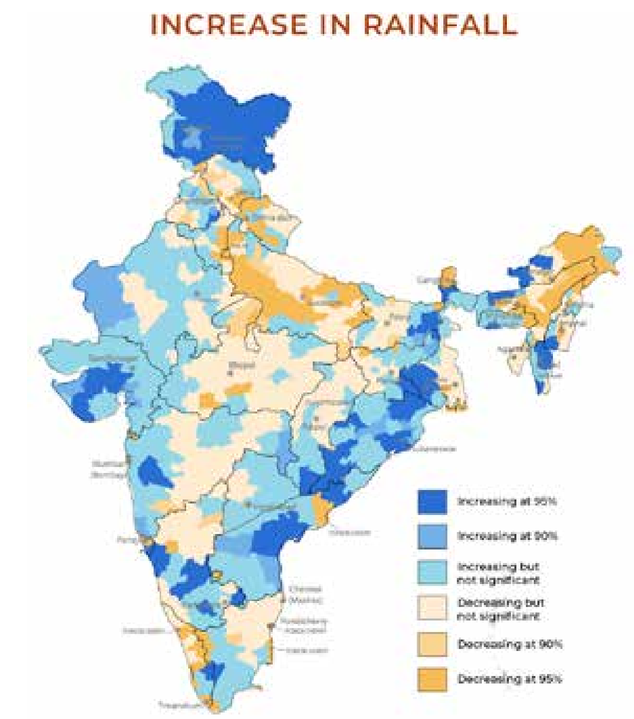
Adapted from (Kannan, Paliwal, & Sparks, 2017)



Adapted from (Mohanty, et al. 2019)



Adapted from (Mint 2018a)



Adapted from (India Climate Dialogue, 2018)

A recent report published on the impact of climate change on maternal and child health expands on the indirect impacts of climate change on the health of vulnerable populations interact through a broad range of mechanisms and may have far-reaching social, economic and health consequences.

- **Heavy precipitation** may lead to floods, resulting in damage to infrastructure and critical services, crop loss, population displacements and disrupted access to maternal and child health services.
- **Shortage of safe water** and sanitation may lead to an increase in diarrheal disease, gastrointestinal parasite infections and cholera outbreaks.
- **Drought** may lead to failed crops and livestock deaths, and consequently malnutrition and household poverty, further increasing the nutritional gap in low- and middle-income countries in women of reproductive age and neonates who are at greatest risk.
- **New internal displacement patterns** are of increasing concern due to climate change and climate-related disasters.
- **Competition** over depleted natural resources can in turn spark conflict between communities.
- **Other indirect consequences** of climate change may be altered disease patterns and an increase in vector-borne diseases such as malaria, dengue and schistosomiasis, which are important complicating infections during pregnancy, malaria in particular (Roos, et al. 2021).

Image 56 | Infant health detriorating due to heat stress

● Individuals accessing healthcare services

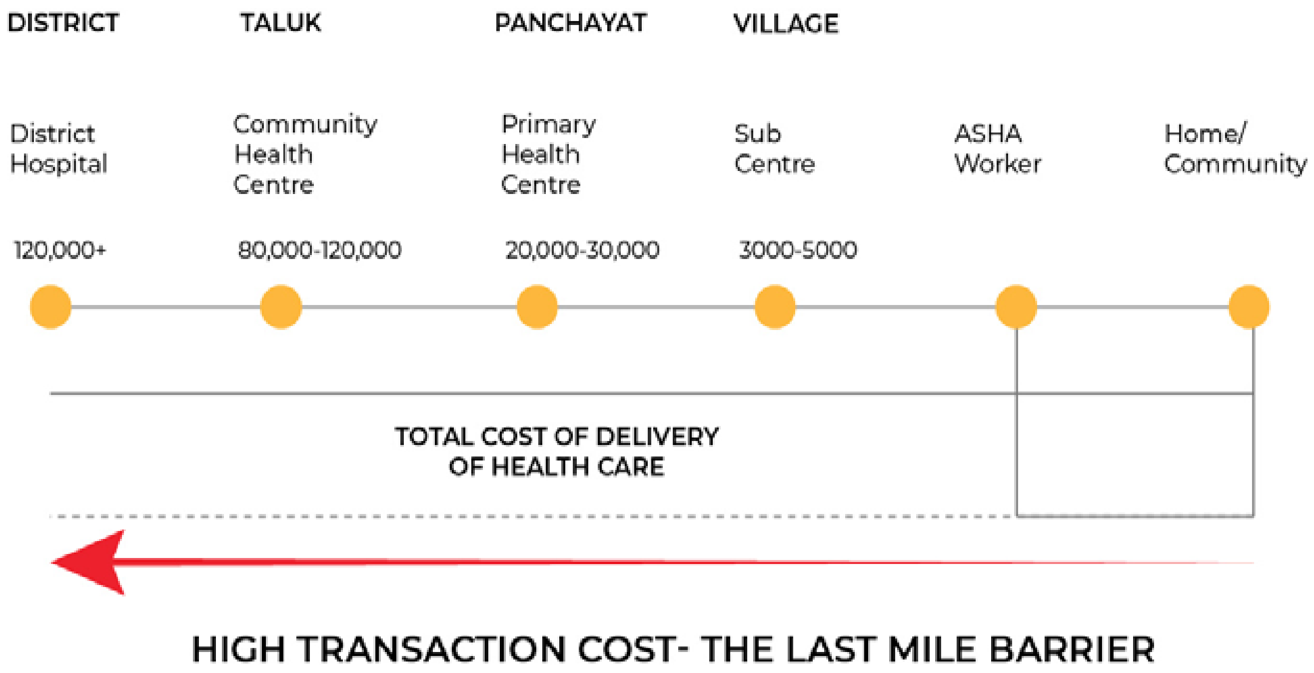
✚ Doctors present for treatement

✙ Community Health Workers/ Medical Assisstants

⚡ Availability of Reliable Power

💰 Cost of Accessing Healthcare

In addition to being more exposed to the impacts of climate change, underserved communities also face a disproportionate burden of the health impacts due to the inability of the health infrastructure to cater to their needs. **Affordable and equitable access to healthcare is a function of two aspects- one, resources required to deliver health care, and two, cost of accessing health care. In our design of health systems, the latter is often not prioritised.** Those living in poorly resourced regions with a poor health infrastructure have to "save up" in a condition of sickness, in order to afford the cost of a long distance trip for a simple medical check-up. The distance that they cover can be as high as 25-30 kms, with little or no transportation infrastructure. A visit to the nearest working health centre is a day's commitment- worrying the sick (and their families) of lost incomes or even lost employment because of a day of missed work. Nearly 86% of all the medical visits in India are made by rural populations with the majority still travelling more than 100 km to avail health care facilities of which 70-80% is born out of pocket landing them in poverty. Thus, even if health care services are "free", the transaction costs of travel, lost wages, home care, etc. are borne by those least able to afford it and most vulnerable.



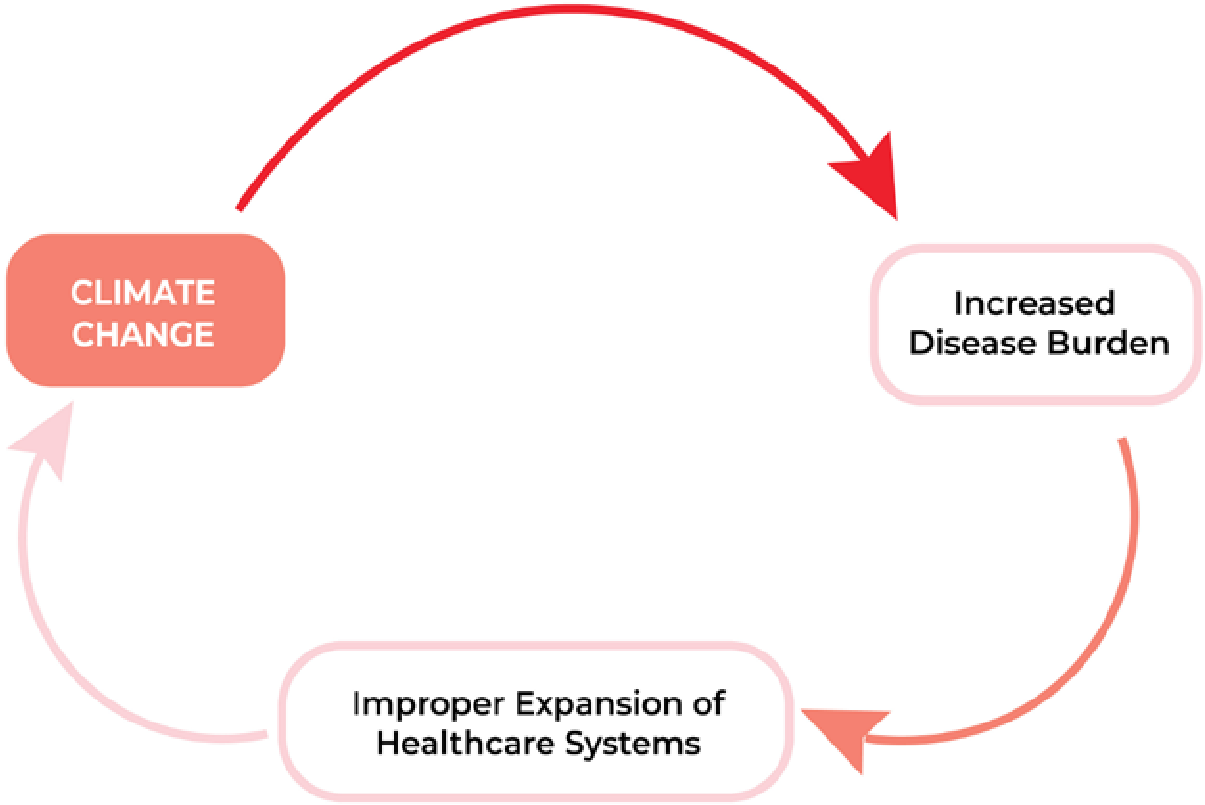
In order to equip the last mile communities with the health infrastructure to be able to adapt to the health challenges of climate change, access to health care as well as quality of health care needs to be improved in low resource contexts.

Image 57 | Woman getting a routine health check up in a mobile medical van

7.1b Health Sector as a Contributor to Climate Change

In September 2019, Health Care Without Harm and Arup issued Green Paper One, Health Care's Climate Footprint which reported that healthcare climate footprint to be 4.4% of net global greenhouse gas emissions. **If the healthcare sector was a country, it would be the fifth largest emitter on the planet. To provide context, this global health care climate footprint is equivalent to the annual greenhouse gas emissions from 514 coal-fired power plants.** When measured across the sector, combustion of fossil fuels was found to make up for more than half of the emissions. US, China and countries of the EU account for 56% of the climate footprint of the health sector. The US health sector, the world's number one emitter in both absolute and per capita terms, produces 57 times more emissions per person than does India. While India has the seventh largest absolute health sector climate footprint, it has the lowest health-related emissions per capita of all 43 nations considered in the study (Healthcare without Harm & Arup 2019) .

Additionally, according to the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), the average hospital uses 2.5 times the amount of energy as other commercial building types. This is largely due to 24/7 operation, inefficient medical equipment, and inherently high requirements for energy and clean water resources. **Energy is a critical resource in a healthcare facility, where a disruption in power supply can be life threatening (Gudehouse Insight, 2018).**



There is a clear link between those countries facing severe climate threat, those that need to make the most progress towards universal health coverage, and those which are emitting less per capita. Increase in emissions, while increasing access to health is inevitable, but there is a need to de-link the two.

7.2 Innovation Gaps: Access and Quality of Healthcare

In the past few years, evidence has been emerging that expanding healthcare infrastructure alone does not necessarily result in improved health outcomes. A Lancet report states that access is no longer the only binding constraint for improving survival in Low and Middle Income countries— health systems quality must be improved simultaneously. It further reports that almost 122 Indians per 100,000 die due to poor quality of care each year.

Apart from poor quality care, insufficient access to care caused a major share of deaths from cancer (89%), mental and neurological conditions (85%), and chronic respiratory conditions (76%) (Guidehouse Insights, 2018).

Lack of access of public healthcare infrastructure in many cases also means high health expenditure for the poor- 51% of households in India went to private facilities for healthcare, with 80% citing at least one quality concern (India's District Level Household and Facility Survey). **A quality concern was defined as mentioning any of the following as a reason for bypassing government facilities: inadequate infrastructure, doctor not available, absent health workers, poor quality, drugs not available, inconvenient hours, long wait time, or distrust (IndiaSpend, 2018a).**

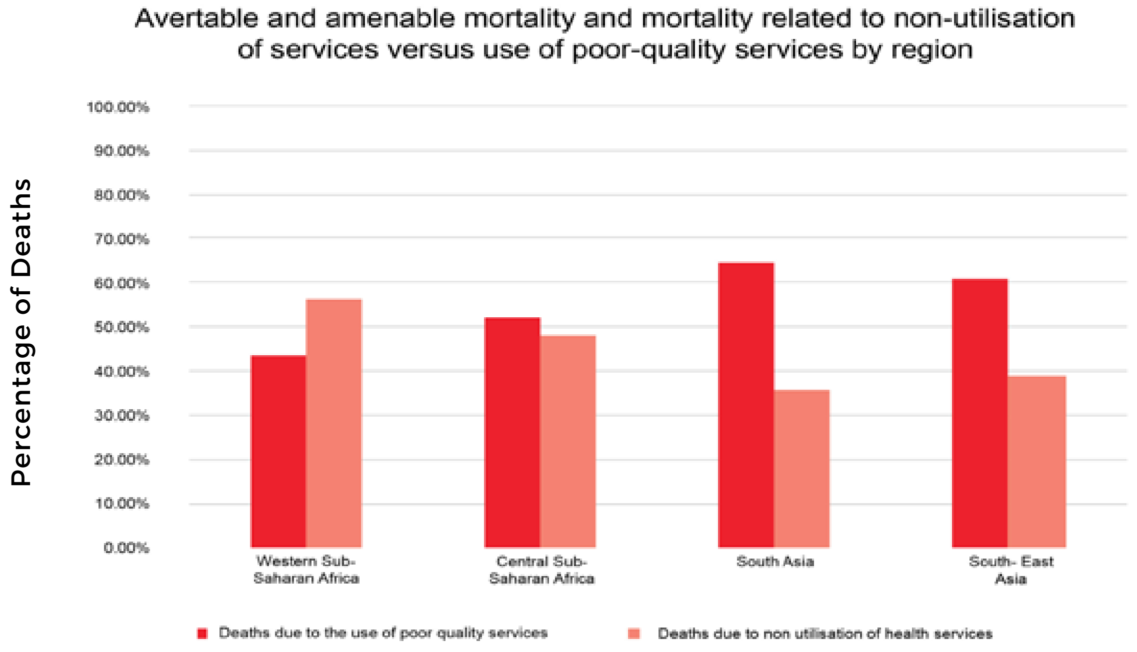


Table : Avertable and amenable mortality and mortality related to non-utilisation of services versus use of poor-quality services by region

Avertable mortality was defined as the sum of preventable deaths (averted through public health and other population-level intersectoral policies or interventions that prevent the disease or condition in the first place) and amenable deaths (averted by health care once a condition occurs). Amenable deaths comprised deaths due to use of poor-quality services and deaths due to non-utilisation of health services (Kruk, et al. 2018).

Deaths amenable to healthcare in India:

- Deaths due to poor quality of care- 1,599,870
- Deaths due to non-utilisation of health care services- 838,473

Climate Resilient Health Infrastructure

Risks associated with climate change can impact the disease burden in a particular geography (or for a particularly vulnerable population), and also disrupt the functioning of the health centres. For example, flooding can cause significant damage to hospital medical equipment while contaminating available water sources (WHO, 2020). Stagnant water can also result in spreading of water-borne diseases, with a higher transferability rate amongst economically and socially poor communities living in highly dense habitats.

Assessing costs of extreme weather events: Kerala, India (WHO, 2020)

Extreme weather events can increase health system costs in a number of ways. By disrupting health care facilities, including their infrastructure and supply chains of essential food, medicines and other equipment, they increase capital, operating expenses and other costs.

The 2018 floods in Kerala, India greatly impacted the public health system in the state. Backup power is set at 72 hours in many countries. In Kerala, hospitals faced power outages anywhere from three to nine days causing inadvertent shutdown of cold storage systems. Many hospitals reported damage to entire stocks of vaccines and other essential refrigeration-dependent medical supplies, along with damage to computer equipment with several hospitals losing patient records. The Directorate of Health Services estimated a loss of over US$ 15 million to government hospitals.

Another example is the impact of heat stress in maternal and child care. Pregnancy and neonatal periods are characterized by physiological and anatomical changes which decrease the ability to thermoregulate. A large number of studies suggests an association between heat exposures and the risk of preterm birth, premature rupture of membranes, low birthweight and stillbirth. Low birthweight infants have increased susceptibility to a series of complications, including infections. In addition, dehydration from increased sweating as part of thermoregulation in pregnant women can trigger the onset of early labor and prolong duration of labor (Roos, et al. 2021).

It is important to note that climate change is challenging the current health infrastructure and points of health care delivery. Ensuring monitoring and diagnostics at the last mile, supervised deliveries and increase in number of water and vector borne diseases, non communicable diseases due to undernutrition and food security is a key challenge that need to be accounted for in the re-design of health infrastructure.

As the health sector looks towards expanding its reach to achieve Universal Health Coverage[6], the sector must decouple this growth from its climate emissions. The sector must reinvent ways to deliver quality care and follow a need based approach which is driven by challenges of the geography, disease burden, specificities of the demography etc. The health sector must also simultaneously build resilienc - facility resilience and systems resilience, while enhancing its role as an integral member of many communities to serve as an anchor for community, climate and economic resilience (Health Care Without Harm n.d.).

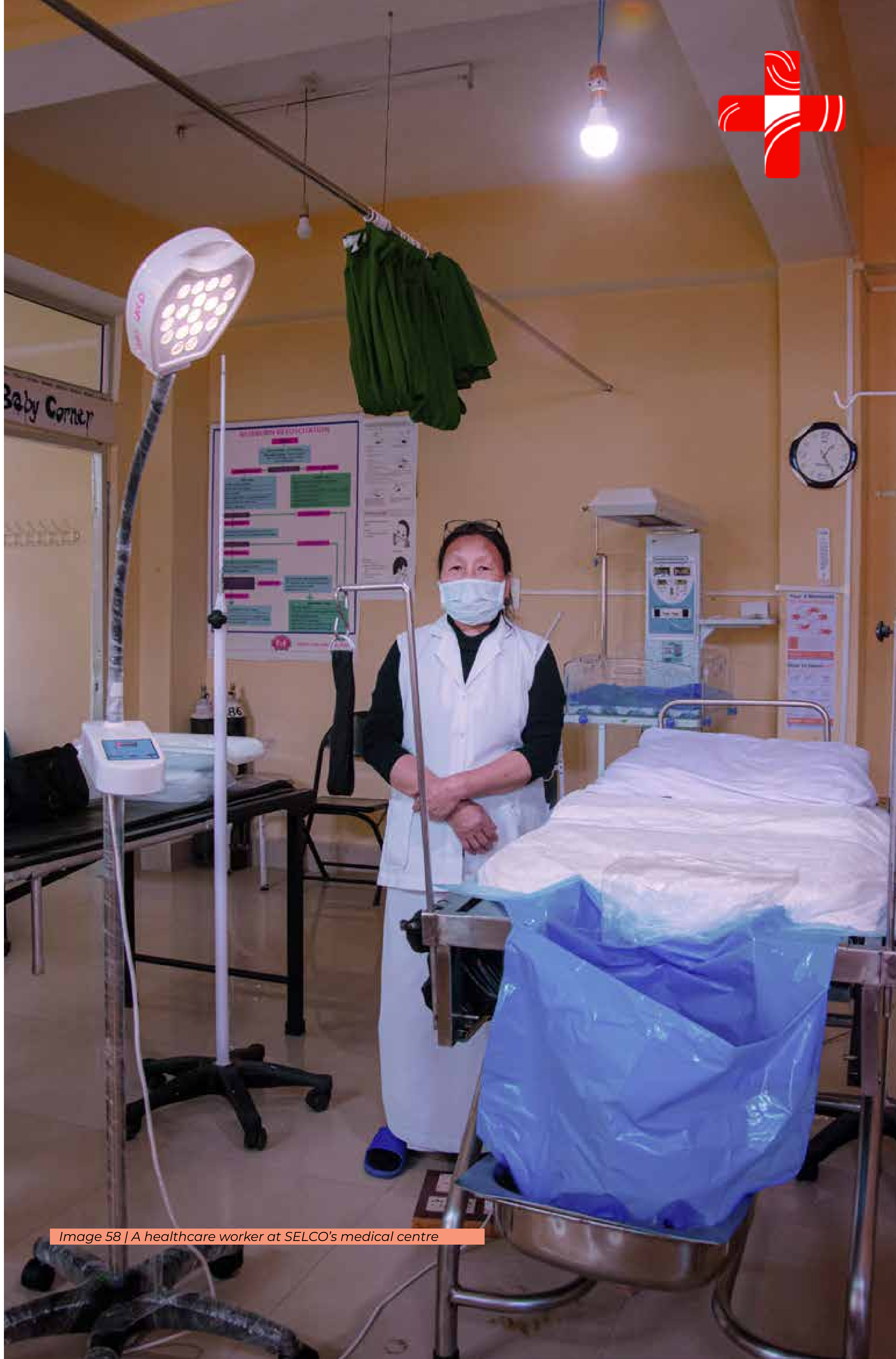


Image 58 | A healthcare worker at SELCO's medical centre

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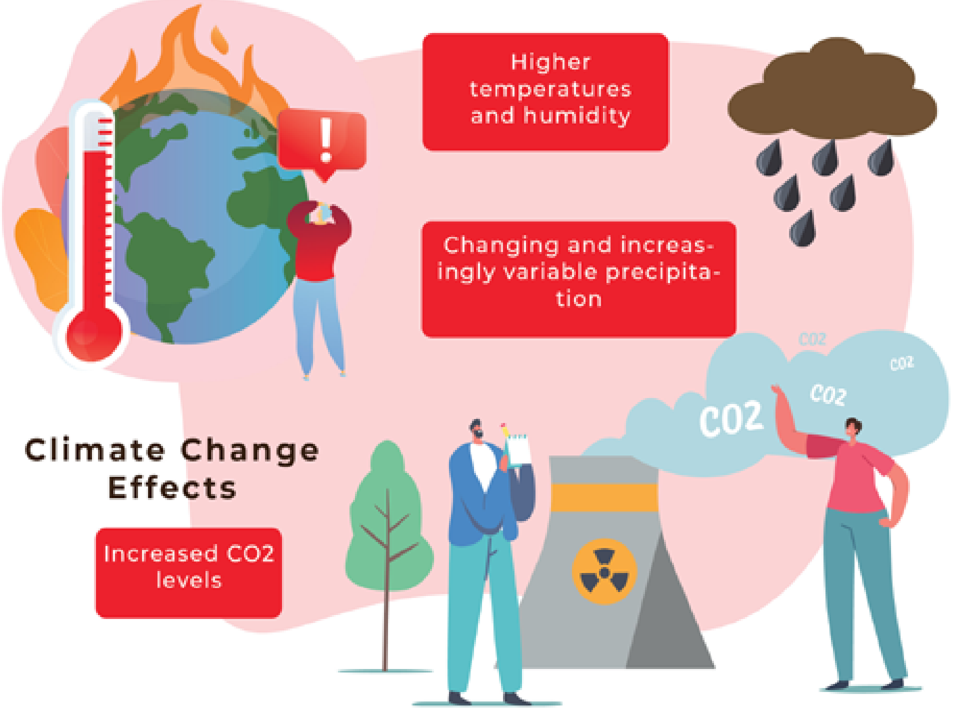
6 - Universal Health Coverage (UHC) is firmly based on the 1948 WHO Constitution, which declares health a fundamental human right and commits to ensuring the highest attainable level of health for all. Under this program, WHO supports countries to develop their health systems to move towards and sustain UHC, and to monitor progress. Source: https://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-(uhc)

CHALLENGES: HEALTH

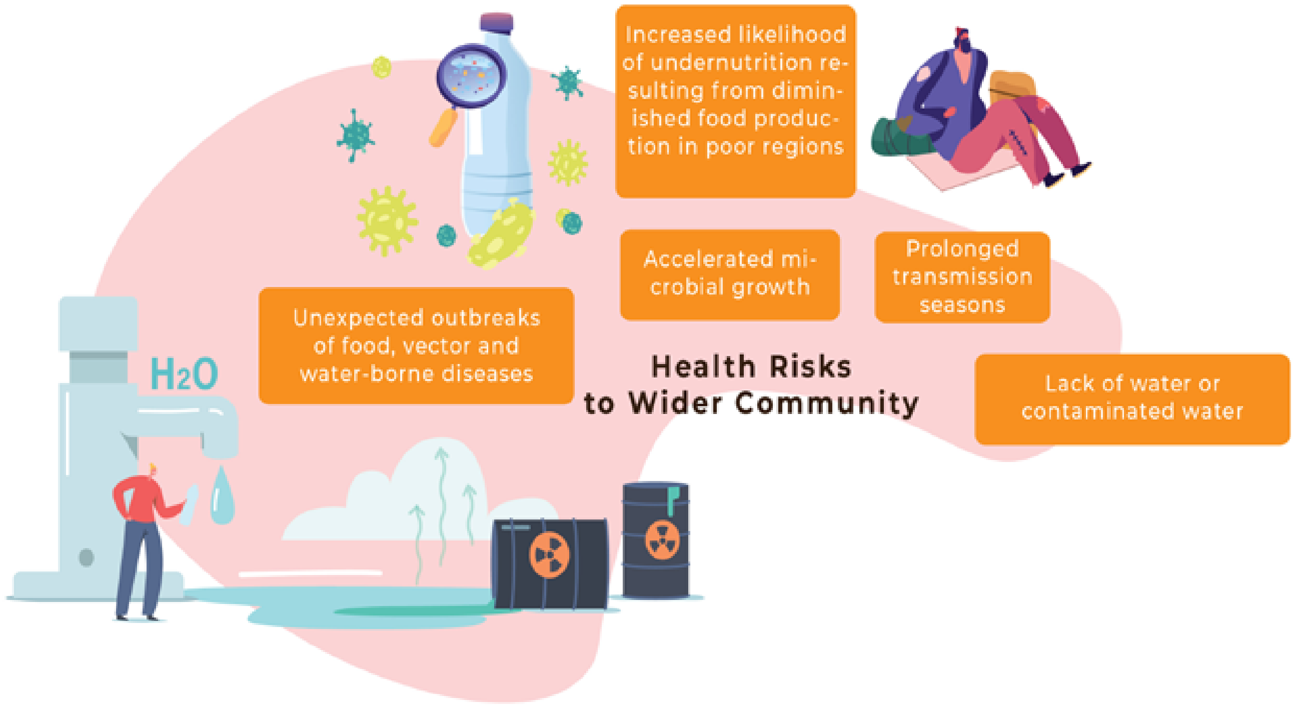


Climate Change Effects

Higher temperatures and humidity

Changing and increasingly variable precipitation

Increased CO2 levels



Health Risks to Wider Community

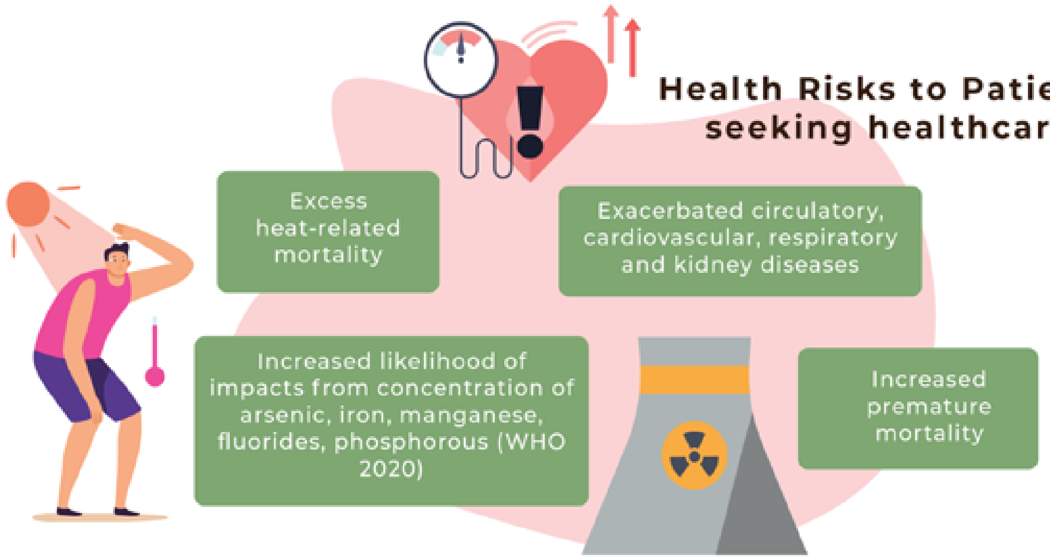
Increased likelihood of undernutrition resulting from diminished food production in poor regions

Unexpected outbreaks of food, vector and water-borne diseases

Accelerated microbial growth

Prolonged transmission seasons

Lack of water or contaminated water



Health Risks to Patients seeking healthcare

Excess heat-related mortality

Exacerbated circulatory, cardiovascular, respiratory and kidney diseases

Increased likelihood of impacts from concentration of arsenic, iron, manganese, fluorides, phosphorous (WHO 2020)

Increased premature mortality

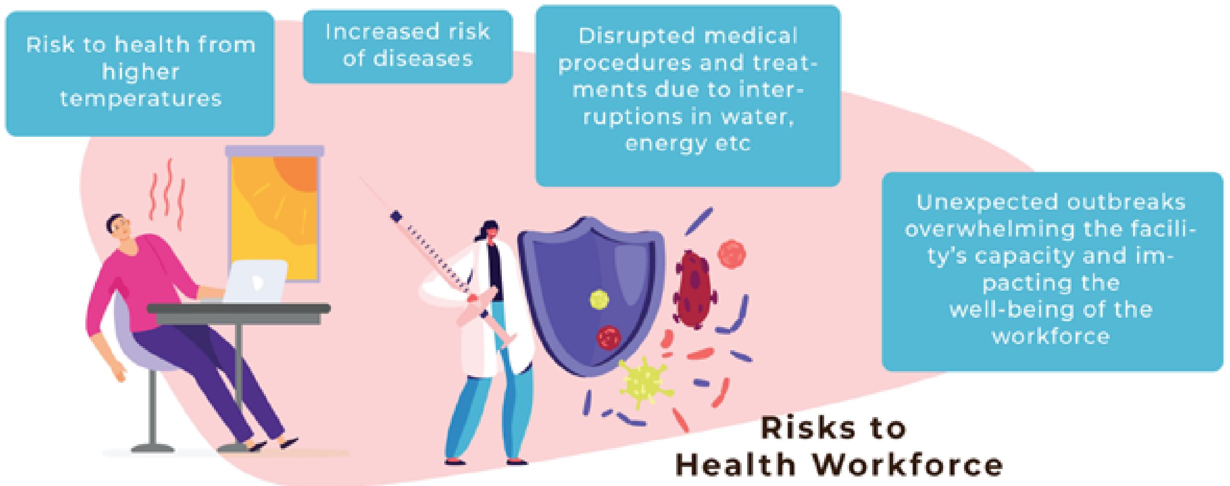
Health Risks to Marginalised Communities

Increased incidence of heat exhaustion, heat stroke and bed sores in elderly population, and persons with disability

Increased premature skeletal and tissue disorders due to water contamination

Increase in premature deliveries and high risk pregnancies

Increase in malnutrition amongst children



Risks to Health Workforce

Risk to health from higher temperatures

Increased risk of diseases

Disrupted medical procedures and treatments due to interruptions in water, energy etc

Unexpected outbreaks overwhelming the facility's capacity and impacting the well-being of the workforce

🟥 Climate Change Effects

🟧 Health Risks to Wider Community

🟩 Health Risks to Patients seeking healthcare

🟥 Health Risks to Marginalised Communities

🟦 Risks to Health Workforce

POINTS OF INTERVENTION: HEALTH

India currently reports a high CDD per year of 3000-4500.[1]

Many of the Primary Health Centres and Sub-centres lack optimised cooling solutions. In remote locations, metal roofing traps heat further increasing the temperatures.

Space Cooling

Space cooling in the health sector is not just pertinent for the well-being of health care workers and patients; it is also a requirement in delivering critical health services and maintenance of medical equipment.

The healthcare climate footprint is reported to be 4.4% of net global greenhouse gas emissions. This is equivalent to the annual greenhouse gas emissions from 514 coal-fired power plants.

The climate impact from hospital cooling alone is significant and rising. Globally, roughly 365 Mt CO2e (+/- 90 Mt) annually comes from hospital cooling which is equivalent to the emissions from over 75 million cars on the road or 110 coal-fired power plants for an entire year.

70% of the medical decisions are based on diagnostics.[5]

Heavy medical bills and premature deaths can be prevented by expanding preventive care.

Laboratory and Diagnostics

With growing disease burden due to climate change, early diagnostics and monitoring of systems for optimised health care delivery becomes critical.

As per a survey, there are only around eight diagnostic labs per 100,000 people in India and diagnostic facilities have a very low reach in small towns and villages.

Immunization

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.[4]

In 2014, a study across a number of Gavi (The Global Alliance for Vaccines and Immunizations)-eligible countries showed that up to 90% of health facilities were not equipped with adequate cold chain equipment.[3]

Other Specialised Care

With growing disease burden in rural areas due to malnutrition, air and vector borne diseases (diabetes, cardiovascular, cancer etc), there is a need to expand beyond primary care and develop infrastructure for specialised care delivery in rural areas.

Maternal and Child Care

A large number of studies suggests an association between heat exposures and the risk of preterm birth, premature rupture of membranes, low birthweight and stillbirth.
Low birthweight infants have increased susceptibility to a series of complications, including infections.

With more high risk pregnancies, access to supervised delivery and access to medical appliances for diagnostics and treatment is critical.[2]

Air pollution has also been shown to increase the risk of low birthweight infants and preterm birth.

Preterm birth represents 11% of all births globally and 35% of all neonatal deaths, and is hence the leading cause of neonatal death globally and a significant contributor to long-term ill-health.

Additionally, with no space cooling in most of the public health centres accessible to the poor, dehydration from increased sweating as part of thermoregulation in pregnant women can trigger the onset of early labor and prolong duration of labor.

🟧 **Gaps and Growing Demand**
◻ **Points of Intervention**
◼ **Adaption**
🟥 **Mitigation**

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1 (Hovland Consulting LLC & Health Care Without Harm 2018)
2 (Roos, et al. 2021)
3 Bill & Melinda Gates Foundation analysis based on data from 57 Gavi-eligible countries, 2014
4 (University of Birmingham n.d.)
5 (Medical Buyer 2018)

7.3 Healthcare Solutions for a Climate Smart and Equitable Future

As the world progresses and urbanizes, the focus in the health sector has been skewed towards technological advancements in city/urban settings and less on diversification of its utilization across all financial segments of the society, particularly remote, rural areas. The innovations on technology and services, and the corresponding resources have been focussed more on specialised care and needs of the more developed communities. This approach assumes that human, financial resources and energy will be in abundance, which is not always true. It has also resulted in a system which is more and more centralised, increasing the inequality of services offered to communities living in smaller towns or rural geographies.

The solution presented here set out an approach for rapid transformations towards low-carbon and optimised health delivery solutions- one which prioritises both reducing health sectors contribution towards climate risks, as well as improved delivery of reliable health care for the under-developed and poorly resourced.

Image 59 | Medical Diagnostics at SELCO's medical centre

7.3a Energy Efficiency and Sustainable Energy for Last Mile Healthcare

It is estimated that tens of thousands of health centers across low- and middle-income countries either have no grid or one that supplies unreliable electricity. For example, one in every two primary health centers in India are either un-electrified or suffer from irregular primary supply. Many health facilities depend on expensive, polluting and inadequate alternatives such as diesel generators or kerosene lamps. A similar number of hospitals suffer from frequent and debilitating blackouts. This helps explain why infrastructure – including electricity – is the main driver behind the additional US$274 billion in spending needed per year by 2030 to make progress towards Sustainable Development Goal 3 (Health). And yet closing this health access gap by 2030 will not be possible through existing electrification targets (Adair-Rohani, Lewis and Porcaro 2018). Further, electrification target, will lead to future climate and health emergencies.

The health-related SDG has focused the world's attention on the need for expanded access to skilled care, essential medicines and medical technologies for priority diseases and health conditions. Attention has to be centered around the specific need for energy that cuts across all of the gaps in healthcare today, while also optimising for a climate smart future.

It is also often assumed that electrification itself can catalyze appropriate health services. These presumptions could lead to more expensive solutions, as they dont optimise on consumption of energy as per the health need in the region; thereby resulting in higher emissions, and further exaggerated climate crisis. **Decentralised Renewable Energy combined with efficiencies of medical technologies can be one of the most critical components to democratize the delivery of health around the world.** If implemented in the right way, a sustainable energy access ecosystem approach can result in not just improvement in the energy gap in the health infrastructure, but improvement and decentralization of the health infrastructure itself because of innovations triggered by energy access. It is often naively assumed that electrification itself can catalyze appropriate health services. These presumptions could lead to more expensive solutions that then hinders the replication and scalability of sustainable delivery models.

Background: Last Mile Healthcare and Sustainable Energy

The public healthcare system in India can be broadly envisaged as a three-tier structure comprised of primary, secondary, and tertiary healthcare facilities. In rural India, primary healthcare is provided through a network of Sub Health Centres (SHCs), Primary Health Centres (PHCs), and Community Health Centres (CHCs). As of 31st March 2019, there are 157,411 SHCs, 24,855 PHCs and 5335 CHCs in rural areas which are functioning in the country.[7]

The Sub Centre is the first contact point between the primary health care system and the community. The centres are assigned tasks related to interpersonal communication to bring about behavioural change and provide services in relation to maternal and child health, family welfare, nutrition, immunization, diarrhoea control and control of communicable diseases programmes. PHCs on the other hand, have an extremely important role to play as they are the first contact point between the village community and the medical officer. The PHCs are envisaged to provide an integrated curative and preventive health care to the rural population with emphasis on basic medical care, maternal, neo-natal and preventive care.

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7 - Rural Health Statistics, 2018-19.

According to government statistics, more than 39,000 SCs and nearly 800 PHCs still operate without any access to electricity. Beyond the number of unelectrified health facilities, a study analysing the District Level Household and Facility Survey (DHLS-4) indicated that in as many as 11 out of 29 states, the number of PHCs with access to regular electricity supply were below the national average of 50 per cent.[8] The same study also states, "Eighty-one percent of PHCs with regular electricity access provided delivery services, while only 33% of PHCs with no electricity connection were able to provide the same", highlighting linkages between improved energy reliability and service delivery.

The key challenges include:

1. **Unreliability affecting service delivery:** One in every two primary health centers in India are either un-electrified or suffer from irregular power supply and in more remote regions, there are frequent and debilitating blackouts. Unreliable access to electricity leads to vaccine spoilage, interruptions in the use of essential medical and diagnostic devices, and lack of even the most basic lighting and communications for maternal delivery and emergency procedures.
2. **Cost implications:** Many health facilities depend on expensive, polluting and inadequate alternatives such as diesel generators or kerosene lamps to overcome the issues with unreliability and enable service delivery. The operational hours of these generators are restricted due to inadequacy of funds for diesel. In addition, sometimes in remote locations, and during any kind of disaster the supply of diesel remains heavily interrupted.

One of the effective ways to provide reliable energy to rural health centres is via decentralized renewable energy systems coupled with low power using medical devices and more efficient built environment solutions.

a. Energy efficient equipment including basic lighting, fans, refrigerators etc. and medical equipment can optimize the capacity of decentralized PV systems and make them more affordable for healthcare facilities.

b. Powering these equipment on decentralized solar PV systems can ensure greater reliability and can be customized for each facility according to the health needs of the local areas.

c. Redesigning health centers with efficient daylighting and ventilation can alleviate issues of extreme heat, cold etc. and lead to better design of power systems required for the PHCs.

The table below captures the main services at the primary health care level and highlights activities that are dependent on reliable electricity.

Primary Health Care Services	Activities reliant on Energy Access and efficiency	
Medical care and basic diagnostic services: This, including 24 hours emergency services, OPD and in-patient services, laboratory and diagnostic services	Medical procedures, monitoring community health and disease prevention, including customized lighting for operations, autoclave sterilizers for instruments, microscopes, centrifuge, Non-Communicable Diseases kits.	Space cooling and heating, through energy efficiency and green building designs Other general needs including lights, fans, computers, mobile charging stations, water pumping and purification systems.
Maternal and Child Health Care, including Family Planning and Immunization: Antenatal Care, Intra-natal care: (24-hour delivery services both normal and assisted), Postnatal Care, Newborn Care, Nutrition and immunization services, Medical Termination of Pregnancies, sexual health	Maternal and child health care needs such as baby warmers, suction machines for deliveries, phototherapy etc. Immunization and cold storage, which includes deep freezers and refrigeration to store drugs, blood, vaccines and medicines.	

DRE solutions can further boost the government's national program - National Rural Health Mission, where the primary aim is to establish a fully functional, community-owned, decentralized health delivery system with inter-sectoral convergence at all levels.

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8. Data from the fourth round of the District Level Household and Facility Survey (DLHS-4)

Appropriate Technology Design: Energy efficient appliances and appropriate solar energy systems

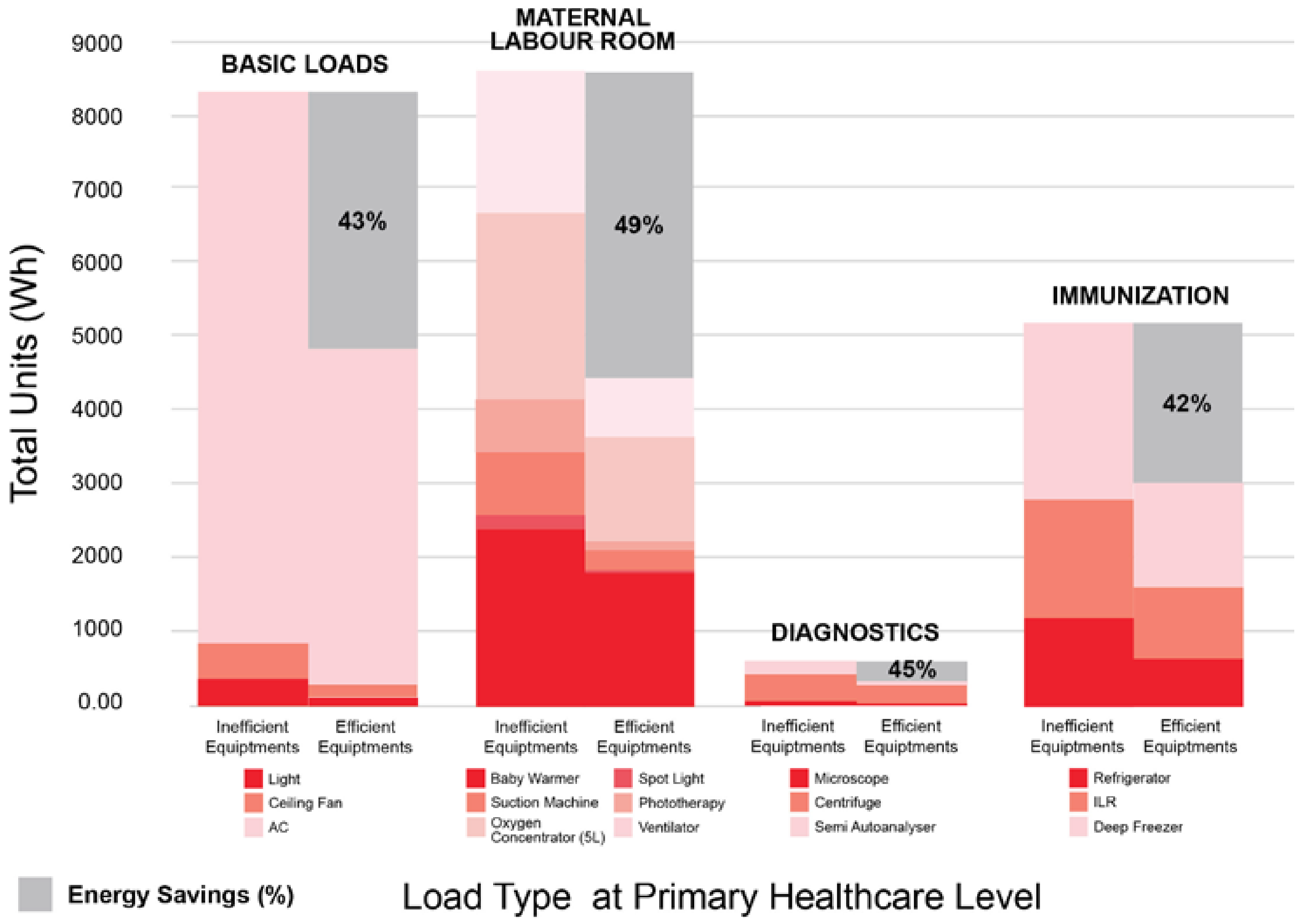
Holistic energy-health interventions that combine sustainable energy systems with efficient appliances and sustainable built environment designs seek to respond to specific challenges faced by public health facilities including:

a. Inefficient electrical and medical device usage resulting in higher energy requirements and higher operational costs of running critical care services that overburden public health centres.

b. Critical load identification and prioritization to determine the type of solar energy system design (combination of DC or AC back-up) and cost implications of the same.

c. Inefficient building design, leading to increased usage of lighting during the day and active cooling measures (such as fan, coolers, air conditioners) for thermal comfort particularly in heat stress regions which further increases energy consumption at the facility; Poor climate responsive built spaces also affect recovery capacity among patients and reduce wellbeing and productivity of the medical practitioners working in the facilities.

Decentralized, renewable energy solutions, coupled with energy efficiency measures, have great potential to expand health facility access to cost-effective, reliable electricity in many low-income settings where the grid is unreliable or non-existent. As illustrated in the figure below, today there are more efficient options for each appliance required at the level of Primary healthcare- be it basic energy, cold chain and refrigeration or maternal and newborn care.



Health Services (PHC)	Load Distribution	Energy Efficiency Improvement
Basic Loads	36.64%	34.76%
Maternal Labour Room	37.87%	41.06%
Diagnostics	2.64%	2.64%
Immunization	22.85%	21.53%

Image 60 | Patients waiting in line for medical care

The differences in appliance efficiency, significantly change the sizing of the decentralized solar energy system- both PV panel and battery capacities- which in turn change the cost of powering the system and the future cost of maintenance.

Case study 1 on Meghalaya sub centers illustrates how the cost of powering a center with all existing loads compares to one where efficient appliances are powered to provide the same set of services. The cost of powering a center with inefficient appliances is three times more than the cost of powering one with efficient appliances. Including the cost of appliances would still mean the inefficient appliance center is 35% more expensive than the one with efficient appliances.

The section below illustrates some case studies captured from the ground which demonstrates the use of energy efficiency measures, along with sustainable energy design for last mile health centres. These solutions use renewable energy as a bridge to meet the health needs of the communities in a manner that optimizes energy usage while limiting negative climate impact.

India's total energy requirement for Primary Health Centres and Sub Centres is 62,000,000 MT which if centralised is replaced with decentralised cold storages, can reduce 33,945,000,000 kWh energy units per year. 29 coal fired plants can be avoided if moved from centralised to decentralised cold storage units. This has a GHG mitigation potential of 6200.11 kgCO2e/unit/yea

Image 61 | SELCO's Solar powered mobile medical unit

Covid rips through rural India's threadbare healthcare system


Source: (The Guardian 2021)

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Source: (Mint 2018b)

INDIA'S RURAL PUBLIC HEALTH FACILITIES NEED URGENT FIXING

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Source: (The Print 2021a)

'IF THERE IS HELL... IT'S HERE' — A DAY WITH PATIENTS IN DMCH, NORTH BIHAR'S MAINSTAY HOSPITAL

WORLD HEALTH LEADERS: CLIMATE CHANGE IS PUTTING LIVES, HEALTH SYSTEMS AT RISK

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Source: (Inside Climate News 2018)

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4 years of Swachh Bharat but 38% govt hospitals in rural India don't have staff toilets


Source: (India Today 2019)

SOLUTION 1

7.3B: DECENTRALISED RENEWABLE ENERGY AND ENERGY EFFICIENCY FOR HEALTH CARE

IMPROVING RELIABILITY, ACCESS AND COST EFFICIENCY TO ADAPT TO INCREASING HEALTH CARE NEEDS DUE TO CLIMATE RISKS FOR LAST MILE COMMUNITIES AND HEALTH CARE WORKERS

Image 62 | New- born infants at an Indian hospital

Background

The state of Meghalaya has 477 functional Sub Centers in rural areas, of which 157 (35%) do not have electricity. Based on discussions with key government actors within the state, unreliability of electricity is also a challenge in a large percentage of these sub-centers. The state has recorded an MMR of 187 per 100,000 live births and an IMR of 34 per 1000 live births. Both of these are worse than the national average of 113 per 100,000 live births (MMR) and 32 per 1000 live births (IMR). In the absence of well-functioning labour rooms and unreliable access to electricity to run key appliances, the risks associated with maternal and child care are exacerbated.

SOLUTION:

While hilly terrain, low population density and climatic conditions in the state are a challenge to provision of reliable grid-based electricity, they create immense opportunity for using decentralized energy solutions to power public health facilities statewide. Through engagement with Managing Director of the National Health Mission in Meghalaya (MD- NHM) and other representatives of State Health Department, a plan was presented to improve energy access across all Sub-Centers, starting with 100 centers where there is an unmet demand for critical services such as maternal and newborn care, or areas that are particularly remote with limited access to higher tiers of healthcare services (such as PHCs, CHCs or district hospitals). The need to strengthen these services was recognized by health department based on which energy based efficient solutions were designed and recommended. The chosen solution option includes efficient appliances and solar energy systems for (a) basic energy needs (b) vaccine storage (c) labour room (d) staff quarter energy needs with a power requirement of 1.02 KW. 50% of total project cost will be contributed by the State NHM.

1. Importance of energy efficiency drive:
    a. In absence of energy efficient appliances, energy system cost would be three times higher and total cost including efficient appliances would be 35% more.
    b. Assuming battery replacement after every five years, over a 20 year period, the total savings on the system powering efficient loads would be more than 60% compared to a larger system with inefficient appliances.
    c. For each center, this would mean a savings of more than INR. 11 lakhs ($14,822) over a 20 year period. Across the 100 SCs, the savings would mean that at today's value, more than 150 SCs can be powered.

2. Increased reliability and life of the system:
    a. System design based on weather conditions: With fewer days and intensity of sunlight, the system design has been divided such that loads like luminaries and fans are part of a DC solar off-grid system with three days of autonomy while the AC system for other loads functions with two days of autonomy. To overcome the risk of an inverter failure shutting down the entire operation, instead of a single AC inverter based system for all loads, the energy system is split into two allowing for continued use of certain loads. In remote areas, while designing a 100% AC system, a standby-inverter is recommended to increase the reliability.
    b. Strengthening the vaccine chain: Use of vaccine and ice pack storage powered using stand-alone solar systems and direct drives, without batteries, that function for 12 days without backup once fully charged. This stand-alone vaccine storage system is recommended because the ice line refrigerator not only requires a significant initial investment but also requires proper input voltage which is difficult to guarantee in rural areas.
    c. Labour room requirements: Design of labour room with stand-alone solar system so this critical service is not affected by energy consumption in other services of the PHCs. Typically, the energy system in a labour room is designed to include an energy efficient baby warmer, a suction apparatus and spotlight with an average of three hours back-up per day and two days of autonomy.

This collaborative intervention creates a framework that can be replicated and scaled in other parts of North East to build more resilient health facilities on ground.

Image 63 | Vaccination in progress

OWNERSHIP AND DELIVERY MODEL 1

Meghalaya State, North East Region

Background:

The state of Meghalaya has 477 functional Sub Centers in rural areas, of which 157 (35%) do not have electricity. Based on discussions with key government actors within the state, unreliability of electricity is also a challenge in a large percentage of these sub-centers. The state has recorded an MMR of 187 per 100,000 live births and an IMR of 34 per 1000 live births. Both of these are worse than the national average of 113 per 100,000 live births (MMR) and 32 per 1000 live births (IMR). In the absence of well-functioning labour rooms and unreliable access to electricity to run key appliances, the risks associated with maternal and child care are exacerbated.

Solution:

While the hilly terrain, low population density and climatic conditions in the state are a challenge to the provision of reliable grid-based electricity, they create an immense opportunity for using decentralized energy solutions to power public health facilities across the state. Through engagement with the Managing Director of the National Health Mission in Meghalaya (MD- NHM) and other representatives of the State Health Department, a plan was presented to improve energy access across all Sub-Centers, starting with 100 centers where there is an unmet demand for critical services such as maternal and newborn care, or areas that are particularly remote with limited access to higher tiers of healthcare services (such as PHCs, CHCs or district hospitals). The need to strengthen these services was recognized by the health department based on which energy based efficient solutions were designed and recommended.

The chosen solution option includes efficient appliances and solar energy systems for

a. Basic energy needs

b. Vaccine storage

c. Labour room

d. Staff quarter energy needs with a power requirement of 1.02 KW. 50% of the total project cost will be contributed by the State NHM.

Importance of energy efficiency drive:

- In the absence of energy efficient appliances, energy system cost would be 3 times higher and the total cost including efficient appliances would be 35% more expensive.
- Assuming battery replacement after every 5 years, over a 20 year period, the total savings on the system powering efficient loads would be more than 60% compared to a larger system with inefficient appliances.
- For each center, this would mean a savings of more than INR. 11 lakhs ($14,822) over a 20 year period. Across the 100 SCs, the savings would mean that at today's value, more than 150 SCs can be powered.

Increased reliability and life of the system:

- System design based on weather conditions: With fewer days and intensity of sunlight, the system design has been divided such that loads like luminaries and fans are part of a DC solar off-grid system with 3 days of autonomy while the AC system for other loads functions with 2 day of autonomy. To overcome the risk of an inverter failure shutting down the entire operation, instead of a single AC inverter based system for all loads, the energy system is split into two allowing for continued use of certain loads. In remote areas, while designing a 100% AC system, a standby-inverter is recommended to increase the reliability.
- Strengthening the vaccine chain: Use of vaccine and ice pack storage powered using stand-alone solar systems and direct drives, without batteries, that function for 12 days without backup once fully charged. This stand-alone vaccine storage system is recommended because the ice line refrigerator not only requires a significant initial investment but also requires proper input voltage which is difficult to guarantee in rural areas.
- Labour room requirements: Design of labour room with stand-alone solar system so this critical service is not affected by energy consumption in other services of the PHCs. Typically, the energy system in a labour room is designed to include an energy efficient baby warmer, a suction apparatus and spotlight with an average of 3 hours back-up per day and 2 days of autonomy.

This collaborative intervention creates a framework that can be replicated and scaled in other parts of the North East to build more resilient health facilities on the ground.

1. Financial model: Given the dire need in the region, the capital cost for this intervention was grant funded. For operations and maintenance, based on the learnings from other facilities, the Health center has been advised to enter into an agreement with the energy enterprise where untied funds of the RKS (Health center management committee) will be used to cover the 1-2% annual maintenance cost.

This intervention has resulted in:

- Savings on diesel fuel of more than INR. 3000 INR. ($40) per month
- Timely immunization for children and pregnant women using a well-functioning cold chain system
- Safer deliveries and better conditions for doctors and nurses to treat patients
- Improved working conditions and increased convenience for staff in the health facilities

Image 64 | Solar powered district hospial in Ukhrul

"The availability of regular power with DRE is a boon to this facility. We are able to conduct deliveries without any difficulties and it has also helped us provide better maternal and child care, much required in this geographic setting." **Medical Officer, Alopati, PHC, Assam**

OWNERSHIP AND DELIVERY MODEL 2

Alopati PHC, Assam, North East Region

Background:

Alopati Majarchar PHC (In Barpeta District of Assam) was designed to cater to a population of roughly 25,000 people. But in the absence of other health facilities in the area, it serves a population of nearly 100,000- well over its capacity. The PHC also provides maternal and newborn care services, conducting upto 60-70 deliveries a month. This is significantly higher than the recommended IPHS guidelines of 20-25 deliveries per month for a PHC, all this while being unelectrified and unconnected to the grid. In the absence of electricity, the PHC was dependent on small solar powered lights and a diesel generator to meet their critical power needs. The scenario was particularly challenging for health workers to work in:

- Doctors and nurses forced to conduct deliveries in extremely stressful conditions
- Usage of equipment such as baby warmer and cold chain solutions for vaccine storage were often affected by the shortage of fuel
- High operating costs of running the center using diesel generators, where the expenditure was INR. 3000 to INR. 3500 ($40 - $47) per month. During the rainy seasons, the center often spent nearly INR. 1500 to INR. 1800 ($20- $25) more on travelling to the nearest petrol station to procure the fuel because of limited supply
- Lack of proper access to electricity and infrastructure and the inability to use critical appliances affected the motivation and well-being of staff members.

Solution:

The center was identified for energy-health interventions by Doctors For You (DFY), a pan India humanitarian organization, that works in disaster and conflict hit areas on providing medical care and emergency medical aid to the vulnerable communities during crisis and non-crisis situations. The DRE solution for this PHC was implemented in February 2020.

- Technology solution: The PHC was provided with two DRE systems of 3.96 kWp each and energy efficient equipment including a baby warmer, phototherapy, suction machine and spot lights. Electrical loads such as lights and fans were replaced with efficient appliances. The system includes 2 inverters so in the event that one fails, the other is always available to support critical loads. In a remote region with no other source of power, this is important to factor in.

8

SELCAP

Image 65 | Heat Stress impacting at last mile

SELCAP *for*
COOLING

8

SELCAP *for* COOLING

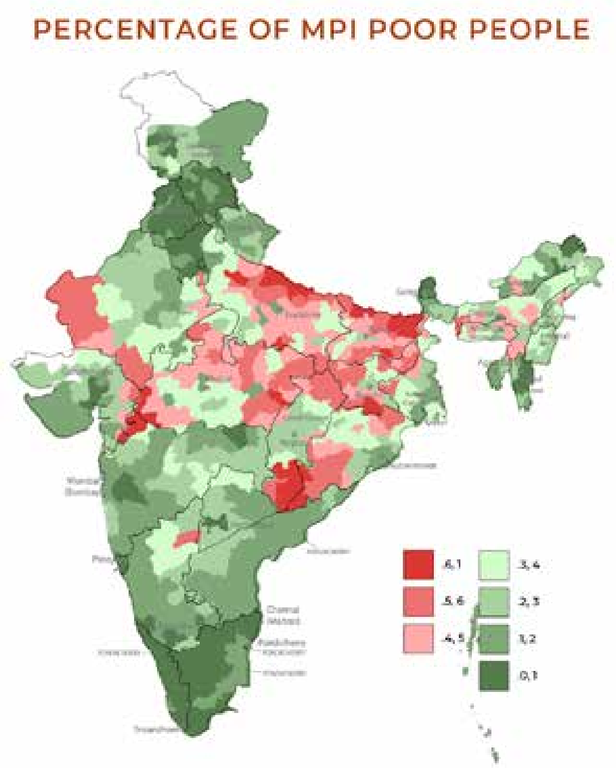
COOLING AFFECTS THE SUPPLY OF FOOD, MEDICINE AND IS ALSO A CRITICAL COMPONENT TO ENSURE WELL-BEING OF ALL LIVING BEINGS. THE LACK OF ADEQUATE ‘COLD CHAINS’ OF REFRIGERATED WAREHOUSING AND TRANSPORT CAUSES TWO MILLION VACCINE PREVENTABLE DEATHS EACH YEAR, AND THE WASTE OF 200 MILLION TONNES OF FOOD

8.1 Cooling, Poverty and Climate Change

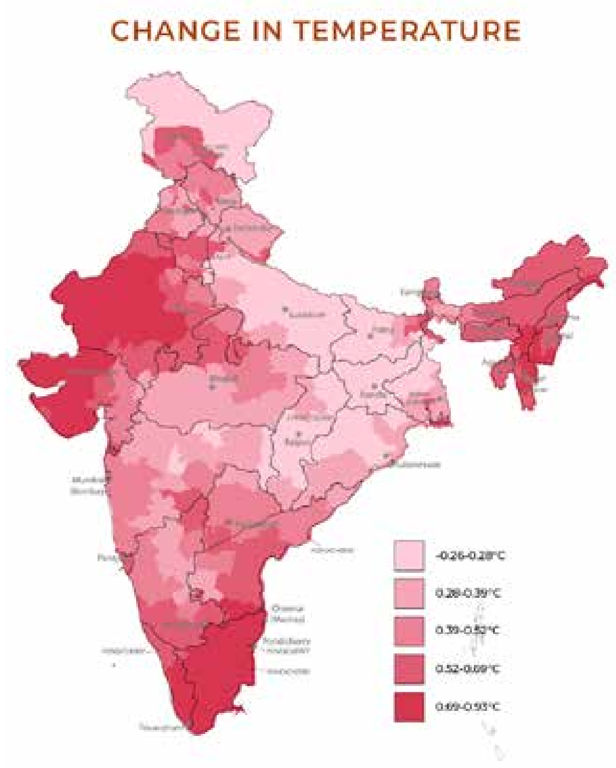
Cooling affects the supply of food, medicine and is also a critical component to ensure well-being of all living beings. The lack of adequate 'cold chains' of refrigerated warehousing and transport causes two million vaccine preventable deaths each year, and the waste of 200 million tonnes of food – with consequences far beyond hunger and inflated food prices. Food wastage occupies a land area almost twice the size of Australia; consumes 250km3 of water per year, three times the volume of Lake Geneva; and emits 3.3 billion tonnes of CO2, making it the third biggest emitter after the US and China (University of Birmingham n.d.).

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 due to wastage and negative impact on quality of produce, as well as long-term impacts on health and well-being.



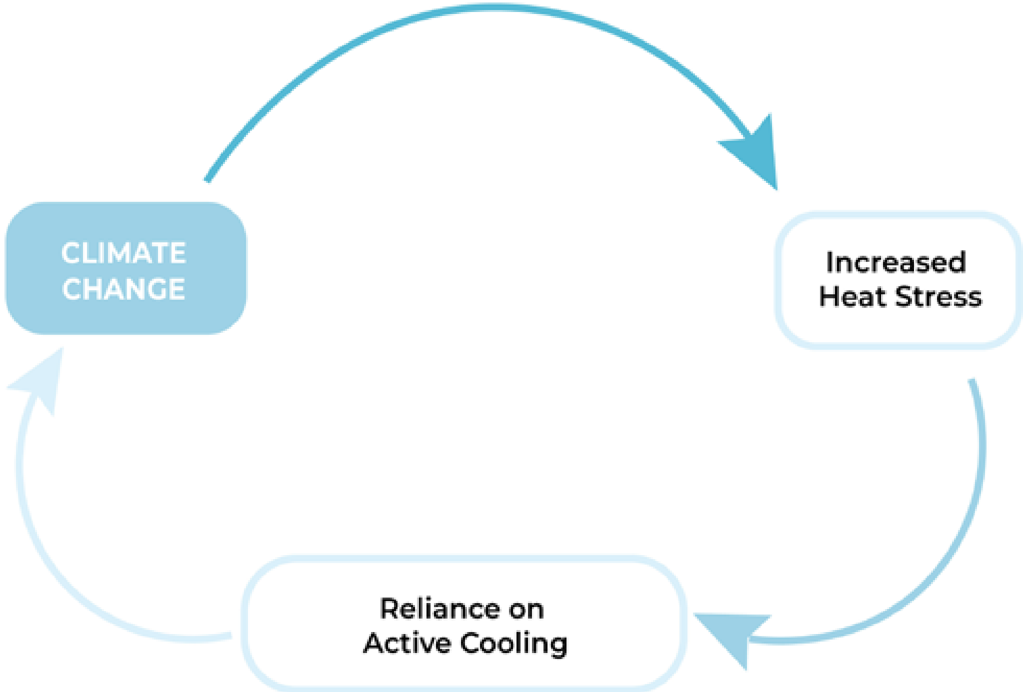
Adapted from (Reddit n.d.)



Adapted from (Mint 2019a)

Image 66 | Men bathing under water taps due to heat stress in India

A report by the Birmingham Energy Institute (University of Birmingham n.d.) also laid out the role of cooling in reference to other UN's Sustainable Development Goals. It presents evidence on the need to look at cooling as a solution for conserving food, water and other resources; tackle poverty, hunger, health and climate change; and underpin growth and development. But with the growing need of cooling in multiple sectors becoming more and more critical, the report also states that if the new cooling needs were catered to by using conventional technologies, it will only solve one set of problems by creating another – quite possibly an environmental catastrophe.



8.2 Innovation Gaps: Cooling as the Next Big Inequality Factor[9]

The role of passive cooling is often underestimated in optimizing 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 if electricity demand from space cooling is not reduced. It states that:

- 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[10], given the right incentives

However, in the context of the poor, 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.

Poorer populations 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.

Image 67 | A man resting under minimal shade in the heat

9- (The Guardian 2018)

10 Rising demand for electricity is driven by various uses including space cooling which – particularly at certain times of the day – threatens the power sector's ability to deliver secure, affordable and net zero power. If electricity demand growth from space cooling is not restrained, or electricity supply is not expanded, we will see an increasing number of power outages, and consequent economic and health costs. As recently as August 2020, there were power outages throughout California as the grid became overwhelmed by energy demands during a heatwave. The power operator had to declare a statewide state of emergency for the first time since 2001 (The Economist 2020)

Agriculture and Animal Husbandry value chains have different cooling needs at different stages. Some needs can be fulfilled by passive cooling designs, however the need for active cooling is prevalent due to a gap. Needs which could have been met with passive solutions are now ineffective due to rising temperatures and variable precipitation based weather changes. Based on climatic conditions, the stage of maturity of the crop, the required shelf life and cooling needs accordingly, many solutions would be required to meet those needs. For instance, in active cooling in agriculture, there are several factors influencing 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, due to a variety of commodities being stored by farmers at different time periods, there is regular walk in which increases heating load

CUSTARD APPLE VALUE CHAIN

RIPENING CHAMBER	HARDENER	DEEP FREEZER
TEMPERATURE: 20°C TO 25°C	TEMPERATURE: (-)35°C	TEMPERATURE: (-)22°C

POTATO VALUE CHAIN

SEED POTATO	TABLE POTATO	TABLE POTATO
TEMPERATURE: 2°C TO 4°C	TEMPERATURE: 18°C	TEMPERATURE: 10°C TO 12°C
RELATIVE HUMIDITY: 90% TO 95%	RELATIVE HUMIDITY: 50% TO 80%	RELATIVE HUMIDITY: 90% TO 95%
SHELF LIFE: 6 TO 8 MONTHS	SHELF LIFE: 45 DAYS	SHELF LIFE: 9 TO 10 MONTHS

Decentralised cold storages help farmers protect their price and in reducing wastage of perishables. Different commodities have different cooling requirements at the post harvest stage.

As illustrated alongside, custard apples at their post harvest stage would require a temperature range of 20-25 degrees celsius while seed potatoes require 2-4 degrees celsius. The shelf life of these commodities are also varying with seed potatoes that could last for 6-8 months and table potatoes for 45 days.

However, a commodity like custard apple has different cooling requirements at different stages i.e. post ripening it would require a harderener at negative 35 degrees and once post processed into a pulp for value addition, it would require a deep freezer at negative 22 degrees temperatures.

Across the value chain stages, each commodity would have it's own cooling requirements which need to be met with different efficient cooling technologies for farmers to realise better prices at the markets as well as in reducing wastage.

It links to the nodal point of activity, shelf life, temperatures and humidity.

Image 68 | Solar Powered Cold Storage set up by SELCO in Sambalpur

A recent report by the Economist Intelligence Unit (The Power of Efficient Cooling) stated that space cooling plays a significant role in driving growth in electricity demand. It is forecast to account for the second-largest end-use of total electricity demand growth out to 2040, after industrial motors, and it accounts for more than the electricity used by electric vehicles (EVs). The report also estimates that, globally, total electricity demand for space cooling will grow by 6.1% per year out to 2030, from 3,300 terawatt-hours (TWh) in 2019 to 5,950 TWh (The Economist 2020).

With rising global temperatures, the lack of space cooling solutions is a major inequality issue. The most adversely affected are the poor and those living in densely populated areas. Some typologies where these are predominant are urban slums. With communities living in densely populated and small, cramped spaces, solutions for ventilation naturally and through passive mechanisms are restricted to reactive techniques like cool roofing paints and active cooling mechanisms like air coolers and air conditioners. Both these solutions result in radiant heat (reflected off rooftops or exhaust from AC compressors) being exhausted into the micro climate furthering issues of urban heat island effect. In rural and remote communities, the issues are worsened due to lack of shaded spaces and poorly built envelopes.

Heat is more than just high temperature and it is influenced by several other factors such as humidity, wind, direct or indirect radiation from the sun and indices take into account these factors and give an idea of how hot one really feels.

Heat Stress Impacting Impacting Productivity of Home-based Businesses[11]

Small dwellings with tin sheets roofs increase the indoor temperature by more than 3-4 degrees. In Ahmedabad when the outside temperature is 39-40 degrees Celsius the in-house temperature is at least 43-44 degrees. These conditions make it very dangerous for the poor to live or conduct any kind of livelihood activity.

Dilshaadben has a family of 17 and was living in a 2 room house. Their house is a narrow structure, with rooms stacked one behind the other and common walls on all three sides. Due to this the rooms are extremely dark with no ventilation. The metal sheet roofing also results in increased temperatures inside.

Dilshaadben and her household members usually take up livelihood activities at home- linking to vendors who provide them with raw materials and buy-back the finished products. For example, in the months of October to February, the family members engage in kite making. Kite making, as a livelihood, works on small margins and requires the family members to work for long hours. They work throughout the day, but due to the tin sheet roof and no windows, the productivity decreases significantly on warmer days. The lights are switched on the whole day, and the afternoons are unbearable because of the heat- resulting in higher consumption of energy in the form of coolers and fans. Fans are used during the winter months as well, and coolers are in need by early spring. Further, the poor quality of the roofing results in leakage during the monsoon resulting in damage of household material. In the year 2021, Ahmedabad was also hit by the cyclone Tauktae[12], devastating many houses with tin sheet roofs.

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11 - The case studies documented in this section, have been done in partnership with Mahila Housing SEWA Trust

12 - (Times Now 2021)

Laxmiben Chavda lives with her family of 5 in Rajeevnagar Slum. Laxmiben has a busy schedule, shuffling between household work and income generating activities. Laxmiben is a tailor and craftswoman, using scrap material to make decorative items such as letter holders, bags, and embroidered skirts. She usually does this work in the afternoon when she is free from household chores. Being in a two room house (and one kitchen), the main room is used by Laxmiben's mother and children to watch TV. Since tailoring in the room causes disturbance, Laxmiben shifted her workspace into her bedroom on the first floor. The afternoon, however, is the hottest time of the day, creating uncomfortable working environment. Furthermore, Laxmiben had a metal sheet roof which would further increase the temperature inside the room- pushing her to rely on air coolers, increasing her consumption of energy.

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 following:

- **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 machinery that generates heat also determines the heat stress and thus, the design of the intervention. As mentioned earlier, poor households use their homes for livelihood activities. Many such activities are drudgery driven, or require a continuous heat source (a cook stove or furnace) thus causing further heat stress. Also, 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 machineries

Image 69 | A Home-based Yarn Winding Unit in Tumkur

POINTS OF INTERVENTION: COOLING

AGRICULTURE

Decentralised Cold Storage Units

Energy efficient cold storage systems powered by decentralised sources of energy can help save upto 73,54,75,00 Mwh of energy every year in India
Reduce energy consumption with efficient cold storage systems. Positive impact greenhouse gas emissions via savings on energy expended via transportation to centralised cold storages.

In Jharkhand, a Farmer Producer Organisation using a solar powered 5 MT cold storage, has saved on 150 MT of wastage per year amounting to USD 5000 - resulting in USD 145 of savings per farmer per year (Nearly 10% of the farmers total annual income).

Food Security: Natural resources should be efficiently used and with food wastage lower in the supply chain mitigated. Lower wastages would also contribute to food security.

Reduced Transaction Costs for Farmers Farmer incomes can be positively impacted by climate friendly cold storages. At decentralised scales they would also help reduce transportation costs.

HEALTH

Cooling and Thermal Comfort for Health Centres

Reduced Health Risks: Increased heat stress leads to high risk pregnancies, dehydration from increased sweating in pregnant women can trigger onset of early labour and prolong duration of labour. Additionally, increasing certain types of diseases, and musculo-skeletal disorders in disabled people affect thermoregulation in their bodies. With space cooling in health centres, these health risks can be averted.

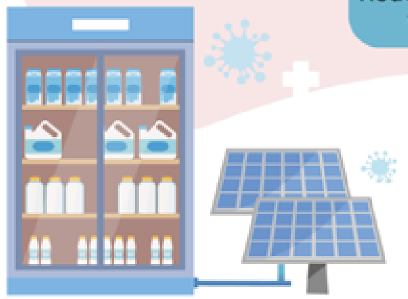
Better comfort: With better designs, efficient equipment and access to uninterrupted energy, patients and health workers can comfortably use health spaces while adapting to climate variations.

Reduced emissions : By using sustainable energy and designs of spaces, active cooling needs like air conditioners are reduced and can be kept to a minimum in extremely heat stressed regions. The need for air conditioners will only keep increasing with increasing temperatures whose emissions can be offset.

Last Mile Immunization

Reduced health risks: With access to immunization due to efficient vaccine fridges at the last mile, timely vaccinations would be possible leading to better health outcomes and reduced risks.

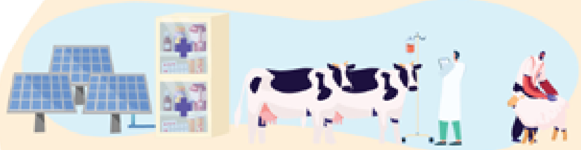
Reduced wastage: With unreliable energy, vaccinations are prone to wastage which can be reduced with efficient vaccine fridges and solar power.



Reduced emissions: The need for vaccinations are only increasing with more health risks, epidemics which will increase the need for vaccinations and vaccine storage. Efficient solar powered vaccination units can displace emissions caused by inefficient grid powered units as well as emissions from diesel gensets. With units placed at the last mile, transportation emissions can also be reduced.

ANIMAL HUSBANDRY

Vaccination and Immunization for Livestock



Reduced mortality risk: With increasing disease burdens due to climate stresses, livestock require more frequent vaccinations. With decentralised vaccine refrigerators, last mile delivery of vaccinations through worker like pashu sakhis can be carried out

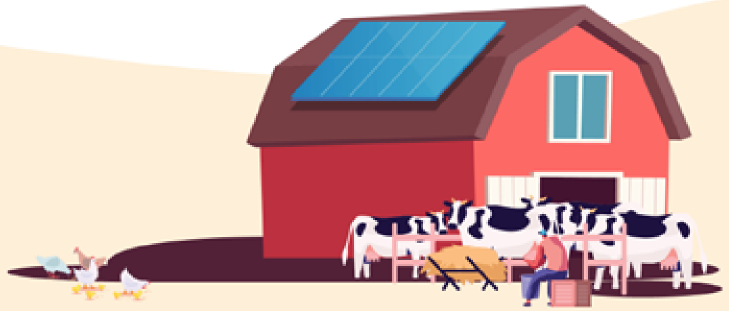
Increased incomes and savings: Farmers input costs and emissions from rearing livestock can be utilized by increasing mortality rates of livestock. Natural resources used in rearing livestock can also be utilized to the fullest with longer life spans.

Reducing emissions from transport: With vaccine refrigerators placed closer to communities, the transportation of people and vaccinations can be reduced drastically leading to reduced emissions. With increased disease burden, the number of times vaccinations are needed to be carried out are also increasing, thereby more transport emissions which can be controlled.

Reducing emissions from increased vaccine refrigerators: With the requirement for more vaccine refrigerators, inefficient grid powered ones would lead to more energy based emissions. With decentralised solar powered vaccine fridges, these emissions can be displaced.

A total quantity of 223,872,938 vials of vaccination are required per year to meet vaccination demands which if replaced with decentralised solar powered vaccination units, can reduce 31,051,176.501 kWh of energy units per year.

Cool Sheds for reduced stress amongst animals



Increase in savings and farmer incomes:
With cool sheds, there will be a reduced cost for farmers and an increased productive cohort of livestock which will lead to increase in incomes

Reduced mortality risk:
With increase disease incidences due to moisture in sheds and soil, improved sheds can offset mortality rates and increase efficiency in resource utilisation

Reduced GHG emissions through improved health:
Poor health management of livestock leads to higher mortality rates which in turn doubles the investment of resources for the same yield/ production and therefore increases GHG emissions. Poor health can also affect bodily functions of certain livestock and increase their production of specific emissions that contribute to global warming.

Energy efficient appliances lead to energy savings and reduce pollution:
Energy efficient appliances like lighting, dehumidifiers can reduce emissions at per shed level

■ **Solutions**
■ **Climate Adaptation**
■ **Climate Mitigation**
■ **Cooling Solutions for Sector**

CHALLENGES: COOLING-
WELL BEING AND OTHER LIVELIHOODS

Cool Roofs

Roofs trap the most amount of heat in a structure as it is directly exposed to solar radiation throughout the day. Often, there is no shading for roofs, which walls have in the form of mutual shading. Poor materials like tin, asbestos, kaccha thatch roofs, tarpaulin are used which increases heat gains due to which heat stress is caused.

Active - increasing height of roof and adding turbo ventilators

Passive - Cool roofs with better materials, adding air gap insulation, shading the roof, colouring the roof in lighter paint which reflect the light, clerestory windows

Cooling for Schools

Schools are often made with temporary materials like tin sheets and asbestos. Schools often have no ventilation, no light, no windows which lead to poor learning outcomes. In some child care centres (anganwadis) and schools where cooking is a part of their function, they have no clean cooking areas with no separation between cooking and classroom. They often use firewood with increased smoke indoors causing respiratory problems. This impacts learning and health of the children, teachers, cooks and helpers

Active - Efficient lights, fans, clean cookstoves, coolers in heat stressed regions

Passive- Better materials, thermal comfort, windows and ventilators, sky lights, shaded angans and play spaces
Segregation of cooking and learning spaces with ventilators and furnaces
For temporary spaces, insulated structures for transitional learning spaces or spaces with no land rights

Heat Extraction and Cooling for Home Based Solutions

Workspaces are cramped with no openings or chimneys. They often don't have ventilation also because in some livelihoods like say blacksmithy or cooking spaces, one cannot have direct wind action as it affects the heat source.

Materials used like tin sheet roof, asbestos, tarpaulin, thatch lets in a lot of heat into the space

Passive- Prevent Heat Infiltration:
Insulated walls and roofs, painting roof white/ tiling roof with white tiles, addition of windows and ventilators according to wind direction to promote extraction of smoke

Heat Extraction: Chimney for furnace, exhaust fans, turbo ventilators

Active Solution: Installation of fans in the farther end of the furnace

Refrigerators for Commercial Use

Due to heat stress, communities cannot stock a lot of perishables like cool drinks, milk, curd etc impacting small businesses.

Inefficient fridges consume more power and due to inefficiency there is wear and tear and spoilage

Active - efficient retail fridges

Passive - Location of fridge is critical in heat stressed regions, If placed outdoors, shading would allow it to perform efficiently.
For indoor use, better built designs of the space for passive cooling, cool roofs, ventilators etc. which would improve the efficiency of the technical solution

Active Cooling Solutions for Food Processing Units

Many of the food processing units are home-based or decentralised at small workshop level in India. These homes or workshops are made out of metal. Further, the enterprises use large cookstoves or roasters which generate heat.
The difference in ambient temperature (indoor to outdoor) is a minimum of 5⊠.

Many enterprises consulted during the stakeholders engagement mentioned that during peak summer months, they operate only early mornings and late evenings.

Active- cooling solutions such as fans or coolers might not be preferred for these workspaces, as the air circulation from most active solutions might:
1. Impact the heating of the furnaces
2. Challenge the management of the by-products or raw material (for example, flour, chips, puffed rice etc)

■ **Cooling Requirements**

■ **Need**

■ **Opportunities for Cooling Equality**

Puffed Rice Making Unit

North Karnataka

Climate

Actual temperature

11 (Dec) 25 (Avg) 39 (Apr)

Humidity

30% (Jan) 80% (Aug)

Density

- **Geography:** Rural/ Peri- Urban
- **Density:** Medium density
- **Planning (affecting air circulation):** Mnimum 0 to 3.3ft setbacks.

Building Materials

Roofing: Tin Sheet/ cement-asbestos sheet

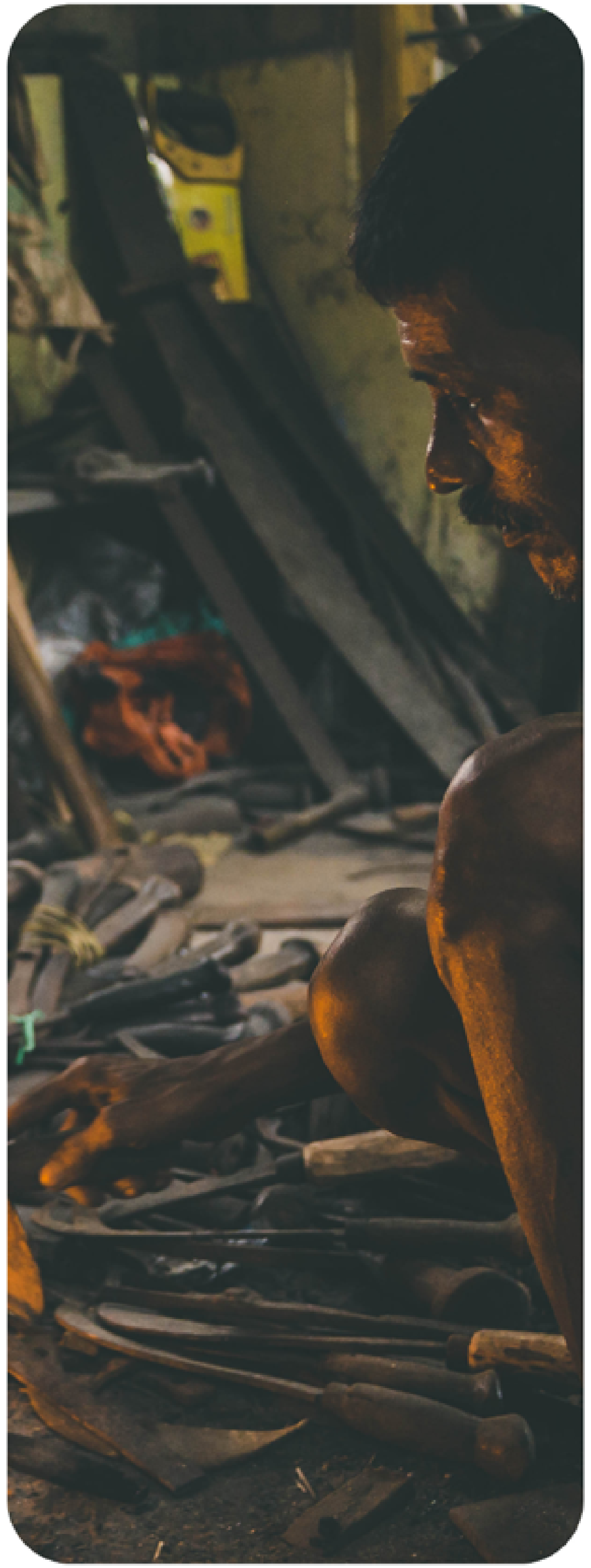
Activities

- **Heat Generating Source:** Roaster for puffing, Chulha for boiling paddy
- **Drudgery driven physical work:** Boiling the paddy, puffing rice using hot sand.

Conventional Cooling Solution	Opportunities for optimised cooling solutions
Felt temperature (max) 45 (General Workspace) >50 (Spot heating near heat sources)	Potential Felt temperature (max) 26 33
PREVENT HEAT INFILTRATION	
• Provision of windows	• Add insulation to roofs, introduce windows and ventilators for the workplace. • Insulate the water • Spatial design to isolate heat sources from general workspace. • Shading devices to cut off direct radiation to walls and windows.
HEAT EXTRACTION	
• Placing chulha in the open air	• Chimney for roaster and chulha
ACTIVE SOLUTION	
None	• Spot wind- chill effect with the introduction of air cooler or fans for ambient cooling.

Blacksmithy Unit

Hilly Manipur



Climate

Actual temperature

04 (Jan) 17 (Avg) 30 (Apr)

Humidity

10% (Dec/ Jan) 90% (July)

Density

- **Geography:** Rural/ Remote
- **Density:** Low density
- **Planning (affecting air circulation):** >5ft setbacks.

Building Materials

Roofing: Tin Sheet or split bamboo mat itch cloth screens and tarpaulin

Activities

- **Heat Generating Source:** Forge
- **Drudgery driven physical work:** Hammering the metal to shape. Poor ergonomics in seating and forging activities .

Conventional Cooling Solution	Opportunities for optimised cooling solutions
Felt temperature (max) 35 (General Workspace) >40 (Near the forge)	Potential Felt temperature (max) 26 28
PREVENT HEAT INFILTRATION	
• Generally open on all directions • Allows rain, heat and other elements to enter	• Insulated roofs, strategically located windows and ventilators to prevent changes in temperature of forge shading devices to cut off direct radiation to walls and windows.
HEAT EXTRACTION	
None	• New efficient forge to control temperature for heat and smoke extraction • Turbo ventilator for redial heat and smoke extraction.
ACTIVE SOLUTION	
None	• Exhaust fans to aid cross ventilation.

Urban Slums

Coastal Odisha

Climate

Actual temperature

16 (Dec-Jan) 29.5 (Avg) 43 (May)

Humidity

50% (Jan) 100% (Aug)

Density

- **Geography:** Rural/ Peri- Urban
- **Density:** High density
- **Planning (affecting air circulation):** 0ft setbacks.

Building Materials

Roofing: Wooden battens with thatch and tarpaulin converting, tin and asbestos cement roofs.

Activities

- **Heat Generating Source:** Cooktop/ Chilean for cooking and boiling water
- **Drudgery driven physical work:** None.

Conventional Cooling Solution

Felt temperature (max)

55

Opportunities for optimised cooling solutions

Potential Felt temperature (max)

32

PREVENT HEAT INFILTRATION

Conventional Cooling Solution	Opportunities for optimised cooling solutions
None	Insulated walls and roofs, addition of windows and ventilators shading devices to cut off direct radiation to walls and windows.

HEAT EXTRACTION

Conventional Cooling Solution	Opportunities for optimised cooling solutions
None	Chimney or turbo ventilators for cooktop/ chulha

ACTIVE SOLUTION

Conventional Cooling Solution	Opportunities for optimised cooling solutions
Fans in all rooms Air coolers Window ACs	Exhaust fans in the kitchen. Installation of fans in all usable areas, efficient ACs or coolers

Image 70 | Identified local requirements for solaw powered cooling solutions

Inefficient habitats and heat trapping construction technologies have increased energy expenditures on cooling across the globe. It is estimated that the demand for cooling in India will be dramatic, particularly in urban geographies. On one hand, concerns have been raised on the carbon emissions related to cooling technologies (which further increase emissions, contribute to climate change and growing heat stress), and on the other, access to cooling technologies and high energy expenditures have been flagged as factors resulting in energy poverty.

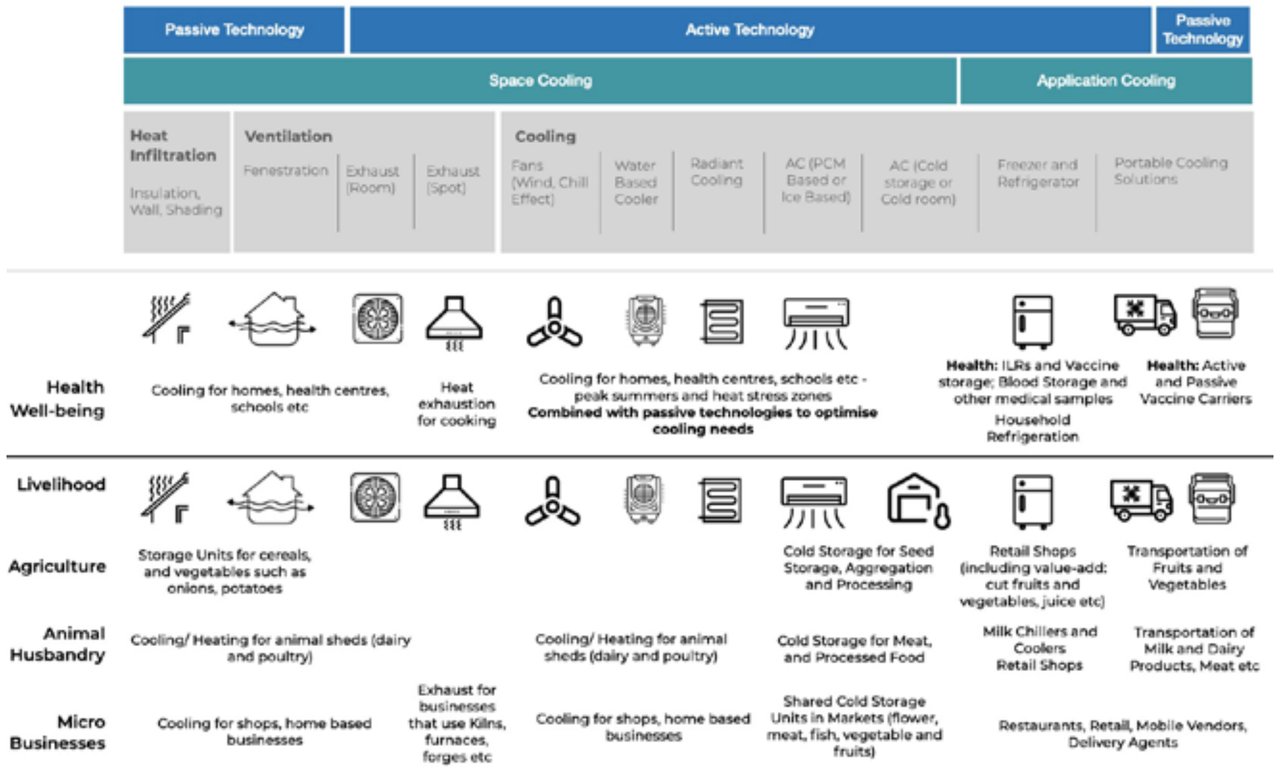
An inclusive technology innovation approach that combines both active and passive cooling solutions is pertinent for the poor to be able to optimise on their cooling needs. As already mentioned in the earlier section, a need-based, decentralised renewable energy driven approach will keep optimisation of consumption at the centre of the innovation process. This is critical in the context of climate change and cooling being recognised as one of the biggest contributors globally today.

Cooling is already a major and growing emitter: one estimate suggests refrigeration and air conditioning cause 10% of global CO2 emissions – three times more than is attributed to aviation and shipping combined. Another suggests 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.

Innovations in clean cooling technologies and efficiency in cooling could provide cooling at lower environmental and financial cost. But 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**.

The diagram below showcases a spectrum of cooling solutions (combination of active and passive) that make them more affordable and accessible to affected communities. Combining active and passive methods of achieving the required temperature also ensures that new benchmarks are set on consumption. This ensures we can cater to the cooling demand in an equitable manner, while keeping within the planetary boundaries.

Need : Spectrum of Cooling



Inclusive cooling solutions prioritise need and curb the source of heating. As already detailed in the previous sections, due to inefficiency of building design, heat generating machines, inefficiency ways of cooling; the heat burden on the poor has been increasing.

Active and space cooling solutions can be optimised further by adopting the following strategies:

Prevent Heat Infiltration and Design for Improved Thermal Insulation: For example:

- **Decentralised agri cold storage units** innovate on the material to provide improved insulation and reduced dissipation. This improves the energy efficiency of the technology
- **Cool roofs** provide improved insulation from the external temperature and prevents the space indoors to get heated up
- **Energy performance of technologies** can be dependent on the ambient temperature. Thus, placement of technologies in cooler parts of the rooms, or spaces which receive natural ventilation and shade can result in improved energy performance.

Ventilation / Heat Extraction: Planning strategic placement of furnaces, windows, ventilators and exhausts from points of heat generation, in order to reduce the burden on active cooling, and thus energy consumption and expenditure. For example:

- **Heat extraction by adding furnaces** to kitchens or food production businesses which use a constant heat source
- **Ensuring more active points** in a building are located in spaces with windows and ventilators- kitchens and workspaces

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

As brought out previously in the report, implementation strategies for access to cooling, needs to be looked at from an ecosystem approach considering the collaboration between inclusive financial models, efficient technologies, policies, capacity building programs, and necessary market linkages to make the cooling technologies feasible and to improve the access and local ownership of the cold chain.

The following two solutions showcased bring out different aspects of the ecosystem that has been developed in order to result in scale of these solutions.

- **Cooling for Schools**: After initial pilots implemented with multiple NGOs and block level education officers, the approach has been adopted by State Government in Bihar (over 30 schools in specific chosen backward districts).
- **Commercial Refrigeration Technologies:** Pilots implemented across multiple user typologies and business models proved financial feasibility of the technology for nano and micro enterprises. These pilots (of about 50 enterprises) has been used to unlock financing from over 20 national and rural banks across four states. The solutions developed have also been taken forward by the technology manufacturer/ vendor in other geographies.

POINTS OF INTERVENTION: COOLING

AGRICULTURE

Decentralised Cold Storage Units

Energy efficient cold storage systems powered by decentralised sources of energy can help save upto 73,54,75,00 Mwh of energy every year in India
Reduce energy consumption with efficient cold storage systems. Positive impact greenhouse gas emissions via savings on energy expended via transportation to centralised cold storages.

In Jharkhand, a Farmer Producer Organisation using a solar powered 5 MT cold storage, has saved on 150 MT of wastage per year amounting to USD 5000 - resulting in USD 145 of savings per farmer per year (Nearly 10% of the farmers total annual income).

Food Security: Natural resources should be efficiently used and with food wastage lower in the supply chain mitigated. Lower wastages would also contribute to food security.

Reduced Transaction Costs for Farmers Farmer incomes can be positively impacted by climate friendly cold storages. At decentralised scales they would also help reduce transportation costs.

HEALTH

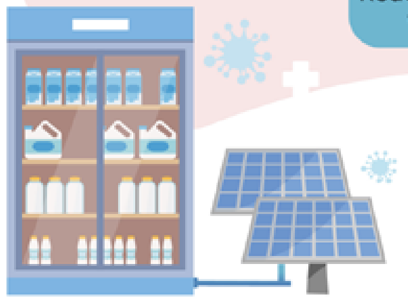
Cooling and Thermal Comfort for Health Centres

Reduced Health Risks: Increased heat stress leads to high risk pregnancies, dehydration from increased sweating in pregnant women can trigger onset of early labour and prolong duration of labour. Additionally, increasing certain types of diseases, and musculo-skeletal disorders in disabled people affect thermoregulation in their bodies. With space cooling in health centres, these health risks can be averted.

Better comfort: With better designs, efficient equipment and access to uninterrupted energy, patients and health workers can comfortably use health spaces while adapting to climate variations.

Reduced emissions : By using sustainable energy and designs of spaces, active cooling needs like air conditioners are reduced and can be kept to a minimum in extremely heat stressed regions. The need for air conditioners will only keep increasing with increasing temperatures whose emissions can be offset.

Last Mile Immunization



Reduced health risks: With access to immunization due to efficient vaccine fridges at the last mile, timely vaccinations would be possible leading to better health outcomes and reduced risks.

Reduced wastage: With unreliable energy, vaccinations are prone to wastage which can be reduced with efficient vaccine fridges and solar power.

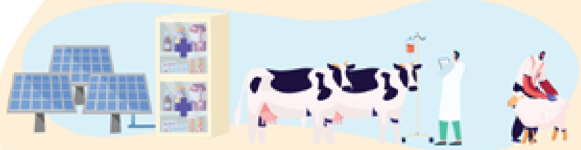
Reduced emissions: The need for vaccinations are only increasing with more health risks, epidemics which will increase the need for vaccinations and vaccine storage. Efficient solar powered vaccination units can displace emissions caused by inefficient grid powered units as well as emissions from diesel gensets. With units placed at the last mile, transportation emissions can also be reduced.

ANIMAL HUSBANDRY

Vaccination and Immunization for Livestock

Reduced mortality risk: With increasing disease burdens due to climate stresses, livestock require more frequent vaccinations. With decentralised vaccine refrigerators, last mile delivery of vaccinations through worker like pashu sakhis can be carried out

Increased incomes and savings: Farmers input costs and emissions from rearing livestock can be utilized by increasing mortality rates of livestock. Natural resources used in rearing livestock can also be utilized to the fullest with longer life spans.

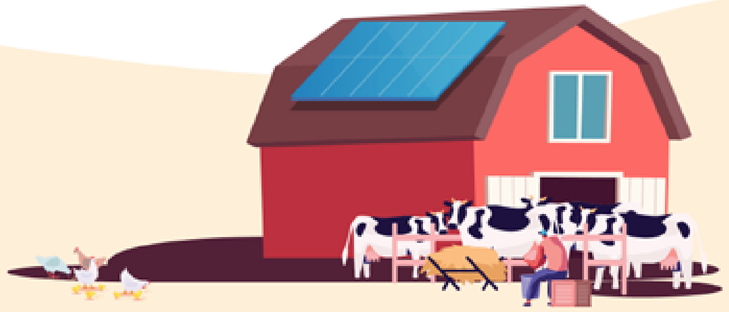


Reducing emissions from transport: With vaccine refrigerators placed closer to communities, the transportation of people and vaccinations can be reduced drastically leading to reduced emissions. With increased disease burden, the number of times vaccinations are needed to be carried out are also increasing, thereby more transport emissions which can be controlled.

Reducing emissions from increased vaccine refrigerators: With the requirement for more vaccine refrigerators, inefficient grid powered ones would lead to more energy based emissions. With decentralised solar powered vaccine fridges, these emissions can be displaced.

A total quantity of 223,872,938 vials of vaccination are required per year to meet vaccination demands which if replaced with decentralised solar powered vaccination units, can reduce 31,051,176.501 kWh of energy units per year.

Cool Sheds for reduced stress amongst animals



Increase in savings and farmer incomes:
With cool sheds, there will be a reduced cost for farmers and an increased productive cohort of livestock which will lead to increase in incomes

Reduced mortality risk:
With increase disease incidences due to moisture in sheds and soil, improved sheds can offset mortality rates and increase efficiency in resource utilisation

Reduced GHG emissions through improved health:
Poor health management of livestock leads to higher mortality rates which in turn doubles the investment of resources for the same yield/ production and therefore increases GHG emissions. Poor health can also affect bodily functions of certain livestock and increase their production of specific emissions that contribute to global warming.

Energy efficient appliances lead to energy savings and reduce pollution:
Energy efficient appliances like lighting, dehumidifiers can reduce emissions at per shed level

■ **Solutions** ■ **Climate Adaptation** ■ **Climate Mitigation** ■ **Cooling Solutions for Sector**

POINTS OF INTERVENTION: COOLING

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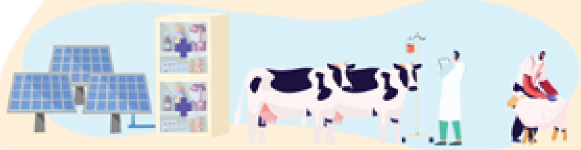

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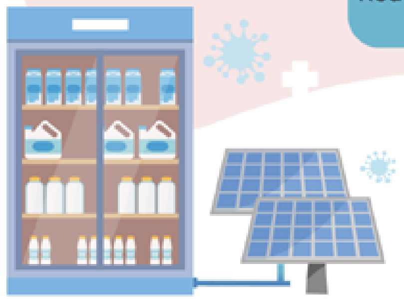

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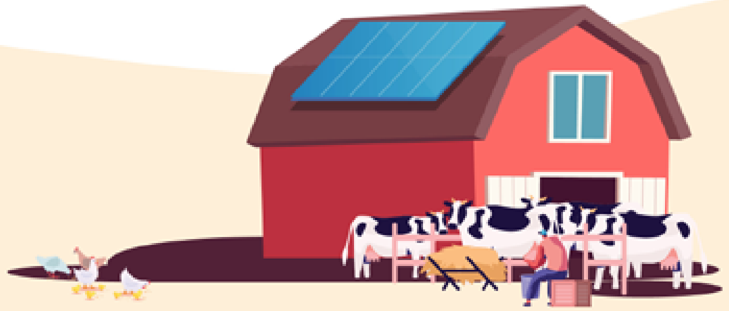

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🟦	Solutions
🟦	Climate Adaptation
🟦	Climate Mitigation
⬜	Cooling Solutions for Sector

Can India reduce food wastage with community refrigerators?

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Source: (DownToEarth 2018)

Why Rural India needs to widen domains for micro-enterprises

Source: (Social Story, 2017)

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Source: (Thomas Reuters Foundation News 2019)

WARMING WATERS HEAT UP FISHING COSTS ALONG INDIA'S MALABAR COAST

BRACE FOR HOTTER SUMMERS AS TEMPERATURES RISE ACROSS INDIA

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Source: (India Climate Dialogue 2021)

SOLUTION 1

8.3A SOLAR POWERED COMMERCIAL REFRIGERATION TECHNOLOGIES

REDUCES LOSSES ON PERISHABLE FOODS IN THE LAST MILE AND MEETS COMMUNITIES' INCREASING DEMAND FOR CHILLED PRODUCTS IN HEAT STRESS AREAS, WHILE CREATING SUPPLEMENTARY INCOMES FOR LOCAL ENTREPRENEURS AND FARMERS.

Lack of efficient retail fridges at last mile

- Lack of last mile cold chain infrastructure results in spoilage and wastage of perishables such as fruits, vegetables. dairy products, etc. in turn contributing to increased use of soil, water and emissions. Every tonne of fruits and vegetables wasted results in approximately 1.1CO2eq. Emissions in the South Asian region.
- At a larger scale, the estimated post-harvest losses of fruits and vegetables due to poor refrigeration facilities are USD 8.4 billion per annum in India. Annually, 16% of perishable fruits and vegetables are wasted due to improper refrigeration facilities
- Need for safety nets and alternate income generation sources to help farmers reduce their dependence on agriculture and allied sectors- where droughts and unpredictable rainfalls have affected income security
- Increasing temperatures and heat stress contribute to an increase in communities' demand for chilled products in rural areas. In the absence of reliable power, refrigeration services cannot effectively meet the needs of these communities, that could also contribute to adverse health outcomes.

SOLUTION: SOLAR POWERED RETAIL REFRIGERATORS [1]

1. Solar powered, efficient retail refrigeration can support product and service diversification for established small resilient businesses while providing alternate livelihood opportunities for farmers and those affected by uncertain incomes. In the face of increasing temperatures, this solution also improves the shelf life of products and helps meet communities' demand for chilled products.

2. The main parts of the system design include the refrigerator and an optimum solar component designed to suit the requirement on the field. The units of energy consumed by the fridge (kWh) along with the autonomy (the number of hours or days the refrigerator can maintain the temperature below a certain level with the combination of refrigerator's insulation property + battery back or phase change material's capacity) required for the intervention drive the design of the panel (wattage) and batteries (Ah).

3. Wattage (W) of the panel and battery storage capacity (Ah) will be designed from the energy usage of the fridge (kWh) and the modality of usage by a small business owner – type of products, usage heaviness, climatic conditions, autonomy required drive the choice of refrigerator and solar components.

Typology	Solar Design Example	End user typologies and use cases
Small 100L - 150L	**Panels**: 100Wp x 2 **Battery**: 100Ah,12V (For 1 day autonomy))	Petty shop/mobile, cold drinks, good irradiation, moderate usage
	Panels: 100Wp x 2 **Battery**: 200Ah,12V (For 2 day autonomy)	Canteen/ petty shop, dairy products + cold drinks, occasional cloudy climatic conditions
Medium 150 L – 240 L	**Panels**: 300Wp **Battery**: 80Ah x 2,12V (For moderate usage)*	Petty shop/ canteens, regular usage with steady customers throughout the day
	Panels: 250Wp x 2 **Battery**: 150Ah x 2,12V (For heavy usage)	Canteen/ petty shop, heavier usage with more number of door openings, dairy products distribution & sales, food products
Large 240 L and above	**Panels**: 250Wp x 3 **Battery**: 200Ah x 2 ,12V (For general cooling)	Petty shop/ canteens, regular usage with steady customers throughout the day
	Panels: 250Wp x 4 **Battery**: 120Ah x 4,12V (For Ice creams/ freezer)	Petty shop, canteens, freezing options – Ice creams, fish, and other frozen products

Image 71 | SELCO's Solar powered retail refrigerator

Image 72 | SELCO's Solar powered retail refrigerator open

TECHNOLOGY: INEFFICIENT RETAIL REFRIGERATOR UNITS VS EFFICIENT SOLAR POWERED RETAIL REFRIGERATOR UNITS

CENTRALISED VS DECENTRALISED

Local context and business models:

- Based on the climate variations, the business models and ownership models, the refrigeration needs vary. The size of solutions would be defined by the same. At the last mile with unreliable or no access to energy, this solution works towards controlling the cost of supply and wastage of a perishable commodity which is at risk due to climatic variations. This also helps with value additions to a small business owner. Inefficient fridges consume more energy and an expensive proposition to communities on a longer time horizon.
- With increasing heat stress, for the fridge to perform well and have a long life span, the placement is critical. Fridges placed outdoors with direct harsh sunlight, leads to pressure on the compressor leading to early wear and tear and poor performance. However, in heat stressed regions, indoor spaces also tend to trap a lot of heat, temperatures often being higher than outdoors. Hence, it is important to include built environment solutions like better passive ventilation, cool roofs to ensure better performance of the technical solution. It also adds to the comfort of the end user and their customers, if in a productive use space.

A total quantity of 81,000,000 litres of milk is produced in a year which if inefficient refrigerators are replaced with efficient solar powered units, can reduce 351,084,375 kWh of energy units per year resulting in 59.38% of savings. This has a GHG mitigation potential of 496.01 kgCO2e/unit/year

Image 73 | SELCO's Solar powered retail refrigerator in commercial use by small village shops

Image 74 | Retail refrigerator used in local shop to store perishables

OWNERSHIP AND DELIVERY MODEL 1

Individually-owned

These may be accessed for existing micro entrepreneurs as part of service diversification for additional income generation, or for establishment of new businesses. These businesses range from petty shops to canteens to home based entrepreneurs.

Mangala, Chitradurga, Karnataka

Climate Risks:

- Heat Stress
- Dry and arid

Main Sources of Income

She runs a petty shop that sells basic products, grocery items, curd, milk and snacks.

Problem and Solution

Mangala has a small petty shop where she used to sell a few basic products earning a revenue of INR 2,500 per day. Her work space was cramped, dim and poorly designed, increasing heat stress indoors. The solutions provided to Mangala include a solar powered retail refrigerator, solar powered photocopier and redesigning and rebuilding her entire shop space. Due to her not owning the land where her workspace is, the panchayat (local governance body) gave her permission to build a temporary structure. With the technological solutions, she is now able to stock and sell more products which includes curd, milk, snacks etc and the photocopier diversifying her business further. Her daily income now is INR 5,000, double of what she was earning earlier. The better designed workspace is giving her a lot of more room, storage space and a sitting area for customers. This has led to an increased footfall and better thermal comfort for both Mangala and her customers. Due to the region being heat stressed, with a better built environment solution, the technological solutions are also performing well.

OWNERSHIP AND DELIVERY MODEL 2

Individually-owned for storing produce

For small scale fisherfolk, dairy farmers, horticulture farmers, this solution could help reduce losses through wastage, increase incomes and sell produce individually as well with the asset.

Small Scale farmers

Climate Risks:

- Heat Stress

Main Sources of Income

She runs a petty shop that sells basic products, grocery items, curd, milk and snacks.

Problem and Solution

The entrepreneur needed to make frequent visits to the town to buy the fish which was often not possible due to the time constraints. This created inconsistency in catering to the local markets and lled to sellers from the town coming to the villages to sell the fish. The price was higher and there was no local entrepreneurship. Due to having to use ice and fuel, the input costs were high which included transaction costs. With the ice melting and not having access to cold storage facilities, there was high spoilage of fish leading to lesser income. The solution provided was a 150 litre commercial refrigerator which led to increase in fish sold per day by 5-10 kgs, 100% reduced expenses on purchasing ice, reduced visits to the town. The selling price of the fish also increased by INR 20 as often, the last few kgs of fish were sold for very low price due to lack of storage. The average increase in revenue/ month because of solar fridge was INR 19,000.

Image 75 | Retail refrigerator used in local shop to store perishables

IMPACT

Individual entrepreneur level:

- Additional income generation potential for micro and small businesses: Based on a study across 40+ sites in Karnataka, India, the net profit for small enterprises that added the refrigerator ranged between INR. 2000 ($27) to INR. 7650 ($ 101) per month depending on the size of the refrigerator and the type of business. A recent pilot study across different states in India found that micro-enterprises using off-grid solar refrigerators had the potential to increase profits by roughly USD 57 per month. This is particularly important given the unreliability and poor quality of electricity faced by micro and small businesses in rural and periurban areas.

Adaptation benefits:

- Improved income security: Micro businesses with add on services such as refrigeration could function as a supplementary income source for farming households, particularly in areas where income from agriculture and allied activities are uncertain and at risk from climate hazards.
- Reduces loss of perishable products and enables communities to access fruits, vegetables and chilled products in areas with increasing temperatures and facing conditions of heat stress, contributing to better health outcomes for local populations.

Mitigation benefits:

- Contributes to reduced GHG emissions by avoiding wastage of food (and water used in production) as well as reduced transportation by localizing delivery services and reducing the movement of products between regions to ensure access to refrigeration and longer shelf life
- Leads to energy savings through the use of energy efficient appliances for refrigeration, rather than those currently functioning on the grid that may be less energy efficient and consume more power.

Image 76 | Refrigerator in commercial use

Kids brave blistering heat in schools without roofs, fans or power.


Source: (News Click 2021)

WITH POOR INFRASTRUCTURE AND LACK OF FACILITIES GOVERNMENT SCHOOLS PERFORM THE WORST ACROSS INDIA

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Source: (The Times of India 2018)

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ATTENDANCE THINS IN SCHOOL, GOVT TEACHERS BLAME THE HEAT

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Source: (Hindustan Times 2016)


Source: (The Times of India 2017)

KIDS TO NOW FALL PREY TO HEAT AS SCHOOLS CONTINUE SUMMER TIMINGS

MID-DAY MEALS THAT WENT UP IN SMOKE

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Source: (The Hindu 2014)

SOLUTION 2

8.3B COOLING FOR SCHOOLS

IMPROVING SPACE COOLING EFFICIENCY USING PASSIVE COOLING METHODS FOR EDUCATIONAL SPACES

Background

Schools play a critical role in the society in providing for a safe and health learning environment. Children spend a large part of their days in schools, and thus the quality of the habitat can have a significant impact on their mental and physical growth. According to the Unified District Information System for Education (UDISE) report, 2017-18 , over 36% of schools in India are unelectrified. Furthermore, many others have unreliable electricity. Others, specifically located out of poor resource contexts are constructed out of inefficient materials (asbestos or metal sheet roofing). These schools are ill-equipped to protect children and teachers from heat waves, high rainfall and droughts that are happening in increasing number across the globe.


Image 77 | Students trying to remedy heat stress

This affects school finances in contexts where resources are already a constraint. Prioritising teacher's salaries, basic school infrastructural needs, lengthy maintenance lists, the school administration often have to de-prioritise cooling, impacting student's health and academic performance. Thus, it is important that resilient and cooling strategies are devised for schools- one that optimises capital and operational expenditures.

TECHNOLOGY:

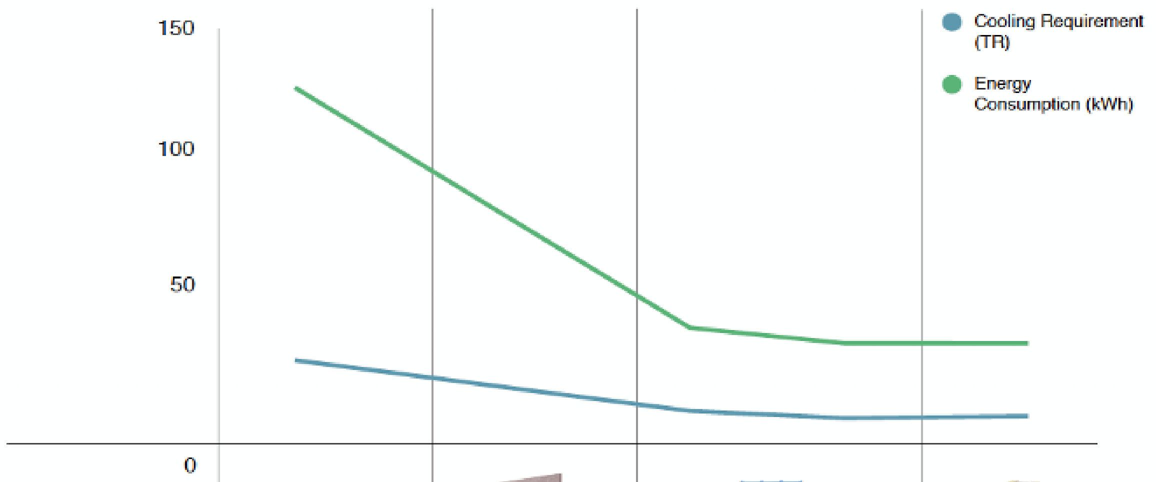
Prevent Health Infiltration

- Building Envelope: Usage of low thermal conductivity and insulated building material for walling and roofing, respectively. This prevents the heat transfer into the classroom and reduces internal temperature.
- External Shading Devices: The roof made from insulated foam sandwich panels are further cooled by a second canopy of rooftop solar panels.

Ventilation and Heat Extraction

- Window Orientation & Design: The orientation, size and material used for the frame of the window and its design reduces the amount of solar heat entering the building, significantly. The placement of the windows should also be done in a manner that it allows for cross-ventilation.

Technical comparisons between standard building materials for prefabricated schools



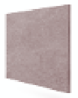
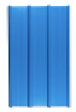
	 Metal Sheet (Original)	 Bison Boards	 Puff Panels		 Ecoboard (Upgraded)
THICKNESS	0.45 mm	18mm - 50mm (air gap) - 18mm	60 mm	100 mm	18mm - 50mm (air gap) - 18mm
COOLING REQUIREMENT	16 TR	10 TR	5 TR	4 TR	4 TR
ENERGY CONSUMPTION	127.2 kWh	79.5 kWh	39.75 kWh	31.8 kWh	31.8 kWh
AIR LEAKAGES	Yes (Can increase cooling requirement up to 24 TR)	No	No		No
THERMAL CONDUCTIVITY	Steel - 50.2 W/m-k	1.2 W/m-K	0.021 W/m-k		0.09 W/m-k
INTERNAL SURFACE TEMPERATURE	55°C	48°C	44°C	40°C	40°C

Image 78 | Children shudying in a cool school

Image 79 | Cooling solutions at Bridge School

OWNERSHIP AND DELIVERY MODEL 1

Bridge School, Prahladnagar, Ahmedabad

Climate Risk:

- Heat Stress

Main sources of income:

- Communities work as daily wage labourers, have petty shops, tailoring units etc.

Problem and Solution:

Under various government and NGO initiatives, shelters are built as creches and tent schools for communities that are migratory in nature and where working parents are present. These creches are usually constructed from tarpaulin, asbestos, metal sheets, mud floors and casuarina poles tied with rope. One season of monsoon can completely wash away such structures and on a daily basis, they have no security from vandalism or rodents. Children study and play in dark, hot ad-hoc shelters with poor ventilation in hot conditions of 35˚C to 50˚C with limited learning material impeding them further from accessing much learning or growth.

The school at Prahladnagar, Ahmedabad is around 665 sq ft in area and caters to the education of 50-60 students living in the nearby migrant slum community. The initial structure of the slum school was made up with building materials of high thermal conductivity i.e. metal sheet that resulted in very high indoor temperatures and had two openings as windows of size 2ft by 2ft which provided no respite due to limited ventilation.

This solution was designed using combination of passive and active cooling technologies.

- The prefabricated technology with thermal efficient materials like eco panels were used for the building envelope.
- The windows of the slum school have aluminium insulated window frame and face north. Also, windows are located across each other so as to improve the natural cross ventilation within the building, adding to the indoor thermal comfort and air quality.

The stated passive solutions when applied together brought down the temperature of the indoor environment up to T 4˚C to 5˚C, compared to the outdoor environment. This ultimately reduces the dependence on the active cooling measures, especially in the case of solar powered devices, as it increases its efficiency. The structure's cooling requirements was brought down from 16TR to 4TR. This also reduces the energy consumption by almost 75% (also illustrated in the figure on page 224).

IMPACT OF COOLING FOR SCHOOLS

Adaptation benefits:

- Better learning outcomes : With reduced indoor heat stress, children are able to study better, more comfortably leading to better learning outcomes and experience.
- Reduced health risks : In some public educational spaces where cooking is a function, often, the space is not segregated leading to a lot of indoor smoke. This is also caused due to the use of firewood for cooking. By using sustainable designs and efficient cook stoves, children, teachers and helpers have reduced health risks.

Mitigation benefits:

- Reduced emissions : With increasing heat stress, the need for air conditioners can be displaced by climate smart designs and efficient coolers or fans, reducing emissions.

Image 80 | Heat Stress growing among school students

9

CONCLUSION

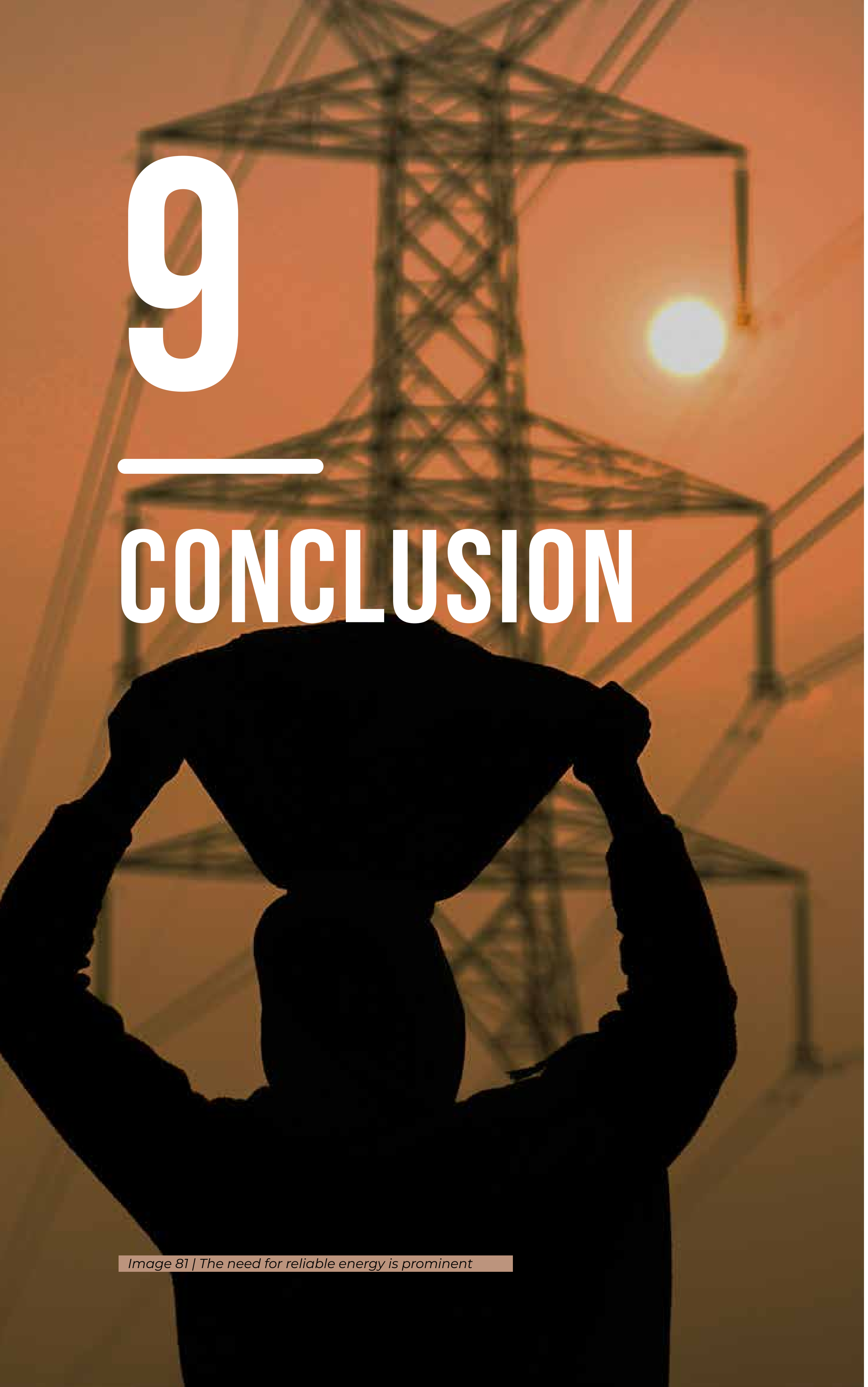


Image 81 | The need for reliable energy is prominent

The approach and solutions showcased in this document reinforce that decarbonization, climate resilience and poverty alleviation can be mutually reinforcing. Using the lens of Decentralised Renewable Energy, strategies for climate action and inclusive development can be delivered synergistically. But taking these solutions forward and building an enabling environment that allows for replication and scale up of these approaches will require incentivization of stakeholders to get away from business as usual practices and take bold steps.

Governments will have to create and implement stricter policies enforcing protection of environment. Parallely, they need to create enabling policies encouraging grassroot focused environmentally friendly solutions combining sustainability and development.

- Channel inputs subsidies towards efficient decentralised solutions within the larger goal of reducing emissions and improving accessibility across the country
- Work closely with banks and local institutions like cooperatives and community based organizations to extend part loans for solutions or support interest subvention, alongside input subsidies
- Mandate and support climate friendly practices according to region specific risks and needs to incentivize and integrate use of solar energy in existing government programs for disaster, health, community well-being, livelihoods, etc.

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 poor to get out of poverty.

- Support to NGOs and local champions involved in promoting and enabling efficient climate smart practices
- Support to NGOs and enterprises involved in the last mile working with end users to improve awareness, training and capacity building on usage of efficient technologies and mitigating risks like climate friendly practices, troubleshooting and others.
- Providing support in creating local assets to boost entrepreneurship, create and hand-hold community led institutions like farmer producer organizations, cooperatives and local enterprises

Incubators need to support capacity building of enterprises to innovate and force actions within their processes to drastically reduce the impact on the environment because of their products and services.

- Build inclusive incubation programs that support innovation and entrepreneurship amongst local individuals which can respond to local challenges of climate change and the poor communities
- Support innovations that create new benchmarks of technology development for the poor to follow a much more futuristic, bolder and transformational thought process that converges the efforts for poverty alleviation, climate mitigation and adaptation.
- Build capacity to provide a practitioner's lens in building businesses in under-served geographies as well as to communities with under-developed ecosystems
- Provide mentorship in developing innovations on delivery models that let technical innovations to reach the last mile.

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 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.

10

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(Wang and Horton 2015)

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