CLIMATETECH HORIZONS 2026

GSMA
Mobile for Development

M4D

GSMA

The GSMA is a global organisation unifying the mobile ecosystem to discover, develop and deliver innovation foundational to positive business environments and societal change. Our vision is to unlock the full power of connectivity so that people, industry and society thrive. Representing mobile operators and organisations across the mobile ecosystem and adjacent industries, the GSMA delivers for its members across three broad pillars: Connectivity for Good, Industry Services and Solutions, and Outreach. This activity includes advancing policy, tackling today's biggest societal challenges, underpinning the technology and interoperability that make mobile work, and providing the world's largest platform to convene the mobile ecosystem at the MWC and M360 series of events.

We invite you to find out more at **gsma.com**

UK International Development
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Sweden Sverige

This initiative is funded by UK International Development from the UK Government and the Swedish International Development Cooperation Agency (Sida), and is supported by the GSMA and its members.

GSMA ClimateTech programme

The GSMA ClimateTech programme unlocks the power of digital technology in low- and middle-income countries to enable their transition towards a low-carbon and climate-resilient future. We do this with the collective support of the mobile industry, as well as public and private actors. Through our research and in-market expertise, we catalyse strong partnerships, facilitating innovative digital solutions that address key challenges. Our work spans climate mitigation, adaptation and resilience strategies across the globe.

For more information about the ClimateTech programme, visit **gsma.com/climatetech**.

Acknowledgements:
This publication was developed by the GSMA ClimateTech programme, drawing on insights and case studies from across GSMA Mobile for Development programmes, including the GSMA Innovation Fund, AgriTech, Mobile Money, Central Insights Unit, Digital Utilities and Mobile for Humanitarian Innovation, as well as the GSMA Climate Action team. We are grateful to the contributors who generously shared their time and expertise through interviews and to colleagues across the GSMA whose input and support were invaluable in shaping this report.

Foreword

from Dr. Eng. Festus K. Ng'eno, MIEK, CBS

Principal Secretary, State Department for Environment and Climate Change
Ministry of Environment, Climate Change and Forestry, Kenya

In 2025, the global response to climate change is increasingly shaped by human resilience supported by digital innovation. Around the world, communities are demonstrating how ingenuity, connectivity and collaboration can convert climate risk into opportunity. Mobile and digital technologies now play a critical role in this transition by linking people to information, markets and essential financial services that strengthen their capacity to manage and adapt to climate shocks.

The scale and maturity of these digital systems are evident. In 2025, mobile money platforms processed more than USD 1.7 trillion, underscoring their significance as trusted financial infrastructure. Beyond facilitating transactions, these platforms are enabling access to insurance, emergency support, savings and climate-smart services – tools increasingly central to household and enterprise resilience.

In Kenya, technology and community-driven solutions are building a more resilient, sustainable future. The Kenya Meteorological Department uses mobile alerts, real-time data sharing and digital forecasting tools that empower communities, farmers and local authorities with timely and accurate climate information to plan and adapt to changing weather patterns. Partnerships with telecoms have expanded access to weather-based insurance, providing vital financial safety nets for those most affected by climate shocks. The National Environment Management Authority (NEMA) is strengthening environmental stewardship and supporting public participation and informed decision-making through real-time monitoring, improved data collection and transparent communication. Finally, Kenya's ambitious "15 billion Tree Growing" initiative uses digital mapping, satellite monitoring and community engagement platforms to coordinate tree planting efforts, monitor progress and ensure sustainable management of forest resources.

This edition of the ClimateTech Horizons Report highlights how such capabilities are being deployed in practice. It features solutions as well as examines the evolving role of mobile network operators, whose connectivity, IoT systems and data insights are enabling new forms of environmental monitoring, climate finance delivery and community-level resilience.

The GSMA's work across climate, digital inclusion and innovation seeks to address these challenges by fostering collaboration between policymakers, industry leaders, humanitarian actors and technology innovators. This report should therefore be read as an invitation to deepen collective effort. With concerted action, the potential to deliver transformative, equitable impact is well within reach.

Introducing ClimateTech Horizons

from Akanksha Sharma

Head of ClimateTech and Digital Utilities programmes,
GSMA Mobile for Development

The second edition of the *ClimateTech Horizons* report reiterates the GSMA Mobile for Development (M4D) programme's commitment to harnessing mobile and digital technologies for low-carbon, climate-resilient solutions, but does so against an increasingly volatile backdrop. Over the past 12 months, we have witnessed more frequent and severe natural calamities on every continent, shifts in geopolitical relationships and a contraction in global climate finance flows, all of which disproportionately affect vulnerable communities in low- and middle-income countries (LMICs).

Digital innovation, however, continues to offer a lifeline and the role of technology in climate action has only gained momentum. Advancements in AI, data-sharing protocols and mobile money systems are opening new avenues to reduce emissions, strengthen early warning systems and deliver climate finance at scale. Our past work has shown how mobile operators and start-ups are using these tools to connect farmers to weather index insurance, deliver emergency cash assistance via mobile wallets and optimise resource use across cities. In this edition we look further ahead, exploring how emerging technologies – combined with digital public infrastructure initiatives – can empower communities in LMICs to build lasting resilience to climate change.

Looking back on 2025, this edition spotlights the power of digital technology to unlock climate finance and drive interconnected solutions across sectors and geographies. Throughout our M4D programmes we've seen what's possible when digital technology meets community ingenuity. This report distils those lessons and offers fresh insights to guide the next wave of impact.

CONTENTS

DRIVING CLIMATE ACTION

GSMA Mobile for Development

Climate impact

72.7M
people reached

21.7M
people supported to adapt to climate change

Innovation funding

£8.6M
awarded to grantees

£54.4M
in follow-on investment raised by Innovation Fund grantees

48 organisations funded across **22** countries

Impact figures are accurate as of January 2026. They were achieved through GSMA projects supported by the Foreign, Commonwealth & Development Office (FCDO) and the Swedish International Development Cooperation Agency (Sida).

GSMA climate action

79
mobile industry members in the GSMA Climate Action Taskforce

80%
of global mobile connections covered

150
countries and territories reached

The challenge

Climate change is the most pressing challenge facing humankind

The impact is global but LMICs are disproportionately affected. Systematic and swift action to address climate change is essential.

The opportunity

Digital solutions are uniquely positioned to drive climate action by:

- Mitigating the primary driver of climate change by reducing greenhouse gas emissions
- Building resilience to the impacts of climate change for the most vulnerable communities
- Driving sustainable use, management and protection of natural resources and the environment in areas exposed to climate stressors

What we do

Our climate initiatives leverage technology to improve climate mitigation, adaptation and resilience strategies

We research insights, evidence and best practices to drive opportunities for digital innovation

We catalyse partnerships between government, mobile operators, innovators and service providers

We fund and support innovative solutions to climate problems

Our work focuses on engaging and impacting **three key groups:**

1. **Vulnerable communities**
2. **Private sector**
3. **Public sector**

We work with **key stakeholders** to **unlock longer-term impact** through:

Government · **Startups/ innovators** · **NGOs** · **Mobile operators** · **Funding partners**

Increasing access to services · **Capacity building and training** · **Sharing insights and evidence** · **Strategic advisory support** · **Technical assistance**

Our scope

Waste management and circular economy

Natural resource management and forestry

Agriculture

Water

Energy

Disaster preparedness and response

Transport, mobility and logistics management

Improving the delivery of climate finance

Climate change education and awareness

Climate change impact on vulnerable groups in LMICS

Climate action

For the GSMA, **climate action**[1,2] means activities that:

reduce greenhouse gas emissions and **mitigate climate change**

build the resilience of the most vulnerable communities to climate change stressors and threats

drive sustainable use, management and protection of natural resources and the environment in areas most vulnerable and exposed to climate change stressors

Climate resilience

Climate resilience[3] means supporting **communities and vulnerable groups to:**

Anticipate

climate variability and risks from extreme climate events, supporting preparedness and planning (e.g. through early warning systems)

Adapt

to multiple, long-term and evolving climate change risks (e.g. through precision agriculture and long-term weather forecasting)

Absorb

adverse conditions, emergencies or disasters (e.g. through access to credit and insurance in the event of a climate disaster)

1. UNDP. (2022). *Climate Action from the Ground Up: Supporting Cities and Local and Regional Governments to Achieve the Paris Agreement.*
2. United Nations Sustainable Development Goals. (2022). "Climate Action".
3. ODI Global. (2015). *The 3As: Tracking Resilience Across BRACED*.

ClimateTech Green Glossary

More and more, environmental challenges are being addressed with mobile and digital solutions. To navigate innovative approaches to climate action, an understanding of key terms is essential.

Our ClimateTech Green Glossary clarifies these terms, defining key concepts at the intersection of climate action and technology.

Our Green Glossary is designed to foster a shared understanding and empower our partners for climate action.

1. THE MOBILE INDUSTRY AND CLIMATE ACTION

Climate action has become a strategic and operational priority for the mobile industry. In 2019, it committed to reaching net-zero emissions by 2050, making it one of the first global industries to do so. Since then, the industry has continued to expand network coverage and data traffic at unprecedented speed while also beginning to decouple growth from emissions through energy efficiency, renewable energy adoption and engagement across the value chain. This chapter examines how that transition looks in practice, and how collective commitments, standardised planning and targeted interventions are moving climate ambition to action.

At the same time, the global energy landscape presents a profound challenge. Emerging markets and developing economies are driving much of the growth in energy demand,[4] but nearly 600 million people are still projected to lack access to electricity by 2030, constraining economic opportunity, digital inclusion and climate resilience.[5] The mobile industry sits at the centre of this tension: highly dependent on energy to operate yet uniquely positioned to extend clean energy access at scale.

Through its climate programmes, research and partnerships, the GSMA has spent more than a decade working at this intersection, supporting renewable-powered networks, pay-as-you-go (PAYG) solar, AI-enabled efficiency and integrated digital energy solutions. Building on that foundation, this chapter explores how coordinated industry action, credible transition planning and collaboration across sectors can accelerate the renewable energy transition while advancing net-zero goals and inclusive connectivity.

GSMA CLIMATE ACTION TASKFORCE

79

mobile network operators working together across

150+

countries and territories

80%

of mobile connections covered

4. International Energy Agency (IEA). (2025). *World Energy Outlook*.
5. World Bank. (2025). *Tracking SDG7: The Energy Progress Report 2025*.

The GSMA Climate Action Taskforce now covers 80% of mobile connections, with 79 members operating networks in more than 150 countries and territories around the world. 81 mobile network operators (MNOs) have set or committed to near-term science-based targets (SBTs), including 71 with validated targets.

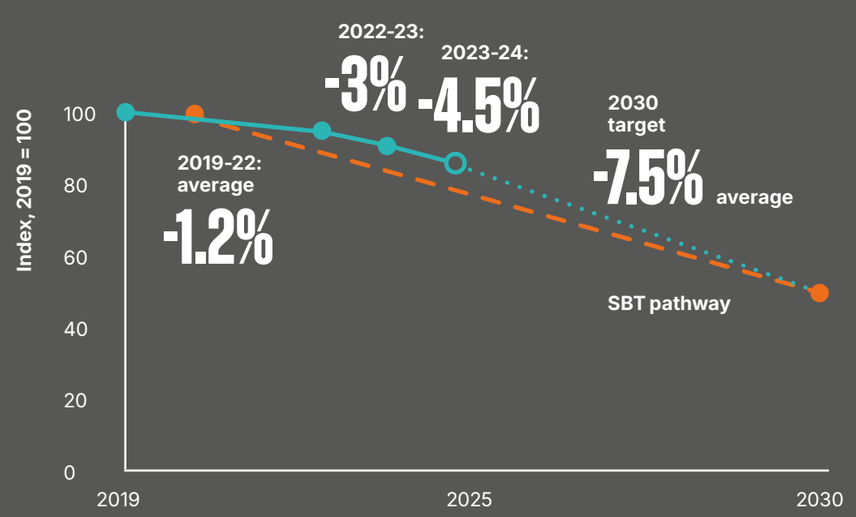
In 2019, the mobile industry set a goal to reach net zero by 2050, becoming one of the first sectors in the world with such an ambitious target. Despite a surge in global network coverage and data demand, MNO emissions fell 8% between 2019 and 2023, while mobile connections rose 9% and data traffic nearly quadrupled. With 70% of the mobile industry's carbon emissions stemming from the value chain (Scope 3, see Figure 1), engaging suppliers and customers is essential to stay on track to net zero. Energy-efficient networks, the use of renewable energy and green and circular products and services are helping the industry lead by example. Renewable energy is already playing a major role in reducing the emissions of MNOs, accounting for nearly half of reductions between 2022 and 2023.

The GSMA *Mobile Net Zero 2025* report reveals that the mobile industry's **operational emissions** (Scope 1 and Scope 2 market-based) were an estimated 125 million tonnes (Mt) of carbon dioxide equivalent (CO_2e) in 2023, equivalent to around 0.2% of global greenhouse gas (GHG) emissions[6] and accounting for around 30% of the industry's global carbon footprint. **Value chain emissions** (Scope 3) were an estimated 290 Mt CO_2e or 70% of the industry's total emissions. 93% of Scope 3 emissions came from six of the 15 Scope 3 categories: 1) Purchased goods and services; 2) Capital goods; 3) Fuel- and energy-related activities; 4) Upstream leased assets; 5) Use of sold products; and 6) Investments.

To support a holistic transition to net zero, the GSMA's *Climate Transition Planning Guidance for Telecommunication Companies* provides the first standardised framework for the mobile industry, co-developed with the International Telecommunication Union (ITU) and the Carbon Trust. The guide reframes net zero from a disclosure exercise to a full-scale business transformation agenda.

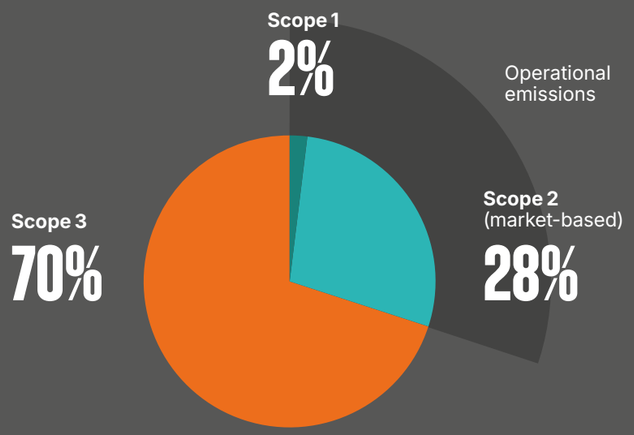
Figure 1: MNO progress on science-based targets and emission reductions

Some regions have achieved rapid reductions since 2019, but further progress across all regions is needed for the sector to achieve its global target by 2030.



Note: SBT pathway shows the subsector pathway for MNOs – a 45% reduction in combined Scope 1 and 2 emissions between 2020 and 2030 – as developed in the Guidance for ICT Companies Setting Science Based Targets. 2024 estimate for MNOs is a preliminary estimate based on available data as of May 2025.

70% of MNOs' overall emissions are Scope 3 emissions from supply chains and customers.



Note: Scope 2 emissions are market-based. Using location-based Scope 2 would result in the following shares: Scope 1 (2%), Scope 2 location-based (31%), Scope 3 (67%).
Source: GSMA analysis based on the latest disclosures from the Carbon Disclosure Project (CDP) and corporate reports.

MNOs committed to publishing Climate Transition Plan in alignment with the GSMA guidance.

AXIAN TELECOM · BT Group · etisalat and · etisalat and PPF Telecom · Globe · kpn · Singtel · SoftBank · TELE2 · telecom · Telefónica · Telia Company · true · Virgin media O2 · vodafone

6. Based on global emissions of 57.1 gigatonnes of carbon dioxide equivalent (GtCO2e) in 2023. See: UNEP. (2024). *Emissions Gap Report 2024*.

CIRCULARITY

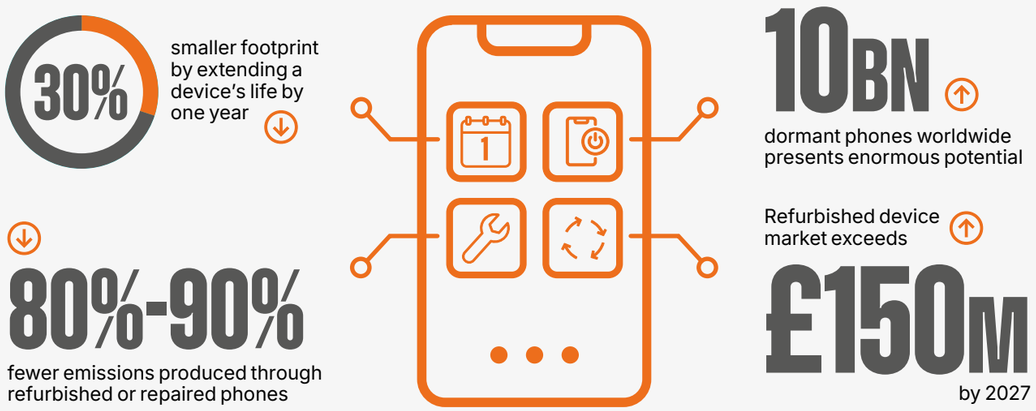
Unlocking hidden value in our mobile future

Every year, more than 1.2 billion new smartphones are sold, emitting more than 60 million tonnes of CO_2e in manufacturing alone. Yet, billions of devices remain idle in drawers, their critical minerals unused or lost to landfill. The GSMA's 2025 research on circularity reimagines this story, showing that what is good for the planet can also be good for business.

In *Rethinking Mobile Phones: The Business Case for Circularity* and *Quantifying the Carbon Savings of Circularity: Mobile Phones and Network Equipment*, the GSMA reveals a powerful opportunity: extending the life of a mobile device by just one year can cut its annual carbon footprint by up to 30%, while refurbished and repaired phones produce 80–90% fewer emissions than new ones. The analysis balances circularity with commercial sense. Circular business models such as repair, refurbishment, leasing and trade-in are now reshaping the mobile ecosystem, offering MNOs new revenue streams, stronger customer loyalty and more resilient supply chains. Globally, the refurbished device market is projected to exceed $150 billion by 2027.

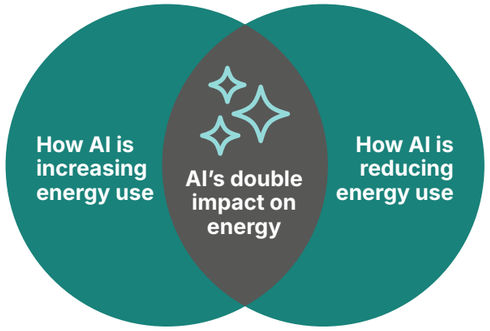
The GSMA's findings also highlight a broader societal benefit: circularity can drive digital inclusion by making affordable, high-quality devices accessible to more people while supporting new local jobs in repair and recycling. With nearly 10 billion dormant mobile phones worldwide, the potential is enormous.

Through collaboration across the value chain, from design to disposal, the GSMA and its Climate Action Taskforce are leading the industry toward a vision for 2050: devices with as long a life as possible, made with 100% recyclable and recycled content, powered by 100% renewable energy and no device ending up as waste. To support this transition in 2025, the GSMA published *Quantifying the Carbon Savings of Circularity: Mobile Phones and Network Equipment*, following the 2022 *Strategy Paper for Circular Economy: Mobile Devices*.



AI and energy use in the mobile industry

Artificial intelligence (AI) is transforming business globally. For the mobile industry, it is vital to take stock of the energy implications of AI and how this could help or hinder progress on the 2050 net-zero goal. A new GSMA report, *The Energy Implications of AI*, provides the industry's first consolidated analysis of how AI creates both new energy demands and new opportunities to make mobile networks more energy efficient.



How AI is increasing energy use

The rapid construction of data centres for generative AI (GenAI) has focused significant public attention on the growing energy use of AI. For MNOs, the widespread adoption of AI by consumers and businesses could alter network traffic patterns and increase energy use in data centres.

For most MNOs, the radio access network (RAN) dominates network energy use, with data centres typically accounting for less than 10% of overall energy use. While data traffic from GenAI remains below 1% today, there is significant growth potential for AI-related traffic, which would affect traffic patterns (such as uplink traffic) and drive up network energy use in the medium term. Several MNOs, including in Asia, are also opening new data centres to accommodate AI workloads. For these operators, data centres are likely to account for a growing share of energy consumption.

The physical location of AI data centre infrastructure and how it is powered also have significant carbon implications. Running AI in regions where grids are mostly powered by renewables could help mitigate the growth in carbon emissions and support MNOs' efforts to reach net zero.

How AI is reducing energy use

At the same time, AI offers significant opportunities to cut energy use. Until now, efficiency has been driven by network modernisation, such as transitioning from 2G/3G to 4G/5G, and the replacement of copper cables with fibre. AI-enabled solutions can deliver additional efficiency gains, including up to 40% reductions in RAN power consumption and 15% reductions in cooling system requirements. AI-enabled predictive maintenance can also help extend the life of equipment, avoiding embodied energy and carbon from replacements.

While these figures are impressive, it should be noted that these results will be limited for most MNOs, as they are still in the early stages of AI integration. Pilot projects are delivering strong local results, but system-wide adoption is limited. To maximise the energy-efficiency benefits, it is imperative to scale these solutions from pilots to production.

How the GSMA is supporting MNOs to leverage AI for energy efficiency

AI is simultaneously helping mobile networks reduce energy use and adding new energy pressures. Beyond improving individual MNO practices, industry-wide coordination is vital. This is where GSMA research and convening provide vital support.

The findings and recommendations of the GSMA's *2026 Energy Implications of AI* report will make a significant contribution to the industry's ability to navigate the complex dynamics of AI adoption. The insights will ensure that MNOs not only capitalise on AI's potential to improve energy efficiency, but also manage and mitigate new energy impacts effectively.

In addition to the latest report, the GSMA's AI in Action Project Group brings MNOs from different regions together to discuss challenges and practical solutions to scaling AI-enabled energy efficiency. One example of the group's work is the GSMA AI Traffic Observatory initiative, which aims to understand how the use of AI shifts traffic patterns, uplink demand and network planning requirements.

SPOTLIGHT:

Accelerating the transition to renewable energy in Nigeria's mobile industry

The mobile industry is a cornerstone of Nigeria's digital and economic transformation. Contributing nearly 15% of GDP, the growth of the sector increasingly depends on being powered by reliable, affordable and sustainable energy.[7] Recognising these challenges, the GSMA, in partnership with the World Bank and Nigeria's Rural Electrification Agency (REA), is taking an integrated approach.

The GSMA has united some of the largest MNOs in Nigeria, as well as the Democratic Republic of the Congo (DRC), to scale renewable energy solutions for MNO infrastructure and share lessons, blueprints and replicable models with MNOs across the continent. Meanwhile, the Distributed Access through Renewable Energy Scale-up (DARES) programme, a $750 million World Bank-funded initiative, is delivering clean, reliable electricity to more than 17.5 million people and 237,000 micro-, small and medium enterprises (MSMEs)[8] – a unique opportunity to accelerate renewable energy access and expand digital connectivity.

From working in parallel to partnership
The GSMA has provided MNOs with new geospatial analysis linking tower sites, proposed tower expansions, grid infrastructure and mini-grid deployments. High-potential areas have been identified for anchor business community (ABC) models in which telecoms towers provide reliable anchor loads for mini-grids that also serve surrounding households and enterprises. The ABC model has faced several challenges[9] with implementation, financing and stakeholder alignment. However, the increase in financing[10] for mini-grid projects in Nigeria, geospatial planning tools for identifying optimal deployment sites, growing mobile industry interest in decentralised renewable energy (DRE solutions) and successful pilots, are all signs of a maturing mini-grid sector, as evidenced by firms like Husk Power, Engie Energy Access and WeLight.

Greater integration through policy and finance
DARES' results-based financing mechanisms (performance-based grants and minimum subsidy tenders) are being tailored to encourage the co-location of digital and energy infrastructure, with additional incentives for developers to integrate telecoms towers in their mini-grid designs.

A Memorandum of Understanding (MoU) between REA and the Nigeria Communications Commission (NCC) has also been signed, and a joint strategic committee is creating a framework for the secure exchange of tower location and energy access data – critical for integrated planning.[11,12] This collaboration helps break long-standing silos between the energy and telecoms sectors.

Unlocking commercial and climate benefits
Tower sites powered through renewable mini-grids also enhance local energy resilience and reduce the overall cost of rural connectivity. GSMA research shows that customers in off-grid areas with solar access demonstrate higher mobile usage and financial inclusion, reinforcing the "energy-digital inclusion loop" in which energy access drives digital participation and vice versa.

These outcomes are informing the next phase of the GSMA-World Bank collaboration under DARES, which will demonstrate how renewable-powered digital infrastructure can reduce costs, expand coverage and contribute to Nigeria's universal access and broadband goals.

Challenges:

- Energy costs now consume up to 60% of MNOs' operating expenses, driven by a 37% surge in diesel prices and rising theft and maintenance costs.
- 30,000 mobile towers across Nigeria consume more than 40 million litres of diesel a month, according to the NCC.
- Without a structural shift to renewables, the mobile sector risks eroding its profit margins and undermining digital inclusion.

~15%
Mobile industry's contribution to Nigeria's GDP

30K
mobile towers across Nigeria

40 MILLION
litres of diesel consumed monthly by these mobile towers

60%
Share of operating expenditure consumed by energy costs for MNOs

237K
Micro, small and medium enterprises to gain electricity access via DARES

17.5 MILLION PEOPLE
expected to gain clean, reliable electricity through DARES

7. Umeh, J. (4 September 2025). "High energy cost may erase profit margin in telecom industry". *Vanguard*.
8. DARES: Scaling-Up Nigeria's Energy Access.
9. Kibala Bauer, G. (4 September 2024). "Why and how mobile operators are looking to renewables to power networks across Africa". *GSMA Mobile for Development Blog*.
10. Husk. (24 October 2023). Husk Power secures $100+ million in equity and debt to supercharge growth of community solar minigrids in rural Sub-Saharan Africa and South Asia
11. Wolfenden, K. (3 July 2025). "REA, NCC Launch Strategic Committee to Drive Rural Connectivity and Energy Access in Nigeria". *TechAfrica News*.
12. Tunji, S. (3 July 2025). "NCC, REA inaugurate committee to boost digital energy inclusion". *Punch*.

SPOTLIGHT:

MBalik providing affordable solar electricity to Malagasy households

In Madagascar, less than 40% of the population has access to electricity due to geographic isolation and frequent power outages.[13] Multiple reports highlight that oil lamps and candles are still the main sources of light for 35-40% of households. However, domestic solar kits like MBalik – a product of MNO Yas Madagascar – are bringing sustainable electricity solutions to Malagasy families. The kit contains a USB plug to charge phones and devices (a television, ceiling lights, fans or radios), also enhancing connectivity.

To ensure the solution is affordable, Yas Madagascar has implemented a flexible payment solution whereby customers can pay regularly based on daily sun hours. After an initial deposit of approximately 10% of the total price, customers recharge their kit periodically through instalments. Once the customer has paid the full price, they become the owner and the kit is unlocked. In 2024, more than 124,000 households were equipped with MBalik, doubling the number of households served in 2023.

MBalik is closely integrated with M'Vola, Madagascar's mobile money provider. Since all instalments are made digitally, mobile money adoption has been boosted nationwide while offering customers a safe and transparent way to pay, eliminating long trips to payment points and helping them manage their budgets. This has made MBalik an important financial literacy tool, as it encourages users to assess the economic benefits and plan for their financial future.

This initiative epitomizes Yas Madagascar's sustainability vision, creating products and services that drive socio-economic progress while lowering GHG emissions. MBalik provides a clean, affordable alternative to fossil fuel-based lighting through domestic solar kits for underserved households. It expands access to energy and, at the same time, supports business growth by promoting the use of mobile money and digital services.

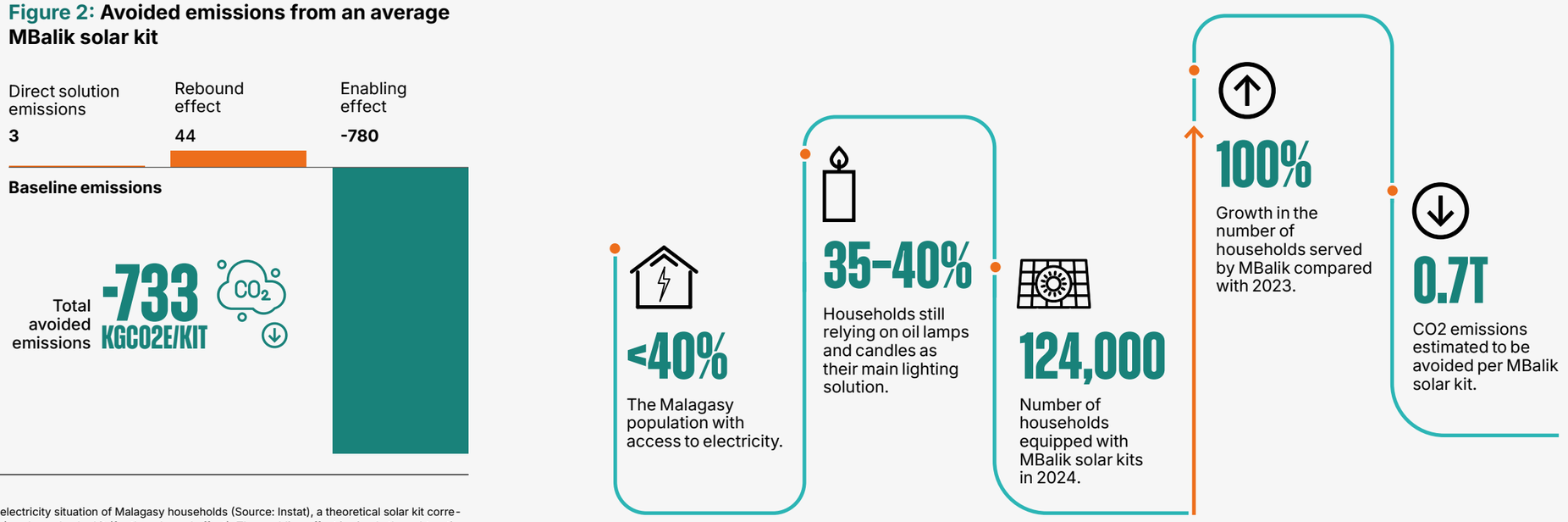
Yas estimates that each MBalik solar kit avoids around 0.7 tonnes of CO_2e.[14] By enabling low-carbon phone charging and replacing grid or fossil-based power, MBalik helps cut use-phase emissions from Yas's sold devices and reduces the company's overall carbon footprint. The initiative also highlights the powerful link between low-tech solar solutions and high-tech digital development.

Figure 2: Avoided emissions from an average MBalik solar kit

13. Access to electricity (% of population) – Madagascar, World Bank Open data, 2023.

14. Yas Madagascar and parent company AXIAN's internal evaluation based on the average electricity situation of Malagasy households (Source: Instat), a theoretical solar kit corresponding exactly to the low lighting solutions typically used (for direct solution emissions) and a real solar kit (for the rebound effect). The enabling effect is simply the subtraction of the baseline emissions since there are no use-phase emissions.

Figure 3: Mobile phone being charged by an MBalik solar kit



2. INNOVATION FUNDING

The GSMA Innovation Fund identifies and amplifies the role that digital technology can play in climate action, unites sectors through investment and addresses a shortage of early-stage financing for climate adaptation and resilience solutions in LMICs.

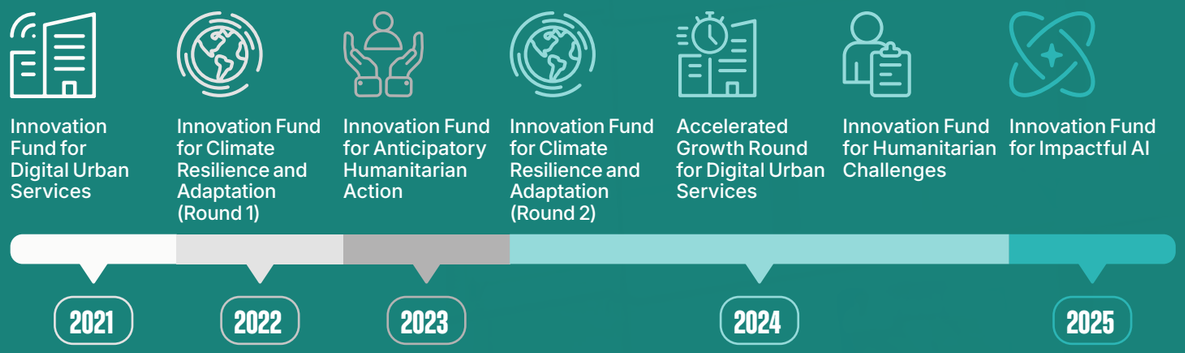
With support from UK International Development (UK Government) and the Swedish International Development Cooperation Agency (Sida), the GSMA Mobile for Development (M4D) programme has awarded equity-free grants ranging from £100,000 to £250,000, alongside tailored technical and commercial support, to startups across Africa and Asia. These include the GSMA Innovation Fund for Digital Urban Services launched in 2021, the Accelerated Growth Round (AG Round) in 2024 and two rounds of the Innovation Fund for Climate Resilience and Adaptation, awarded in 2022 and 2024. Lessons are also drawn from the AgriTech Accelerator programme, which provided in-kind support for scaling up the innovators' solutions.

Sectors: agriculture, fisheries and aquaculture, energy, early warning systems, mapping and weather alerts, financial inclusion, food loss and waste, sanitation, circularity and waste management, water

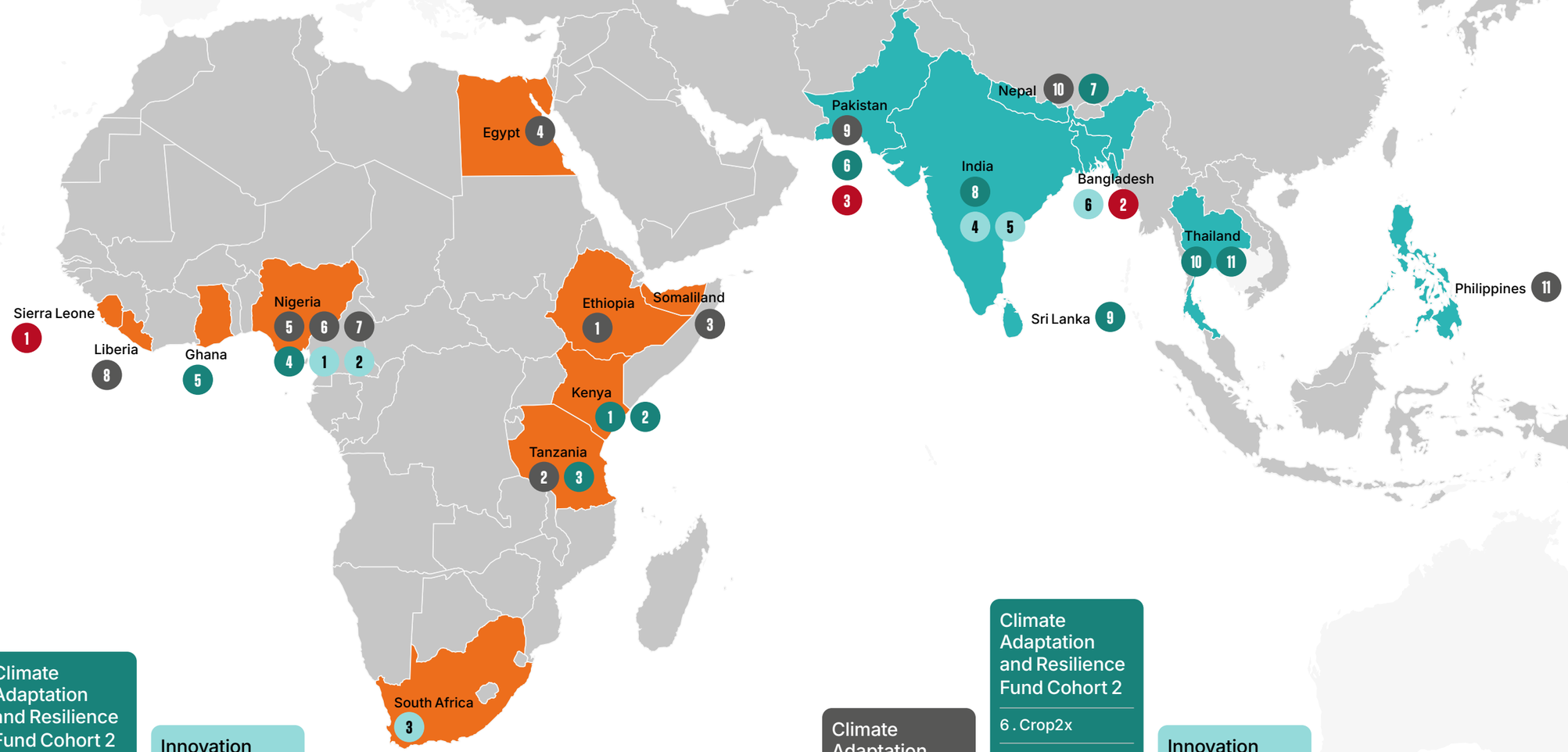
While GSMA research had already been helping to map emerging solutions and convene stakeholders across the mobile, development and public sectors, it had become evident that many promising innovations had stalled before they could scale due to a lack of risk capital, operational evidence or partnerships to move from pilot to deployment. The funding rounds were therefore structured to de-risk early innovation, generate evidence in underexplored areas such as regenerative agriculture, fisheries, early warning systems (EWS) and nature-based solutions (NbS), and catalyse collaboration between startups, MNOs, governments and humanitarian actors.

Importantly, the GSMA's funding strategy recognises that climate resilience cuts across sectors. Startups supported through the Innovation Fund for Anticipatory Humanitarian Action (2023) and the Innovation Fund for Impactful AI (2025) often operate at the intersection of multiple systems. Supporting a diverse portfolio across multiple funds enables the GSMA to test complementary approaches, reveal common barriers and identify where digital solutions reinforce one another.

This chapter draws on lessons from Innovation Funds that are supporting digital climate solutions, highlighting those with the greatest potential for impact and scale. It also synthesises insights from startups and their partnerships with MNOs.



GSMA CLIMATE ACTION GRANTEES



Climate Adaptation and Resilience Fund Cohort 1
1. Lersha
2. Simusolar
3. Dayaxa Frankincense
4. BENAA
5. CoAmana
6. Crop2Cash
7. Hello Tractor
8. J-Palm Liberia

Climate Adaptation and Resilience Fund Cohort 2
1. Ujuzi Kilimo
2. Farm2Feed
3. Bizy Tech
4. Pricepally
5. Sommalife

Innovation Fund for Digital Urban Services Cohort
1. Koolboks
2. Soso Care
3. Regenize

Accelerated Growth cohort
1. Freetown Waste Transformers

AFRICA

Climate Adaptation and Resilience Fund Cohort 1
9. BaKhabar Kissan (BKK)
10. GeoKrishi
11. Komunidad

Climate Adaptation and Resilience Fund Cohort 2
6 . Crop2x
7. Aloi
8. InQube
9. SenzAgro
10. HydroNeo
11. Monsoon Tea Company

Innovation Fund for Digital Urban Services Cohort
4. JanaJal
5. ReCircle
6. Bhumijo

Accelerated Growth cohort
2. ATEC
3. Diyalo

SOUTH & SOUTHEAST ASIA

LESSONS FROM THE GSMA INNOVATION FUNDS

Although Innovation Fund grantees operate in different contexts and offer diverse services, cohorts faced similar trends and navigated common challenges in their journey to scale their climatetech solutions and strengthen the resilience of the communities where they work.

BaKhabar Kissan (BKK)
Pakistan

BaKhabar Kissan (BKK) received a GSMA Innovation Fund grant to enhance its digital weather platform and provide smallholder farmers with real-time, hyperlocal weather information. It launched 155 new automated weather stations across Pakistan's agricultural centres, mainly in underserved rural areas. By incorporating AI algorithms for data analysis and pattern recognition, BKK could offer more accurate and timely forecasts and increase resilience to weather-related challenges.

Interesting insight: BKK developed and piloted an automatic speech recognition system for the Urdu language, aimed at improving their interactive voice response (IVR) and call centre services. This system has been successfully deployed in three districts of the Punjab region. However, scaling to other areas, such as Khyber Pakhtunkhwa (KPK), presented challenges due to its diverse linguistic landscape. With more than 77 languages spoken across the country, BKK has learned the importance of thoughtful product design, robust sample collection and extensive dataset preparation for reaching more farmers with their solution.

J-Palm
Liberia

J-Palm received GSMA funding to develop and deploy a mobile blockchain app for full traceability, from palm fruit to palm oil and palm kernel, and a mobile app to track tree health and carbon storage. More than 3,000 palm harvesters and collectors are now using the apps. Funding was also used to build and distribute manual mini-mills to expand J-Palm's model to 30 communities.

Interesting insight: In cash-based and low-connectivity contexts, direct onboarding by staff was more effective than village coordinators. Although mobile money adoption was limited, J-Palm's traceability technology and mini-mills delivered clear commercial and productivity gains, stabilising farmer incomes, improving oil extraction and reducing processing time and water use.

Crop2Cash
Nigeria

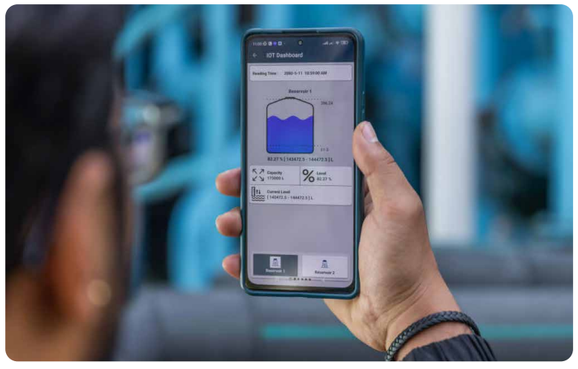
Crop2Cash received GSMA funding to connect smallholder farmers in Nigeria to crop insurance and high-yielding, drought-resistant seeds through a USSD marketplace and AI-powered IVR weather advisory. This solution provides vital access to financial services for smallholder farmers, who must adapt their operations to changing weather patterns but are often left out of the financial system. 92% of the farmers reached reported an increase in yield as a result of using the marketplace and 96% reported an increase in income.

Interesting insight: Crop2Cash has shown that scaling digital agricultural services requires combining trusted human channels with a variety of simple digital tools offered in a farmer's own language. Radio and extension agents were critical to raising awareness and last-mile adoption, while USSD marketplaces drove sustained use when they aligned with farmers' seasonal needs. Bundling inputs, advisory, insurance and weather services through strong partnerships delivered measurable gains in yields, loan recovery and farmer resilience. Through the Innovation Fund grant, Crop2Cash also identified that women play a more central role in planting seed, weeding, harvesting and post-harvest operations, leading it to prioritise women as a target user group.

Diyalo Technologies
Nepal

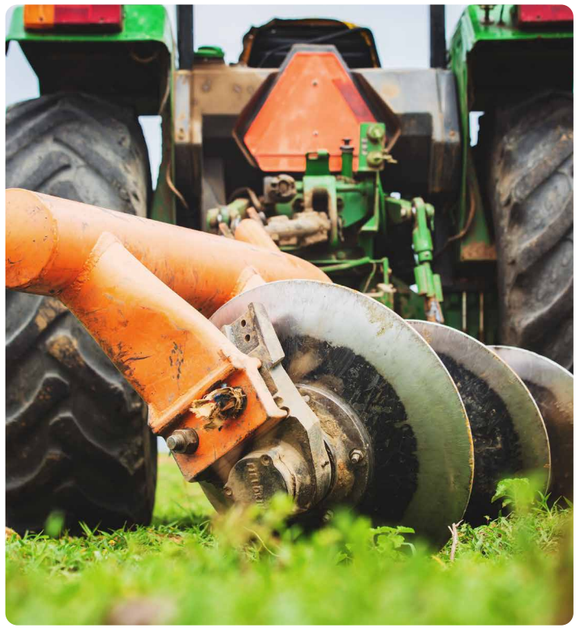
Only 52% of Nepalis have access to piped water for their homes. One of the reasons is that, according to government data, less than 30% of Nepal's 44,000 water schemes are fully functional. The GSMA supported Diyalo to enhance its enterprise resource planning (ERP) solution, Watermark, by adding a customer mobile app, IoT integrations and an enterprise dashboard which it piloted with 16 utilities. Over the grant period, Diyalo saw its client base grow substantially, from 175 water providers at the start of the grant to more than 800 by the end. This means its solution is being used by water providers serving approximately 1.2 million households or around 5 million people, roughly 20% of Nepal's population.

Interesting insight: Delivering its solution required intensive outreach and capacity building with water providers, many of whom had never engaged with digital solutions of this kind. The GSMA supported Diyalo with a follow-on grant to scale its solution and make IoT integration affordable and practical for small and medium-sized utilities. Central to this effort was a shift to in-house development of its IoT hardware, enabling end-to-end control over hardware cost, design, functionality and integration with the Watermark ERP. During the follow-on grant period, Diyalo expanded its reach even further, securing 27 new water utility clients and reaching an additional 89,000 utility customers with its services.



Hello Tractor
Nigeria

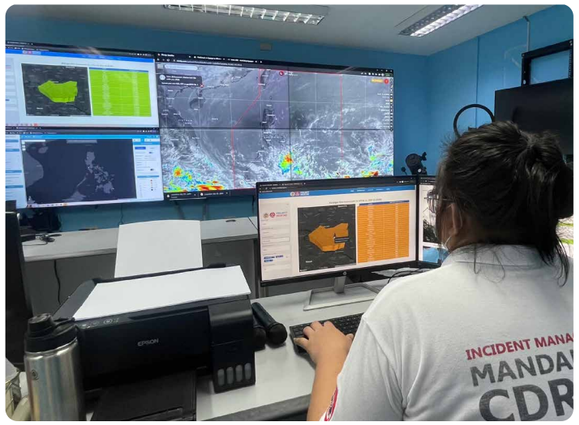
Hello Tractor used its Innovation Fund grant to develop a predictive demand weather forecasting tool that mapped historical associations between rainfall activity (and other variables) and tractor usage. This tool was used by 10 new pay-as-you-go (PAYG) tractor owners. 15 training and marketing outreach workshops were organised for 600 farmers and digital learning tools were developed for 3,541 farmers.



Interesting insight: Hello Tractor learned that prioritising customer needs and preferences made adoption considerably easier. Since predictive weather modelling is a relatively complex process for users to draw conclusions, it needs to be rolled out in the simplest form, embedding familiar concepts such as “recommendation of booking agents” in regions with high demand. Building trust and community engagement also proved to be key in building long-term engagement with existing customers and acquiring new users.

Komunidad
Philippines

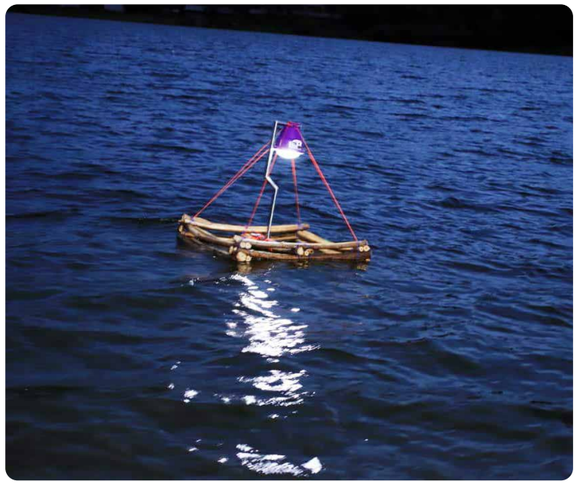
Komunidad received funding from the GSMA to empower local governments and low-income and vulnerable communities in Siargao Islands, which were devastated by Typhoon Rai in December 2021. A data-driven approach was used to integrate environmental intelligence, early warning systems (EWS) and mobile phone alerts on four different interfaces: a web app dashboard, a mobile app, SMS alerts for municipalities and a public web app for tourists and residents.



Interesting insight: Komunidad pilots demonstrated that EWS have the greatest impact when climate data is localised, embedded in government workflows and paired with capacity building. Success in Siargao enabled 97% of disaster officials to better anticipate typhoons despite connectivity constraints. However, user retention during leadership changes and regulatory hurdles persist, requiring long-term agreements and strategic regulatory navigation.

Simusolar
Tanzania

Simusolar received an Innovation Fund grant to develop and commercialise its IoT-enabled fishing light, which is energy efficient, locatable and trackable, and launch an app for fishers. This was integrated with a mobile app that tracks usage, monitors weather conditions and helps manage fishing operations. The tracking feature enables Simusolar to share anonymised data with the Ministry of Fisheries, aiding their fishery digitalisation efforts. With these products, Simusolar proved to fishers that its fishing light enables them to catch 15% more than its competitors.



Interesting insight: Although there was a clear market gap, launching a new product required Simusolar to navigate multiple operational and regulatory issues in collaboration with the Tanzanian government. Adapting the product to local user preferences, such as offering SMS-based beach listings instead of map views, also proved essential for adoption and customer retention.

Sommalife
Ghana

Sommalife received funding from the GSMA Innovation Fund to enhance its digital platform, TreeSyt, which enables smallholder shea farmers to connect with international markets and access advisory and training content, and allows field agents to digitalise their operations. The funding helped Sommalife develop a farmer verification feature using near-field communication (NFC) technology, integrated digital weighing of produce, plant health monitoring and inventory management. To date, the project has supported more than 87,000 shea farmers in Ghana, the majority of whom are women in remote farming communities.

Interesting insight: While shea farming is a female-led industry, our research revealed that female farmers faced significantly greater barriers to accessing loans and assets than their male counterparts – challenges that Sommalife’s services directly help to overcome. The project also highlighted the deep commitment of these women to protecting and conserving shea trees, as they derive a substantial portion of their income from them. Ultimately, this initiative has empowered female farmers, providing them with a stronger platform for community leadership and decision-making.

Farm to Feed
Kenya

Farm to Feed received a grant from the GSMA Innovation fund to develop a farmer-facing app and USSD platform for farmers to sell imperfect fruit and vegetables, the aim of which was to reduce food waste, improve environmental sustainability, prevent lost income and strengthen local food security. The grant also helped Farm to Feed develop an e-commerce platform, with 124 local businesses signing up to offtake imperfect and surplus produce from registered farmers.

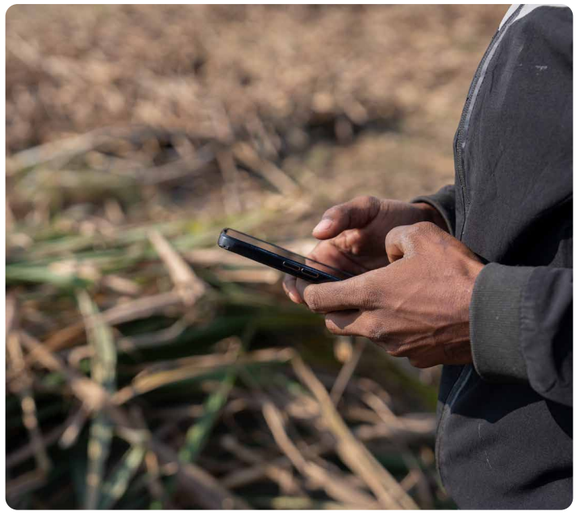
Interesting insight: Buyers of the imperfect produce saw little difference in quality compared to ordinary market produce, stating that the nutritional value was the same but at a lower price. However, the unpredictable quality, aesthetics and quantity of imperfect produce meant that profit margins were tight for Farm to Feed. In response, the company developed

domestic and export strategies focused on processing imperfect produce into higher-value products, such as concentrates and powders.

Crop2X
Pakistan

Crop2X received funding from the GSMA Innovation Fund to provide farmers with real-time soil health data and actionable farming insights to optimise agricultural productivity and strengthen resilience to the impacts of climate change. The grant helped Crop2X develop its soil probe and satellite imagery monitoring features. 485 farmers were successfully onboarded and use the service to receive summaries of their farming activities, soil pH and moisture readings with soil probes installed. Farmers opting for satellite imagery readings receive crop health, fertiliser and water content readings, as well as personalised farming recommendations.

Interesting insight: While farmers found the recommendations useful, most required additional support from Crop2X, including in-person contact, to act on them. This highlighted that gaps in awareness and digital literacy can be a barrier for farmers to use agricultural advisory services. Some farmers reported



that access to satellite images (as part of the recommendations) helped them to better visualise and understand soil health issues on their farm and take targeted action.

Pricepally
Nigeria

Pricepally used its GSMA Innovation Fund grant to tackle food insecurity, using digital technology to link farmers to markets with consistent demand for their produce. It developed an online grocery platform that has helped more than 500 farmers decide exactly what and how much to plant. The service helps to reduce waste incurred through unsold produce or transport and logistics, makes produce more affordable by creating a more efficient supply chain and gives farmers more control over their farming and sales by having a reliable buyer.

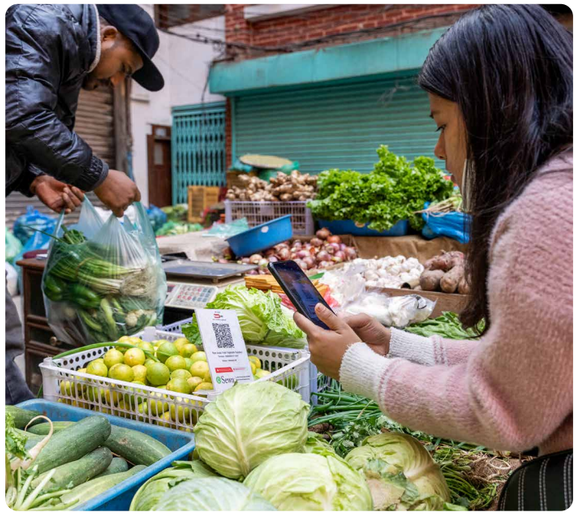
Interesting insight: Our research indicates that access to real-time market data allows farmers to better align their crop variety and volume with actual demand. This foresight, combined with Pricepally's timely collection services, has minimised spoilage and provided farmers with

a reliable offtaker. Ultimately, this partnership has given farmers greater financial stability and agency over their livelihoods.

Aloi
Nepal

Aloi received funding from the GSMA Innovation Fund to increase financial inclusion for dairy farmers and support them in adapting to climate-smart agro-forestry practices. The GSMA grant helped Aloi develop a digital platform for credit profiling, disbursing cashless, affordable loans to be spent on accredited green and sustainable vendors (e.g. biogas equipment suppliers) and for loan repayment through milk sales. Through the project, more than 1,200 dairy farmers were issued digital credit profiles, improving their access to financing.

Interesting insight: Aloi's partnership-based business model highlighted that smaller cooperatives had far less capacity to support farmers with financial planning and provided less access to financing compared to those who were part of larger cooperatives. As a result, Aloi prioritised working with small and medium cooperatives to target farmers with the greatest need. Farmers reported that Aloi's



training improved their financial planning and management, and that the loan application process was accessible due to Aloi's ongoing support.

UjuziKilimo
Kenya

UjuziKilimo, supported by the GSMA Innovation Fund, has developed a platform to advance data-driven decision-making for farmers in Kenya. The funding helped UjuziKilimo deploy IoT-integrated soil testing kits and enhance its soil advisory features with insights on soil health, local weather, disease outbreaks and best crop management practices. To date, the project has supported more than 16,200 farmers, with 20,600 soil health tests conducted.

Interesting insight: From an operational perspective, the soil testing device proved to be a significantly more affordable solution than traditional lab testing, which often costs twice as much. Most farmers found the service highly insightful and credited UjuziKilimo with providing supportive, data-driven agricultural recommendations. Farmers stated they

would be open to conducting more soil tests (primarily on an annual basis), which may be an opportunity for commercial sustainability, but also a clear chance for recurring engagement.

Monsoon Tea Company
Thailand

Monsoon Tea Company, supported by a GSMA Innovation Fund grant, has pioneered the use of IoT bioacoustics sensors and mobile technology to incentivise forest-friendly tea farming in northern Thailand. By developing a dedicated web app and biodiversity measurement process, the company provides farmers with premium payments based on verified positive ecological impacts.

Interesting insight: Our research showed that while many partner farmers already practiced traditional sustainable farming practices, Monsoon Tea empowered them with deeper ecological insights that helps preserve Indigenous farming methods while increasing local incomes through formal recognition of their environmental impact.

To learn more, read our full case studies on Innovation Fund grantees in Africa and Asia.

Scaling up: the AgriTech Accelerator and Digital Utilities Accelerated Growth grants

In May 2021, the GSMA launched the Innovation Fund for Digital Urban Services, supported by FCDO. The Fund backed startups using digital technology to enhance the accessibility, reliability, sustainability and affordability of essential services in LMICs. Among the companies selected were ATEC in Bangladesh, Diyalo in Nepal and Freetown Waste Transformers in Sierra Leone. In 2024, these three grantees were selected for the Accelerated Growth Round (AG Round), which offered 10 months of follow-on funding to help them move from proven pilots to sustainable scale.

Agritech Accelerator cohort members

The GSMA AgriTech Accelerator ran from June 2023 to October 2025 and supported promising agriculture startups (Figure above) address the challenges they face in finding the right product-market fit, streamlining the user experience and securing external funding to support their growth objectives. Smallholders are the backbone of agricultural food systems in LMICs, producing an estimated 30% of the world's food and up to 80% of the food consumed in Asia and Sub-Saharan Africa. However, rising temperatures, shifting precipitation patterns and more frequent extreme weather events are putting unprecedented pressure on their livelihoods.

Together, these two funds offered complementary perspectives on what it takes to scale climate action-oriented digital innovation in underserved markets, from basic urban services to digitalising agricultural services in climate-vulnerable contexts. Across both funds, clear patterns emerged in business models, user-centred design, partnerships and the enabling environment, highlighting the conditions that determine whether digital climate solutions can achieve sustainable and inclusive scale.

- **User-centric, context-adapted design unlocks scale.** Across both funds, growth-stage startups learned that product-market fit depends on deep user experience (UX) research and iterative design. Since many smallholders and low-income users have low literacy and limited connectivity, successful ventures prioritised simple interfaces, offline functionality and local languages. Trust was built by launching a minimum viable product (MVP) that solved one core pain point, then layered features on top based on real usage data. AG Round grantees also adapted their solutions to behavioural, financial and operational realities, ensuring affordability and usability for low-literacy urban users, including low-income households, informal workers and municipal staff.

- **A mix of digital and physical engagement is critical for adoption and retention.** Human touchpoints remain essential for onboarding,

trust building and behaviour change. Agritechs found that agent networks, field demos, community training and radio and social media campaigns accelerated adoption, while digital nudges reinforced learning at scale. Agent apps, USSD support and redesigned onboarding journeys, as seen with Esoko, Winich and Farmspeak, improved retention.

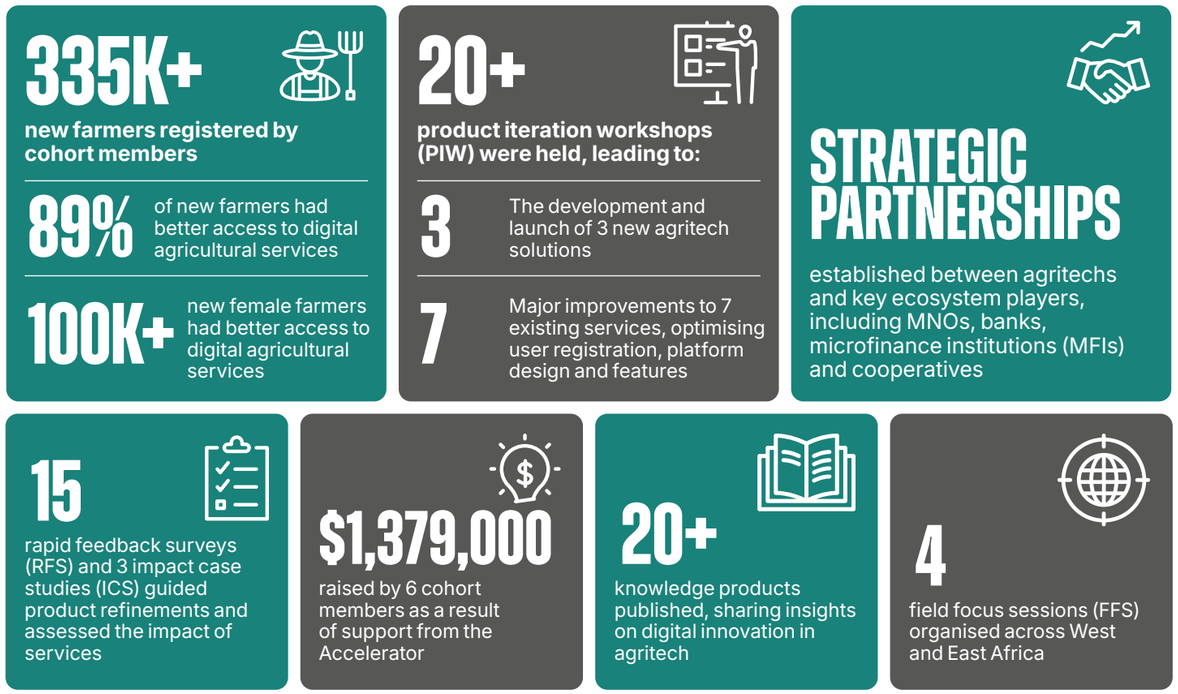
AG Round grantees faced similar realities. Whether deploying sanitation systems, waste-collection hardware or energy products, they learned that physical presence, user demonstrations, community champions and iterative troubleshooting were indispensable. Digital channels alone could not address scepticism, safety concerns or the need for repeated reinforcement in dense urban neighbourhoods.

- **Sustainable business models rely on diversified revenue streams and value beyond end user payments.** Smallholder farmers and low-income urban residents often cannot bear the full cost of climate-smart services, and free alternatives frequently undermine willingness to pay. Agritechs found success when they combined business-to-business (B2B) contracts with agribusinesses, freemium/tiered pricing, instalment plans and embedded finance, as well as new revenue from environmental value such as carbon credits. Evidence shows that ventures with clear financial models and strong unit economics attracted significantly more investment.

  AG Round innovators experienced similar constraints: predictable scale required institutional contracts, municipal partnerships, outcome-based financing and blended grant/capital structures. Many transitioned from selling directly to households to revenue models anchored in service contracts with city authorities, utilities or large private-sector buyers, improving revenue stability while enabling affordability for end users.

- **Strategic partnerships and ecosystem integration are the primary levers for scale.** Both funds showed that partnerships ultimately determine whether innovations scale. Agritechs that partnered with cooperatives, NGOs, MNOs, banks or governments extended their reach, strengthened their credibility and were able to bundle value propositions. The AG Round confirmed that urban innovators scaled fastest when their solutions were integrated in municipal systems, utility workflows or government service delivery channels.

Figure 4: Key achievements of the AgriTech Accelerator



SPOTLIGHT:

Delivering climatetech services that meet women's needs

While men and women experience climate disruption equally, women often shoulder greater household responsibilities in response to it and receive little or no support to cope. The GSMA studied how its grantees engaged with women users and discovered the following key findings:

Fair and reliable markets transform outcomes. When women have direct access to dependable buyers, incomes stabilise, stress declines and confidence grows. For example, market linkage solutions such as Winich Farms, which improved sign-ups after simplifying onboarding, help women to capture more value from systems traditionally dominated by intermediaries.

Access to finance remains a critical barrier. Women's limited access to credit and collateral restricts investment in climate-resilient practices. **Greenovator**, for example, introduced household finance features after finding women were key decision-makers in Cambodia, unlocking participation and enabling productive investment.

In-person engagement is key. Workshops, training sessions and field agents were crucial for raising awareness, building skills and increasing confidence in using climatetech. Feedback from these interactions informed iterative, gender-responsive design. Programmes that engaged both women and household decision-makers achieved stronger results.

Gender strategies drive inclusion. Many grantees recognised gender inclusion as central to climate resilience and business growth. **OKO** hired more female agents, increasing the proportion of women users to **35%**, and several grantees redesigned services based on sex-disaggregated insights. Sustained support is vital, as gender inclusion is often deprioritised without structured guidance.

Scaling up through MNO partnerships

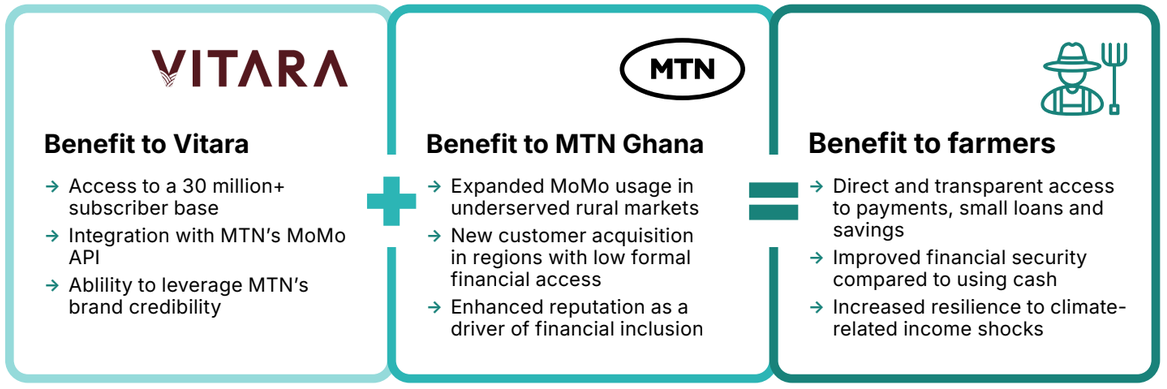
In the current funding winter, partnerships between MNOs and agritech startups are enabling climate resilience for those who need it most. By combining the innovation and agility of startups with the scale, infrastructure and trust of MNOs, these collaborations can deliver impactful services to smallholder farmers at scale.

Since 2020, the GSMA Innovation Fund has tracked 30 MNO partnerships within its portfolio of 62 startups in Africa and Southeast Asia. Two standout examples include Vitara's work with MTN Ghana and BaKhabar Kissan's collaboration with Jazz Pakistan.

Improving resilience to climate shocks for Ghana's smallholder farmers

Vitara (formerly known as Sommalife) partnered with MTN Ghana to digitalise agricultural value chains and improve financial inclusion in underserved northern regions of the country. Farmers who had previously lacked access to formal financial services can now receive payments and small loans directly through MTN Mobile Money (MoMo), enabled by API integration with Vitara's TreeSyt platform. TreeSyt digitalises commodity buying, farmer education and tree care in areas with limited or no internet access.

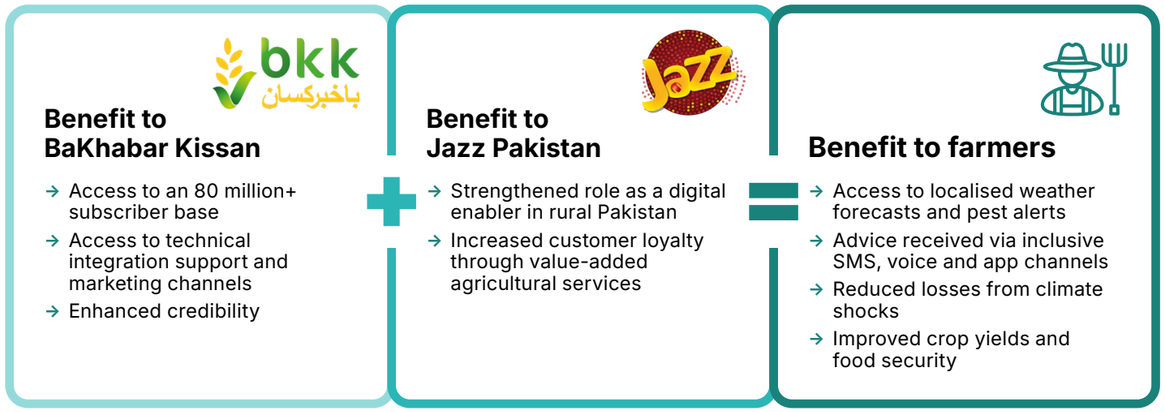
The partnership enables climate-vulnerable farmers to transition from cash to digital finance, building resilience and long-term sustainability.



Boosting climate resilience for Pakistan's smallholder farmers

Using Jazz's mobile platforms and vast subscriber base across the country, BaKhabar Kissan (BKK) disseminates climate-smart agricultural advisory, including localised weather forecasts, crop management tips and pest alerts. These services are critical in helping farmers adapt to shifting rainfall patterns, extreme weather and pest outbreaks linked to climate change.

Farmers benefit from actionable and accurate information delivered via SMS, voice and app channels in local languages, which ensured advisory was accessible regardless of literacy levels. For Jazz, the partnership strengthens their role as a digital enabler in rural Pakistan while enhancing customer loyalty.



By bridging innovation with infrastructure, startups like Sommalife and BaKhabar Kissan have scaled solutions that directly empower farmers to adapt to climate change. As climate pressures intensify, MNO-startup partnerships are critical to ensuring food security and sustainable livelihoods across LMICs.

What next?

The GSMA has launched the Innovation Fund for Green Transition for Mobile, supporting small and growing enterprises across Africa, Central and South America, and South and Southeast Asia. The Fund targets the dual challenge of digital and clean-energy transition, including innovative approaches to refurbished handsets which is critical as the mobile industry advances toward net-zero while ensuring inclusive, sustainable connectivity.

Eligible organisations with active users and commercial revenue using mobile or digital technologies (including AI) to drive digital inclusion and climate action are encouraged to apply.

Applications close 6 April 2026, 23:59 GMT.

Details and submission can be accessed here.

3. EARLY WARNING SYSTEMS AND HUMANITARIAN RESPONSE

Climate change is now a leading driver of humanitarian crises worldwide. Floods, storms and droughts account for most global emergencies, placing millions of families at risk.

According to the Climate Risk Index 2026, 9,700 extreme events between 1995 and 2024 have caused more than 832,000 deaths and approximately $4.5 trillion in economic losses. Early warning systems (EWS) are one of the most effective defences. Issuing warnings 24 hours before an event can reduce damage by 30% and investing $800 million in multi-hazard systems in LMICs could avert $3–$16 billion in losses every year.[15] The integration of digital technologies, particularly AI, is expanding what these systems can deliver, from more accurate forecasting to more targeted and inclusive emergency alerts.

This chapter examines how mobile-enabled digital solutions are strengthening climate resilience across three critical dimensions. First, it looks at how AI-powered EWS are improving hazard prediction and enabling multi-channel, mobile-first warning delivery. Second, it shows how mobile money platforms are evolving beyond emergency payments to offer savings, credit and insurance that help households absorb and recover from climate shocks. Finally, it examines how anticipatory cash assistance, triggered by early warnings, can protect lives and livelihoods before disasters strike.

This chapter illustrates the important role the mobile ecosystem can play in shifting climate response from reactive humanitarian relief to proactive resilience.

EARLY WARNING: COSTS VS. IMPACT

30%
reduction in damage with 24-hour warnings

$800M
needed to build multi-hazard early warning systems in LMICs

$3–$16B
in annual losses averted with early warning investment

15. Global Centre on Adaptation. (2019). *Adapt now: A global call for leadership on climate resilience*.

AI for early warning systems

Traditional EWS rely on historical patterns and manual analysis to predict hazards. AI transforms this approach by processing vast, complex datasets in real time, identifying patterns less visible to humans, improving the accuracy of prediction and enabling personalised alerts at scale. Machine learning (ML) models can integrate satellite imagery, IoT sensors, weather data and community observations to detect emerging threats earlier and forecast climate risks with greater precision. This capability is particularly valuable in climate-vulnerable LMICs where extreme weather is intensifying and resources are constrained.

MNOs provide essential connectivity infrastructure and communication channels for EWS. With increasing mobile penetration across LMICs, MNOs can deliver alerts through cell broadcast (CB),[16] SMS, USSD, IVR and mobile apps alongside traditional channels, reaching remote and disconnected populations. The GSMA Mobile for Development (M4D) programme supports capacity building, research and advocacy, and facilitates partnerships between governments, humanitarian agencies, MNOs and tech startups to strengthen EWS.[17] M4D research has explored the diverse ways in which some of the most climate-vulnerable LMICs and Small Island Developing States (SIDS) are piloting or scaling AI-enabled EWS.[18]

AI is expanding what EWS can deliver: faster and more accurate hazard prediction and more targeted warnings. SIDS that are highly exposed to climate-driven natural hazards are advancing multi-hazard early warning systems (MHEWS) that use mobile-first, multi-channel delivery and increasingly integrate AI for hazard prediction and timely alerts. In the Pacific, AI-enabled MHEWS are emerging through multi-sector partnerships. In 2024, Vanuatu's meteorological department partnered with US startup Tomorrow.io, funded by the US Trade and Development Agency (USTDA), to embed AI in its national MHEWS and strengthen forecasting and preparedness. In Timor-Leste, local startup Similie, backed by UNICEF's Venture Fund, developed Parabl – an open-source platform combining IoT devices and ML for hyper-local forecasting of hydrometeorological hazards – providing early community warnings and testing open-source viability for such systems.

16. GSMA. (2023). *Cell Broadcast for Early Warning Systems: A review of the technology and how to implement it*.
17. GSMA. (2024). *Mobile-Enabled Early Warning Systems: The GSMA and the Early Warnings for All Initiative*.
18. GSMA. (July 2024). *AI for Africa: Use cases delivering impact*.

GSMA Innovation Fund supports startups in LMICs to enhance early warning systems

In the Philippines, Innovation Fund grantee Komunidad uses AI to extend the reach of its EWS and make it more inclusive and reliable. In April 2024, it launched Curbeet, an AI-powered platform that integrates ground sensors, satellite imagery and crowd-sourced data to deliver timely, localised alerts. By automating hazard detection and data integration, Curbeet strengthens anticipatory action and disaster preparedness.

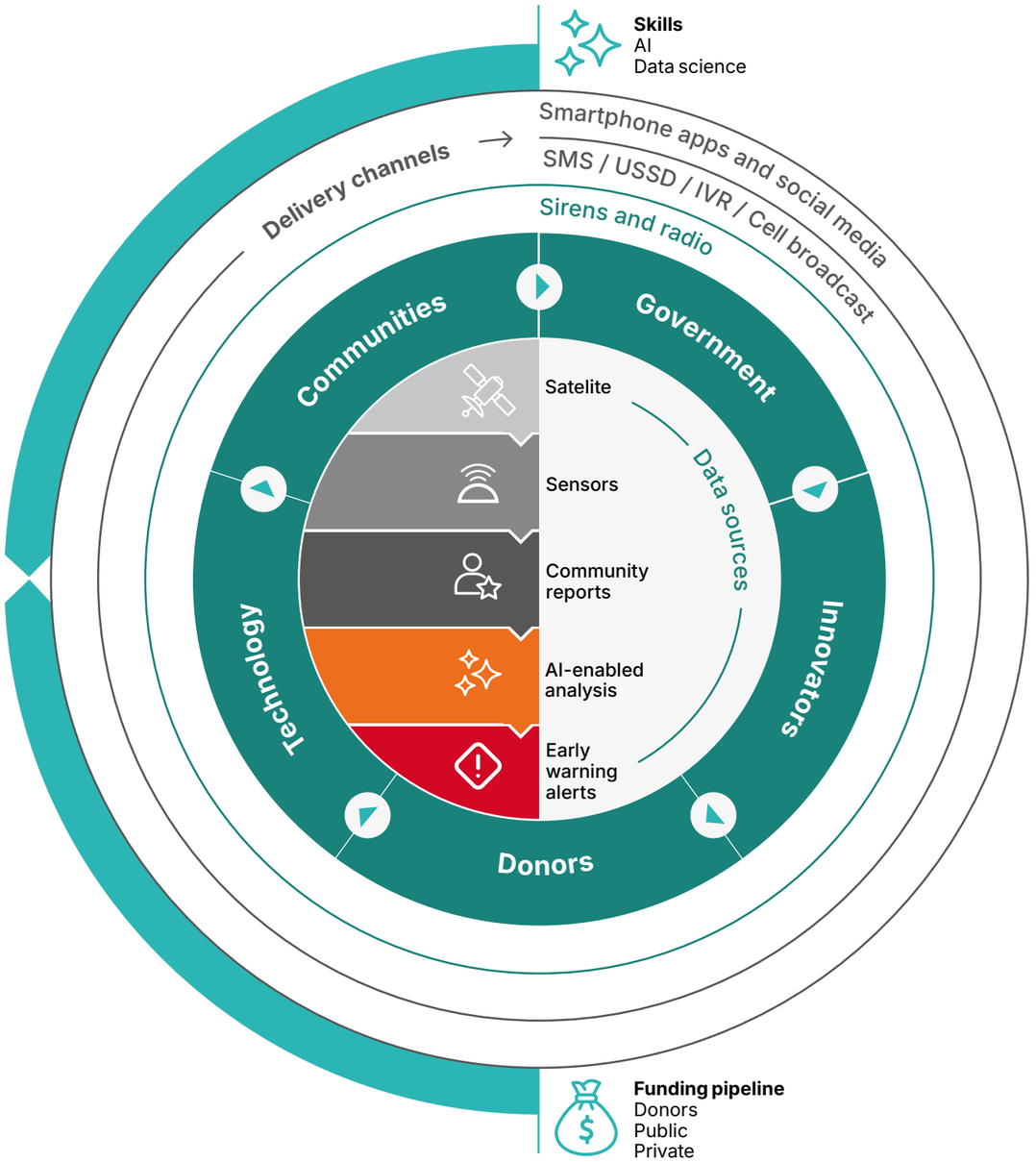
To ensure alerts reach everyone, the Fund backs ConnectHear in Pakistan, which developed an AI-enabled communication tool providing real-time sign language interpretation and AI-generated alerts for people with hearing impairments, seeking to benefit more than 1 million at-risk individuals. It also supports Viamo, a voice-first GenAI voice companion accessible via a toll-free hotline with MNO Ufone. Users can ask questions in Urdu about disaster preparedness and response and receive tailored voice guidance. The assistant draws on materials from national and provincial disaster authorities to ensure the information provided is locally relevant and aligned with national standards.

Recommendations for developing AI-enabled early warning systems

As AI-enabled EWS scale across LMICs, M4D research highlights four key lessons:

1. **AI-driven hazard prediction depends on reliable, high-quality and usable data.** However, this is often scarce in LMICs. Combining satellite imagery, sensor networks, historical records and community observations improves detection, but data quality has a direct impact on model performance and trust. Using open-source datasets with locally collected data, as will be seen in pilots in Nepal and Ethiopia, provides a practical starting point. Building local language datasets is also vital for inclusive, voice-based systems.
2. **Partnerships drive scale.** Successful EWS require collaboration between governments, innovators, donors, researchers and communities, and must be embedded in national disaster protocols. Multi-hazard systems in Pacific SIDS have demonstrated the power of multi-sector partnerships.
3. **Multi-channel delivery ensures inclusion.** Forecasting is ineffective without accessible alerts. AI-enabled EWS should combine traditional methods (sirens, radio) with mobile-first tools (SMS, IVR, USSD) and smartphone apps to reach all users, including those with disabilities or low literacy levels.
4. **Sustainability depends on capacity and lasting financial support.** Local technical expertise in AI and data science are critical to system upkeep. Long-term public and private investment, rather than just short-term donor funding, is essential to sustain and scale these systems.

Figure 5: **Ecosystem of AI-enabled early warning systems**



Source: GSMA research and analysis

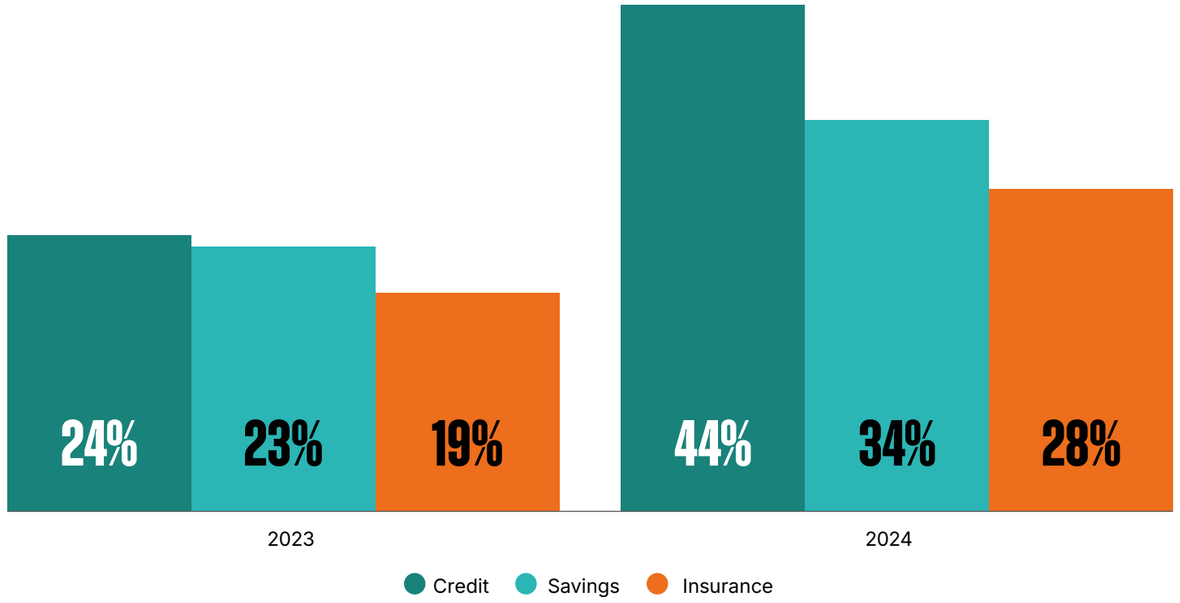
Mobile money and financial tools for climate resilience

Mobile money providers (MMPs) are changing the way traditionally unbanked communities engage with digital financial services (DFS) – an important enabler of global financial inclusion that contributes to 15 of the 17 Sustainable Development Goals (SDGs).[19] With more than 2.1 billion registered mobile money accounts,[20] most of which are in South Asia and Sub-Saharan Africa where climate shocks are felt most acutely,[21] mobile money can be a lifeline.

Remittances sent via mobile money channels are the most common type of transaction following an extreme climate event,[22] with payments from friends or family arriving faster on average than in-kind aid or donations.[23] With an estimated one in four adults in LMICs experiencing a natural disaster in the past three years, two-thirds of whom lost income or assets as a result, mobile money provides essential access to financial support both in times of relative normality and in the aftermath of an adverse weather event.[24]

However, one-off payments fail to account for the ongoing impacts to livelihoods, food or housing, which may not be felt until months after a climate event. Several MMPs now offer adjacent financial services like credit, savings and insurance to empower individuals and communities so that they do not need to rely solely on traditional forms of disaster relief or government aid.[25]

Figure 6: **Mobile money providers offering adjacent financial services**



Note: Data based on responses to the 2025 GSMA Global Adoption Survey.
Source: GSMA (2025): *The State of the Industry Report on Mobile Money 2025*.

19. GSMA. (2025). *The State of the Industry Report on Mobile Money 2025*, p. 80.
20. Ibid., p. 9.
21. Zetterli, P. (14 August 2025). "New Data Show the Key Role of Inclusive Finance in Climate Adaptation". *CGAP Blog*.
22. Sirtaine, S. and McKay, C. (2 June 2022). "In an Era of Urgent Climate Risk, Does Financial Inclusion Matter?" *CGAP Blog*.
23. Ibid.
24. World Bank. (2025). *The Global Findex Database 2025*.
25. GSMA. (2025). *The State of the Industry Report on Mobile Money 2025*, p. 44.

Figure 7a: Customers using a mobile money account to take out a loan

Customers who used mobile money to take out a loan in the past 12 months by country, 2023 and 2024

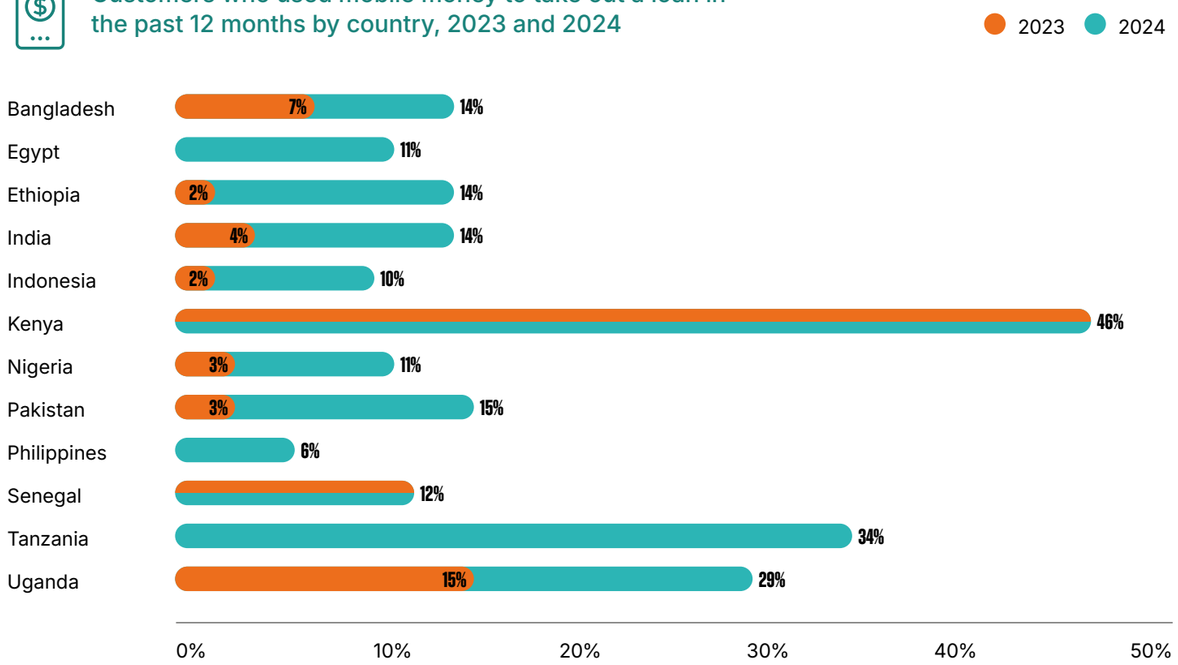
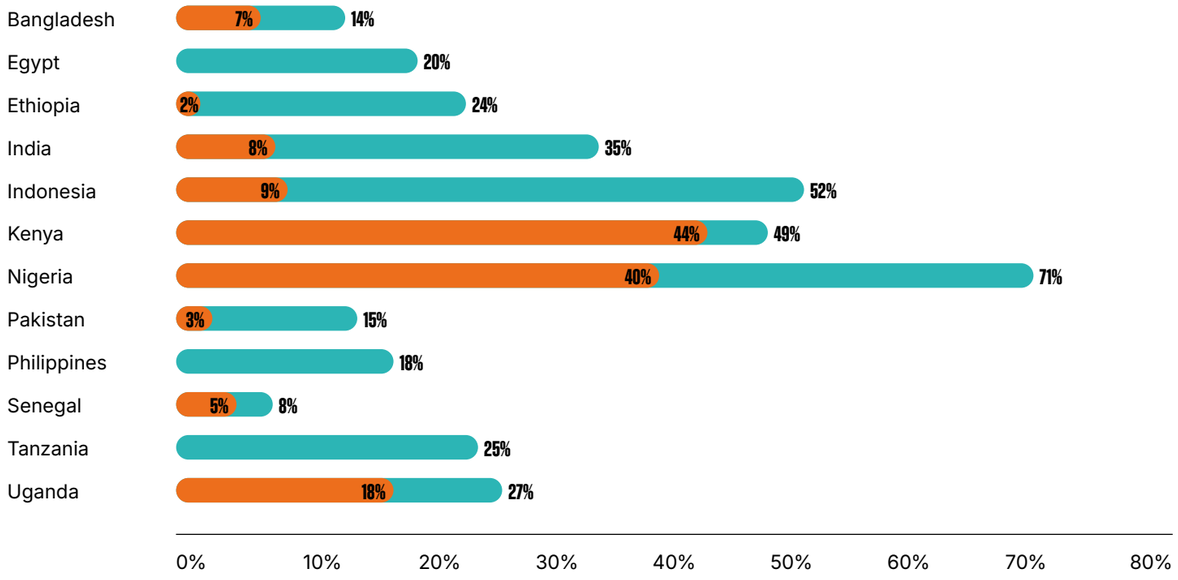


Figure 7b: Customers using a mobile money account to save

Customers who used mobile money to send money to a savings account in the past 12 months by country, 2023 and 2024



Note: No 2023 data was available for Egypt, the Philippines or Tanzania.
Source: GSMA (2025): *The State of the Industry Report on Mobile Money 2025.*

Credit is the most common form of adjacent financial service that MMPs provide. Typically, these products are offered in partnership with a financial institution (to comply with national regulatory conditions) and can, when used diligently, help households replace equipment or materials that may have been destroyed by an adverse weather event.

Savings are the second most-offered adjacent financial service, with many MMPs encouraging customers to put money aside in their mobile money accounts, which can serve as emergency funds in the aftermath of an adverse weather event. However, some stop short of being able to offer interest payments given national regulations.

Insurance products enable many agricultural workers in Sub-Saharan Africa to deal with income or yield losses from weather shocks, reducing risk and aiding recovery.[26] We have seen MMPs such as Safaricom or Vodacom extend insurance offerings to their millions of customers by partnering with underwriters and technical service providers, indicating positive growth potential for the market.[27]

Lersha is an Ethiopia-based startup and Innovation Fund grantee that has integrated mobile money services such as Telebirr and M-PESA on its platform to allow previously unbanked farmers to access credit and insurance through their mobile phones and invest in sustainable agriculture practices. In Ethiopia, smallholder farmers are responsible for 95% of the country's agricultural output, yet they are the most vulnerable to the negative impacts of an adverse weather event. Lersha's value proposition highlights the potential for mobile money to transform agriculture, ensuring that even the most remote farmers can thrive in a changing climate.

Figure 8: Number of farmers receiving insurance claim payouts, 2023–2024

Source: GSMA. (2025). *State of the Industry Report on Mobile Money.*

26. Read more about our work with OKO and Orange Money here.
27. GSMA. (2025). *The State of the Industry Report on Mobile Money 2025*, p. 47.

SPOTLIGHT:

Anticipatory humanitarian cash assistance in Nepal

With natural hazards becoming more unpredictable, anticipatory humanitarian assistance can be a lifeline. Disbursing cash before disaster strikes gives households vital time to prepare and protect their assets. Despite this being an ambition of the humanitarian sector for decades, cash delivery in humanitarian contexts can still be reactive and slow. Weeks can pass before funds reach households, by which time many have already lost their homes or livelihoods. Instead, timely and targeted humanitarian finance can mean the difference between safeguarding assets and losing everything.

The GSMA Innovation Fund for Anticipatory Humanitarian Action supported two organisations in Nepal – NAXA and Rumsan – to develop innovative digital models for delivering anticipatory cash assistance.

NAXA's platform, Digital and Spatial Technologies for Anticipatory Action (DASTAA), combines geospatial data, household surveys and mobile alerts to identify at-risk households and link them directly to cash disbursements triggered by early warnings. In July 2024, when extreme rainfall triggered flash floods, 870 households collectively received $32,000 through their mobile wallets before the floods hit.[28] Zero casualties were reported – evidence that households acted on the warnings and used the cash effectively.

Rumsan's Rahat platform integrates flood forecasts with blockchain-based smart contracts.[29] When trigger thresholds are reached, the system automatically sends early warnings via SMS or IVR in local languages and releases digital tokens to pre-assigned households. In 2024, 774 households received $109 each within 5.5 hours of activation.[30] The blockchain layer ensured each transaction was transparent and traceable. In Rumsan-supported communities, 95% of recipients expressed satisfaction with the speed and reliability of these mobile-enabled disbursements.

KEY ENABLERS:

Strong partnerships with humanitarian agencies, financial service providers and local governments

Mobile connectivity and widespread use of mobile money

Targeted early warning alerts, timely information and cash assistance

28. GSMA. (2025). *Case Study: NAXA – Digital and Spatial Technology for Anticipatory Action in Nepal*.
29. A smart contract is a self-executing digital agreement. It automatically triggers action when predefined conditions (e.g. a flood forecast) are met. In this instance, it included sending cash assistance or early warning messages.
30. GSMA. (2025). *Case Study: Rumsan – Leveraging blockchain for anticipatory action and cash assistance in Nepal*.

The results showed strong demand for these approaches, attracting significant new investment. NAXA secured $454,000 in follow-on funding during its GSMA grant, while Rumsan attracted $688,000. Both are now looking beyond Nepal – NAXA is expanding to Bangladesh and Malawi while Rumsan is developing multi-hazard applications through new partnerships with NGOs and financial service providers in Kenya and Cambodia.

Together, these projects demonstrate how anticipatory finance can be embedded in humanitarian systems, with digital tools ensuring that assistance reaches people quickly, directly and when it matters most.

"When the heavy rainfall in July partially damaged my home, I felt helpless, unsure of how to move forward. Living with a disability already made things challenging, but the support I received gave me a new beginning. With the cash assistance, I equipped myself with synthetic hands and started driving an electric rickshaw. Now, I no longer depend on others; I earn for my own living."

Male community member

SPOTLIGHT:

OKO's weather index insurance for smallholder farmers

Mali is among the top 10 countries globally most vulnerable to climate shocks, including erratic rainfall, droughts and flash floods. With 80% of the population dependent on agriculture, droughts affect around 400,000 people, reducing crop revenue by $9.5 million every year. Access to formal financial services is limited as banks and microfinance institutions (MFIs) are reluctant to lend to farmers without collateral or risk mitigation tools. Mali's insurance penetration rate is just 0.43%, with very few companies offering insurance products to smallholders.

OKO provides weather index insurance to smallholder farmers exposed to climate risks. Using satellite data, OKO applies a parametric approach to automate risk management and claims. Payouts are triggered automatically when weather thresholds are met, such as too much or too little rain. This removes the need for in-person field assessments and ensures timely support for farmers after climate shocks.

OKO integrates mobile money platforms like Orange Money, enabling farmers to self-subscribe using USSD, pay premiums and receive payouts directly to their mobile phones. It also operates an agent model, with field agents and mobile money agents facilitating sales and premium collections. To promote gender inclusion, OKO actively recruits and trains female agents to boost adoption among women farmers.

To support customer outreach and provide access to credit, OKO partners with MFIs that have access to large numbers of smallholder farmers, such as the Micro-Institution Income Growth (RMCR) Network-VisionFund Mali. For MFIs, weather index insurance is a type of risk mitigation, reducing the need for farmers to provide traditional collateral or guarantees when applying for credit.

OKO's digital approach allows for rapid scaling, even in remote areas, by making the product accessible via USSD and leveraging satellite data for weather monitoring.

KEY ENABLERS:

Mobile connectivity and the widespread use of **mobile money** in Mali – 94% of OKO's user base are subscribed to the mobile money service, Orange Money.

OKO's agent model includes female customer touchpoints, which builds trust and **supports adoption and gender inclusion** in rural communities.

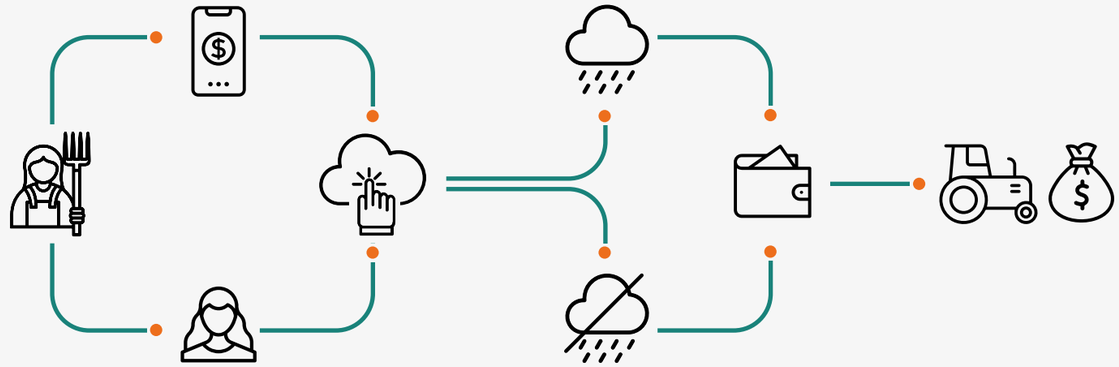
Partnerships with MFIs and NGOs help OKO **reach more farmers** and bundle insurance with other financial services.

Affordable and accessible insurance in rural Mali

- High satisfaction with the registration process and premium prices
- **91%** of farmers prefer paying premiums in instalments
- Improved understanding of insurance
- More acceptance of the benefits of OKO's product

- Insured farmers are seen as more creditworthy by financial institutions
- The bundled insurance and loan product led to 56% of farmers reporting that insurance played a key role in securing a loan
- 82% of OKO-insured farmers surveyed feel better able to absorb and recover from climate events
- 89% of recipients use the funds for basic needs, farm investment or debt repayment
- New opportunities arise to invest in their farms and build resilience
- Improved food security
- Decreased borrowing from informal sectors

Figure 9: OKO's smallholder insurance process



Smallholder farmers in Mali can access OKO's insurance service through a USSD feature on Orange, or through in-person agents.

Farmers can choose to pay the insurance premium in full or in instalments.

When an adverse climate event, such as a flood or drought, meets a certain threshold, an automated insurance payment is triggered and paid directly to the farmer's Orange Money wallet.

With the insurance payout, farmers build stronger financial resilience and can absorb the cost of the adverse climate event and maintain their livelihoods.

4. THE BLUE ECONOMY

The blue economy involves economic activities associated with the ocean, seas and coastal regions while preserving the health of these ecosystems. Over the past decade, the pace of these activities has increased exponentially, contributing to warming, acidification, declining fish stocks and coastal vulnerability. A study by the Organisation for Economic Co-Operation and Development (OECD) projects that the ocean economy could exceed $3 trillion by 2030, underscoring both the scale of the opportunity and the risk of unsustainable growth.[31]

As the largest carbon sink and with more than 600 million people in LMICs depending directly on marine and coastal resources, investment in the blue economy is urgent. This chapter reflects on efforts to protect natural assets at the intersection of climate science, digital innovation and inclusivity. The examples presented here draw on evidence and insights from Innovation Fund grantees, alongside complementary research and analytical work.

GLOBAL FISHERIES ECONOMY

USD $3T

ocean economy expected by 2030, according to OECD projections

600M

people in LMICs depend directly on marine and coastal resources.

3.2B

People rely on aquatic animal foods

31. OECD. (2025). *The Ocean Economy to 2050*.

Digitalising shrimp aquaculture

Indonesia is the world's second-largest exporter of shrimp, with aquaculture contributing more than $2.2 billion to the economy. Farming models vary widely, from a small number of intensive, high-density farms with sophisticated infrastructure, to semi-intensive, moderate-density farms and traditional farms relying on natural cycles. While traditional systems are the most prevalent, they are less productive and more vulnerable to climate change, fluctuations in water salinity and disease outbreaks. Expansion often comes at the expense of mangrove ecosystems, highlighting the need for solutions that balance productivity with sustainability.

IoT technologies are increasingly seen as part of the solution. They enable smarter resource management, improve environmental monitoring and support data-driven decisions. In 2025, the GSMA, with the support of the Icenergy Institute, TSIC, Indosat Ooredoo Hutchison and GIZ, conducted research on how IoT is being used in shrimp farming in Indonesia, and the extent to which it is leading to positive socio-economic and environmental impact.

Three main applications of IoT for shrimp farming have emerged:

Water quality monitoring

Sensors track pH, temperature, dissolved oxygen and salinity in real time, alerting farmers when parameters fall outside safe ranges.

Feeding automation

Timed feeding improves shrimp growth rates and feed conversion while reducing waste.

Aeration systems

Paddle wheels activate automatically when oxygen levels drop, cutting energy use.

KEY ENABLERS:

Our research identified six enablers that can meaningfully scale IoT in shrimp farming:

- **Infrastructure –** expanding reliable internet and off-grid power
- **Policy and regulation –** clear standards to incentivise sustainable practices and encourage digital monitoring
- **Conservation partnerships –** integrating IoT with mangrove protection initiatives
- **Technology readiness –** more durable sensors and locally available repair services
- **Farmer education –** peer-to-peer learning and training programmes to build digital confidence
- **Blended finance –** co-financing models to reduce risk and enable access for traditional farmers

When integrated, these tools can create holistic farm management systems accessible through mobile apps. Farmers report tangible benefits: cleaner water, healthier shrimp and reduced costs. For example, automated feeding can shorten harvest cycles by up to 10 days, while smart aerators have reduced electricity costs by as much as 30%. IoT has also lowered workloads and created new roles such as local technicians and digital troubleshooters.

Yet, adoption remains uneven. Intensive farms with strong business models can afford IoT tools and act on the data. Traditional farms, however, face barriers including high upfront and subscription costs, unreliable connectivity, limited maintenance support and concerns that buyers or regulators will misuse their data. As a result, some discontinue IoT use once a pilot ends. Farmers recognise the potential of digital tools, but success depends on affordability, readiness for local conditions and clear evidence of long-term value.

Promising initiatives are emerging. In 2023, Indosat Ooredoo Hutchison, the GSMA and GIZ piloted IoT-powered shrimp farming in North Kalimantan, combining water quality sensors with geospatial tools to track mangrove coverage. Data flowed via smartphones into a shared platform, enabling farmers to make better management decisions. The pilot has since expanded to four additional provinces, demonstrating the potential for scaling digital aquaculture practices in tandem with ecosystem conservation.

IoT in Indonesia's shrimp sector has now reached national scale, attracting investment from a range of stakeholders and catalysing innovation. The technology has strong potential to increase productivity, improve farmer incomes and reduce environmental pressures. However, its success depends not just on smart devices, but also on inclusive delivery models, regulatory clarity and local support systems.

SPOTLIGHT:

HydroNeo: smart shrimp aquaculture management in Thailand

HydroNeo is a Thailand-based startup offering a smart, IoT-enabled shrimp farming solution along with market access. Its hardware collects water quality data from shrimp ponds, enabling farmers to make more informed, data-driven decisions. With support from the GSMA, HydroNeo expanded its digital farm app with new features including shrimp size tracking, a pricing index, disease detection and a farmer diary. The app was also made available to farmers who do not use HydroNeo's IoT hardware, extending the reach of the solution.

Through this upgrade, HydroNeo provided vital support to more than a thousand shrimp farmers across central, eastern and southern Thailand. Endline analysis found that 79% of farmers felt features such as the farming diary improved their ability to track farming activities and monitor pond conditions. Feedback on the disease radar feature was more nuanced, with farmers recognising its strong potential to mitigate disease risk, but many had not experienced an outbreak during the study period or felt that more localised data would be needed to fully demonstrate its value in their specific context.

The survey also highlighted that 70% of shrimp farmers had completed higher education, compared to only 6% of farmers in other agricultural sectors in Thailand. This suggests that shrimp farming is an agro-industry with relatively high barriers to entry, and with relatively strong digital literacy among shrimp farmers in Thailand, this increases the potential for scaling digital solutions such as HydroNeo.

Key insights:

Farmers with large farms and multiple ponds became early adopters, as they quickly recognised the financial advantages and overall value of scaling technology across their operations, compared to farmers with small farms and single ponds, who were initially more hesitant to adopt technology for farm management due to uncertainty over value for money.

It is important to note that the app is part of a comprehensive package of smart farm management tools and farmers still gravitate towards more traditional tools than the new app. App features that digitalised previously inefficient processes, such as farm inventory and diary keeping, were better received than features that sought to digitalise processes that were efficient regardless, such as measuring the size of shrimp.

Digital tools for sustainable fisheries: improving management and combatting illegal, unreported and unregulated fishing

The world's oceans are facing an unprecedented crisis threatening livelihoods, food security and the GDP of seafood-exporting countries.

Traditional fisheries management, limited by insufficient data, weak enforcement and limited resources, has struggled to combat unsustainable fishing. Fisheries managers have primarily relied on paper logbooks filled by vessel masters, which are prone to loss and falsification, sporadic dockside inspections and observers onboard fishing vessels, which is not only costly but also potentially dangerous. This approach has perpetuated overfishing and enabled illegal, unreported and unregulated (IUU) activities to persist undetected.

Digital technologies are now playing a key role in making fishing activities more transparent. For example, satellite-based Vessel Monitoring Systems (VMS) and Automatic Identification Systems (AIS) now track fishing vessels continuously across exclusive economic zones and the high seas, generating real-time data on vessel position, speeds and movement patterns.[32] When enhanced with AI and ML algorithms, these systems can automatically detect suspicious behaviours, such as vessels conducting illegal trans-shipments at sea, boats entering marine-protected areas or patterns suggesting systematic fishing quota violations.[33]

Remote-sensing technologies can now detect vessel signatures even when tracking systems are deliberately disabled, revealing so-called "dark fleets" that previously evaded all monitoring. Predictive analytics take this further, using historical patterns to estimate where IUU fishing is most likely to occur, allowing authorities to deploy limited patrol resources with maximum effectiveness.[34] For LMICs with vast coastal territories but minimal capacity for surveillance, these technologies are creating opportunities to monitor fishing activity at scale that would otherwise require significant patrol resources to cover.

OVERFISHING

35%+

of global fish stocks are **overfished**[35]

26M

tonnes of fish taken **illegally each year**

$10-23

billion lost annually to IUU fishing[36]

3 BILLION

people rely on seafood as a key protein source and

600M

people depend on fisheries for their livelihoods[37]

32. Dunn, D.C., et al. (2018). "Empowering high seas governance with satellite vessel tracking data". *Fish and Fisheries*, 19(4), pp. 729–739.
33. Global Fishing Watch. (2018). "Tracking the Global Footprint of Fisheries". *Science*, 359(6378), pp. 904–908.
34. GSMA. (2025). *Advancing Sustainable Fisheries with Digital Technologies: The Gulf of Thailand*.
35. FAO. (2025). *Review of the state of world marine fishery resources - 2025*.
36. FAO. (2009). *Illegal, unreported and unregulated fishing*. FAO Fisheries and Aquaculture Department Technical Paper.
37. FAO. (2020). *The State of World Fisheries and Aquaculture 2020: Sustainability in Action*.

Enhancing data collection

Digital tools like electronic logbooks and mobile apps are allowing fishers to record and share real-time catch data, improving accuracy and speed, as seen in Indonesia's dockside data systems.[38] In South Africa, ABALOBI empowers small-scale fishers by combining catch reporting with market access, weather alerts and financial services, rewarding sustainable practices with better prices. Similarly, Peskas in Timor-Leste and East Africa integrate mobile reporting and solar-powered GPS trackers in a cloud dashboard, providing real-time visibility of small-scale fishing activity.

The role of AI

More and better data from vessels, sensors and satellites are enabling data-driven fisheries management.

Creating transparency through traceability

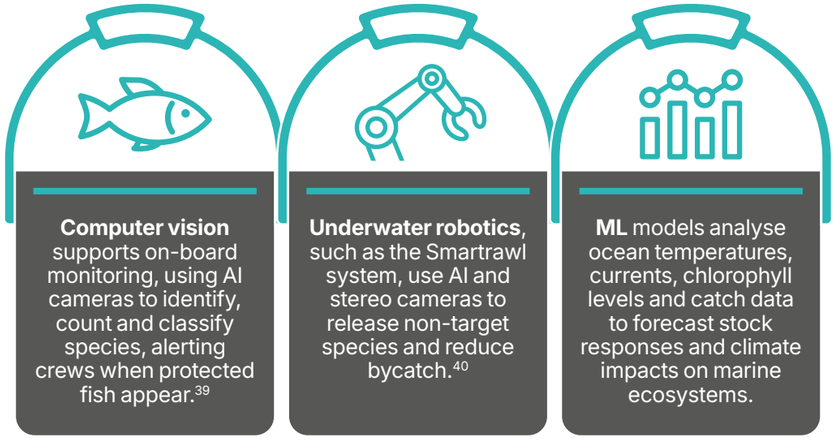
Blockchain-based traceability systems combat IUU fishing by creating immutable "sea-to-plate" records that verify seafood origin and movement through the supply chain. Each catch receives a digital ID (QR or RFID) tracked from vessel to retailer, ensuring credibility for consumers and market access for sustainable fishers. Pilots for high-value species like tuna show strong potential; the next challenge is scaling cost-effective systems for small-scale and lower-value fisheries.

Regional cooperation for stronger impact

Because fish stocks cross borders and IUU operators exploit weak jurisdictions, regional collaboration is essential. Digital platforms now enable shared monitoring and enforcement. The TUFMAN2 system links 17 Pacific Island nations through a cloud database integrating vessel and catch data for coordinated tuna management,[41] while the Gulf of Guinea Regional Fisheries Commission partners with Global Fishing Watch to enable 11 African countries to share vessel-tracking data and combat IUU fishing worth more than $2 billion annually.[42] These regional systems pool analytical capacity and enforcement resources that individual nations often lack.

Tailoring digital tools to different contexts

GSMA research in the Gulf of Thailand highlights the need for locally relevant, low-cost technologies suited to small-scale fisheries. Tools must withstand harsh marine conditions, work offline and use intuitive, icon- or voice-based interfaces for low-literacy users. The most effective solutions bundle monitoring with useful services like weather alerts, safety features, market access and financial tools, all of which drive adoption and ensure sustainability.



38. Ibid.
39. Environmental Defense Fund. (2021). *SmartPass: Technology for more Sustainable and Productive Fisheries*.
40. Jack, L. (28 June 2023). "AI-empowered fishing net to help prevent marine bycatch". The National Robotarium.
41. SPC Oceanic Fisheries Programme. (2019). *Tuna Fisheries Data Management system (TUFMAN2)*. Pacific Community.
42. Global Fishing Watch. (2024). "Global Fishing Watch and Gulf of Guinea Regional Fisheries Commission forge partnership in fight against illegal fishing".

Enabling conditions for success

Digital technology alone does not guarantee more sustainable fisheries management. Other critical enabling conditions include:

Inclusive governance: Fishers must be partners in designing and implementing systems, not passive subjects of monitoring.

Capacity building: Local fisheries managers and experts need training in data analysis, system maintenance and enforcement.

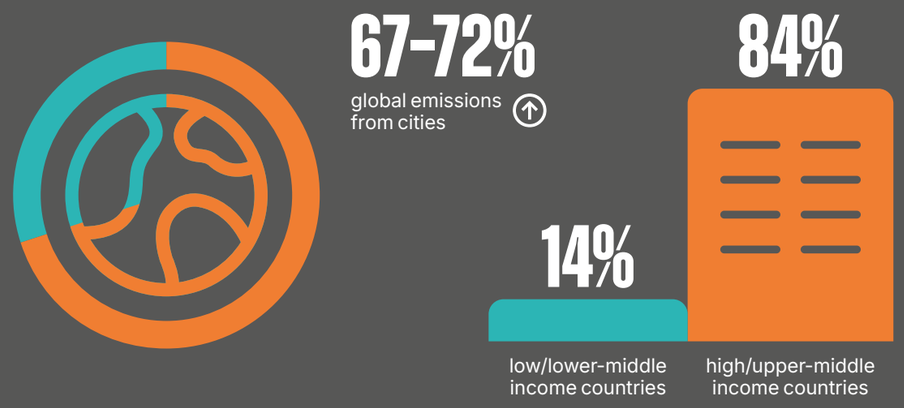
Appropriate incentives: Subsidies, or co-financing, may be necessary to overcome initial adoption barriers, particularly for small-scale fisheries.

Data governance frameworks: These are essential to ensure that information is used for legitimate management purposes and not to exploit vulnerable communities.

5. CITIES

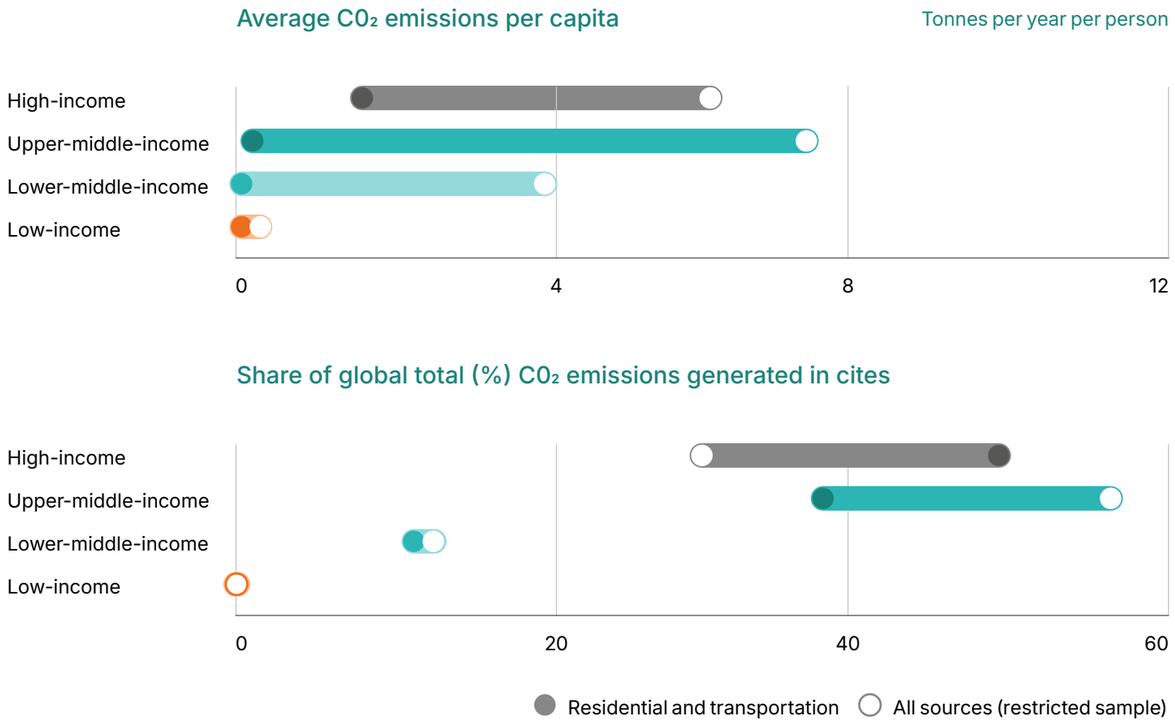
As centres of economic activity, cities generate the majority of GDP and tax receipts in most countries. As of 2018, the world's largest 3,000 cities accounted for 67% of global GDP, and the World Bank estimates the urban share as high as 80%.[43,44] With this prosperity comes significant emissions – the Intergovernmental Panel on Climate Change (IPCC) estimates that cities accounted for 67–72% of global emissions in 2020.[45] Strikingly, 84% of urban emissions come from high- and upper-middle income countries, while low- and lower-middle income countries generate only 14% of urban emissions despite housing a third of the world's urban population.[46]

CITIES AND EMISSIONS



43. McKinsey Global Institute. (2018). *Superstars: The dynamics of firms, sectors, and cities leading the global economy*.
44. World Bank. (n.d.). Urban Development web page.
45. IPCC. (2022). *Climate Change 2022: Mitigation of Climate Change*.
46. Based on World Bank population data.

Figure 10: Average CO_2 emissions per capita and share of global emissions generated in cities, 2015



Source: World Bank. (2022). *Thriving: Making Cities Green, Resilient, and Inclusive in a Changing Climate*

Urban populations in LMICs are set to double by 2050 and will contribute roughly one-third of global urban growth.[47] However, the potential of cities can only be realised when people have the essential services they need to thrive: water, energy, waste management and transport. Digital solutions provide important pathways to extend essential services while also building effective governance and contributing to climate mitigation and adaptation. However, this requires investment, and in 2019 the United Nations estimated that 75% of the infrastructure needed by 2050 had yet to be built. Much of what already exists must also be strengthened against climate threats. Therefore, our recent urban research has drawn attention to three broad modes of digital adoption in cities:

- **Mega-cities and national programmes** deploying large-scale digital infrastructure, often with strong policy coordination.
- **New city developments**, where greenfield planning can hardwire digital utilities and climate resilience from the outset.
- **Intermediary cities** (less than 1 million people) are an overlooked growth frontier. They are already home to around 60% of the urban population and, particularly in Africa, will absorb a significant share of urban growth (of the 50 fastest-growing cities between 2010 and 2030, 36 are African and 31 of those are intermediary).

This chapter captures highlights from two publications this year, building on years of work on urban resilience.

47. AfDB, Cities Alliance, OECD/SWAC and UCLG Africa. (2025). *Planning for Urban Expansion: Africa's Urbanisation Dynamics 2025*.

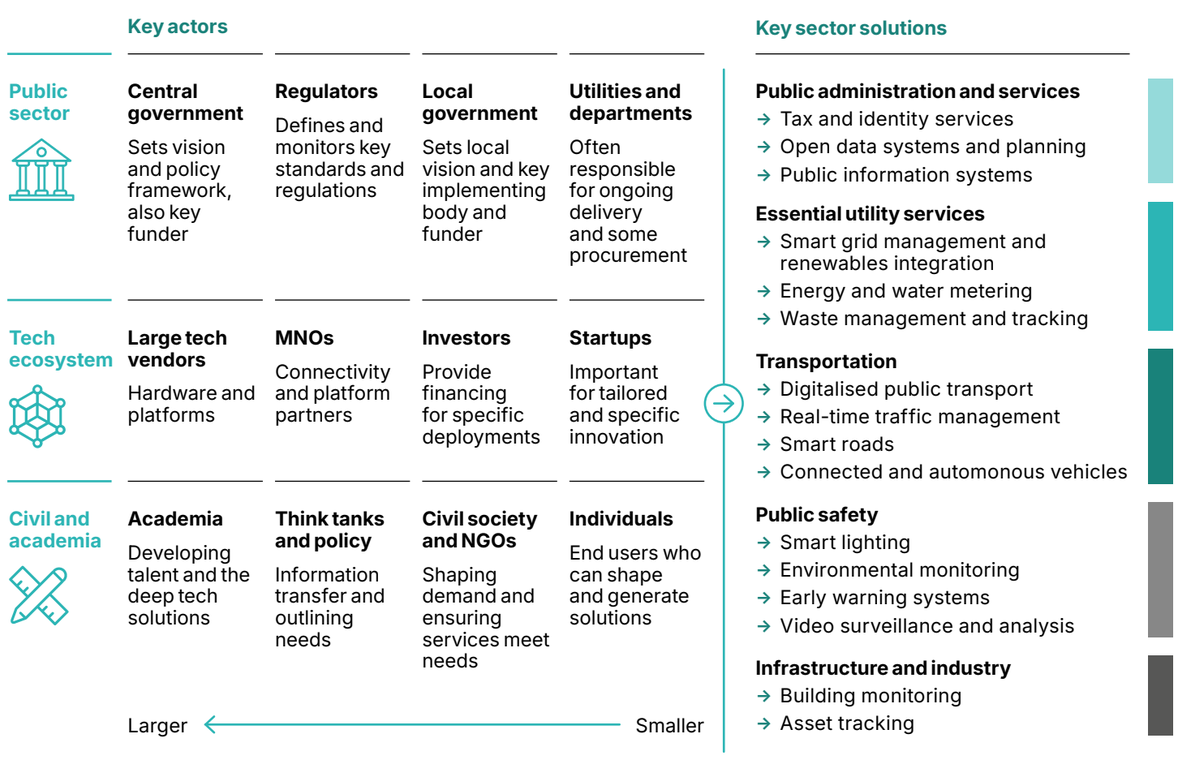
Smart cities and digital utilities: the foundations

In June, the ClimateTech programme published *Digital Foundations: The Path to People-Centred Smart Cities*, which built on two earlier reports, *IoT for Development* and *IoT and Essential Utility Services*. Together, these provide global connectivity data, new estimates for IoT deployments to 2030 and a review of adoption across 17 utility use cases in Sub-Saharan Africa, South Asia and Southeast Asia.

A few cross-cutting themes are clear:

- **MNOs play a vital role.** In LMICs, rapid digital adoption and mobile-first economics allow smart utility solutions to deploy faster and scale.
- **New technologies are expanding what is possible.** This includes 5G and network slicing, LPWA (NB-IoT, LTE-M), digital payments and advances in AI. Predictive AI has long underpinned smart grids, and GenAI is now augmenting forecasting, anomaly detection and decision support.
- **Policy momentum is real.** National urban plans, digital transformation agendas and long-term "vision" documents increasingly include smart-city objectives, and connectivity – through fibre, public Wi-Fi, 3G/4G/5G and fixed wireless – is treated as essential infrastructure.
- **The opportunity is material.** By 2030, utility solutions will represent nearly **30% of IoT connections across our focus regions. Smart-city IoT connections grew from 173 million in 2020 to 271 million in 2024 and are set to add another 222 million by 2030 – a $38 billion** cumulative revenue opportunity across the four regions studied.

Figure 11: Key smart city actors and use cases



Source: Authors, adapted from Arup and ThinkCity. (2021). *Smart City Handbook: Malaysia.*

SMART CITIES IN INDIA:

Digital public infrastructure + flagship programmes = scale

Digital public infrastructure (DPI) has been a major focus in India. India Stack, a combination of national digital ID (Aadhaar), payments (UPI) and data-sharing systems, enables the targeted delivery of social transfers and subsidies, usage-based pricing for utilities and rapid disbursement of disaster relief. While Aadhaar has enrolled 99% of the adult population as of 2025,[48] the Unified Payments Interface (UPI) accounted for more than 80% of digital transactions in India in 2024.[49]

Two national programmes anchor the deployment of smart utilities at scale:

- **Revamped Distribution Sector Scheme (RDSS):** One the world's most ambitious smart-metering drives, which aims to replace **250 million** meters by 2026.
- **Smart Cities Mission:** Operational since 2015, it has mobilised **$22 billion** for nearly **8,000 projects** across **100** cities.

To help scale up deployments, the GSMA M4D programme have been supporting dialogue and partnerships between MNOs and municipalities.

In November 2024, the GSMA Digital Utilities programme, in partnership with Climate Collective, hosted a forum in Delhi to discuss challenges and opportunities in scaling smart metering in India. In agreement with MNOs, policymakers, meter manufacturers, DISCOMs and smart grid startups, the following initiatives are being undertaken:

- **Policy and regulatory agenda:** The Digital Urban Utilities Forum (DUUF) developed a short list of regulatory and policy priorities (data sharing, standards, tariff design, procurement models) that now guides the GSMA's follow-up engagement with regulators and line ministries on smart metering.
- **Platform for structured collaboration:** A closed-door forum was created for utilities, MNOs, meter vendors, multilateral development banks (MDBs) and regulators to align on smart metering use cases and roles, laying the foundation for working groups and bilateral MoUs on pilots and standards.

In March 2025, the GSMA, in partnership with the WASH Innovation Hub at the Administrative Staff College of India, convened the DUUF in response to Bengaluru's escalating water crisis. Water sector experts, ecosystem enablers and startups came together to explore digital innovations for sustainable solutions to the city's water challenges through:

- **City-level problem framing and agenda setting:** The DUUF produced a shared map of Bengaluru's water risks and priority intervention areas, feeding into future city water resilience plans and utility roadmaps.
- **Coalition and coordination architecture:** Utilities, startups, manufacturers and research organisations agreed in principle to keep working together (through one-on-one follow-ups and a light-touch working group), strengthening the platform for coordinated pilots and advocacy.

48. Government of India. (n.d.). "Approximately 99% of adult population has been enrolled in Aadhaar: UIDAI CEO". Press release.
49. The Digital Fifth. (2025). *Crafting the Future of Real-Time Payments: From Less Cash to Cashless*.

MNO LEADERSHIP:

From connectivity to city infrastructure

1

MTN (Nigeria)

After building a data centre in Lagos to support its smart city initiatives, in March 2025, MTN partnered with the Lagos State Government to launch the My Lagos App. It integrates various services on a single digital platform, enabling residents to access real-time transportation updates, pay utility bills, report emergencies, locate businesses and explore tourism options.

2

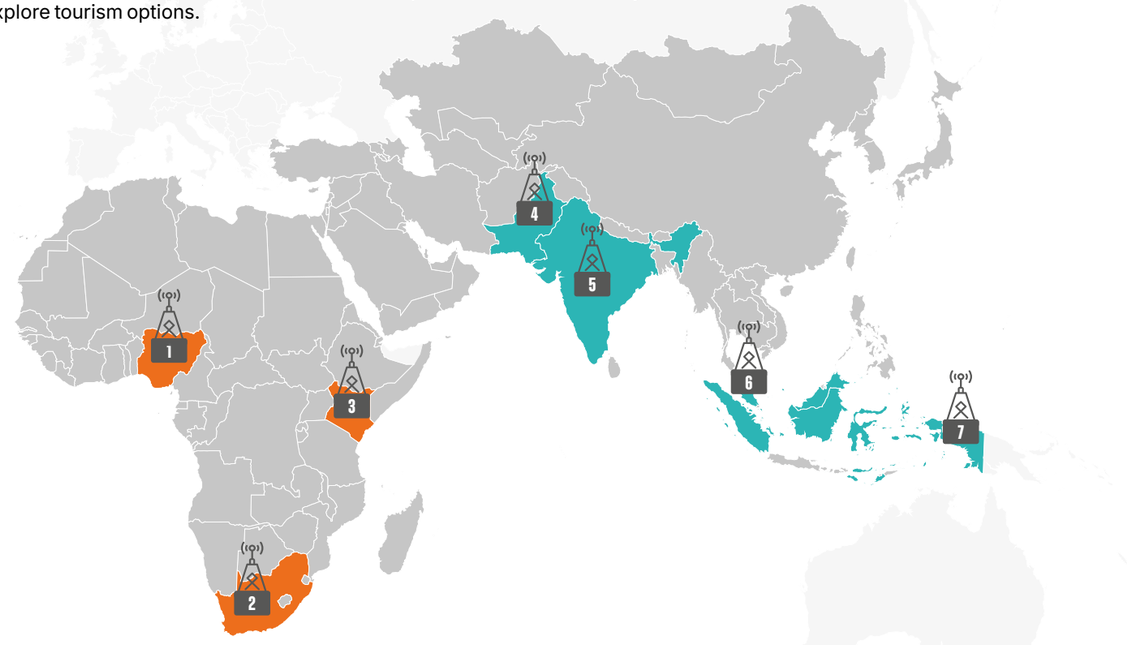
MTN (South Africa)

With 4G covering around 97% of South Africa's population and 5G around 44% (April 2025), MTN is digitalising municipal utilities with a focus on private 5G networks for smart cities, enterprise IoT and sector-specific digital solutions. A contract with the National Treasury targets smart electricity and water metering across 257 municipalities, improving resource efficiency, billing and collections – crucial for municipal financial sustainability.

3

Safaricom (Kenya)

A launch of national 5G roll out across all counties and NB-IoT for enterprise solutions, resulted in covering 97% of the population. Partnerships include MyNairobi and MyCounty, bringing permits, payments and service requests to unified platforms, as well as smart water pilots with the Kenya Water Institute.



4

Telenor (Pakistan)

Deployed 4G LTE, LTE-M and NB IoT, and is preparing for future 5G deployment by providing IoT connectivity and an IoT analytics platform service. Its White-Label Platform provides connectivity for various types of SMS communication (allowing users to customise services to their requirements) and solutions like Auxo Fleet, an end-to-end fleet management platform used by SMEs.

5

Reliance (India)

One of the largest 5G SA networks globally with more than 170 million users. Its JioThings platform targets a billion IoT connections, with deployments spanning commercial NB-IoT smart meters (e.g. Tata Power Delhi), e-mobility charging (with Zingbus) and telematics for two-wheelers (with PURE EV). Jio Brain supports domain-specific AI at scale.

6

CelcomDigi (Malaysia)

Operates the country's largest 4G LTE network, covering 97% of populated areas. CelcomDigi pairs NB-IoT/LTE-M with a decade-long partnership to transform Hulu Kelang into a smart district, bundling fibre backbones with 5G to underpin public safety, mobility and municipal services. The portfolio spans IoT platforms and network APIs to data analytics and AI enablement, supported by a dedicated business division that oversees its smart city initiatives.

7

Telkomsel (Indonesia)

Launched a 5G network in 2021 in major cities and offers NB-IoT connectivity for smart city applications and streamlined access to its network APIs via the Digihub platform. Deployed IoT for air quality monitoring (e.g. Surabaya) and traffic analytics (Bandung) and is collaborating on smart solutions for the new capital, Ibu Kota Nusantara (IKN).

Intermediary cities: digital adoption and startup ecosystems

The next decade of urban transformation will be led by intermediary cities – large enough to achieve scale, small enough to move fast. Here, climate tech and digital utilities intersect directly with people's daily lives.

Africa's startup ecosystem shows the investment is real. Between 2019–2024, fintech raised $8.8 billion (just under half of all tech funding), while climatetech raised the second highest amount at $4.3 billion (nearly a quarter of all funding). In October 2025, the GSMA Digital Utilities team published *Priming Urban Development: Digital Innovation in East Africa's Intermediary Cities*, in partnership with UN-Habitat, Connected Places Catapult and the Rwanda Smart Cities Hub. The research reveals where digital tools are already changing service provision in Kenyan, Rwandan and Ugandan cities and what is needed to mainstream adoption. The research builds on more than a decade of experience supporting innovators to develop new urban services, most recently with the GSMA Innovation Fund for Digital Urban Services and the Accelerated Growth Round cohort.

Nine Innovation Fund grantees collectively raised more than $24 million within one year.

In September 2025 Koolboks – a solar refrigeration startup – closed its $11 million Series A round to develop manufacturing capacity in Nigeria and scale regionally.

In September 2025 ATEC raised more than $3 million in new funding and initiated a new carbon finance project in Malawi under a bilateral agreement with Switzerland and closed a $15.5 million series raise to scale its clean cooking solution in African and Asian markets.

Freetown Waste Transformers has secured additional investment and cemented its role in Freetown's formal waste ecosystem.

Funding momentum in Africa's startup ecosystem (2019–2024)

Fintech vs climate tech

$24 MILLION+

Follow-on funding raised by the Digital Urban Services grant cohort within one year of grant close.

$11M

Series A funding closed by Koolboks in September 2025 to expand manufacturing in Nigeria and scale regionally.

$3M+

New funding raised by ATEC in September 2025.

$15.5M

Series raise closed by ATEC to scale its clean cooking solution in African and Asian markets.

SPOTLIGHT:

Freetown Waste Transformers: urban waste management in Sierra Leone

Freetown Waste Transformers (FWT) is a Sierra Leone-based startup offering a digitalised waste management service. Its DortiBox waste app allows businesses and households, particularly in informal settlements, to request organic waste collection, diverting the amount of waste going to landfills or being improperly discarded in the local environment. The waste is then fed into an anaerobic digestor and converted to green clean energy.

With the support of the GSMA Innovation Fund for Digital Urban Services, Freetown Waste Transformers has enhanced its digital solution and streamlined the waste collection process. The initial grant saw more than 300 waste collectors join DortiBox, serve more than 46,500 residents of the city, divert 12 tonnes of organic waste from landfill and generate 12,205 kWh of clean energy.

This was followed by support from the Accelerated Growth round of funding, in which FWT launched Dortibox 2.0, an upgraded, more inclusive version of its digital waste management platform. A key innovation was the introduction of a USSD service (*380#), developed in partnership with Orange Sierra Leone, which allowed waste collectors and users without smartphones to access the platform. To make it even more accessible, the platform incorporated voice prompts in both Krio and English, as well as visual symbols to support low-literacy users. These improvements addressed a challenge observed during the initial grant: that limited smartphone access and low digital literacy among waste collectors can cause adoption to lag.

Most significantly, FWT's DortiBox app was adopted by Freetown City Council as the official digital infrastructure for citywide solid waste management operations. The company secured a five-year municipal concession for Block 6, covering more than 15,000 registered customers requiring weekly collection service.

"The new partnership between FWT and FCC sets a powerful precedent for how technology-driven solutions can improve service delivery in rapidly growing urban areas. By leveraging innovative solutions like DortiBox and adopting a structured public-private partnerships model, the Freetown City Council has taken critical steps to address long-standing waste challenges. The success of this initiative will serve as a valuable blueprint for the future urban waste management reforms, showcasing the power of collaboration between city authorities, private companies, and the integration of technology-driven solutions."

Yvonne Aki Sawyerr,
Mayor of Freetown

6. CLIMATE FINANCE

This chapter explores how digital tools and emerging technologies are reshaping carbon markets through practical examples, shining a spotlight on innovators. We also examine government actions to accelerate the adoption of digital measurement, reporting and verification (dMRV), from investing in interoperable infrastructure to fostering collaboration and technical capacity. Ultimately, digital tools are not just improving integrity – they are unlocking new pathways for climate finance that reach communities most in need.

Mobile money is proving to be a game-changer, enabling households to afford clean energy assets through micro-payments, while also serving as a channel for distributing carbon credit revenues. Drawing on the experiences of GSMA Innovation Fund grantees, market actors and policy partners, this chapter shows how mobile technology can scale inclusive climate finance and deliver real impact.

$1.9T

Global climate finance hits an all-time high in 2023

$10-40B

value to be unlocked from carbon markets by 2030

MULTIPLE CO-BENEFITS

- improved health
- economic opportunities
- reduced energy costs
- enhanced security and resilience

Government pathways to scalable, high-integrity carbon systems

The credibility and efficiency of carbon markets depend on robust systems for measurement, reporting and verification (MRV). Digital technologies are essential tools enabling accurate tracking of carbon credits, the preparation and adjustment of national GHG inventories and monitoring of sector performance. They also verify environmental, social and governance (ESG) safeguards and support benefit-sharing mechanisms. By automating these processes, digital systems reduce costs, mitigate risks and enhance integrity, helping countries meet their Nationally Determined Contributions (NDCs). To unlock these benefits, governments must take deliberate steps to integrate dMRV systems in carbon market operations. The following are five key actions that can accelerate this transition:

1. **Investing in infrastructure and encouraging interoperability between systems.** National governments can take proactive steps to build functional infrastructure systems with interoperable registries, standardised reporting frameworks and integrated digital platforms. Governments in LMICs must invest in two layers of infrastructure:

   - **Foundational connectivity infrastructure (hard infrastructure):** This includes mobile network coverage, reliable internet connectivity and supporting backbone systems such as fibre-optic cables and data centres. Without these, IoT devices and cloud-based MRV platforms cannot transmit or process data consistently.

   - **Digital systems and processes (soft infrastructure):** Governments must establish interoperable registries, standardised reporting frameworks and integrated digital platforms. These systems ensure that data flows seamlessly across agencies and markets, enabling transparency and compliance. For example, Indonesia's One Map Initiative consolidates spatial data from multiple agencies into a unified platform. While its primary purpose is to reduce land disputes, it now feeds data into centralised dMRV systems for forest monitoring, illustrating how interoperable systems can serve multiple objectives.

2. **Encouraging collaboration and knowledge sharing.** Governments play a central role in convening stakeholders to share best practices, address challenges and scale solutions. International collaboration has an even greater impact by promoting harmonisation and efficiency. The Coalition to Grow Carbon Markets, launched by Kenya, Singapore and the UK, aims to boost confidence in voluntary carbon markets (VCM) by promoting high-integrity credits. Embedding digital technology standards in these principles would ensure integrity is supported by robust, tech-enabled systems.

3. **Providing technical support.** A lack of local technical expertise hinders the development and implementation of such solutions. For example, low digital literacy among users, lack of experienced staff due to limited access to relevant digital technologies and lack of regulatory experience in the use and security of digitally stored data. Through strong national regulations, governments can ensure how data is collected, stored and used, as well as provide training and technical support to regulators, local communities and project developers.

Policy spotlight: Q&A with Kenya's Climate Envoy

Kenya is emerging as a leader in digital climate finance innovation. In this interview, its Special Envoy for Climate, Amb. Ali Mohamed, discusses how policy and mobile innovation intersect, and how mobile money can channel climate funds to local communities. This conversation also draws insights from a recent high-level workshop co-hosted by the Envoy's Office and the GSMA in Nairobi.

Kenya has been at the forefront of carbon market development in Africa. What progress has been made on the policy side, and why was the recent workshop on mobile and digital solutions convened?

Kenya's policy landscape has evolved significantly over the past year. We amended the Climate Change Act in 2023 to allow participation in carbon markets through bilateral and multilateral agreements, private sector trading and voluntary markets. The amendments also empowered the Cabinet Secretary to appoint a Designated National Authority and establish a National Carbon Registry. In 2024, we finalised the Climate Change (Carbon Markets) Regulations, 2024, providing detailed governance, project eligibility criteria, safeguards and corresponding adjustments to prevent double counting. Together, this regulatory framework guides compliance and voluntary carbon credits and lays the foundation for Kenya's engagement in Article 6 cooperative approaches under the Paris Agreement, with institutional arrangements and tracking systems now being implemented to support international carbon trading.

The results so far are encouraging. Kenya ranks second only to the Democratic Republic of Congo in Africa for carbon credit issuances, and in 2024 Kenyan projects accounted for about 23% of all voluntary carbon market revenue on the continent. While this is significant achievement, it still represents only a small share of the global market and Africa as a whole remains underrepresented.

We see huge potential to scale up, but two challenges remain central: strengthening MRV systems and ensuring climate finance benefits communities on the ground. That's why we held a workshop on strengthening Kenya's carbon markets along with the GSMA in July 2025. It convened over 60 stakeholders, including project developers, regulators, MNOs and fintech innovators, to explore how Kenya's vibrant mobile money ecosystem and emerging digital MRV tools can bridge the gaps in transparency and benefit-sharing.

Digital MRV (monitoring, reporting, verification) is known to improve the integrity of carbon projects. What role do mobile technologies play in the same? How is Kenya planning to leverage dMRV to develop and grow its carbon markets?

Robust MRV is the bedrock of credible carbon markets. Traditionally, MRV in projects like reforestation or clean cooking relied on manual data collection and infrequent verification, which can be inefficient, costly and prone to error. By contrast, digital MRV solutions offer real-time or near-real-time monitoring. For example, remote sensing and satellite imagery can track forest cover changes continuously and IoT sensors embedded in devices like cookstoves can directly measure usage and emissions reductions. These technologies greatly improve accuracy and lower the cost of verification. AI-driven models can also predict carbon sequestration, enhancing our ability to forecast and plan.

Mobile technology is a key enabler of these MRV advances. Mobile connectivity allows IoT devices in the field to transmit data to cloud platforms, and mobile applications enable project officers, and even community members, to upload geotagged observations and receive feedback in real time. In Kenya, the ubiquity of mobile phones means we can crowdsource some monitoring data (for instance, farmers reporting on tree growth via a mobile app), thus democratising MRV.

We plan to leverage dMRV to strengthen transparency, accuracy and credibility in our carbon markets. By using digital tools for data collection, monitoring and verification, the sector will reduce verification costs, minimise double counting and improve investor confidence while aligning projects with its national climate priorities.

For example, in our landscape and forestry projects, we are exploring how satellite imagery and mobile data tools can track tree cover, biomass growth and community activities in near real time, ensuring reported carbon credits reflect reality on the ground rather than paperwork in an office. This, we believe, will attract buyers who are interested in high-integrity credits while at the same time reassuring communities that the impacts are real and verified.

Mobile money has been cited as a "game-changer" in connecting climate finance to communities. How is Kenya leveraging mobile payment platforms to ensure climate funds reach the local level?

Mobile money is one of our most powerful tools for inclusivity. In Kenya, services like M-Pesa have near-universal reach, even in rural areas. We are well positioned to make the switch to digital MRV, owing to our robust mobile infrastructure, vibrant tech ecosystem, and an increasingly supportive regulatory environment focused on the integrity of climate finance flows. We are integrating mobile payment channels into climate finance initiatives so that funds flow directly to those who implement climate solutions.

During our workshop, one of the highlighted solutions was an IoT-integrated carbon platform (the CaVEx platform) that aggregates data from distributed projects and uses a blockchain ledger for carbon credits. Notably, it channels payments to project owners via mobile money. This kind of approach ensures even a small community tree-planting project or a household solar installation can reliably receive its earnings without expensive intermediaries.

Ultimately, by leveraging mobile banking infrastructure, we reduce transaction costs and money to reach local communities faster. It also improves transparency as every payment is recorded digitally, creating a clear trail of how climate funds are used. For Kenya, where mobile money is deeply trusted, this means climate finance can be scaled up rapidly and fairly. We're proud that our mobile innovation ecosystem is helping operationalise climate policies, acting as a last-mile delivery channel that makes high-level finance flows tangible in people's lives.

SPOTLIGHT:

Innovation meets policy: ATEC's Article 6 breakthrough

After joining the GSMA Innovation Fund for Digital Urban Services in 2021, ATEC launched an IoT-connected electric cookstove, the eCook stove, paired with a mobile app. This app allows users to track their electricity use, see the carbon credits earned from their cooking activity, access customer support and make payments digitally. Crucially, ATEC's innovation was not just technical, it was also financial. The company's model generates valuable carbon credits from the use of each stove. ATEC secured a long-term offtake agreement with ENGIE for up to 11.5 million tonnes of digitalised carbon credits, guaranteeing a future revenue stream for expanding access to clean cooking.

The GSMA then provided another round of funding to ATEC in 2024 under the Accelerated Growth (AG) Round to accelerate active daily use of the cookstoves. ATEC rolled out a gamified "cook-to-earn" programme via the mobile app and households were rewarded for meeting a modest daily use target (2 kWh of cooking) with mobile money payments through bKash, a popular wallet in Bangladesh. These incentives were a significant amount relative to tariffs – a family hitting the target every day would receive 100 Bangladeshi Taka (BDT) per week ($1.00 or more) as a rebate. For those on the lowest ("lifeline") electricity tariff, this incentive fully offset their weekly eCook electricity cost, making clean cooking essentially free. ATEC also provided smartphones to around 220 of its highest-use customers as a further incentive. With this change, ATEC also pivoted their pricing model. Originally, the eCook stoves were sold through a PAYG instalment plan.

While eCook was scaling up, ATEC decided to remove upfront cost barriers entirely by using anticipated carbon credit revenues to subsidise the price of the stove. The retail price dropped from $100 to $35, and with new distribution partnerships and digital marketing, this pricing change fuelled an 18% growth in the user base during the AG Round.

These combined strategies – usage incentives and price subsidies – increased the number of users cooking electrically every day. By the end of the AG Round period, about 17.1% of app users were consistently meeting the 2 kWh/day target for clean cooking. This reduced annual GHG emissions by more than 4,000 tonnes – more than double the impact of the initial grant period.

Beyond emissions, the benefits for families were significant. More than 10,000 people now enjoy better indoor air quality (due to less smoke in their homes) and an estimated 500 tonnes of firewood are being saved each year as households abandon wood-burning stoves. For low-income households, the financial relief is tangible. On average, low-income households saw their incomes rise $1.40 per day and saved up to three hours per day that used to be spent gathering fuel or tending inefficient fires. These are hours now freed for income-generating work or household tasks, illustrating how climate finance can improve daily lives.

ATEC signed a deal to sell a portion of its digitally verified carbon reductions under an Article 6 framework via an agreement with the KliK Foundation as part of an Internationally Transferred Mitigation Outcome (ITMO) transaction between Switzerland and Malawi. For ATEC, this Article 6 engagement is a breakthrough that validates its approach on a global stage and could unlock new funding streams beyond the voluntary carbon market. It also shows how an agile startup can align with emerging climate policy mechanisms to scale its impact.

Figure 12: **ATEC's impact during the Accelerated Growth Round**

ADOPTION & RESEARCH

11.5M
Tonnes of digitalised carbon credits through a long-term offtake agreement with ENGIE.

100 BDT
Weekly mobile money rebate earned by households meeting the 2 kWh/day clean cooking target.

220
Smartphones provided to high-use customers as an incentive to increase daily engagement.

18%
User base growth achieved during the Accelerated Growth Round.

CLIMATE & ENVIRONMENT

17.1%
App users consistently meeting the 2 kWh/day clean-cooking target by the end of the AG Round.

4,000+
Tonnes in annual greenhouse gas reductions achieved through increased daily electric cooking.

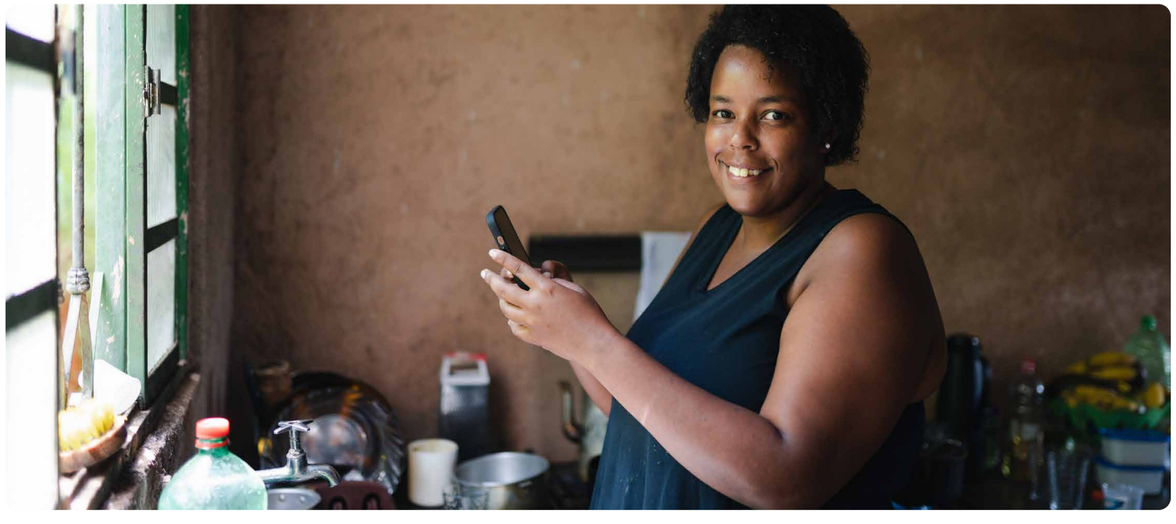
10,000+
People experiencing improved indoor air quality due to reduced household smoke exposure.

HOUSEHOLD IMPACT

500+
Tonnes of estimated annual firewood savings as households transition away from wood-burning stoves.

$1.40
Average daily income uplift observed among low-income households.

3
Hours per day saved daily as households are no longer gathering fuel or tending inefficient fires.



MNO's role: The power of connectivity

MNOs are emerging as critical enablers of digital climate solutions. Safaricom has pioneered three transformative initiatives that leverage connectivity, IoT and mobile money to address environmental monitoring, carbon market access and clean energy adoption. These innovations demonstrate the role of telcos in delivering scalable, data-driven impact for businesses, communities and ecosystems.

Distributed environmental monitoring: enhancing operational sustainability

Safaricom faced high operational costs and had limited visibility of the environmental conditions of its generator-powered sites. Traditional third-party audits for air quality, vibration and electromagnetic field (EMF) exposure were sporadic, creating data gaps and delayed responses, which in turn posed risks for technicians and surrounding communities.

To address these challenges, Safaricom developed an internal IoT-based monitoring system to measure air quality (PM2.5, PM10, CO_2, NO_2, VOCs), EMF radiation, temperature and vibration. Data is transmitted to a cloud-connected dashboard with real-time alerts, historical trends and automated logic for proactive shutdowns when thresholds are breached.

The solution benefits technicians through safety alerts, environmental, health and safety teams via compliance dashboards and communities through improved emissions management. A pilot site is now live, with plans to scale to 6,000 locations within two years. Challenges such as sensor calibration and user adoption are being addressed through firmware updates and training.

Cavex: digital MRV for inclusive carbon markets

Access to voluntary carbon markets (VCM) remains difficult for small-scale projects due to costly, manual verification processes. Cavex, developed by 4R Digital, deploys a cloud-based dMRV platform that automates data collection, processing and verification using IoT sensors, GSM-enabled devices and satellite imagery. Cavex adheres to ISO standards and the Integrity Council for the Voluntary Carbon Market (ICVCM) framework, boosting buyer confidence.

Integration with mobile money ensures traceable financial flows to communities implementing climate projects, making carbon finance more transparent and equitable. To date, Cavex has enabled capital flows to more than a thousand individuals through clean cooking, biogas, solar water pump and e-mobility projects. Three clean energy methodologies have been validated and the platform is ready to scale. Amid regulatory uncertainty, Cavex's design supports interoperability with Article 6 frameworks, positioning it as a catalyst for inclusive carbon markets.

Bonga for Biogas: loyalty points for clean energy

For Kenya's smallholder farmers, affordability is a major barrier to the use of biodigesters. Safaricom's Bonga for Biogas initiative, in partnership with Sistema.bio, addresses this by allowing customers to donate or redeem loyalty points (Bonga Points) to fund the purchase of biodigesters, which convert waste into clean cooking gas and organic fertiliser, reducing methane emissions and improving farm productivity.

IoT-enabled smart meters monitor gas flow and temperature for accurate carbon credit generation, while mobile integrations facilitate point redemption and loan repayments. Farmers dial a USSD code to participate, making the process accessible even in low-connectivity areas.

The campaign aims to install 3,000 biodigesters by 2028, building on Sistema.bio's track record of 14,000 installations in Kenya. Challenges include upfront costs and digital literacy gaps, but partnerships with cooperatives and NGOs are helping to scale adoption. Policy support for subsidies, awareness campaigns and recognition of bioslurry as an organic fertiliser would accelerate impact.

Transparency and inclusivity: InQube's digital MRV platform

InQube, a startup driving digital innovation in agricultural and forestry value chains, is reshaping climate action by tackling one of the most critical challenges in climate finance: scepticism about claims of carbon reductions. Through its pioneering dMRV platform, GreenQube, it is enhancing transparency and inclusivity in nature-based carbon projects like forest conservation, tree planting and soil carbon enhancement. Its impact was recognised globally when GreenQube, supported by the GSMA Innovation Fund for Climate Resilience and Adaptation, was selected under the category "Measurement, Reporting and Verification (MRV) / Mature solutions" at the 2024 Innovation Zero World Congress in London.

InQube at the 2024 Innovation Zero World Congress, London

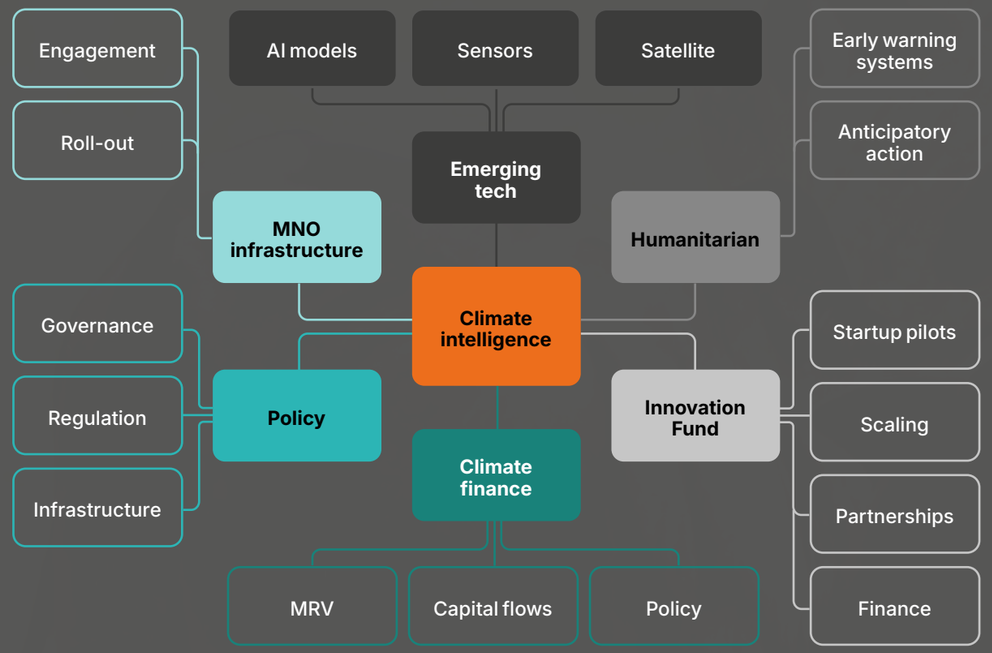
GreenQube's suite of digital tools:

- **Enhances accuracy and efficiency:** GreenQube integrates real-time or near-real-time data to measure biomass growth, soil carbon levels and overall ecosystem health through satellite monitoring.
- **Improves transparency and trust:** Every step in the dMRV process is traceable and auditable. The platform ensures that all stakeholders, from local communities to carbon credit buyers, can verify how a carbon credit came to be. This level of transparency builds trust.
- **Supports standardisation and compliance:** The platform is built on the major carbon standards (e.g. Verra's VCS and Gold Standard).
- **Empowers local communities:** GreenQube includes simple mobile apps that allow local stakeholders, like farmers, forest rangers or community members, to contribute data directly. They can upload geotagged photos of tree growth, report on project activities or flag issues using just a smartphone. Not only does this create richer data, it also gives communities a sense of ownership.
- **Enables adaptive management:** The platform ensures that projects stay on track to deliver the carbon and co-benefits they promised.

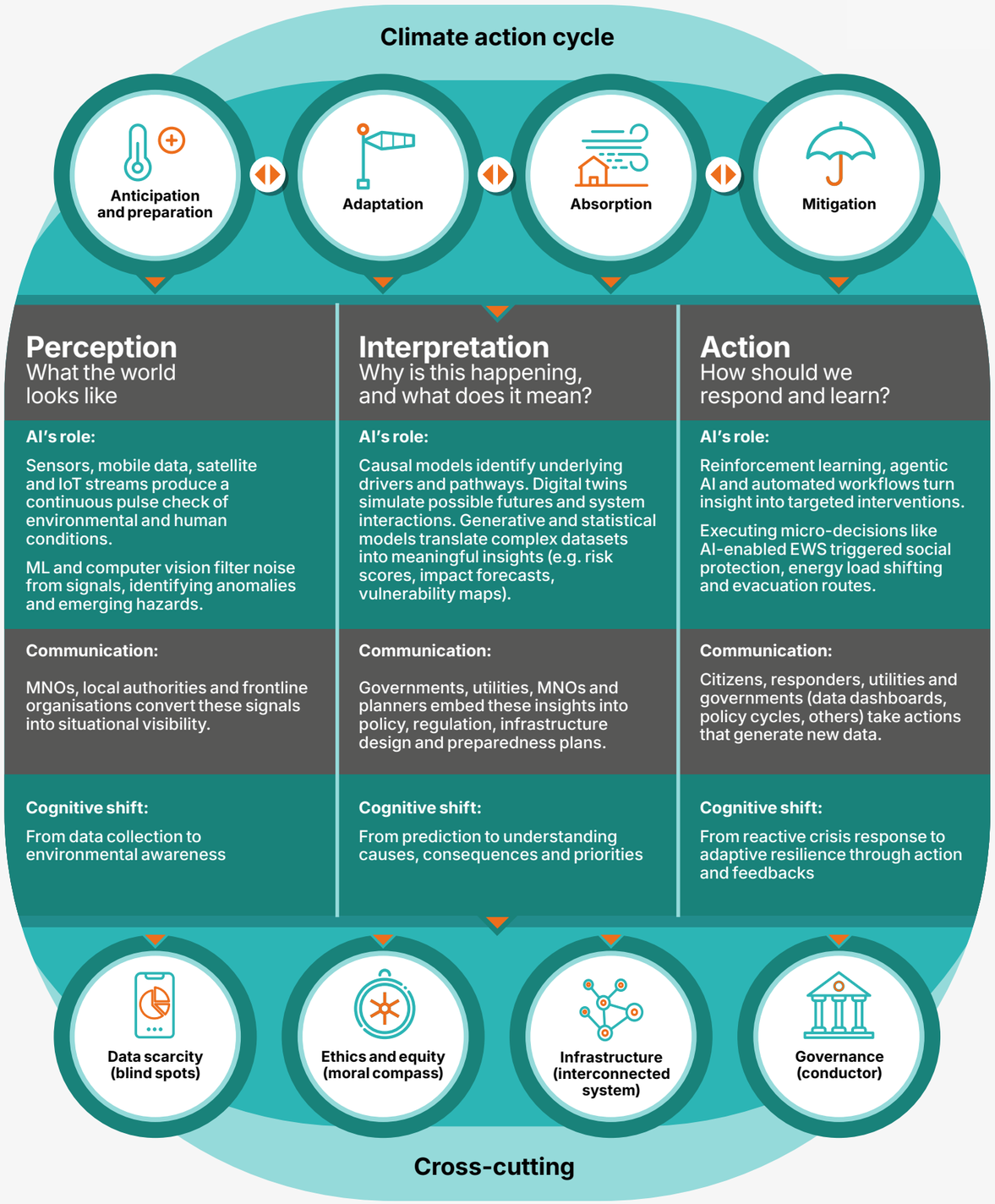
InQube is currently deploying GreenQube in various projects across India and Bangladesh. These include innovative interventions like reducing emissions in rice farming by using alternate wetting and drying (AWD) irrigation methods, a blue carbon initiative in the Sundarbans mangrove forests, converting agricultural waste like corn stalks into biochar and even applying silica dust to fields for permanent carbon capture in soil. The breadth of these pilots shows how flexible the platform is – not limited to one type of project or ecosystem. Collectively, the projects currently using GreenQube are expected to remove around 50 million tonnes of CO_2 over the next decade.

By combining technological precision with inclusive community participation, InQube is making carbon credits from forests and farms more credible, which in turn attracts more investors and buyers to fund these projects. As climate finance and carbon markets expand (including new opportunities via Article 6), InQube is demonstrating how digital innovation can ensure nature-based climate solutions deliver on their promise of carbon sequestration, resilience and sustainability.

7. THE CLIMATE INTELLIGENCE LOOP



THE CLIMATE INTELLIGENCE LOOP:
A mental model for systemic resilience



Source: GSMA Analysis

The examples in this report clearly show that digital solutions are no longer isolated interventions. Rather, that together they form a learning system in which signals, decisions and behaviours constantly interact. The Climate Intelligence Loop is a mental model that captures how AI and emerging technology, connectivity and human action combine to create this adaptive system and provides a systemic way to understand how climate intelligence moves through society. It draws from all previous chapters to show how climate intelligence already exists in fragments and how the GSMA and its partners can shape it into a coherent system.

1. Perception: detecting what the planet is saying

Perception is the sensory foundation of climate intelligence. It encompasses all the ways environmental and behavioural signals are captured via mobile phones, on-device IoT sensors, tower-based weather probes, satellite imagery, drone mapping, field agents and citizen reporting. AI models such as machine learning (ML) and computer vision filter noise from these streams, identifying flood anomalies, soil moisture stress or patterns of energy use that reveal vulnerability.

Across this report, perception is everywhere: in UjuziKilimo's soil sensors, Simusolar's PAYG telemetry, Komunidad's hazard feeds and InQube's forest-level satellite analytics. Mobile networks play a major role in providing infrastructure that sees: sensing, transmitting and stitching signals across vast geographies and communities.

2. Interpretation: understanding what it means

Perception without interpretation is not intelligence. Causal AI identifies drivers like deforestation, unplanned drainage and heat island effects. Digital twins simulate future scenarios, allowing cities or utilities to rehearse climate futures before they happen. Generative and statistical models turn raw data into adaptive plans or vulnerability maps.

This layer has appeared throughout our chapters: in GreenQube's ability to turn raw forest imagery into MRV-ready insights, in GeoKrishi's localised agronomic recommendations, in climate finance pilots that convert device usage patterns into verified carbon credits and in city-level risk dashboards that translate hazard feeds into municipal decision-making.

3. Action: responding to and reinforcing the system

Action is where interpretation becomes impact. AI-enabled systems trigger flood alerts via SMS, shift irrigation schedules, reroute supply chains, release anticipatory cash transfers and optimise microgrids. Reinforcement learning and agentic AI make micro-adjustments that accumulate into system-level resilience. Every action creates new data, feeding back into perception and strengthening the loop.

In this report, we have seen powerful examples: Rumsan and NAXA disbursing mobile money before disasters; ATEC turning clean cooking into income; OKO generating rapid insurance payouts; Komunidad enabling city-level early action; and countless MNO-enabled services reaching last-mile communities at scale.

This recursive loop is how climate systems and societies become intelligent. AI accelerates the loop. Connectivity delivers it. Communities validate it. Together, they form the foundation for a climate-resilient future.

However, intelligence is only as strong as the systems that sustain it. Data scarcity can blind the models we use; ethical gaps can distort who benefits; weak infrastructure can break the chain between insight and action; and fragmented governance can stall the learning on which resilience depends.

Yet, these are precisely the challenges that the GSMA and its partners are positioned to confront. By strengthening data ecosystems, embedding ethics and equity in every layer, investing in robust digital and mobile infrastructure and shaping governance frameworks that promote trust and interoperability, we can turn a fragile set of climate signals into a durable cycle of climate intelligence.

Looking ahead

The lessons and innovations showcased in this report remind us of the transformative potential of digital technology to tackle climate change. From empowering vulnerable communities to enhancing climate resilience, these solutions are paving the way to a more sustainable and equitable future.

The GSMA Mobile for Development (M4D) programme remains committed to fostering collaboration across the mobile industry, startups, policymakers and global partners. Together, we can transform bold ideas into action and create solutions needed for the challenges ahead.

Join us on this journey.

To learn more, visit the GSMA ClimateTech website and explore our latest resources.

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