The Cooling Dividend

Building a market for low-cost cooling that protects lives and livelihoods in Africa and South Asia

Evidence from the Scaling Passive and Affordable Cooling for Economic Resilience and Sustainability (SPACES) program in India, Nigeria and Ghana

Shell Foundation | UKaid from the British people | Transforming Energy Access | intellecap | NDARAMA WORKS Local Knowledge | Global Expertise

Contents

Table of Contents

Foreword by Shell Foundation

Extreme heat is not a future challenge. It is already affecting the lives and livelihoods of millions of workers across emerging markets, reducing productivity, constraining incomes and creating growing risks for businesses that depend on resilient supply chains and thriving local economies.

While record temperatures, droughts and extreme weather events often dominate headlines, the everyday economic impact of heat is far larger, yet receives far less attention. For a delivery rider, it means fewer trips completed in a day. For a market trader, it means losing customers during the hottest hours. For a farmer, it means produce spoiling before it can be sold. Repeated hundreds of millions of times across economies, these disruptions translate into lower earnings for workers, reduced productivity for businesses and slower economic growth. Today, 2.4 billion workers are exposed to excessive heat at work and, by 2030, heat stress is projected to cost the global economy the equivalent of 80 million full-time jobs.

The challenge is particularly acute for the informal workers and small enterprises that constitute the majority of employment and economic activity in much of Africa and Asia. Unlike workers in formal employment, many have no employer or insurer to absorb the impact of lost working hours or damaged goods. When heat prevents them from working, the financial consequences are immediate.

This report offers reason for optimism.

The Cooling Dividend presents new evidence from the first year of SPACES, a collaborative initiative led by Shell Foundation, Foreign, Commonwealth and Development Office, Intellecap and Ndarama Works. Across India, Nigeria and Ghana, more than 12,000 workers tested simple, affordable cooling technologies that require no electricity, including evaporative cooling jackets, reflective cooling canvas and radiative cooling film.

The findings demonstrate that low-cost cooling solutions can deliver measurable economic value. Across the pilots, between 68% and 100% of users reported less heat-related fatigue and illness. Cooling jackets enabled workers to recover between one and three additional working hours that would otherwise have been lost to heat, while delivery riders reported completing two to five additional deliveries each day, translating into income gains of 15-25%. Vendors traded for longer, perishable goods were protected from spoilage, and businesses became more resilient to rising temperatures.

Particularly encouraging were the gains reported by women-led enterprises, which recorded some of the strongest commercial results in the programme. Net income margins increased by 34-38 percentage points among users of cooling canvas and by almost 25 percentage points among users of cooling film. These findings highlight the potential for affordable cooling technologies to strengthen women's economic resilience and enterprise growth in some of the communities most exposed to heat stress.

Importantly, the evidence presented here points towards solutions that can be delivered and sustained at scale by the private sector. Each of the solutions featured in this report has been tested in a commercial environment, with manufacturers, distributors and prospective purchasers involved from an early stage. Creating those markets will require innovation, investment and collaboration across these actors as well as policymakers and investors.

This is where catalytic philanthropy plays a vital role. By funding early-stage testing, generating evidence of impact and helping to de-risk initial commercial adoption, philanthropic capital can help demonstrate viability and unlock significantly larger flows of private investment. Shell Foundation's role is not to subsidise these solutions indefinitely. It is to help prove they deliver both impact and commercial value, creating the conditions for sustainable growth.

The opportunity is significant. The cooling market in developing economies is projected to reach at least US$600 billion annually by 2050, creating substantial opportunities for businesses while helping workers and communities adapt to rising temperatures. The evidence in this report suggests that affordable cooling strengthens livelihoods, improves productivity and builds resilience at a time when all three are urgently needed.

As the world gets hotter, we must find practical ways to protect the people whose labour powers our economies. The findings presented here show that effective solutions already exist. We look forward to working with partners to scale them.

Jonathan Berman
Chief Executive Officer
Shell Foundation

This material has been funded by UK International Development from the UK government; however, the views expressed do not necessarily reflect the UK government's official policies.

Executive Summary

A $600 billion market, and a livelihood dividend

Cooling is on track to become one of the largest consumer-focused themes in Africa and South Asia with an estimated market potential of around US$600 billion a year by 2050, projected to grow sevenfold in Africa and fourfold in South Asia. Yet more than a billion people in these same regions cannot access cooling at all. The SPACES program set out to test whether that gap can be closed profitably and found that creating a self-sustaining commercial ecosystem around frugal passive cooling innovations can raise the net income margins of micro-entrepreneurs by 10 to 38 percentage points.

US$600bn annual cooling market by 2050	**2.4bn** workers exposed to heat at work	**10–38%** gain in net income margin in pilots
US$2.4tn global productivity loss by 2030	**20–37%** more output per shift with cooling	**12,000+** units deployed in three countries

Source: ILO, Heat at Work (2024) and Working on a Warmer Planet (2019); SEforALL, Chilling Prospects (2025); IFC & UNEP Cool Coalition, Cooler Finance (2024); SPACES Year 1 pilot

The problem

Extreme heat has moved from being a seasonal discomfort to a permanent tax on income. Some 2.4 billion workers are exposed to extreme heat at work, including about 93% of the workforce in Africa, 75% in Asia and the Pacific and about 84% of the workforce in the Arab states. While workers in high-income economies like UAE and Saudi Arabia can mitigate impact of extreme heat through access to better infrastructure and cooling innovations, majority of workers in African and South Asian economies do not have access to solutions which can protect them from extreme heat, thereby exposing them to heat stress. For such workers, the productivity cost, alone, is projected at US$2.4 trillion a year by 2030, equivalent of 80 million full-time jobs. It is estimated that worker productivity drops by 2-3% for every degree of additional warming above 20°C.[1] The impact of heat stress is not only restricted to loss of productivity, but it also results in food losses thereby impacting livelihood opportunities of those who are involved across the food supply chains ranging from farmers, Farmer Producer Organizations, transporters, vendors and even consumers of food items. As per a joint report published by the Food and Agriculture Organization and World Meteorological Organization, damage to food production from extreme heat is pervasive across the agricultural sector. Yields of staple crops like maize and wheat are projected to decline by up to 10% for every 1°C of additional warming. By 2100, nearly 50 percent of the world's cattle could be exposed to dangerous heat, with annual productivity losses nearing USD 40 billion in 2005 dollars.[2]

Those losses are not evenly distributed. They fall hardest on people who work outdoors or in unventilated spaces, who are paid by the day or by the sale, and who have no way to pass the cost on viz. street vendors, farm laborers, construction and brick-kiln workers, delivery riders, waste pickers and home-based producers. For them, heat is not just a health statistic, it is the hours of livelihood opportunities lost and the food stock that spoils before it sells.

Need for a focused cooling solution

Cooling solutions, both active systems that use electricity and passive solutions that leverage reflection, radiation and heat dissipation, have well-evidenced potential to reduce heat stress. Annual market for these solutions in developing economies is projected to reach around US$600 billion by 2050.[3] Currently, more than a billion people, globally, are at high risk from lack of access to cooling, and what defines this group is not only limited livelihood opportunities but the absence of reliable power sources; across sub-Saharan Africa some 450 million rural people still live without electricity, and at least 70% of them are involved in agriculture. For such workers, active cooling solutions which rely on access to electricity and can provide cooling only within an enclosed space is not the most relevant solution. Instead, passive cooling innovations like reflective coatings, shading, ventilation, evaporative and radiative materials can prove to be more effective. Studies across South Asian case studies find that such solutions can reduce indoor temperature by 2–7°C with benefit–cost ratios between 1:1 and 4:1.[4] But most efforts to scale passive cooling

[1] Climate Change and Workplace Heat Stress, World Meteorological Organization (WMO); World Health Organization (WHO), 2025
[2] Adjusted to the value of money as per the purchasing power in the year 2005
[3] Cooler Finance: Mobilizing investment for the developing world's sustainable cooling needs, International Finance Corporation, 2024
[4] Primer for cool cities: Reducing excessive urban heat, ESMAP, 2020

solutions have focused on buildings and the built environment. Mobile street vendors, open-air market traders, and outdoor workers have been largely left out because the solutions they need are not packaged, priced, or distributed for them.

What SPACES found

Scaling Passive and Affordable Cooling for Economic Resilience and Sustainability (SPACES), a partnership formed by Shell Foundation, Foreign, Commonwealth and Development Office (FCDO), Trane Technologies, Intellecap and Ndarama Works to pilot frugal, passive cooling innovations with the low-income workers and explore commercialization potential of such solutions, deployed three low-cost passive cooling technologies with nearly 12,000 workers and micro-entrepreneurs across India, Nigeria and Ghana to understand the impact of innovative passive cooling solutions on the lives and livelihoods of microentrepreneurs, gig and informal workers. The Year 1 evidence across technologies and geographies is summarized below:

- **Cooling jackets** helped recover one to three hours of work during daytime that are otherwise lost to heat stress, improved worker productivity and comfort, and aided an increase in food order deliveries across user segments like construction workers, gig workers, delivery riders, farmers, security guards, and vendors.
- **Cooling canvas** reduced heat-related spoilage for vendors in Nigeria and Ghana, improved physical comfort, prevented loss of working hours during daytime, and lifted net income margins by 10-38% for micro-entrepreneurs, street vendors, and Point of Sale (POS) agents.[5]
- **Cooling film** turned the afternoon from the worst trading window into one of the best for 93% of users, helped reduce heat fatigue and improved productivity for construction workers, raised net income by 13-35% for fruit and vegetable vendors, and also reduced heat-related spoilage of fruits and vegetables.

Across the portfolio, between 68% and 100% of users reported less heat-related fatigue and illness. Women users recorded the largest income gains in Africa.

What has not been solved

Every product in these pilots was given away to establish proof of concept and test the efficacy of the innovations. Today these products costs more to make and land than users are able and willing to pay. Critically, it is freight, duties, and small order volumes rather than the materials themselves that account for most of that gap. SPACES is actively working with local manufacturing enterprises, aggregating demand, exploring local supply chains and end-user financing as a few of the levers to meet the demand-side requirements.

The opportunity

The prospect for commercializing the first cohort of technologies piloted under SPACES is substantial. More than a billion people currently lack access to adequate cooling, concentrated in South Asia and sub-Saharan Africa. In India alone, the World Bank has characterised the cooling sector transformation as a US$1.6 trillion investment opportunity by 2040.[6]

What it will take

Philanthropic capital cannot fund cooling for a billion people; instead, what it can do is remove uncertainty and barriers that keep commercial actors away by establishing evidence of product efficacy, strengthen local supply chains and create commercial demand by building confidence in product efficacy. To accelerate this shift, other like-minded stakeholders can come together to create resilient ecosystems for low-income workers and support livelihood opportunities by scaling and commercializing frugal cooling solutions.

The cooling dividend

Currently, when imported, a cooling jacket lands at about seventeen dollars. Against this outlay, on an average, delivery riders reported two to five additional deliveries a day, a 15–25% increase in earnings, and users in Nigeria cut weekly spending on cooling by 41%. When measured against recovered deliveries alone, the jacket repays its cost in about a month's time, then keeps returning for the rest of its working life. Cooling canvas and film cost more to land today, but the nature of return demonstrates similar impact i.e. increase in net income margins by up to 38% and 35% respectively, with heat-related spoilage significantly reduced.

This is the cooling dividend: a return on investment measured not in degrees but in earnings, accruing to the people with some of the least capital to deploy and the least room to absorb a hotter world. Year 1 of SPACES has established this dividend exists and

[5] POS Agents are authorized local intermediaries who use electronic terminals to provide basic banking services, such as cash withdrawals, deposits, and bill payments, directly to communities

[6] World Bank, *Climate Investment Opportunities in India's Cooling Sector*, November 2022

in subsequent years, SPACES intends to attempt to take this dividend to the hundreds of millions of workers across the African and South Asian geographies. What remains is to bring the cost of the asset down to the point where the workers earning that return can afford to make the upfront investment themselves.

Agricultural workers face heat-related mortality rates thirty-five times higher than workers in other industries[7] *Representative image, generated by AI*

[7] [Impacts of Climate Change and Heat Stress on Farmworkers' Health: A Scoping Review, *Frontiers in Public Health*, 2022]

01

The challenge of heat stress

Why extreme heat has become an economic and livelihood problem, and who carries the cost.

Brick kiln workers face both extreme ambient temperatures and intense radiant heat from the kilns. Source: [Dreamstime]

1.1. Rising heat and its cost on health and livelihood

African and South Asian countries are projected to face unendurable heat extremes by mid-century, and the trend is already visible. With roughly 1°C of global warming to date, heatwaves in South Asia have become about thirty times more likely than in the past. India's Ministry of Earth Sciences records heatwave-linked mortality rising 62.2% over the past four decades. Twenty-three Indian states now have active heat action plans to adapt to heatwave-type situations during peak summer seasons.[8]

Today the economic consequences of rising heat stress are better quantified than they were a decade ago. The International Labor Organization estimates that 71% of the global working population, or about 2.4 billion workers, are exposed to excessive heat, which is a 35% rise from the start of the 21st century.[9] This study estimates that 93% of the total workforce in Africa, 75% of the workforce in Asia and the Pacific, and about 84% of the workforce in the Arab states are exposed to excessive heat at workplaces. While workers in high-income economies like UAE and Saudi Arabia can mitigate impact of extreme heat through access to better infrastructure and expensive cooling innovations, majority of workers in African and South Asian economies do not have access to solutions which can protect them from extreme heat thereby exposing them to heat stress. For such workers, the productivity cost, alone, is projected at US$2.4 trillion a year by 2030, the equivalent of 80 million full-time jobs. It is estimated that worker productivity drops by 2-3% for every degree of additional warming above 20°C.[10] The impact of heat stress is not only restricted to loss of productivity, but it also results in food losses thereby impacting livelihood opportunities of those who are involved across the food supply chains ranging from farmers, Farmer Producer Organizations, transporters, vendors and even consumers of food items. As per a joint report published by the Food and Agriculture Organization and World Meteorological Organization, damage to food production from extreme heat is pervasive across the agricultural sector. Yields of staple crops like maize and wheat are projected to decline by up to 10% for every 1°C of additional warming. By 2100, nearly 50 percent of the world's cattle could be exposed to dangerous heat, with annual productivity losses nearing USD 40 billion in 2005 dollars.

Table 1: The economic cost of heat, from global to household

Level	Measure	Scale of loss
Global	Annual productivity loss by 2030	US$2.4 trillion (80m full-time jobs)
Asia–Pacific	Share of workforce heat-exposed &% productivity loss per worker	75% of all workers; 2-3% per worker for every degree of additional warming above 20°C
Africa	Share of workforce heat-exposed &% productivity loss per worker	93% of all workers; 2-3% per worker for every degree of additional warming above 20°C
India	Working hours lost to heat by 2030	5.8%—equal to 34m full-time jobs

[8] Ministry of Earth Sciences, Government of India, Press Release, Dec 2023

[9] Heat at work: Implications of health and safety, ILO report, 2024

[10] Climate Change and Workplace Heat Stress, World Meteorological Organization (WMO); World Health Organization (WHO), 2025

Level	Measure	Scale of loss
India	Labor hours lost in 2022	191 billion hours
Firm level	Output decline per 1°C rise	2–3.5%
Worker level	Delhi street vendors reporting income loss in extreme heat	49% (80% report fewer customers)

Source: ILO, Heat at Work (2024); ILO, Working on a Warmer Planet (2019); World Bank; The Lancet Countdown (2023); Journal of Political Economy, vol. 129; The Indian Express

These figures reveal a global phenomenon where heat destroys income at household level and impose disproportionate economic burden on the most vulnerable strata of the society. For a salaried worker, extreme heat is an inconvenience absorbed by the employer. For the roughly 90% of workers in India and much of sub-Saharan Africa who are informally employed, the loss is immediate and personal, with no back-up options. Plant-level studies in tropical manufacturing industries show output falling 2–3.5% for every additional degree Celsius.[11] For a daily-wage worker or a vendor trading on margin, that translates directly into a choice between income and safety, and the evidence suggests most choose income until their body forces the decision.

1.2. Who is most exposed

Heat exposure is concentrated in a predictable set of occupations. Agricultural workers face heat-related mortality rates thirty-five times higher than workers in other industries.[12] In India, close to 60% of construction workers report mild to severe heat-related symptoms during summer.[13] Brick-kiln workers endure both extreme ambient temperatures and intense radiant heat, with summer conditions frequently exceeding international safety limits for work.

Informal workers like street vendors, hawkers and small shopkeepers operate out of specific spots. Vendors, often, operate in unshaded, open-air markets with no ability to modify their workplace, and their income depends on being present at their workplace irrespective of the weather conditions.

Informal workers operate in unshaded, open-air conditions and cannot modify their workplace. Source: imagesbazaar

Table 2: Sectors with the highest heat exposure among low-income workers

Sector	Typical roles	Exposure	Why
Agriculture	Landless laborer, seasonal farm workers	Very high	Open fields during peak summer
Construction	Daily-wage laborer, masons, helpers	Very high	Long hours in direct sun, minimal shade
Gig-workers	Rickshaw pullers, delivery riders, loaders	Very high	Physically intense work in open environments
Brick kilns	Brick makers, kiln operators, loaders	Very high	Ambient heat plus radiant kiln heat
Waste management	Rag pickers, waste segregators	High	Outdoor dumpsites, long walking distances
Informal retail	Street vendors, hawkers, shopkeepers	Moderate–high	Unshaded open-air markets
Home-based work	Garment, food and craft producers	Moderate–high	Poorly ventilated homes; equipment heat

Source: Adapted from Intellecap analysis in the Indian Passive Cooling landscape report (2026).

Three examples of a typical working day experience during extreme heat

	What the day looks like	What heat costs
Farm laborer	Six to eight hours in open fields, often through the hottest part of the day, paid by the day or by volume harvested	Heat-related mortality 35 times higher than in other industries; work stops before the day's target is met

[11] The Impact of Temperature on Productivity and Labor Supply: Evidence from Indian Manufacturing; Journal of Political Economy, vol. 129
[12] Impacts of Climate Change and Heat Stress on Farmworkers' Health: A Scoping Review, Frontiers in Public Health, 2022
[13] Perceived heat stress and health effects on construction workers; National Library of Medicine, 2015

	What the day looks like	What heat costs
Construction worker	Long shifts on unshaded sites with minimal protection or rest infrastructure	Close to 60% report mild to severe heat symptoms in summer; 191 billion labor hours lost nationally in 2022 in India
Street vendor	Stationed in an open-air market through peak footfall hours, trading perishable stock on thin margins	49% report income loss and 80% report fewer customers during extreme heat; stock spoils before it sells

Source: ILO; The Lancet Countdown (2023); National Library of Medicine; The Indian Express.

1.3. Gendered and social dimensions of heat exposure

Heat does not fall evenly across a household. In low- and middle-income countries, female-headed rural households lose 8% more of their income to heat stress each year than male-headed households, which translates to an income gap of US$37 billion annually.[14] On current trajectories, every 1°C rise in long-term average temperature is estimated to associate with a 34% greater reduction in the incomes of female-headed households.[15] This vulnerability is due to higher dominance of women in trades that are most exposed to spoilage viz. agri-produce vending, cooked food, dairy, small-scale farming.

Women often work in indoor spaces that are poorly ventilated and hotter than outdoor conditions. Source: [imagesbazaar]

Although women across African and South Asian countries, spend most of their time indoors, this does not translate to greater protection. In fact, the opposite may be true. Rigid cultural norms and gender roles like cooking, caregiving and water collection often restrict women's ability to respond to heat-related risks. Many remain confined to poorly ventilated homes with limited access to cooling, making them especially vulnerable during extreme heat events. This is particularly concerning given that a significant share of the world's home-based workforce, comprised largely of women, operates in similar conditions. Women make up about 65% of these informal workers globally. Biologically, women are around 3.7 times more likely to experience heat intolerance than men.[16]

As heatwaves intensify, these gendered and social vulnerabilities risk deepening existing inequalities in health, income, and climate resilience. Without targeted, inclusive interventions that address the distinct needs of these groups, progress in poverty alleviation, sustainable urban development, and equitable adaptation to climate change may be severely undermined.

The compounding disadvantage

- **Health:** women report 2.3 times more heat-related illness and 35% more heat-stress symptoms than men.
- **Economic agency:** 71% lower average income and 58% less decision-making authority over housing, limiting the ability to buy or install cooling.
- **Household losses:** women-headed households in low- and middle-income countries face heat-related income losses 8% higher than male-headed households.
- **Life stage:** pregnancy raises vulnerability by about 25% and increases the risk of preterm birth and maternal mortality during heat exposure.

Source: Analysis based on ADB data; FAO, The Unjust Climate; Down To Earth.

[14] The Unjust Climate: Measuring the impacts of climate change on rural poor, women and youth, FAO, 2024
[15] The Unjust Climate: Measuring the impacts of climate change on rural poor, women and youth, FAO, 2024
[16] Women and exertional heat illness: identification of gender specific risk f actors National Library of Medicine, June 2015

02

The passive cooling solutions landscape

What passive cooling solutions exist today, and why they are not reaching the people who need them most.

Reflective cool-roof coatings are among the most accessible passive cooling solutions available today. Source: [Dreamstime]

2.1. Cooling options available

Cooling solutions are divided into two broad categories viz. Active cooling which uses mechanical systems and energy inputs like air conditioners, fans, evaporative coolers and passive cooling which minimises heat gain and promotes heat loss without mechanical systems or energy input, using materials, design and natural resources. The two are generally complementary rather than competing with each other, given that their cost and operating profiles are entirely different.

Table 3: Comparison of passive and active cooling solutions

Parameters	Passive cooling	Active cooling
Mechanism	Materials and design; no energy input	Mechanical systems and refrigeration
Examples	Cool roofs, shading, natural ventilation, reflective films, evaporative fabrics	Air conditioners, electric fans, evaporative coolers
Energy use	Zero to minimal	High
Operating cost	Low to zero	Significant and recurring
Refrigerants	None	Used in most cases
Works during electricity outages	Yes	No
Maintenance requirements	Minimal	Regular maintenance required
Accessibility for low-income users	High	Limited

2.2. Why conventional active cooling solutions remain inaccessible

For many economically disadvantaged communities in Africa and South Asia, conventional active cooling solutions are largely out of reach. The upfront cost of an air conditioner represents several months' income for households in the bottom economic quintile, and operating costs impose a second barrier. Even fans, which are far more affordable, require a reliable electricity supply, something that is still a luxury for more than 40% of Africans who do not yet have access to electricity.[17]

[17] Africa's electricity access gap persists amid investment shortfall, Semafor Africa, August 2026

Ceiling fans remain the primary cooling method for most low-income communities, but they offer limited relief in severe conditions. Meanwhile, the market response to climate and geopolitical shocks in the form of rising prices and supply shortages continues to erode purchasing power.

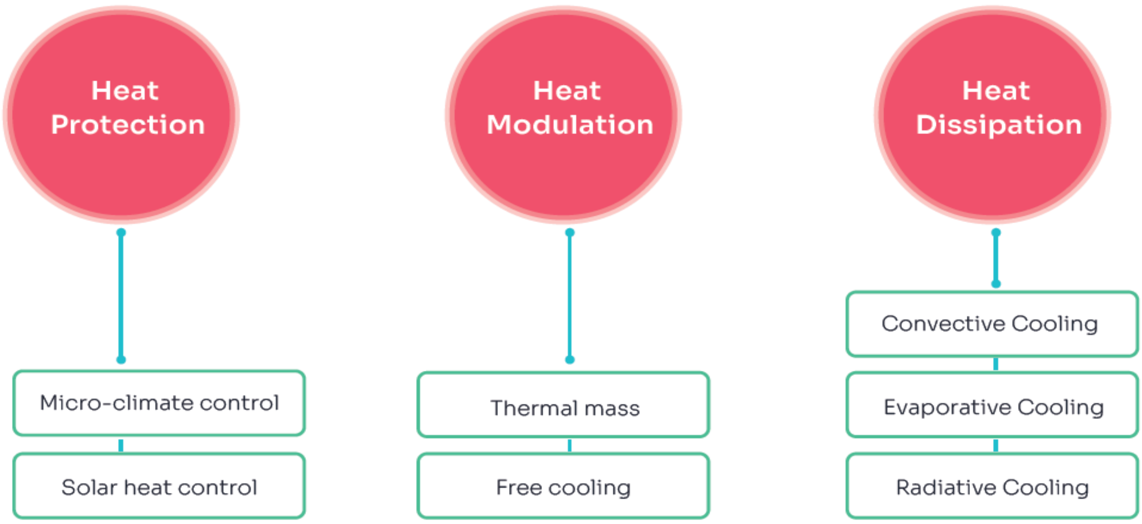
There is a further constraint that cost alone does not capture. A delivery rider moving between addresses, a vendor pushing a cart between markets, a construction worker at an unshaded site, and a farm laborer in an open field cannot be served by a solution that needs to be plugged into a wall or an enclosed space where temperature can be controlled. For this workforce the relevant question is not whether cooling is affordable, but whether a product exists at all. This is the gap which passive cooling solutions can plug into.

2.3. Unique opportunity for passive cooling to plug heat resilient livelihood gaps

Passive cooling solutions operate through three distinct but interconnected strategies, each targeting different aspects of thermal management to create comfortable indoor environments without relying on energy-intensive mechanical systems. A brief overview of each passive cooling mechanism is provided below–

1. **Heat protection** focuses on preventing heat gain through the building envelope, employing technologies such as reflective roofing materials, external shading devices, high-performance insulation, low-emissivity glazing, green roofs and vegetation, cool-colored exterior surfaces, and specialized window films. These elements create a thermal barrier that minimizes solar radiation and conductive heat transfer into the building
2. **Heat modulation** manages the timing of heat flow through thermal mass, utilizing materials like thick masonry walls, concrete floors, phase change materials, earth coupling techniques, thermal labyrinths, and water features to absorb heat during peak daytime temperatures and release it during cooler periods, effectively "shifting" the heat load to more favorable times
3. **Heat dissipation** removes excess heat through natural processes, including natural ventilation (cross-ventilation, stack effect, wind towers), evaporative cooling (direct and indirect), radiative cooling to the night sky, earth tubes, and courtyard designs that create microclimates.

Figure 1: Passive Cooling Strategies and Associated Technologies



Each passive cooling strategy has a mature supply base. Cool roof paints and reflective films are supplied by firms including SpaceCool, COOLROOF, and LuminX, with products cutting roof heat by up to 20°C. Phase-change materials for cold chains and cooling garments come from Pluss Advanced Technologies, Ice Battery and Microtek Laboratories.

Earthen and traditional construction is being revived by the Auroville Earth Institute, CoolAnt and Earth Blocks India, alongside NGOs such as Goonj and Tarun Bharat Sangh. Ventilation is supplied by Aastha Enviro, Maya Fan Air Engineering and TROX India.

Terracotta and earthen materials provide high thermal mass and evaporative cooling without electricity. Source: Dreamstime

Table 4: What low-cost passive cooling solutions cost and deliver

Solution	Climate suitability	Temperature reduction	Cost (US$)	Durability
Cool roofs (specialised paints)	All except cold	4–8°C	1.5–5.6 /m²	3–5 years
Reflective and radiative film	All	8–10°C	50-70 /m²	10–12 years
Reflective and radiative paint	All	5–15°C	5–50 /m²	5–10 years
Insulation from agricultural waste	All	3–5°C	5–22 /m²	10–15 years
Evaporative cooling garments	Hot and dry	3–7°C	5–10 /unit	2–3 years
Earthen construction and shading	Hot and dry	3–8°C	12–16 /m²	15–20 years
Enhanced natural ventilation	All except cold	1.5–3.5°C	1.7–8.2 /m²	10+ years

Source: Based on findings from primary consultations

Few suppliers of innovative passive solutions

The following table provides a list of companies and organizations that are providing heat dissipation solutions through natural ventilation (cross-ventilation, stack effect, wind towers), evaporative cooling (direct and indirect), radiative cooling to the night sky, earth tubes, solar chimneys, and courtyard designs that create microclimates. These organizations represent potential strategic partners for scaling heat dissipation interventions that can directly impact low income populations.

Table 5: Few suppliers of passive cooling solutions

Technology family	Representative suppliers	What they offer
Cool roof paints and reflective surfaces	EXCEL Coatings, COOLROOF by IIE, LuminX, StarShield	Nano-insulated and high-SRI coatings cutting roof heat by up to 20°C; reflecting upto 97% of solar radiation
Phase-change materials and cooling garments	Pluss Advanced Technologies, 98 Fahren, Ice Battery, Microtek Laboratories, Brrf	Reusable PCM plates for cold chains and PCM-based cooling vests
Evaporative and radiative cooling	MittiCool, Ant Studio, RuKart, Q Gen-Next, SpaceCool, SkyCool	Clay refrigeration, terracotta cooling structures, portable produce coolers, radiative paints, cooling jackets
Earthen materials and ventilation	Auroville Earth Institute, CoolAnt, Earth Blocks India, Aastha Enviro, TROX India	Compressed stabilised earth blocks, terracotta facades, turbine ventilators and airflow systems

Source: Based on findings from primary consultations

2.4. Makeshift solutions used by micro-enterprises before SPACES

In the absence of fit-for-purpose supply, the informal workers and microentrepreneurs have devised makeshift solutions to cope heat stress through use of tarpaulins and second-hand market umbrellas; timber-and-thatch kiosks; use of wet towels wrapped around neck and face etc. These improvisations are clearest market signal of unmet demand for cooling. Workers are already spending on cooling; however such adaptations barely address cooling requirements of the workers, tarpaulin blocks the sun while trapping heat beneath it, a thatch kiosk is immobile, and wet towel lasts minutes rather than hours.

A market trader's stall shaded by a tarpaulin and a second-hand umbrella. Nigeria.

Timber-and-thatch kiosk shelters for roadside kiosks. Nigeria.

Source: SPACES field documentation. Images show pre-intervention conditions at pilot sites.

2.5. What passive cooling delivers

Pilots demonstrate that simple passive cooling solutions like reflective white paint on roofs can reduce indoor temperatures by 4-5°C,[18] while innovative rooftop cooling systems using gunny sacks and green shade nets cost one-tenth of air conditioning.[19] These findings are in line with meta-analysis of passive cooling case studies across South Asia which found average indoor temperature reductions of 2–7°C, with benefit–cost ratios ranging from 1.4:1 to 4.2:1 depending on technology and context.[20] Cool roof interventions specifically show benefit–cost ratios of 3:1, while urban greening delivers 1:1 to 5:1 returns and reduces heat-related mortality by up to 35%.[21]

There exist both the data and tools needed to protect world's most vulnerable workers from heat stress but coordinated action to implement solutions at scale is something that is missing.

A study by Mahila Housing Trust across 186 homes in Ahmedabad, Ranchi and Bhopal found lime-wash cool roofs reduced indoor temperatures by an average of 3.4°C—enough to allow families to sleep indoors during peak summer. In a subsequent intervention, cool roof technology for home-based workers reduced indoor temperatures by 3 to 6°C, allowing women who had previously been forced to shift their sewing machines outdoors (under a tree or other shaded area) during daytime to keep working indoors, extending their productive hours and raising their income. That initiative reached over 20,000 homes and was absorbed into Ahmedabad's official Heat Action Plan.

CASE STUDY

Mahila Housing Trust: Women applying their own cooling

In Ahmedabad, where summer temperatures routinely exceed 42°C, Mahila Housing Trust introduced a cool roof initiative aimed at women in informal settlements. The intervention was deliberately simple—UV-reflective white paint applied to rooftops, with hands-on training delivered through posters and simple guidance material.

Women led the application process themselves. Over 20,000 homes have benefited, with measurable reductions in indoor temperature and electricity use, and improved comfort for elderly residents, women and children. The initiative was subsequently absorbed into Ahmedabad's Heat Action Plan.

This example demonstrates that when community takes ownership of a solution, adoption within the community is accelerated. Where women were engaged early and took part in both the learning and the implementation, uptake was faster and more durable than where the intervention was delivered to them.

Passive cooling interventions at the community level can reduce high indoor temperature and encourage self-driven community adoption, making dwellings more liveable during extreme heat. For the informal retail sector, which employs home based workers facing moderate to high heat exposure, interventions show promising results.

The pattern worth noticing

There exist models to scale passive cooling where it can attach to a fixed structure that somebody owns. Cool roofs, insulation, ventilation and earthen construction can be supported via building codes, housing schemes, municipal programs, and public funding schemes.

Scaling of passive cooling solutions is yet to be explored where the user is mobile, the workplace is not a building, and no institution owns the asset. The street vendor, the delivery rider, the market trader and the outdoor laborer fall outside every one of those delivery channels. This is the gap that SPACES intends to address.

The following table summarizes workplace applications and their potential impact across different workplace types.

Table 6: Passive cooling interventions to address heat stress for low-income workers

Workplace type	Relevant sectors	Key challenges	Suitable technologies
Agricultural work shelters	Agriculture	Rural, exposed, field-adjacent shelters	Vegetation shading, evaporative cooling, reflective cooling paints and sheets

[18] Informal settlements try out new cool roof solutions to beat the heat; Citizen Matters, 2025
[19] For sustainable world each one of us should live sustainably; Thrive Global, 2021
[20] Primer for cool cities: Reducing excessive urban heat, ESMAP, 2020
[21] Prioritizing Heat Mitigation Actions in Indian Cities, World Bank Group, 2024; Increasing urban vegetation could have saved over 1.1m lives in two decades, Monash University,2025

Workplace type	Relevant sectors	Key challenges	Suitable technologies
Construction sites	Construction	High sun exposure, mobile tasks, little to no shade	Mobile shading, cooling jackets, hydration points, reflective cooling paints and sheets
Brick kiln sites and high-heat yards	Brick kilns	Extreme radiant heat, long shifts, high ambient temperatures	Shaded rest shelters, radiative sheets, hydration and break protocols
Home-based enterprises	Domestic work, informal retail, manufacturing, hospitality and services	Dual residential and workplace heat stress; equipment heat generation	Sectional cooling, ventilation enhancement, cool roofs
Small workshops and manufacturing	Manufacturing, construction services	Industrial heat, limited scope for modification	Passive downdraft systems, night ventilation, shading systems, reflective cooling paints and sheets
Informal market stalls	Informal retail, transport, hospitality and services, waste management	Direct sun exposure, lack of permanent shelter	Lightweight shading systems, reflective canopies, evaporative cooling, cooling jackets
Security and maintenance booths	Security and maintenance	Enclosed static posts with poor airflow	Ventilation enhancements, cooling jackets, hydration

Source: Findings from SPACES program

The above table informs that targeted passive cooling combined with rest cycles can reduce heat stress and raise productivity across a wide range of user-types, and the technologies required are neither exotic nor expensive. But the rows divide sharply on one dimension. Agricultural shelters, home-based enterprises, and small workshops can be served by fixed interventions, viz. cool roofs, ventilation, and shading systems that attach to a structure, while construction sites, informal market stalls, and security posts require cooling solutions that travel with the work. For such workers, suitable technologies need to be wearable or portable, like cooling jackets, lightweight shading, and reflective canopies.

2.6. Why affordable solutions have not scaled

If passive cooling works and the need for solutions is acute, the obvious question is why the market has not delivered. The ingredients that usually precede a functioning market are, on the face of it, already present. The technologies are proven; raw materials like lime, clay, polymers, and agricultural residue are largely available across geographies. The evidence of benefit is documented. The population that would gain is vast and easy to identify. Discussions with solution providers reveal that cultural inertia and price, rather than ignorance of the product, hold back adoption.

Primary research with manufacturers and solution providers points to four reinforcing barriers.

Table 7: Four barriers preventing low-cost cooling from reaching low-income users

Barrier	What it looks like in practice
Products are not designed for user types	Most passive cooling technologies are built for institutional or premium markets and sold in bulk, at high price points, and not packaged for do-it-yourself application or the irregular structures typical of informal workplaces
Distribution does not reach the last mile	Networks rarely extend into low-income urban settlements or rural areas. Local retailers and contractors are often unaware of these products, do not stock them, and have no link to manufacturers
Import dependency inflates cost	Reflective membranes, PVA inserts, insulation panels and phase-change materials are largely imported or assembled from imported inputs. Freight, duties and small order volumes can exceed the material cost itself
Innovations stall before commercial scale	High-potential solutions remain stuck in pilot stage for want of demand aggregation, procurement pathways or early-stage capital, so unit costs never fall far enough to reach the intended user

Source: Findings from SPACES program

The evidence gap beneath the market gap

Underlying all four barriers sits a less visible constraint, that hinders at-scale commercialization of such innovations, which is a lack of pre-commercial trials of such technologies which could inform a manufacturer, a buyer or a lender whether these products actually work and are effective. Discussions with solution providers found that products in this space are designed for industrial and factory workers, not for informal and low-income workers with no cooling access at all and that awareness among users is high while adoption remains low, held back by cultural inertia, low willingness to pay and the absence of any demonstrated business case.

Traditional evaporative cooling knowledge exists, but rarely reaches informal workplaces as a product. Source: imagesbazaar

Low-cost cooling that travels with the work is the category the market has not yet served. Source: imagesbazaar

This creates a circular problem. Manufacturers are hesitant toward localizing production without demonstrated and sustained commercial demand. Demand cannot be demonstrated without affordable products in the field. Employers will not buy at scale without evidence of productivity gains. Lenders will not finance a category with no performance data. Investors treat passive cooling for low-income users as risky investment because there are no returns data, no policy certainty and small ticket sizes.

Table 8: The financing gap that mirrors the market gap

Financing barrier	Why it persists	Who could bridge it
No dedicated financing instruments	Passive cooling produces no metered savings or revenue, so it does not qualify for green finance or home-improvement lending	Microfinance institutions, cooperative banks and NGOs offering micro-loans and pay-as-you-save products
Low investor confidence	No returns data, uncertain policy uptake and small ticket sizes; even impact investors hesitate without concessional capital	DFIs and climate funds providing first-loss guarantees and blended structures
Low willingness to pay	For low income users even low-cost upgrades are discretionary; most lack credit histories or collateral	Employers through co-payment; philanthropies through targeted subsidy and results-linked incentives
Capital constraints among suppliers	Small and mission-driven enterprises lack the balance sheet to expand or fulfill bulk orders	Concessional debt, recoverable grants and procurement-linked advances

Breaking this circle requires someone to run the pilots that nobody has a commercial incentive to run, measure the outcomes rigorously, and publish the results whether or not they are flattering. That is the specific gap the SPACES program was created to fill.

03

SPACES: plugging the gap

How the program de-risks and commercializes frugal cooling for micro-entrepreneurs and informal workers.

A fruit vendor trading under a stall fitted with reflective cooling film, India. Source: SPACES field documentation

3.1. Program overview and partnership

SPACES, which is an acronym for Scaling Passive and Affordable Cooling for Economic Resilience and Sustainability, is a multi-year program to identify, validate and commercialize ultra-low-cost cooling solutions for low-income communities and micro-entrepreneurs. It works on solutions priced between roughly US$10 and US$100 per unit and focusses on–

1. Testing and validating the impact that these solutions have on the livelihoods of low-income workers and microentrepreneurs
2. Scaling the solutions/innovations to reach multitudes of microentrepreneurs across Africa and South Asia (SPACES is initially, scaling innovations across India, Nigeria and Ghana which may be gradually expanded across other geographies.)

The program's design responds directly to the circular problem set out in the previous chapter. Rather than subsidising cooling indefinitely, SPACES uses philanthropic capital to buy down the pre-commercialization risks viz. sourcing technologies, validating them independently, deploying them at zero cost to users so that demand and impact can be measured, and that evidence can build the case for local manufacturing and commercial distribution and procurement at-scale for low-income workers.

Table 9: How SPACES works

Stage	What happens	Why it is necessary
1. Fund and equip	Scan the global market for technology-ready solutions; procure and prepare them for field conditions	Products for this user do not exist off the shelf and must be sourced and adapted
2. Pilot at scale	Deploy through employers and aggregators at no cost to users; measure comfort, hours, income increase and satisfaction	Evidence of pre-commercial trials is limited; reliable data is a pre-requisite for investment by manufacturers and buyers
3. Localise and commercialize	Use demonstrated demand to localize supply chains, build distribution and enable paid transactions	Import-led barriers hinder local adoption at scale and customization potential

The partnership

Partner	Role
Shell Foundation and FCDO	Anchor funder; frames cooling as a livelihood and resilience intervention and provides catalytic capital

Partner	Role
Trane Technologies	Global climate innovator; technology sourcing, engineering adaptation and independent validation
Intellecap	Implementation partner for India; local delivery, distribution and field monitoring of cooling innovations
Ndarama Works	Implementation partner for Nigeria and Ghana; local delivery, distribution and field monitoring of cooling innovations

3.2. The three technologies taken to market in Year 1

Year 1 concentrated on three passive technologies, chosen for technology readiness, suitability for outdoor and mobile work, and the potential to reach affordable price points once manufacturing is localized.

Table 10: Year-1 technology portfolio, at a glance

	Cooling Jacket	Cooling Canvas	Cooling Film
Mechanism	Evaporative cooling through water-saturated pads	Reflective radiative multi-layer fabric	Reflective radiative film
Primary user	Outdoor and mobile workers	Market traders, vendors among others	Vendors, portable cabins, small premises among others
Where it is used	Worn on the body	Fabricated into market umbrellas and shade structures	Applied to roofs, vans and stalls
Cooling effect	4–8°C for several hours	5–10°C under the canopy	5–13°C interior reduction
Deployed in Year 1	11,970 units	27 rolls → 61 umbrellas	55 rolls

Source: SPACES Year 1 pilot, India, Nigeria and Ghana.

3.3. Cooling Jacket

Field workers wearing cooling jackets, Ghana. Source: SPACES field documentation

The cooling jacket is a wearable vest with poly-vinyl alcohol (PVA) pads stitched to the inner side of the jackets that cool the body by evaporation. PVA pads absorb water in liquid form and then releases it in vapor form by absorbing heat from surrounding environment. The user has to soak the jacket in water, wring it out and wear it to experience the cooling effect. It delivers four to eight degrees of relief for one to four hours (depending on the rate of evaporation) and requires to be re-wetted once the jacket dries out. It performs best under moderate heat stress with high wind flows around it (example - bike riding) and its efficacy reduces with increase in humidity.

11,970
jackets deployed, 30% female users

~30%
Increase in productivity during summer season

~70%
users indicated improved comfort and less heat fatigue

Table 11: Key pilot partners

Geography	Key partners
India	SWIGGY, zomato, TATA PROJECTS Simplify.Create, Reliance Industries Limited, Godrej PROPERTIES, Mahindra
Africa	TGI, FanMilk, FLUDOR, Soilless Farm Lab, Ako Fresh, Green Shield

Source: SPACES Year 1 pilot

Cooling jackets have been deployed at scale in all three SPACES geographies. Across Nigeria and Ghana, 4,990 units were deployed among workers and micro-entrepreneurs across eleven distribution locations in Nigeria and five regions in Ghana. In India a further 6,980 units were distributed through eleven implementation partners, spanning gig delivery, construction, healthcare, manufacturing, financial inclusion, logistics and community livelihoods, and covering hot and dry, composite, warm and humid and temperate climatic zones.

Comfort and health outcomes were consistent across all three countries. In Nigeria 72.7% of users reported greatly improved physical comfort and 68.6% less heat-related fatigue and illness; Ghana followed closely at 66.2% and 60%, with only 3.7% reporting no change at all. India, across a far wider spread of occupations, recorded 69% finding the jacket comfortable and 70.8% saying it kept them cool during peak heat.

A controlled physiological study at a medical college in India found no adverse change in core body temperature or pulse, and adverse symptoms were rare across the user groups. 96% of 120 users at this medical college reported feeling cooler and 94% reported better work performance. All wearers reported the cooling effect diminishing over a two to three-hour period.

The African pilots produced a comparable efficacy proof point, drawn from thousands of everyday users. Across the Nigerian cohort, users rated the jacket 4.46 out of 5, and Ghana returned 4.09 out of 5, with both groups reporting improved comfort and near-universal reductions in heat fatigue. On the measures that matter most to an outdoor worker, comfort held and fatigue avoided through the hottest hours, the jackets delivered impact.

From comfort to improved productivity

Performance of these jackets were not only evaluated for the comfort they provided, but impact on livelihoods due to jackets was also studied. In Africa, users gained up to three hours of work during daytime, which would have been, otherwise, lost due to oppressive heat. The Indian pilots saw about 40% of the surveyed users reporting fewer heat stress-induced break requirements during the day, and 37% reported a direct productivity impact. Delivery riders reported an increase of 2-5 deliveries per day owing to the cooling effect of the jacket resulting in 15-25% in income.

The business case: a delivery rider in Delhi

A delivery rider working a six-hour afternoon shift in May typically loses one to two hours to heat stress-induced breaks and often ends the shift early. At roughly ₹25–35 per delivery, two recovered hours are worth two to five additional deliveries a day.

At a target localized price of US$5–8, a cooling jacket pays for itself within two to three weeks of recovered deliveries before accounting for the reduction in spending on cold drinks and rest breaks. The constraint is not the payback period.

Construction workers wearing cooling jackets on site in India. Source: SPACES field documentation

USER TESTIMONIAL FROM THE FIELD · INDIA

"Good product, it's useful. My productivity has increased compared to last month."

Sudip Das, construction worker, reported that he was comfortable wearing the jacket and that it kept him cool during the hottest hours. Sudip mentioned that given a choice he would prefer to wear cooling jackets while working in outdoor conditions during summer season, going forward. The jacket helped improved Sudip's productivity and reduce heat stress experienced by him previously.

CASE STUDY · NIGERIA

Iya Sukura: cooler days, steadier trade in a Lagos market

Iya Sukura, 55, sells from an open stall in Mushin, one of Lagos's busiest informal markets, where midday heat routinely drains energy and cuts the trading day short. Like most traders around her, she had no cooling to fall back on beyond shade and rest. Through the pilot she received a cooling jacket, and the effect was immediate: ***"I don't feel as much heat as I used to, and my business has improved too."***

Her experience mirrors the wider Nigerian pilot—72.7% of users reported greatly improved comfort and reduction in loss of one to three working hours during daytime due to heat stress, and a fall in what they spent on cooling, with the % of those spending nothing at all rising from 33% to 63%. For a trader working on daily margins, comfort that extends the trading day is, in the end, income.

USER TESTIMONIAL FROM THE FIELD · GHANA

"Once I wet it, I can work 2–3 hours without extreme heat—it has shifted the way I work."

Jonas Asiedu, a farmer in Oda Nkwanta, Ghana, was among the last-mile agricultural workers who tested the jacket—the group that rated it most highly. His experience captures the core benefit: not comfort for its own sake, but working hours reclaimed from the midday heat.

Areas of Improvement

Users also gave feedback on certain features of the jackets which could be further improved–

1. The PVA pads within the jackets have a tendency to harden once it dries, making the jackets uncomfortable to wear
2. Instant access to water to reactivate cooling may be a challenge for delivery riders or construction workers
3. Few users across geographies also mentioned that wearing the jacket immediately after dipping it in water tends to make their clothes wet, which can cause discomfort until the clothes dry
4. Due to rapid wind movement around them, delivery riders experienced drying of jackets in about an hour's time, limiting the cooling effect until the jacket was again dipped into the water.

3.4. Cooling Canvas

Cooling canvas is a durable multi-layered fabric combining radiative and reflective cooling, fabricated into market umbrellas and shade structures. It reduces temperatures underneath by roughly five to ten degrees.

For the pilots, about 27 canvas rolls were fabricated into 61 market umbrellas—20 rolls into 40 umbrellas in Nigeria through four partners, and seven rolls into 21 umbrellas in Ghana, distributed directly to vendors inside a major city market.

A user installing cooling canvas over his stall, Nigeria. Source: SPACES field documentation

50%
Increase in traders now working for full day through peak afternoon heat

38%
Increase in income for women-led enterprises

0%
revenue lost to spoilage, from 3.6% in Nigeria

Physical comfort improved for 100% of Nigerian and 89.5% of Ghanaian users, and comfort was ranked the single most valued benefit in both countries. Median net income margin rose 10.6% in Nigeria overall, but the striking result is among women-led enterprises, where margins rose 34-38% in both countries. 62% of Ghanaian users reported reduced spoilage and longer shelf life for perishable stock.

Durability held up under intensive use: 92% of Nigerian umbrellas were rated 'like new' after sustained deployment, with 84% used six or more hours daily.

Table 12: Key pilot partners

Geography	Key partners
Africa · Nigeria	TGI, Green Shield, Soilless Farm Lab
Africa · Ghana	Ashaiman Main Market trader network
India	Pilots planned for the next phase

The business case: a vegetable trader in Nigeria

A trader selling perishables in an open-air market loses margin twice over during peak heat: stock wilts and spoils, and she stops trading through the middle of the day when footfall is highest.

Under cooling canvas, all-day trading rose from 41% to 93% of users in Nigeria and heat-related spoilage fell to zero for surveyed users. For a women-led stall, the recorded margin gain of 34 to 38 percentage points transforms the economics of the business. Currently, the delivered price of umbrella, ~US$3,000 is a key obstacle, driven by high import costs of the material rather than fabrication related challenges.

3.5. Cooling Film

Cooling film applied on top of worker resting place. Source: SPACES field documentation

Cooling film is a reflective radiative material applied to roofs, vehicles and stall canopies, reflecting a high share of incident sunlight and cutting interior temperatures. When pasted on top of conducting surface like iron or aluminium, cooling film also extracts heat from enclosed space and radiates it into the outer space thereby providing further cooling by up to five to thirteen degrees.

It is an easy to apply film comprising of an adhesive layer, which can be directly pasted on top of the surface where the film needs to be applied. The only prerequisite is that the surface where the film is to be applied, needs to be cleaned and make dirt free before application of the film.

53% → 93%
users with afternoon peak trading

+35%
net income gain

100%
reported better comfort, less fatigue

Cooling Film fitted to a commercial food-vendor van, Nigeria. Source: SPACES field documentation

Deployment of cooling films spanned India and Nigeria, across various use cases. In Nigeria the film was fitted to 45 sales vans across Lagos, Ogun and Ibadan, one greenhouse roof, and retail and point-of-sale outlets, while in India installations, covered worker rest shelters, non-air-conditioned commercial vehicle cabins, street-vendor cart canopies, an ambulance and a livestock shed, across the states of Gujarat, Rajasthan, Karnataka, Telangana, Delhi and Bihar.

The behavioral effect in Nigeria indicated a rise in all-day trading activity from 41% to 98% of users, and the hours between noon and four pm, when traders generally stop work due to heat stress, became peak business time for 93% of users, up from 53%. Net income rose by 13.2% across all users, while heat-related product losses were eliminated entirely, falling from 3.6% to zero.

Indian street vendors, working under film-fitted metallic cart canopies, recorded the same economics through a different measure. 81.3% to 100% of vendors reported improved produce shelf life across different states, lower wastage than control vendors, and up to 35% increase in average weekly income compared with vendors without the film.

The Indian pilots also produced directly measured thermal data for the technology. Semi-enclosed worker rest shelters fitted with the film recorded an average underside temperature of 39.6°C against an ambient 46.4°C, demonstrating a cooling effect of roughly 6.8°C, consistent across midday and mid-afternoon readings. Workers using the treated shelters reported improvements on every comfort indicator measured, viz. perceived cooling relief, better rest quality, and reduced fatigue-related outcomes. The measurement is of surface rather than air temperature and should not be read as an equivalent drop in indoor air temperature.

Table 13: Key pilot partners

Geography	Key partners
India	TATA PROJECTS Simplify.Create; Mahindra; NASVI; Finovista
Africa · Nigeria	TGI; Green Shield; Soilless Farm Lab

Coverage, not climate, determines performance

The most useful finding from the Indian deployment is that the film's effectiveness depends less on how hot the location is than on how much of the exposed metallic surface can actually be covered. Semi-enclosed rest shelters and street-vendor canopies, which offer large continuous metal surfaces, performed strongly and consistently. Partially glazed delivery vehicle cabins did not demonstrate a significant perceived cooling effect for the drivers. Bengaluru recorded the largest comfort improvement of the four cities, most plausibly because the film was applied to cabin doors as well as the roof, while locations with lower coverage saw comfort gains fade as the day went on. An ambulance application of the cooling film produced limited results for the same reason.

User acceptance was high in both regions. Every user in the Nigerian pilot reported improved physical comfort and less heat-related fatigue, with satisfaction of 4 out of 5 and 69% wanting no changes to the product. Installation proved to be easy, with site teams in India learning to apply the film themselves after a single training session. No significant damage or maintenance issues were reported.

A vendor using cooling cart to prolong the shelf life of her produce in India. Source: SPACES field documentation.

USER TESTIMONIAL FROM THE FIELD · INDIA

"Higher earnings from the business helped me support my daughters' education."

Baby Devi, a fruit and vegetable vendor based in Delhi, shared that installing the cooling film on her vegetable cart has extended the shelf life of her products by at least two days, allowing her to sell them for longer. This not only helped her get better prices for her products but also meant she had to make fewer trips to the wholesale markets to buy the next batch of produce, reducing additional expenses for trips to and from the wholesale markets. She claimed that the fruits and vegetables she sold remained fresh longer than her peers', resulting in additional income for her family.

Areas of Improvement

Users also gave feedback on certain features of the cooling film which could be further improved–

1. The canopy placed on top of the cooling cart was sometimes found to make the cart heavy and cumbersome to move
2. The high cost of the cooling film made the prospect of paying upfront for the film a challenge for the vendors

3.6. Geography, reach and emerging findings

SPACES piloted frugal cooling solutions across India, Nigeria and Ghana, initially selected for the combination of heat exposure and dense informal-sector employment in these geographies. The following are the consolidated findings from the pilots conducted in Year 1.

Table 14: Consolidated Year 1 outcomes across the portfolio

Outcome	Result	Where it was strongest
Reach	11,970 jackets, 61 canvas umbrellas, 20 film rolls across 3 countries	Cooling jackets were piloted across the 3 countries, while film was piloted in India and Nigeria and canvas in Ghana and Nigeria
Comfort and health	68–100% report less heat fatigue and illness	100% for cooling film and Nigerian canvas users
Productive hours	20–37% more output per shift; all-day trading up to 93–98%	Cooling film, Nigeria
Income	10–38% gain in net income margin	Women-led enterprises across all three technologies
Cost of cooling	41% reduction in weekly cooling spend	Cooling jacket, Nigeria
Spoilage	Heat-related product loss reduced to zero	Canvas and film, Nigeria

Source: Findings from SPACES program

3.7. Learnings so far

The pilots were designed to test products. They also provided a clearer picture of what commercial entities require before adopting an unfamiliar solution.

- **Institutional intermediaries are the fastest route to users:** Reaching low-income workers individually is slow and expensive. Deploying solutions through institutional intermediaries like employers, aggregators and market associations can enable accelerated outreach to thousands of users and gave the program a counterparty capable of placing a commercial order at scale which could enable wider awareness and encourage retail adoption.
- **The barrier to scale is affordability, not desirability:** Most canvas and film users wanted no design changes at all. What could hold the adoption back is the price of the film and canvas. Notably, women reported higher satisfaction than men while stating lower willingness to pay, which could signal financial autonomy-related challenges rather than product value.
- **Localization could be a key to improving access to innovations:** Freight, duties, and small order volumes can exceed material costs thereby driving up the final cost of the products. Furthermore, importing products from remote geographies result in

poor quality control, longer lead times and contract enforcement related uncertainties. Strengthening local supply chains could help in addressing these issues.

- **Manufacturers need a minimum demand threshold to cater to local markets:** International manufacturers of cooling film and canvas indicated openness to local production once a certain minimum threshold of local, commercial demand is witnessed. Aggregating demand is therefore a prerequisite for cost reduction.
- **Design iteration is still required:** Users asked for longer cooling duration and less water dependence in jackets and lighter-weight canopies for the cooling film, which can be delivered through design improvements and further R&D.
- **An innovative financing mechanism could unlock demand at scale:** Exploring concessional financing or cost-sharing models between employers and workers or EMI-based payment structures could help users overcome challenges around upfront payment of the cooling products. This could unlock commercial demand at scale.

Commercial conversations are now underway, driven by the strength of the Year 1 evidence. Several pilot partners have indicated intent to purchase, and the program's focus has shifted from demonstrating impact to closing the distance between production cost and what users will pay.

04

Conclusion and a call to action

Where the program goes next, how large the addressable opportunity is, and what sustains it beyond grant funding.

Catalytic capital can de-risk the first commercial transactions and crowd in private investment. Source: Dreamstime

4.1. The evidence is now clear enough to act on

SPACES set out to investigate if frugal cooling could actually change anything for the people who are most exposed to heat. Having facilitated pilots and studies across three technologies and three countries and having covered close to twelve thousand users, over a period of one year, the SPACES program has decisively established that there are frugal solutions which can not only protect low-income workers from heat stress but also augment income generation, thereby improving the quality of life and livelihood for these vulnerable communities.

The 1st year of the SPACES program has unlocked three conclusions, and each of them unlocks insights into commercializing frugal, cooling technologies at scale–

First, heat is an income problem, and cooling is an income intervention: The gains recorded in these pilots were not primarily thermal. They were hours of trading recovered, stock that stopped spoiling, and breaks that were no longer necessary. Framing cooling as a health or climate good understates what it does for a household that earns by the day.

Second, frugal cooling works, but its impact depends on application fit: The jacket performed well for construction workers, farmers, and security guards, but fell short for highly mobile delivery riders. The film performed best where it covered large continuous metal surfaces and poorly on glazed vehicle cabins. These are not failures of the technology; they are nuances the market needs to address to design the right variants for different user types.

Third, price is a constraint that needs to be worked upon: Satisfaction with the efficacy of the cooling technologies was high across geographies, and most canvas and film users wanted no design changes at all. Yet stated willingness to pay was significantly lower than the current product price. Incremental costs from freight, duties, and small order volumes add to the product cost and account for the price differential.

4.2. The scale opportunity

The opportunity for commercializing the first cohort of technologies piloted under SPACES is substantial. Cooling is projected to become a market worth around US$600 billion a year by 2050, growing roughly sevenfold in Africa and fourfold in South Asia.[22] More than a billion people currently lack access to adequate cooling, concentrated in South Asia and sub-Saharan Africa. In India alone, the World Bank has characterised the cooling sector transformation as a US$1.6 trillion investment opportunity by 2040.[23]

US$600bn	7× and 4×	US$1.6tn
Annual projected cooling market by 2050	Cooling market growth projected in Africa and South Asia, respectively	India cooling investment to 2040

[22] SEforALL, Chilling Prospects 2025; IFC & UNEP Cool Coalition; Cooler Finance (2024)
[23] World Bank, *Climate Investment Opportunities in India's Cooling Sector*, November 2022

Table 15: Addressable population across the three SPACES geographies

Geography	Addressable base	Composition
Nigeria	30.2–43.1 million microenterprises	64% farmers, 36% retail; extrapolated from pilot sample
Ghana	1.44–3.93 million microenterprises	77% farmers; 55% female
India	380 million people in heat-exposed occupations	Includes 42 million home-based workers, most of them women

Source: SPACES Year 1 analysis

The program's own trajectory targets serving more than a million customers of innovative cooling solutions over the next five years as the platform becomes self-sustaining. Reaching that scale requires significant investments toward identifying and piloting new innovations, creating awareness and providing scaling up support for local supply chains, although this would be a fraction of the private and public sector investments in commercial procurement, it is intended to unlock.

4.3. A call to action

Philanthropic capital cannot fund cooling for a billion people; instead, what it can do is remove uncertainty and barriers that keep commercial actors away by establishing evidence of product efficacy and strengthening local supply chains and demand creators. To accelerate this shift, other like-minded stakeholders can come together and join forces to create resilient ecosystems for the most vulnerable communities of the society and support their livelihood opportunities through scaling and commercializing frugal, cooling solutions.

Table 16: Roles that different stakeholders can play

Who	Role	What it unlocks
Co-funders and philanthropies	Join the scaling phase with catalytic capital, and create confidence in the innovations for commercial investors	Cost-down manufacturing and the first paid pilots at scale
Manufacturers and industrial partners	Commit to local production of relevant cooling innovations	Removal of freight and duty costs and better control on product specifications and quality
Employers and institutional buyers	Place commercial purchase orders for captive workforce, create demand at-scale	The demand volume that triggers localization, and a heat-resilient workforce
Banks, MFIs and insurers	Design instalment, pay-as-you-save and employer co-payment products for cooling	A bridge across the upfront cost that users cannot cross alone
Policymakers and regulators	Write thermal comfort into labor welfare codes, occupational safety standards and public procurement	Cooling treated as worker protection rather than discretionary spend
Researchers and advocacy partners	Extend the evidence base and carry it into global heat and climate agendas	Evidence that is socialized and a cooling agenda anchored in data

4.4. The cooling dividend

Currently, when imported, a cooling jacket lands at about seventeen dollars. Against this outlay, on an average, delivery riders reported two to five additional deliveries a day, a 15–25% increase in earnings, and users in Nigeria cut weekly spending on cooling by 41%. When measured against recovered deliveries alone, the jacket repays its cost in about a month's time, then keeps returning for the rest of its working life. Cooling canvas and film cost more to land today, but the nature of return demonstrates similar impact i.e. increase in net income margins by up to 38% and 35% respectively, with heat-related spoilage significantly reduced.

This is the cooling dividend: a return on investment measured not in degrees but in earnings, accruing to the people with some of the least capital to deploy and the least room to absorb a hotter world. Year 1 of SPACES has established this dividend exists and in subsequent years, SPACES intends to attempt to take this dividend to the hundreds of millions of workers across African and South Asian geographies. What remains is to bring the cost of the asset down to the point where the workers earning that return can afford to make the upfront investment themselves.