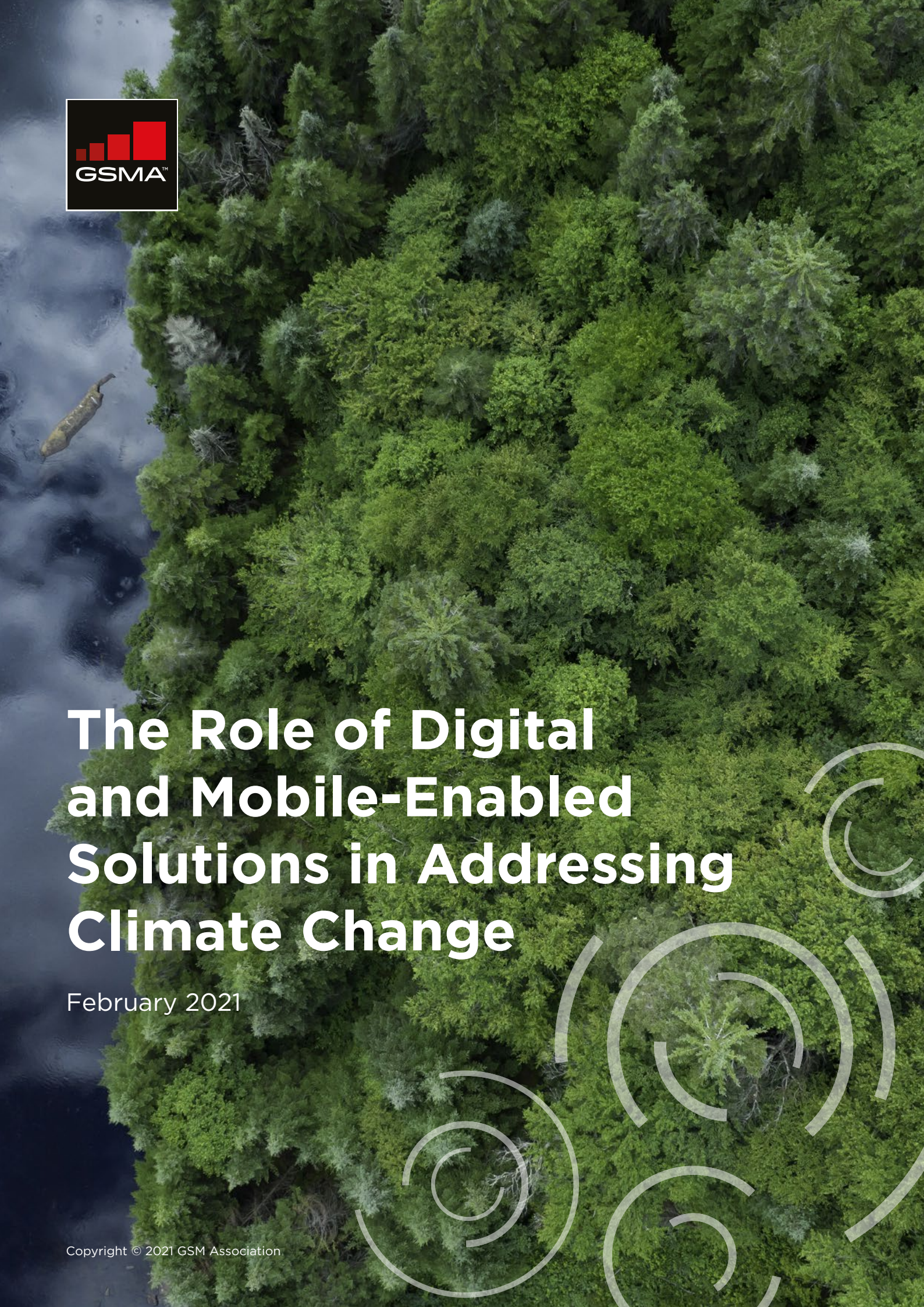


The Role of Digital and Mobile-Enabled Solutions in Addressing Climate Change

February 2021

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GSMA Mobile for Development

The GSMA represents the interests of mobile operators worldwide, uniting more than 750 operators and nearly 400 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces the industry-leading MWC events held annually in Barcelona, Los Angeles and Shanghai, as well as the Mobile 360 Series of regional conferences.

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Foreword

The world has already warmed by more than 1°C since pre-industrial times. The impacts of this warming continue to worsen, profoundly affecting lives, livelihoods and nature. COVID-19 has compounded these impacts, particularly for the world's most vulnerable people. As the world begins its recovery from COVID-19, it will be essential to do so in a manner that creates the clean jobs of the future, builds resilience against all crises, restores nature and leaves no-one behind.

As this report shows, mobile and digital technologies can play a critical role in that recovery. These technologies have already had significant positive impacts in many developing countries by changing the way people access basic services such as banking, agriculture, energy and water and sanitation. The same digital tools that enable many of these services can also help individuals, businesses and governments to reduce emissions and adapt to climate change.

Through the GSMA Mobile for Development (M4D) programme and other partners, the UK's Foreign, Commonwealth & Development Office (FCDO) has funded several business models that use mobile and digital technologies to combat climate change. FCDO was one of the early supporters of the pay-as-you-go solar home system companies, such as M-KOPA, Fenix and PEG, that are now pioneering off-grid clean energy industry. The UK has also helped make communities more climate resilient through the use of digital technologies across a number of sectors via remote monitoring, advisory, payments, logistics, supply chains and other applications.

So ahead of COP26, the mobile industry and technology companies can play a key role as we collectively aim to raise ambition on all aspects of climate action. The seven themes set out in this report demonstrate the range of potential opportunities across energy, transport, nature, agriculture, water, waste management and disaster preparedness. The demand for solutions in each of these areas will only grow in the coming years. And as it does, we must leverage the expertise, innovation and finance of the private sector and major technology players such as the GSMA and its members. Together, we can create the new mitigation and adaptation pathways that we need to bend the emissions curve, close the adaptation gap and realise the goals of the Paris Agreement.



Val Gnanendran

Climate and Environment Director
Foreign, Commonwealth & Development Office, United Kingdom



Executive summary

Climate change is the most pressing challenge facing humankind. Although the impacts are global and felt in every country in often unpredictable ways, low- and middle-income countries (LMICs), will bear a disproportionate share of negative impacts due to limited capacity to address vulnerability and prepare for climate-related shocks.

At the same time, humanity has been experiencing another historical transformation: the rise of mobile and digital technologies. The COVID-19 pandemic has shown how vital digital infrastructure and connectivity has become to building resilient societies, allowing millions of people to continue to work, buy groceries, socialise, access medical care and learn, all without leaving their homes.

Mobile technology is uniquely positioned to provide and enable tools that allow societies to adapt and become more resilient to the impacts of climate change. These opportunities are becoming increasingly evident. By leveraging mobile and digital assets, from basic mobile and payment services to big data, Internet of Things (IoT), artificial intelligence (AI) and other frontier technologies, digital channels can address the challenges spanning climate mitigation, adaptation and resilience.

Intending to build greater understanding and consensus amongst private and public stakeholders, this report provides an overview of the role of digital and mobile-enabled solutions in addressing climate change and highlights a range of interventions that have great potential to mitigate, adapt and build resilience to climate change in LMICs. The report draws on extensive desk research and over 25 key informant interviews, including with international development practitioners with experience in low-carbon technologies, resilience, disaster preparedness and humanitarian response as well as innovation accelerators and investors and tech companies in LMICs that are tackling climate change.

The report discusses seven themes that cover the use of digital technologies in enabling clean energy and energy efficiency; transport, mobility and logistics; natural resource management and forestry; agriculture; managing water solutions; waste management and circular economy solutions; disaster preparedness and response. We further explore the use of mobile and digital solutions for climate finance as well as the use of frontier technologies in combating climate change. Within these themes, we identify high-potential interventions based on their impact on climate change mitigation, adaptation and resilience, as well as the extent to which mobile and digital solutions promise transformational change.

For over a decade, GSMA Mobile for Development (M4D), with funding from our donors, has supported many low-carbon and climate-resilient business models that rely on mobile technologies. Now more than ever, it is imperative to leverage the power of mobile and digital technologies to test, trial and scale innovation in climate change mitigation adaptation and resilience. There is an urgent need for strong partnerships between the mobile industry, governments, investors and innovators to propel climate action in LMICs and worldwide.





1 Understanding climate change and its impact on low- and middle-income countries

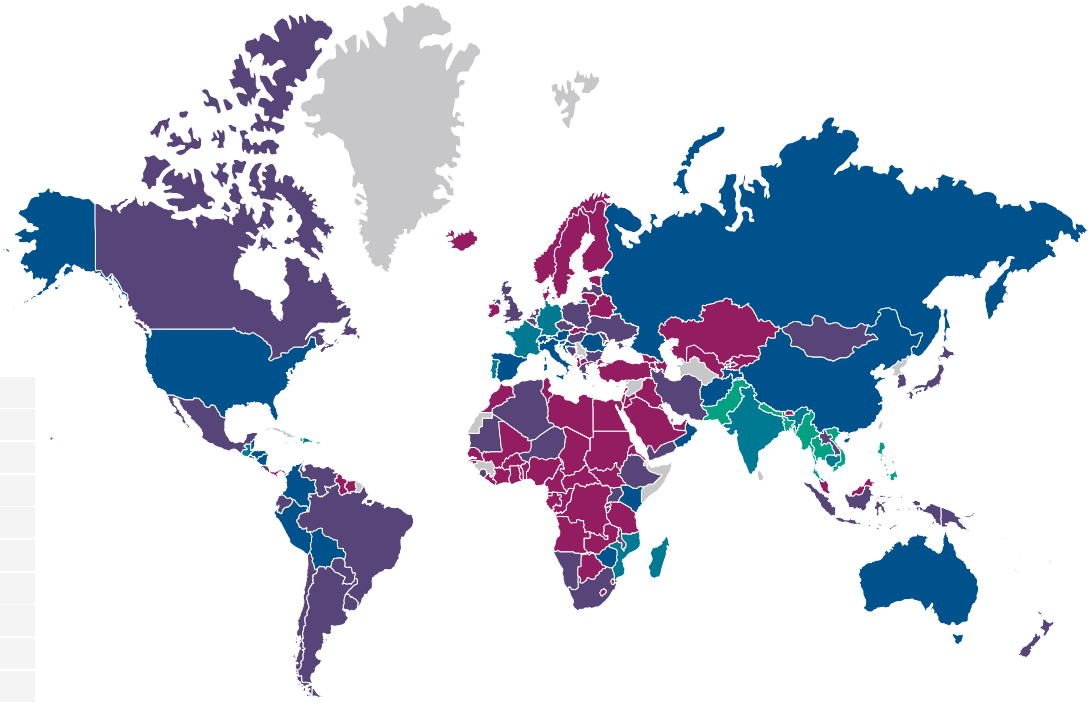
1.1 The climate crisis in low and middle-income countries: the urgency to act

Climate change is the defining challenge of our era. We now live with the perpetual risk of rising greenhouse gas (GHG) emissions contributing directly to climate change. At the very most, we have a decade to keep global warming under 1.5 degrees Celsius. Beyond that, scientists warn that the climate impacts already causing disruption will reach catastrophic levels, with irreversible damage to the planet's vital natural systems.[1]

While every community, city and country around the world will be affected by climate change in different and often unpredictable ways, scientific climate risk modelling shows that LMICs will bear disproportionately large negative impacts while also having limited capacity to address vulnerability and prepare for disasters.[2] Whether in LMICs or HICs (high-income countries), it is broadly agreed that the impacts of climate change will hit the poor hardest. In LMICs, the poorest in society often live in vulnerable dwellings, lack adequate access to water and sanitation and savings or insurance to recover financially from climate-related shocks and stresses.[3] This trend is already evident today: of the 10 countries most affected by extreme weather events between 1999 and 2018, nine were LMICs (Figure 1).[4]

Figure 1

Countries most affected by extreme weather events (1999–2018)



*** Countries where more than 90 per cent of the losses or deaths occurred in one year or event**

Source: Germanwatch[5]

1 McKay, D.A. (2020). "What You Need to Know About Climate Tipping Points and Feedbacks", Climate Tipping Points Info, updated 20 May 2020.
2 See, for example: United Nations General Assembly (2019), "Unprecedented Impacts of Climate Change Disproportionately Burdening Developing Countries, Delegate Stresses, as Second Committee Concludes General Debate", UN Meeting Coverage and Press Releases, Second Committee, Seventy Fourth Session, 4th and 5th Meeting, 8 October 2019.
3 Busch, J. (18 August 2015). Climate Change and Development in Three Charts. Centre for Global Development.
4 Eckstein D., et al. (2020). Global Climate Risk Index 2020. Germanwatch. Note: in order of magnitude of impact, they are: Myanmar, Haiti, Philippines, Pakistan, Vietnam, Bangladesh, Thailand, Nepal and Dominica.
5 Ibid.

1.2 Climate action: understanding mitigation, adaptation and resilience

The United Nations Framework Convention on Climate Change (UNFCCC) identifies two ways of responding to climate change:

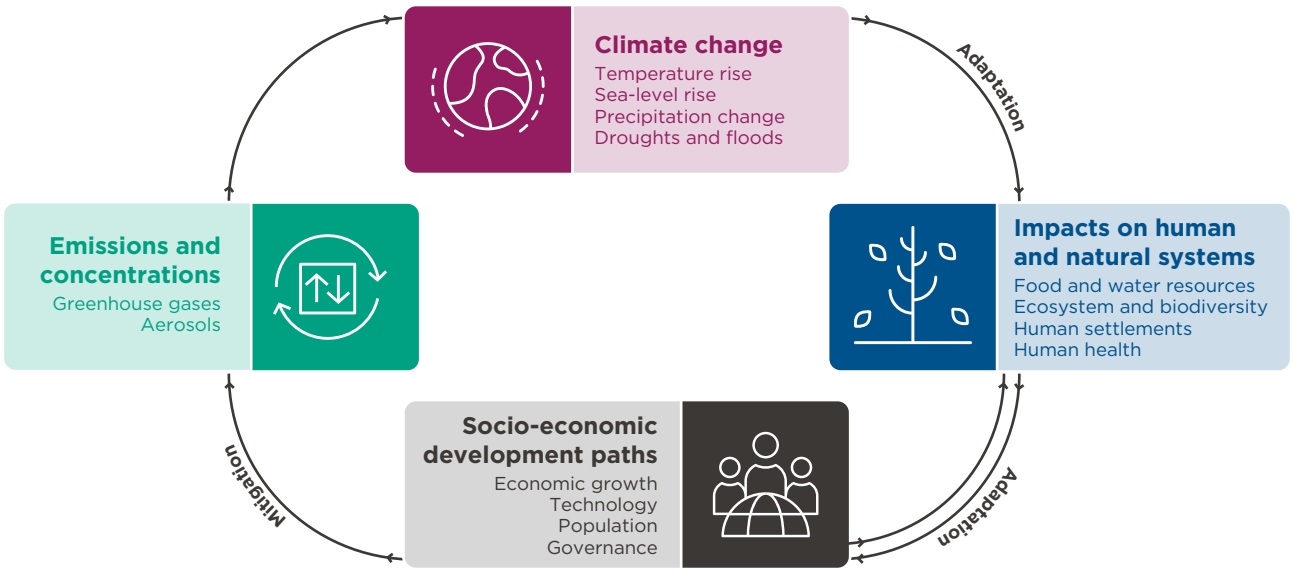
- Reducing GHG emissions and transitioning to a low-carbon economy to slow down the rate of climate change is referred to as **mitigation**. Examples include generating electricity from renewable sources, shifting away from internal combustion engine vehicles and reducing agricultural emissions.
- Adjusting to actual or expected changes brought about by climate change. These are often incremental changes in response to trends caused by climate change, such as droughts. This is referred to as **adaptation**.

Climate resilience is defined as the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning and transformation.[6] Efforts to strengthen resilience often centre around responding to extreme weather events and minimising and managing the impacts on affected areas.

It is important to understand that systematic and swift action following all three approaches is essential to reduce the expected impacts of climate change. Figure 2 from the IPCC is a simplified representation of an integrated assessment framework for anthropogenic climate change[7] and the role of mitigation and adaptation in climate action.[8] The enhanced greenhouse effect caused by emissions and concentrations initiates climate change, which is evident in rising temperatures and sea levels, precipitation changes and extreme events, such as droughts and floods. These, in turn, have impacts on human and natural systems and ultimately affect socio-economic development paths. Development paths also directly impact natural systems (shown by the anticlockwise arrow from the socio-economic development paths box), such as land use changes that lead to deforestation.

Figure 2

Integrated assessment framework of climate change: the relationship between climate mitigation and adaptation



Source: IPCC

6 IPCC (2018) Glossary: 'IPCC Special Report: Global warming of 1.5°C'
7 Resulting from or produced by human activities. See: https://www.ipcc-data.org/guidelines/pages/glossary/glossary_a.html - anthropogenic
8 The reverse arrows show the cycle of cause and effect among the four quadrants in the figure, while the blue arrow indicates the societal response to climate change impacts. For more details, see IPCC (2001). Climate Change 2001: Synthesis Report.





2 The role of digital technologies in addressing the climate challenge

Across all LMICs, digital technologies and solutions are growing rapidly alongside mobile penetration. Together they offer great potential to address development and climate challenges.[9] Beginning with an overview of actions being taken by the telecoms industry, this section explores the role of digital innovation in enabling a much broader range of solutions and services to reduce GHG emissions, adapt and become more resilient to the stresses and shocks that are becoming more intense and frequent as a result of climate change.

9 World Bank (2016). World Development Report: Digital Dividends.

2.1 The telecoms industry and climate change

According to the GSMA, 3.7 billion of the world's 5.2 billion mobile subscribers live in developing markets.[10] By 2025, global mobile subscribers are expected to increase to 5.8 billion, and Sub-Saharan Africa, Latin America and three South and Southeast Asian countries (Pakistan, Indonesia and Bangladesh) are expected to account for a large share of new connections.[11]

The total annual emissions of the mobile sector are approximately 220 metric tons of carbon dioxide equivalent ($MtCO_2e$), or about 0.4 per cent of total global emissions.[12] However, mobile communications also create significant opportunities to reduce GHG emissions via other services and solutions. A conservative estimate by the Carbon Trust suggests that compared to the global carbon footprint of mobile networks themselves, the level of avoided emissions enabled by mobile communications technologies is 10 times greater – a tenfold positive impact.[13] As shown in Box 1, the mobile industry is making significant progress in mitigating its own climate impact, in some cases aiming to attain net-zero emissions.

Box 1

How the GSMA and the telecoms industry are addressing climate change

Reporting industry carbon footprints: For the second year the GSMA disclosed its carbon footprint and emissions reductions activities and plans to the CDP (formerly Carbon Disclosure Project), scoring an impressive A-, a step up from 2019, and above the European and Global averages of C, bringing the GSMA into the "Leadership band" of disclosing organisations.[14]

The GSMA is leading decarbonisation efforts for the mobile industry. As part of a major new GSMA-led initiative, over 50 mobile operators are now disclosing their climate footprint, energy and GHG emissions via the CDP global disclosure system. Additionally, the GSMA has committed to the RE100 initiative – a global corporate leadership initiative by the CDP that brings together influential businesses committed to sourcing 100 per cent renewable electricity.

The GSMA M4D programmes are also engaged in climate change-related interventions:

- CleanTech programme: Works to bring together the mobile industry and private and public actors to unlock the power of digital technology to tackle climate change in LMICs.
- AgriTech programme: Works with mobile operators and climate service providers to research, understand, test and scale operational and business models for digitally-enabled climate resilience solutions for the agriculture sector. The programme supports various climate resilience services, from weather forecasts and agroclimatic advisory delivered via mobile phones, to IoT-enabled data-driven tools and financial services, such as agricultural insurance.
- Mobile for Development Utilities programme: Works to unlock access to essential utility services through mobile, including clean energy, water and sanitation services, for the underserved in emerging markets.
- Mobile for Humanitarian Innovation programme: Works to accelerate the delivery and impact of digital humanitarian assistance, including those who have been impacted by extreme weather events and similar shocks.

In addition, with support from our donors, the GSMA has several innovation funds that focus on providing financial and technical support for digital solutions that address development challenges, including climate change.[15]

10 GSMA (2020). The Mobile Economy 2020.
11 GSMA (2018). The Mobile Economy 2018.
12 Mobile sector emissions of 220 $MtCO_2e$ includes the energy to operate the networks, the embodied emissions of the networks and the emissions of handsets. See GSMA (2019). The Enablement Effect: The Impact of Mobile Communications Technologies on Carbon Emission Reductions. Research conducted by the Carbon Trust.
13 GSMA (2019). The Enablement Effect: The Impact of Mobile Communications Technologies on Carbon Emission Reductions. Research conducted by the Carbon Trust.
14 GSMA (2020). CDP Score Report – Climate Change 2020.
15 GSMA Mobile for Development Innovation Fund: https://www.gsma.com/mobilefordevelopment/innovation/h

The GSMA defines **enablement effect** as any mechanism which, through its use, facilitates the avoidance of carbon emissions. For instance, mobile banking is an enablement mechanism which allows customers to avoid travelling to a bank.[16] Through the enablement effect, mobile operators can act as catalysts for the decarbonisation of other sectors. Their contributions to this transformation are explored in the following sections.

2.2 Enabling digital and mobile-enabled solutions

To grasp the range of possibilities offered by digital and mobile-enabled solutions in the climate context, we developed a conceptual framework (see Figure 3). This framework covers the available mobile and digital assets, key areas that need climate mitigation, adaptation or resilience related interventions, the expected outcomes and enablers in this process.

Mobile and digital assets: four types of mobile and digital assets are typically available to enable digital and mobile-enabled solutions for climate mitigation, adaptation and resilience:

- **Mobile services:** voice, SMS, USSD, interactive voice response (IVR), mobile apps
- **Mobile payment services:** mobile money, mobile money-enabled savings, mobile-enabled credit, mobile-enabled insurance
- **Frontier technologies:** Internet of Things (IoT), artificial intelligence (AI), blockchain, space technologies, Virtual and augmented realities, Drones and Robotics and Big Data
- **Data assets:** customer data, mobile big data (commercial microwave links, call data records, location data/location-based services, data through IoT services) etc.

The range of services that can benefit users will be different in each context depending on available technology and the affordability of local services. It is worth noting that beyond delivering services, mobile technologies also have a role to play in generating better data for enabling evidence-based decision making for climate action.

Themes linked to climate change mitigation, adaptation and resilience: There are a variety of areas in which mobile and digital technologies already have, or have the potential to, accelerate climate action, and we have grouped these into seven key themes (see section 2.3 in annex for more details). Mobile and digital solutions for climate mitigation, adaptation and resilience can produce a range of desirable social, environmental and economic **outcomes**, including:

- Lower GHG emissions;
- Greater resilience to the effects of climate change for economic sectors, value chains, businesses, communities and households, including vulnerable and marginalised groups; and
- A transition to low-carbon pathways via jobs creation and inclusive employment opportunities.

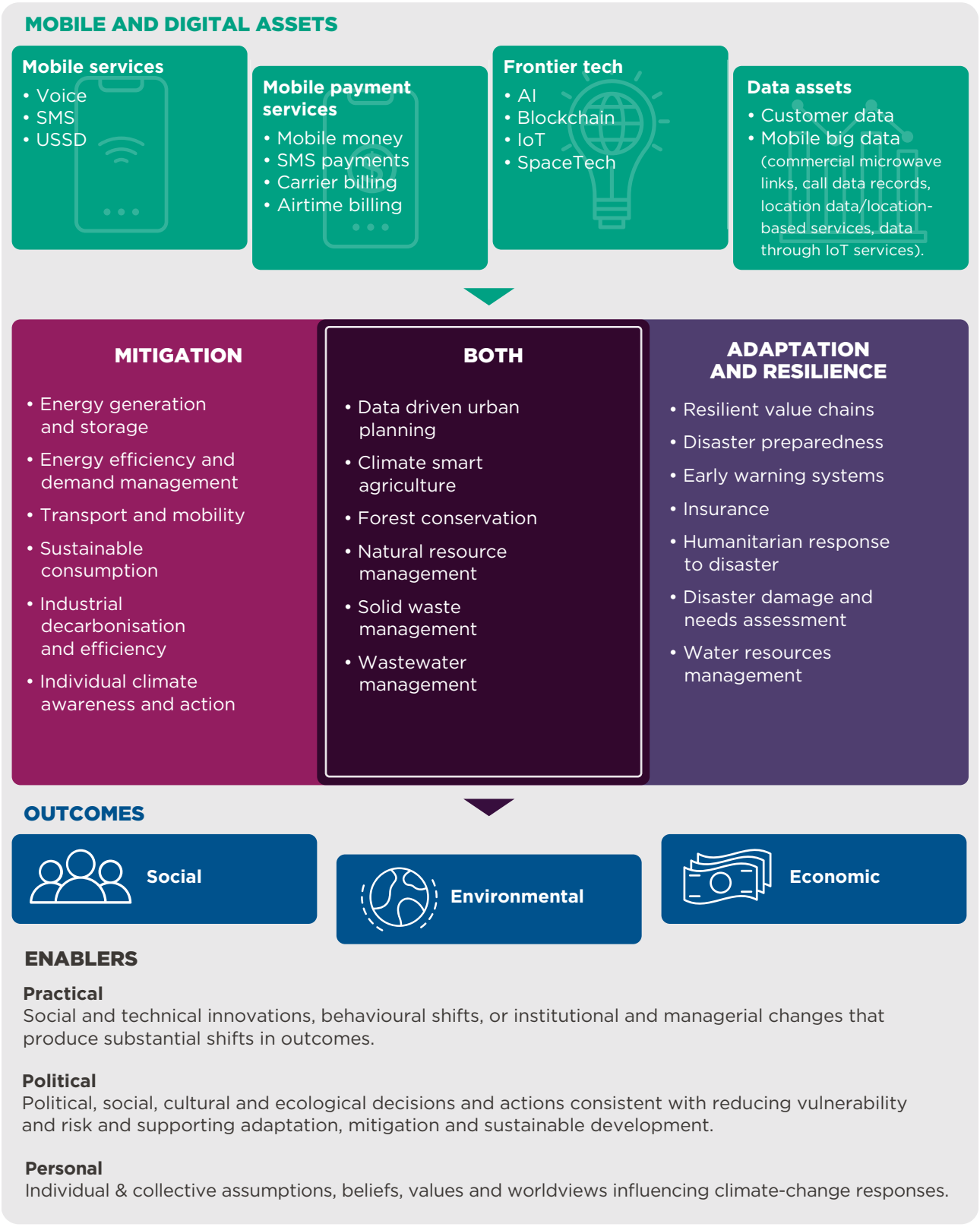
Enablers: three key enablers provide a conducive environment for mobile and digital solutions to be used successfully for climate action:

- **Practical enablers,** including the availability of mobile and digital infrastructure, digital literacy, affordable mobile devices and data, social and technical innovations, behavioural shifts or institutional and managerial changes that produce substantial shifts in outcomes.
- **Political enablers,** which include political, social, cultural and ecological decisions and actions that can help reduce vulnerability and risk, and support adaptation, mitigation and sustainable development.
- **Personal enablers,** such as individual and collective assumptions, beliefs, values and worldviews influencing climate-change responses.

16 GSMA (2019). The Enablement Effect: The Impact of Mobile Communications Technologies on Carbon Emission Reductions. Research conducted by the Carbon Trust.

Figure 3

A conceptual framework for digital solutions to the climate challenge



Source: GSMA Mobile for Development

Box 2

Understanding the linkages to frontier technologies

Digital and mobile-enabled solutions to address climate change can draw on a range of innovations and services made possible by frontier technologies. The most significant of these technologies are highlighted in Table 1, with examples of how they are being applied.

Frontier technology	Basic functions	Examples of application
Artificial intelligence (AI)	• AI is the ability of a machine or computer to emulate human tasks through learning and automation. Machine learning, a subset of AI, uses computer-based algorithms to find patterns across data sets. • Machine learning and deep learning can offer solutions that replicate human processes, such as image and sound recognition, predictive analytics, decision-making support, virtual assistance (via chatbots) and the provision of relevant and tailored information.	• Agritech solutions that help farmers understand how to identify and respond to crop disease or changing rainfall. • AI is used in ride-sharing platforms to enable more efficient and low-carbon mobility.
Blockchain	• The underlying technology that supports bitcoin and other cryptocurrencies. • A blockchain is a decentralised public database that keeps track of transactions chronologically in a way that makes it almost impossible to manipulate or alter. • Blockchain's structure ensures reliable, secure and auditable transactions, replacing the financial intermediary role (e.g. matching borrowers with lenders through a trusted third party) traditionally provided by banks and governments. • Distributed ledger technology (DLT) includes blockchain, and decentralises the process of accounting for and verifying changes in information across a network	• Blockchain can enable peer-to-peer trading of household-generated renewable electricity. The UK Aid piloted this model in humanitarian supply chains. Read more here. • To combat the risk of fraud and litigation surrounding land ownership, countries including India, Ghana, Sweden and Georgia are experimenting with blockchain technology to track land titles. • It should be noted that platforms that use blockchain often rely on heavy energy consumption and therefore may be less carbon efficient. • SolarCoin and VeChain demonstrate how cryptocurrencies can be used to encourage climate-smart development.
Internet of Things (IoT)	• IoT is a network of internet-connected objects that can collect and exchange data using embedded sensor technologies. • Data can allow devices in the network to "make decisions" autonomously based on real-time information. • IoT is greatly enhanced by WI-FI, Bluetooth and 5G. • IoT comprises the nervous system that will underpin emerging digital ecosystems, such as smart cities, smart factories and smart buildings.	• Enabling more responsive and efficient heating and cooling of buildings. • IoT can improve transport and logistics services and processes, reducing emissions. • Industrial IoT can improve efficiency and reduce waste and GHG emissions. • Environmental monitoring and management: IoT sensors can provide accurate real-time data on the environment around us to help understand how humans affect the environment and the steps that can be taken to improve quality of life in cities.[17] • Smart farming uses IoT and sensors to generate and transmit data about a specific crop, animal or practice to support agricultural activities.

17 GSMA (2018). Environmental Monitoring: A Guide to Ensuring a Successful Mobile IoT Deployment.

Frontier technology	Basic functions	Examples of application
Virtual and augmented realities (VR/AR)	• AR creates a hybrid reality using a technology that overlays artificial, computer-generated images and graphics over a user's view of the physical world, typically connected through a mobile phone or computer. • VR is a fully immersive computer-generated experience that uses a headset/head-mounted display.	• Educational applications allow citizens and policymakers to experience and imagine the real effects of climate change. • VR is used in immersive storytelling to raise awareness of the consequences of climate change.
Drones and robotics	• Drones and robotics comprise a wide range of unmanned machines that can fly or access marine or terrestrial environments. • They allow regular or uninterrupted data collection and/or observation. • Aerial drones can contribute vast amounts of data to inform GIS mapping, which is a vital tool in sustainable planning and resource management.	• Monitoring natural resource threats can be enabled by regular or real-time observation by drone cameras. Drones have been used to manage outbreaks of locusts, which have increased due to changes in climate. • Ellipsis Earth maps the distribution of solid waste by drone surveys and machine learning to collect accurate data on solid waste pollution and inform interventions.
Space 2.0	• Space 2.0 is a new age of space technology in which businesses are developing technologies for NASA (or other national space programmes) and commercial use simultaneously. • Satellite imagery	• Climate-related data to inform broader information, scenarios and programmes. • Satellite imagery can enable analysis of vegetation patterns and identify early warning signs of drought. • Satellite imagery is broadly used for agricultural insurance products (e.g. weather index and area yield index insurance) and agri advisory applications.
Big data and AI	• Big data refers to data sets that are too large or complex (in terms of volume, variety and velocity) for traditional data processing application software to deal with. • Big data is used to observe and track occurrences, and often assumes the use of predictive analysis by AI and machine learning methods.	• Combined data sources, such as call data records (CDRs), survey results and satellite imagery, can be analysed to display and predict the impact of climate and climate-related disasters. • AI and machine learning can be used to understand and predict population movements and map them in real time.

2.3 Exploring digital solutions across climate mitigation, adaptation and resilience

Mobile technology is uniquely positioned to provide and enable tools that can be used to mitigate GHG emissions and adapt and build resilience to the impacts of climate change. A recent study by the World Bank on the transfer of low-carbon technologies to LMICs identified mass deployment in just four sectors: energy, industry, transport and buildings.[18] While most of these technologies revolve around solutions for climate change mitigation, many other solutions offer opportunities to build resilience to climate-related shocks and to prepare and respond to disasters.

GSMA M4D has conducted an exploratory research, with an objective to understand the current and potential role of mobile and digital technologies in addressing climate change issues in LMICs and to build understanding and consensus among relevant stakeholders including mobile operators, donors, investor and tech innovators about the commercial opportunities related to these business models. Following extensive desk research and interviews with experts from various climate mitigation and adaptation fields in LMICs, we evaluated a range of areas well suited to mobile and digital interventions for climate action covering the following seven broad themes:

- **Clean energy and energy efficiency**
  Mitigation
- **Transport, mobility and logistics**
  Mitigation
- **Forestry and natural resource management**
  Mitigation, adaptation and resilience
- **Agriculture**
  Mitigation, adaptation and resilience
- **Waste management and circular economy solutions**
  Mitigation, adaptation and resilience
- **Managing water resources**
  Adaptation and resilience
- **Disaster preparedness and response**
  Adaptation and resilience

We evaluated a long-list of intervention areas within these themes based on the following criteria:

- **The potential scale of GHG emissions mitigation or scale of adaptation/resilience impact**
- **The extent to which mobile-enabled solutions offer transformational change**

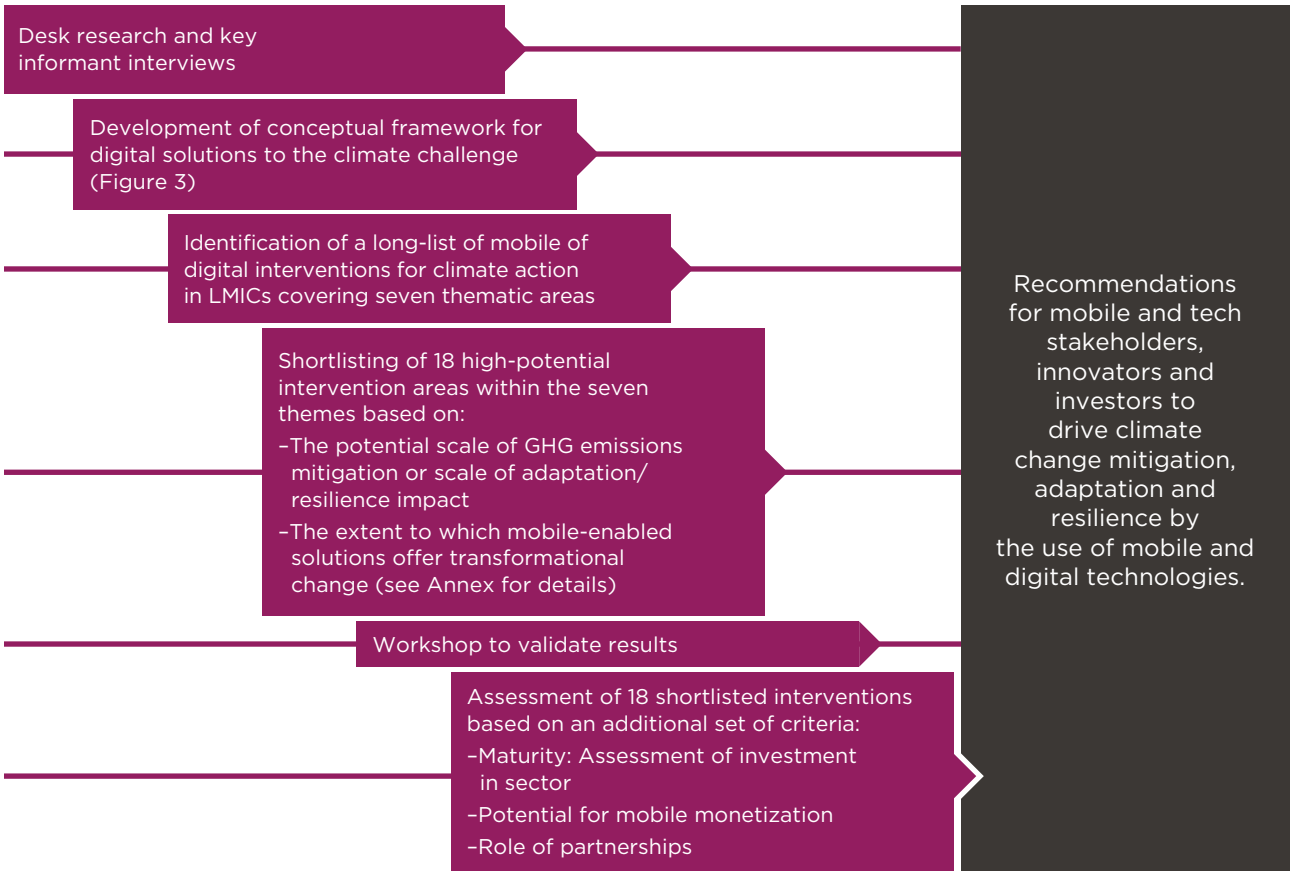
The shortlisted 18 interventions were then assessed against an additional set of criteria:

- **The maturity level of each intervention area, including public and private investment and proven technologies and solutions**
- **The type and potential amount of development impact, such as health or environmental benefits**
- **Sectors with the greatest potential to monetise mobile-enabled technologies at scale**
- **The role of partnerships between mobile operators and other stakeholders in delivering solutions**

18 Pigato, Miria et al.(2020). Technology Transfer and Innovation for Low-Carbon Development. World Bank

Figure 4

Research process: assessing potential interventions to enhance digital solutions



Source: GSMA Mobile for Development

GSMA M4D has been supporting a range of solutions looking at these intervention areas (see Box 1). We intend to use the findings from this research to further engage the mobile industry and private and public actors to unlock the power of digital technology to tackle climate change in LMICs.

On the next pages, we provide an overview of the overall themes, along with examples of solutions we identified as having high potential to address climate change in LMICs. Full details about the 18 specific intervention areas identified through our research, including the selection methodology, criteria and analysis, can be found in the Annex.

THEME 1

Mitigation: clean energy and energy efficiency

Clean energy generation is by far the greatest opportunity to mitigate GHG emissions at a global level.[19] Mobile-enabled solutions can be part of a transformational scaling up of access to clean energy in LMICs, particularly in areas not currently served by transmission grids. There is significant potential for GHG mitigation in replacing diesel back-up generator sets (BUGs). A 2018 IFC report estimated that the emissions produced by BUGs in LMICs is equivalent to 700 to 1,000 coal-fired power stations. In some countries, they account for more energy generation than the grid is capable of producing.[20]

- **Pay-as-you-go (PAYG) models:** PAYG is unlocking a range of business models that enable customers to pay for solar panels, battery storage or clean cookstoves, reduce their reliance on fossil fuels and use more accessible and reliable sources of clean energy. A PAYG pioneer, Fenix International (a GSMA M4D Utilities Innovation Fund grantee), sells solar systems in six markets across Africa. Using Fenix's PAYG financing option, customers make a deposit, take their kit home and repay the loan over 12 to 30 months with daily mobile money payments of as little as $0.14. For many households, this can be their first experience with a formal financial service.[21] In April 2018, Fenix was acquired by global utility company Engie, and is now serving over 600,000 households. It has impacted three million beneficiaries and processed 19 million payments. Through funding from UK Aid, the M4D Utilities programme has been a catalyst for some of the most promising innovations in PAYG solar home system models since 2013, including M-KOPA, Fenix, Mobisol and PEG.

  PAYG models have been replicated in other sectors as well, from water (see Theme 5) and clean cooking to battery storage. A GSMA M4D Utilities Innovation Fund grantee, KopaGas,[22] is using PAYG smart metering technology to replace solid cooking fuel, such as charcoal and wood, with cleaner and more efficient liquid petroleum gas (LPG).

  PAYG models are also serving urban IDPs (internally displaced persons) and refugees and those living in refugee settlements, helping to reduce reliance on unsustainable fuel sources and strengthen the resilience of those most vulnerable to climate shocks. GSMA Mobile for Humanitarian Innovation Fund grantee organisations such as Altech and BBOXX in the DRC are testing new business models for their PAYG solar systems to serve refugee and IDP customers. Another GSMA Mobile for Humanitarian Innovation Fund grantee, United Healthcare Distributors in Uganda are operating a battery exchange model in several camp settings in partnership with community health centres.

- **Energy efficiency:** Energy efficiency in homes, offices, industries and elsewhere is another important area in which digital solutions can help reduce emissions. The exponential boom in demand for cooling over the next few decades is expected to push up global temperatures another 0.5°C by the end of the century without low-carbon alternatives.[23] Efficiency often starts with the ability to measure electricity consumption and costs, enabled by basic meters or smart meters. Smart meters can enable electricity distribution companies and microgrids to improve their operations and energy efficiency, and help them achieve financial sustainability through a range of features, such as flexible billing, customer communications and remote monitoring and control of appliances.

Box 3

Digital solutions to climate change: Jazz, Pakistan

A GSMA M4D Utilities Innovation Fund grantee and one of Pakistan's leading mobile operators, Jazz, along with its technology partner, Company of Intelligent Systems and Networks Research (CISNR) and grid distributor Peshawar Electric Supply Company (PESCO), is implementing a mobile-enabled theft prevention and loss reduction solution for an urban electricity grid distributor.[24] Jazz supports this solution by providing machine-to-machine (M2M) connectivity and cloud hosting for all data generated by the solution. Just three months after being implemented, PESCO's line losses on each of the 254 transformers dropped from 1,088 kW to 560 kW, leading to savings of $78,980 in one quarter.[25]

19 Project Drawdown (n.d.). Table of Solutions.
20 IFC (2019). The Dirty Footprint of the Broken Grid: The Impacts of Fossil-Fuel Back-up Generators in Developing Countries.
21 Fenix International: www.fenixintl.com
22 GSMA Mobile for Development (8 February 2018). Video: Affordable, clean cooking through mobile technology in Tanzania: KopaGas.
23 UNEP and IEA (2020). Cooling Emissions and Policy Synthesis Report.
24 GSMA Mobile for Development (28 January 2020). Video: Improving electricity grid services through smart metering: Jazz.
25 Sarin, R. (10 August 2020). "Partnering to Minimise Electricity Theft and Line Losses in Pakistan – Jazz, CISNR and PESCO", Mobile for Development Blog.

As digital economies become more advanced, more opportunities arise to use mobile-enabled solutions to improve the distribution and efficiency of electricity. A GSMA Innovation Fund grantee and 2020 Ashden award winner[26] ME SolShare, has developed SOLbazaar, an IoT-driven trading platform that enables customers to trade the excess solar energy generated by their solar home systems. SOLbazaar is enabled by a smart meter (SOLBox) and software backend, including a data collection and analysis platform that is integrated with mobile money providers, such as bKash, DBBL and IFIC, and a mobile app to support field agents. As of 2020, the company has set up 30 peer-to-peer solar electricity trading grids across Bangladesh and India. Blockchain technology can also be used for peer-to-peer trading of electricity generated by local household or business-owned renewable sources. There are several pilots operating in LMICs, including in Bangkok, Thailand.[27]

A highly anticipated next step, particularly in rapidly developing cities in China, India and across Southeast Asia, is the integration of electric vehicles (EVs) in flexible and responsive energy grids. Their batteries help to store power when demand is low, and contribute it when demand is high, flattening the peak loads required for power generation. If power is still generated from fossil fuel sources, this can significantly reduce GHG emissions. Using a mobile app interface, EV owners would be able to sell surplus energy when prices are high.

There is also an increasing role for AI to enable more automated person-to-person (P2P) electricity trading. Through the Frontier Technologies (FT) Hub Livestreaming programme with Powerhive, UK Aid is supporting a pilot programme in Western Kenya[28] that aims to demonstrate the technical and commercial viability of the EV business model and integration with the mini-grid. The pilot has revealed the difficulties of implementing such business models in LMICs, including difficult terrains and frequent floods that pose design and safety challenges for EVs in rural areas.

Energy efficiency can also be enabled by building automation systems to control heating, cooling, lighting and appliances, particularly in commercial buildings. The combination of smart meters and internet-connected heating and cooling systems can allow demand response systems to automatically reduce electricity demand during peak usage. However, these models have not yet been implemented successfully in LMICs.

Box 4

Energy efficiency in the mobile industry

The total annual emissions of the mobile sector are approximately 220 MtCO2e,[29] or about 0.4 per cent of total global emissions. These include the energy it takes to operate mobile networks, the embodied emissions of the networks and the emissions of handsets. Investments in renewable energy are an effective way for mobile operators to not only lower their GHG emissions and reliance on diesel fuel, but also generate cost savings that could enable the profitable expansion of mobile networks into rural and other low-density areas.

A new study by the GSMA CleanTech programme[30] estimates that while the number of global mobile towers increased from four to five million in the last six years, they tend to rely on on-site diesel-powered generators, which inflicts a measurable cost on the environment and balance sheets. Mobile operators around the world are taking steps to manage these sites and network energy consumption more efficiently. For example, Orange Group is in the process of procuring and installing solar power for their off-grid and bad-grid sites in Cameroon, the DRC, Liberia, Madagascar, Mali and Sierra Leone.

26 SOLshare (15 December 2020). "Bangladesh-based SOLshare closes 1.46m financing round", The Daily Star.
27 Thomson Reuters Foundation (29 August 2018). In a posh Bangkok neighbourhood, residents trade energy with blockchain.
28 Powerhive (7 December 2020). "Buckle Up for EVs in Rural Africa", Frontier Technologies Hub.
29 GSMA (2019). The Enablement Effect: The Impact of Mobile Communications Technologies on Carbon Emission Reductions. Research conducted by the Carbon Trust.
30 GSMA Mobile for Development (September 2020). Renewable Energy for Mobile Towers: Opportunities for low- and middle-income countries.

THEME 2

Mitigation: transport, mobility and logistics

Transport emissions, which primarily include road, rail, air and marine transportation, accounted for over 24 per cent of global CO2 emissions in 2016. These emissions are expected to grow at a faster rate than any other sector, posing a major challenge to efforts to reduce emissions in line with the Paris Agreement and other global goals.[31] The accelerating development of transport services in LMICs, which is vital for inclusive economic development, must follow low-carbon pathways for global GHG emissions to approach the Paris Agreement goals. Transportation also plays a vital role in local economic development as it enables cities in LMICs to become more inclusive and productive.

- **Active transport and micromobility solutions:** In many HICs, mobile apps have been central to the uptake of active transport solutions, such as cycling and walking, and shared micromobility solutions that help commuters shift away from private vehicle use. These solutions have potential to enable uptake of greener transport in urban and peri-urban settings in LMICs, as well. For instance, dockless shared bicycles have attracted vast amounts of private sector capital over the last few years and now provide a viable zero-carbon, last-mile solution for millions of users.[32] Apps that combine navigation for pedestrians or runners with healthy lifestyle indicators, such as counting steps or even heart rate monitoring, are also increasingly popular and can play a major role in motivating people to walk rather than drive for short journeys.

  Motivations for greener mobility solutions in rural settings are different of course, where people must often walk miles to fetch water, attend school, reach a hospital or other critical activities. Shared PAYG micro-mobility solutions have potential to solve some of these challenges. UK Aid has piloted a PAYG model for bicycle rental or ownership in Zambia together with start-up Onyx Connect. The pilot provided employees of village cooperatives with a bike with a GPS tracker and Samsung smartphone, a helmet and a low-cost pico-solar lamp on a PAYG basis.[33]

- **Electric vehicles (EVs):** Mobile-enabled solutions can also encourage the uptake of EVs. For example, battery swapping is becoming more and more popular in China and other countries with rapidly developing cities. Drivers of two- and three-wheelers, as well as conventional EV cars, can use their phones to locate a depot or kiosk and arrange a battery swap, eliminating time spent charging. This is particularly useful for logistics and taxi services as it allows drivers to spend full shifts in EVs and, in turn, encourages greater uptake of EVs as a replacement for internal combustion engine (ICE) vehicles. For instance, Ampersand, a company in Kigali, Rwanda, is piloting electric motorcycles with networked battery swapping with funding from the FT Hub Livestreaming programme. Although the bikes are powered by grid electricity, they still produce 75 per cent less emissions than petrol.[34] Mobile solutions can also help commercial operators with EV fleet management, and play an important role in alerting drivers to nearby charging points.

- **Digital solutions for shared mobility:** If planned carefully with clear climate impact assessments, these solutions (e.g. minibus and ride sharing) have potential to facilitate a shift away from private vehicles and related GHG emissions. Start-ups, such as SWVL in Egypt and Kenya,[35] Airlift in Pakistan and Grab in Southeast Asia, are pioneering on-demand shared rides in minibuses or other vehicles with a smartphone app. However, it is important to note that the calculated mitigation potential of many shared mobility solutions have a high level of uncertainty, as indicated by a technical report by GIZ that evaluated the potential for GHG mitigation in Kenya's transport sector.[36]

31 Wang, S. and Ge, M. (16 October 2019). "Everything You Need to Know About the Fastest-Growing Source of Global Emissions: Transport", WRI Blog.
32 PwC (2020). The State of Climate Tech 2020: The Next Frontier for Venture Capital.
33 Vigoureux, D. (27 March 2020). "Case Study: Pay-as-you-go bikes in Zambia", Frontier Technologies Hub.
34 UK Aid and Frontier Technologies (n.d.). Top 10 Frontier Technologies for Climate Action.
35 Nkingho, N. (26 September 2019). "Opinion: Egypt's Swvl looks to make inroads into crowded Lagos space", TechCabal.
36 Notter, B. and Weber, F. (17 October 2018). Greenhouse gas mitigation potentials in the transport sector in Kenya: Summary of assumptions and results.

THEME 3

Mitigation, adaptation and resilience: natural resource management and forestry

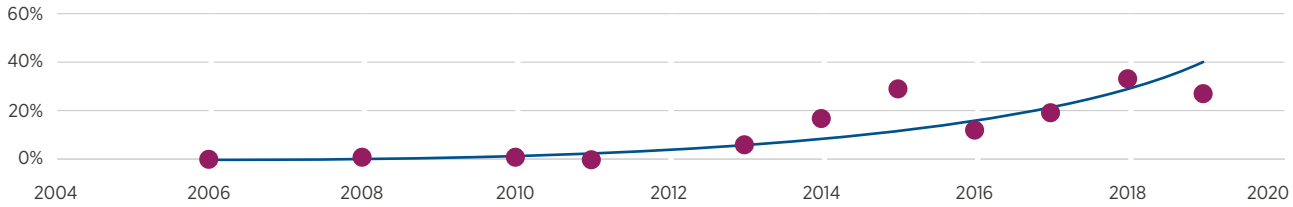
Today, agriculture and forestry-related activities generate 24 per cent of greenhouse gas emissions worldwide.[37] An estimated 150 million people living in poverty count wildlife as a valuable livelihood asset,[38] and 40 per cent of the extreme poor in rural areas – equivalent to 250 million people – live in forested and savannah areas where access to forest products, goods and services is critical to livelihoods and household resilience.[39] Some estimates suggest that close to two billion people rely on forest resources for shelter, livelihoods, water, food and energy security. With implications for climate change mitigation and adaptation, 2021–2030 has been declared the UN Decade for Action on Ecosystem Restoration, giving greater visibility to the challenges and growing opportunities for partnerships and synergies, including via digital solutions.[40]

The GSMA CleanTech programme has conducted research to explore the "digital dividends" of various types of technology on natural resource management in LMICs. The study noted a few "hotspots" for digital innovation, including forest management, wildlife conservation (counter-poaching and species preservation) and sustainable fishing practices (Figure 4). For more details, see Digital Dividends in Natural Resource Management.[41]

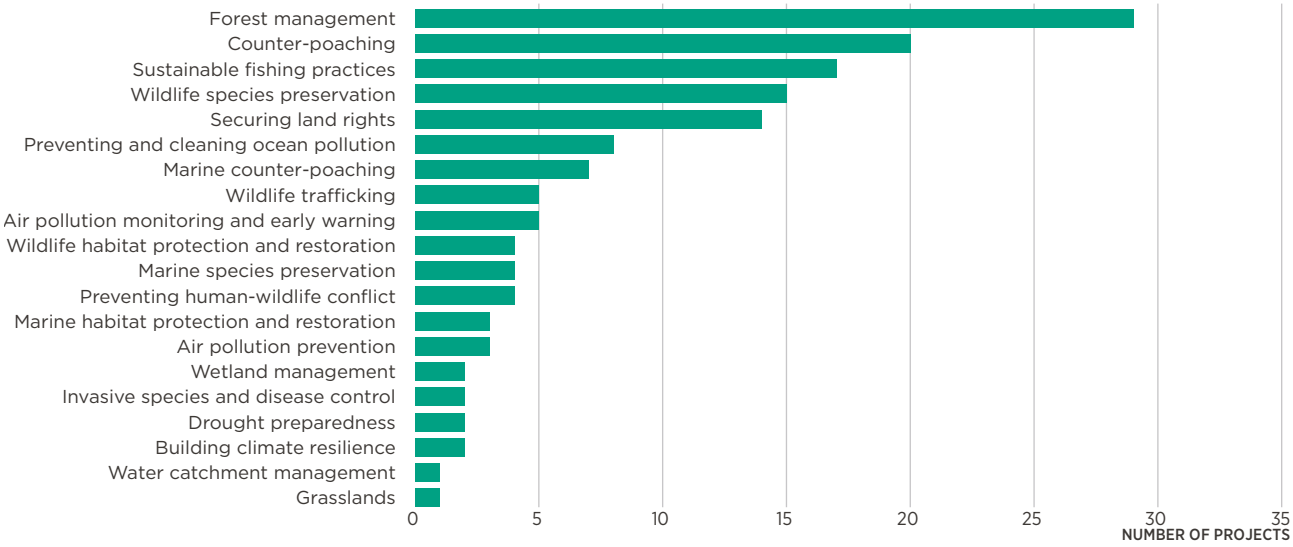
Figure 5

Key insights from the natural resource management heatmap

Over half of all projects were implemented in the last three years, and 90 per cent of all projects were implemented in the last six years



'Hotspots' for digital innovation include: forest management, wildlife conservation (counter-poaching and species preservation) and sustainable fishing practices, which account for over half of all projects



Source: GSMA CleanTech Programme

37 See Project Drawdown website: https://drawdown.org/
38 Roe, D. and J. Elliott (14 March 2006). "Pro-poor conservation: the elusive win-win for conservation and poverty reduction?", Policy Matters, 14.
39 See International Institute for Environment and Development (IIED).
40 UNEP (1 March 2019). Press Release: New UN Decade on Ecosystem Restoration offers unparalleled opportunity for job creation, food security and addressing climate change.
41 GSMA (2020). Digital Dividends in Natural Resource Management.

- **Real-time digital monitoring of natural resources:** While the use of digital technologies in natural resource management (NRM), such as satellites, IoT and AI, is still in a nascent stage, these technologies can bring benefits to organisations that promote sustainable use and management of the planet's natural resources.[42] For instance, automated real-time digital monitoring of land use in protected forest areas using satellite images, drone aerial footage and remote ground-level detection kits can make information widely accessible, protect areas from harm and provide evidence to prosecute those who illegally destroy natural resources. In partnership with the non-profit Rainforest Connection, Huawei's TECH4ALL programme has deployed connected devices and AI to monitor the sounds of the rainforest in real time, allowing authorities to reduce illegal logging and protect wildlife.[43]
- **Engaging and informing communities:** A broad range of technologies and approaches are used to influence positive behaviours or provide communities with the tools they need to actively participate in NRM projects, to access information or support and to receive payments for ecosystem services.[44] Many of these participatory approaches are designed around the ethos that communities know best and are a motivated, reliable and cost-effective channel for obtaining ground truth, rather than passive beneficiaries of NRM activities. Mobile-enabled solutions can connect inhabitants to the digital economy, providing wider markets for sustainable services and products. The ForestLink platform, developed by the Rainforest Foundation UK, enables trained community monitors to use customisable mobile apps to capture evidence of illegal activities or other threats to the forest, and found that working directly with local communities can help reduce monitoring costs and inefficiencies while also improving forest governance.[45]
- **Payments for ecosystem services:** Payments for ecosystem services (PES) schemes are a variety of market-based initiatives that provide payments to community groups or individuals who have agreed to take certain actions that provide environmental value, such as adopting sustainable forest management practices or restoring watersheds. A notable example is forest-owning households in Uganda that are paid to protect natural resources.[46] However, these schemes have not seen much success yet, and have failed to achieve scale. A recent GSMA NRM landscaping study[47] found that poorly measured outcomes, owing to incomplete and unverified data from government ministries or other public stakeholders, have been a roadblock to generating evidence of the effectiveness of these systems. However, better data collection and real-time monitoring using mobile and digital technologies might help to improve assessments of the utility of PES tools in the future.
- **Gamification:** There are good examples of the role of gamification in channelling finance towards afforestation. The largest scale example is Ant Forest, implemented by Ant Financial in China. To date, the game has funded the planting of over 120 million trees across over 100,000 hectares. This has contributed to China becoming the world's leading tree-planting nation.[48] For both climate mitigation and resilience, much can be achieved by restoring habitat.

42 Wilson, M. (4 June 2020). "Digital Dividends in Natural Resource Management: Part One", Mobile for Development Blog.
43 See Huawei website: www.huawei.com/en/cases/rainforest-connection
44 GSMA (2020). Digital Dividends in Natural Resource Management.
45 Ibid.
46 Gaworecki, M. (27 July 2017). "Randomized controlled trial in Uganda finds that paying people not to cut down trees works", Mongabay.
47 GSMA (2020). Digital Dividends in Natural Resource Management.
48 Kretchmer H. (21 July 2020). "This app plants trees when people make lower-carbon choices", The World Economic Forum Covid Action Platform.

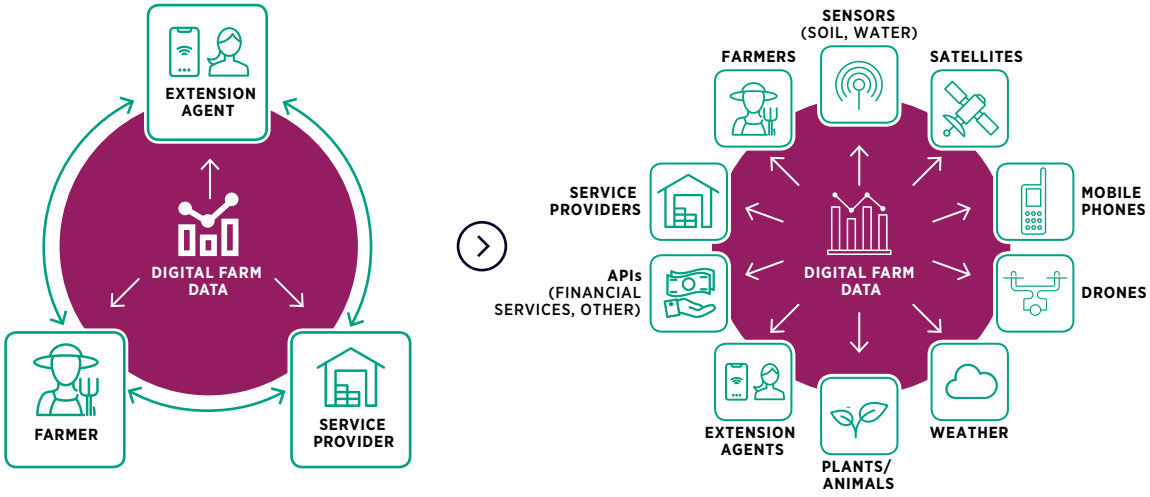
THEME 4

Mitigation, adaptation and resilience: agriculture

Agriculture is a climate-dependent industry. Since many regional ecosystem characteristics are determined by climate, changes in agro-climatic elements, such as temperature, precipitation and sunlight, have an impact on agricultural ecosystems and arable and livestock production. Responsible for the bulk of food production in developing countries, smallholder farmers are particularly vulnerable to climate change.[49] However, mobile-enabled tools are revolutionising the agricultural sector in LMICs, often combining services that can help farmers respond to climate-induced changes. The emergence of low-cost digital technologies has created an unprecedented opportunity for mass collection, aggregation and dissemination of information and data at the farm level (see Figure 5).[50] Although not originally designed for this purpose, "virtual sensing" allows weather data to be collected from smartphones, connected cars and commercial microwave links (CMLs) used in mobile networks to transmit signals.[51]

Figure 6

Evolution of smallholder farming to data-driven agriculture



Source: GSMA AgriTech programme

- **Agricultural information and advisory:** Digital advisory tools delivered via mobile phones by mobile operators, NGOs, governments and tech companies, play an important role in the dissemination of skills and techniques for more efficient and sustainable production techniques, in promoting agri-conservation practices and supporting adaptation to climate change through lower water use. For example, reducing the unnecessary use of fertilisers can be accomplished by raising awareness and motivating farmers to use alternatives. Examples of digital advisory services include those delivered by mobile operators, such as Dialog's Govi Mithuru in Sri Lanka, Econet's EcoFarmer in Zimbabwe and Telenor Pakistan's Khusaal Zamindar. Climate adaptation can also be supported through better advisory services that can lead farmers to adopt climate-smart technologies and practices. Examples include Ignitia's Iska product in West Africa, a 48-hour, highly localised weather forecast service delivered daily via SMS.

The growing availability of data and new technologies to make sense of data, such as AI, machine learning and big data analytics, are making it possible to provide farmers with customised information based on field-level conditions. For example, climate indicators that are linked to on-farm activities. To strengthen adaptation and food security across a broad base, digital advisory needs to be accurate, tailored to users and accessible.[52] One such solution is Precision Agriculture for Development (PAD), which analyses satellite imagery together with soil data and a weather prediction model to provide

49 GSMA AgriTech (2019). Mobile Technology for Rural Climate Resilience: The Role of Mobile Operators in Bridging the Data Gap.
50 Ibid.
51 Ibid.
52 Tesfaye, A., et al. (2020). "Rwanda Climate Services for Agriculture: Farmers' Willingness to Pay for Improved Climate Services", CCAFS Working Paper, No. 314. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

customised advisory to farmers. Peer-to-peer and participatory advisory services are another way to tailor advice to farmers' needs. Wefarm, currently operating in Kenya, Tanzania and Uganda has built a farmer-to-farmer digital network powered by big data, AI and machine learning to enable peer-to-peer, crowdsourced knowledge.

- **Smart farming:** Smart farming refers to the use of sensors, drones, satellites and other farm assets to generate and transmit data about a specific crop, animal or practice to support agricultural activities. Smart farming solutions often rely on connectivity between IoT-enabled devices to optimise production processes and growth conditions, while minimising costs and saving resources. In addition to enabling better field monitoring and management, smart farming tools generate critical agricultural data to support farmers' decision making. Examples of smart farming solutions include remote equipment and operation monitoring, such as irrigation systems and smart greenhouses (e.g. Illuminum Greenhouses in Kenya), livestock and aquaculture management (e.g. Jala and eFishery's smart feeding solutions in Indonesia) and shared assets that enable farmers to access agricultural equipment on demand via mobile apps.
- **Agri e-commerce:** In the agricultural sector, there are promising opportunities for digital solutions in logistics and supply chain integration, such as agricultural e-commerce platforms. These solutions provide a more direct way for farmers to access urban markets and sell their produce, and helps to reduce food waste, a major contributor of GHG emissions. Reducing food waste in LMICs will depend greatly on better infrastructure, including roads and cold storage, as well as more integrated and reliable value chains. For example, InspiraFarms offers energy-efficient, small-scale cold storage and packhouses, asset financing and technical services to address the challenges of post-harvest losses and limited market access for small and growing agribusinesses. In a study funded by UK Aid, Inspirafarms estimated that early cold-chain solutions have the potential to reduce post-harvest losses by 25 to 50 per cent.[53]

Box 5

Digital solutions to climate change: Twiga, Kenya

Twiga is a mobile-based supply platform for Africa's retail outlets, kiosks and market stalls. The company uses a cashless business-to-business (B2B) platform to link grocery retailers in urban areas with farmers and food manufacturers. Grocers use Twiga's digital platform and logistics network to order produce sourced from smallholder farmers in rural areas across Kenya and have it delivered at competitive prices. The solution eliminates the inefficiencies and cost of sourcing perishable foods daily, reduces waste and guarantees farmers a consistent income and timely payments, thereby promoting low-carbon and resilient agricultural practices. Twiga has been sourcing from over 17,000 producers and delivering three times a week on average to over 8,000 retailers.

- **Insurance:** Insurance products, such as mobile-enabled agricultural insurance, can help smallholder farmers cope with the increased risks of climate change and protect their investments. Weather index insurance, which pays claims based on deviation from an index rather than on actual measured losses, is quite common. A 2019 study that looked at scaling insurance for smallholder farmers found that successful solutions have certain things in common: they explicitly target obstacles to farmers earning higher incomes; they integrate insurance with other development interventions; they give farmers a voice in the design of products; and they invest in local capacity and science-based index development.[54]

Box 6

Digital solutions to climate change: Acre index insurance, Kenya

Acre, a weather index insurance service that began in Kenya, matches weather data with the weather (rainfall) conditions required for maize cultivation. Diversion from a set range triggers claim payments to smallholder farmers registered to the service. Claims are paid into farmers' mobile money wallets who can then use the money to repurchase seeds. This ensures that farmers can replant their crops and avoid a total loss of income and enable more resilience to climate changes.[55]

53 Shell Foundation (n.d.) The 'Cold Chain' Opportunity: Reducing Postharvest Losses and Increasing Market Access for Rural Farmers.
54 Greatrex, H., et al. (2015). Scaling up Index Insurance for Smallholder Farmers: Recent Evidence and Insights. CCAFS Report No. 14. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).
55 See Acre Africa website: https://acreafrica.com/

THEME 5

Mitigation, adaptation and resilience: waste management and circular economy solutions

In What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050, the World Bank estimates that with rising income levels, the total quantity of waste generated in low-income countries is expected to increase significantly by 2050. The regions seeing the fastest rate of growth are Sub-Saharan Africa where total waste generation is expected to nearly triple, and South Asia, the Middle East and North Africa where it is expected to double. In these regions, more than half of waste is openly dumped, so rising levels of waste generation will have vast implications for the environment, health and prosperity. Urgent action is required.[56]

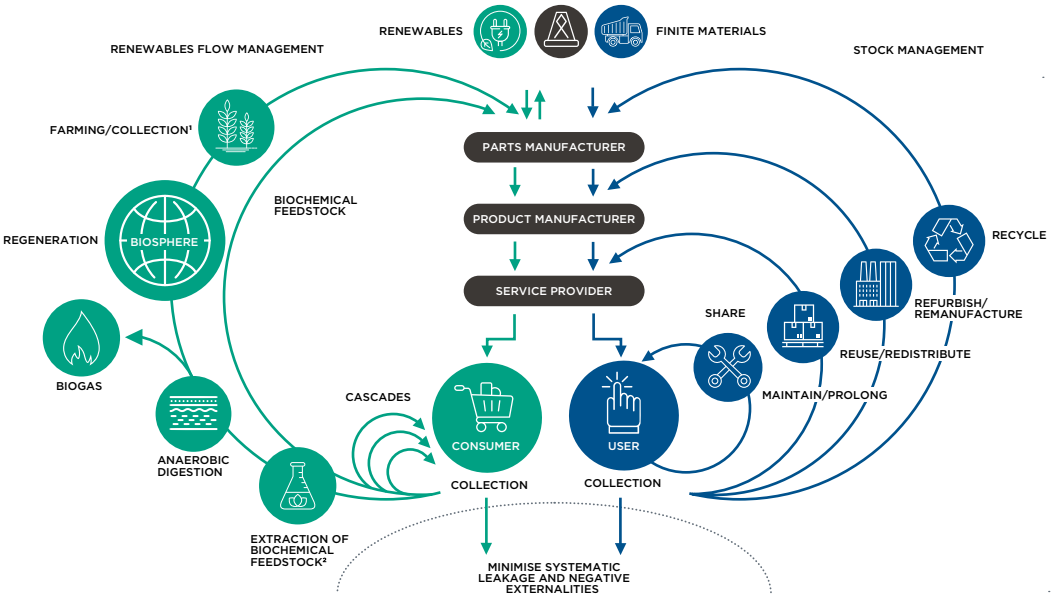
It is estimated that solid waste and wastewater accounted for 3.2 per cent of GHG emissions globally in 2017.[57] Methane, a GHG that is released from decomposing waste, is a particular problem since it is 34 times more potent than carbon dioxide. Reducing emissions from solid waste is becoming more important with the rise of consumerism and waste generation in LMICs, particularly food waste, as mentioned earlier. Equally, as climate patterns change, it will be essential that waste management systems and facilities are designed and built to be resilient to climate-related shocks.

Waste management systems must prepare for extreme weather patterns that may cause waste to clog drainage systems during floods, landfills and dumps to collapse under heavy rains, or damage urban infrastructure and dramatically increase waste volumes. Cities should work to ensure their waste collection, transportation and disposal systems continue functioning, and that their facilities are sited in locations that can withstand extreme weather events.[58]

As well as reducing organic waste, the "circulation" or recycling of materials, such as plastic, steel and aluminium, could have a dramatic effect on the resource efficiency of carbon-intensive industries. A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use and regenerating natural systems (Figure 6).[59] According to the Ellen MacArthur Foundation, establishing a circular economy is a vital step towards achieving climate targets, and circular economy solutions could reduce global emissions by as much as 40 per cent by 2050 across a range of sectors, including industry.[60]

Figure 7

Circular economy systems



Source: Ellen MacArthur Foundation

56 Municipal solid waste includes residential, commercial and institutional waste. Industrial, medical, hazardous, electronic and construction and demolition waste are reported separately from total national waste generation to the extent possible.
57 Bogner, J., et al. (2007). "Chapter 10: Waste Management", in Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Metz, B., Davidson, O.R., Bosch, P.R., Dave, R. and Meyer, L.A. (eds.).
58 The World Bank (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.
59 www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy
60 Ellen MacArthur Foundation (2019). Completing the Picture: How the Circular Economy Tackles Climate Change.

- **Plastic and solid waste management:** Digital solutions can serve as a catalyst for more effective waste management by improving processes throughout the value chain, from the collection, processing and recycling of solid waste to wastewater. In an industry with extremely tight operating margins, digital solutions can stimulate innovation and streamline operations. This has been demonstrated by Coliba, which has been supported by the GSMA to improve plastic waste management in Côte d'Ivoire.

Box 7

Digital solutions to climate change: Coliba's plastic recycling app, Côte d'Ivoire

Coliba received a grant from the GSMA Ecosystem Accelerator Innovation Fund in 2018 to deploy a large-scale, mobile-supported plastic recycling value chain in 10 districts of Abidjan, the capital of Côte d'Ivoire. Serving a population of about three million people, Coliba collects, recycles and resells plastic waste from households and businesses. Through the support of the GSMA Ecosystem Accelerator programme, Coliba has developed an app to enable plastic waste collectors to work efficiently and manage the process as seamlessly as possible. Waste collectors with basic feature phones can also use a USSD interface to access Coliba services.[61]

- **E-waste management:** In 2019, 53.6 million tonnes of e-waste were generated worldwide. Although e-waste represents two per cent of solid waste streams, 80 per cent of global e-waste is not documented (i.e. not recycled following international standards or thrown away).[62] Almost 82 per cent of e-waste is either handled by the informal e-waste sector or it ends up in a landfill and leads to atmospheric, water and land pollution.[63]

  The mobile industry contributes to two main types of e-waste: internal e-waste that mobile operators produce through their own operations (e.g. mobile towers, batteries and other antenna equipment) and external e-waste, which is produced either by customers or the general public (e.g. handheld devices that are often not manufactured by mobile operators themselves, but are central to their mobile operations).[64]

  Many mobile operators are leading initiatives to collect external and internal e-waste generated by the industry. For instance, in Asia, Starhub has partnered with a recycling company and transportation service provider to implement a successful e-waste management project.[65] In South Africa where Vodacom created the first smartphone-only village, they collected all the discarded feature phones from the community and assisted with the end-of-life management of these phones.[66]

  The GSMA CleanTech programme has studied the e-waste policy environment across 85 countries in Africa, South and Southeast Asia, where 17.7 million tonnes of e-waste are produced each year.[67] The study found that 78 per cent of the countries do not have legally binding regulations on e-waste. Only one of the countries (Philippines) has a (draft) policy on mobile waste. While mobile operators in many LMICs voluntarily support e-waste programmes, there is a strong need to support the collection and processing of mobile and other e-waste in LMICs through the drafting and implementation of e-waste policies.

61 See Coliba website and information on the GSMA website.
62 WEF, A New Circular Vision for Electronics: Time for Global Reboot, 2019
63 ITU, The Global e-Waste Monitor, 2017
64 Tillekeratne, D. (24 September 2020). "Lessons learnt from MNO e-waste management across Asia and Africa", Mobile for Development Blog.
65 Ibid.
66 Ibid.
67 GSMA Mobile for Development (n.d.). E-Waste Legislative Framework Map.

THEME 6

Adaptation and resilience: managing water solutions

The impact of climate change on water supply and availability will likely be felt predominantly by the world's poorest 40 per cent, who have the least ability to adapt.[68] Indeed, in their Global Risks Report, the World Economic Forum included water crisis in the top 10 risks for 2020 in terms of both likelihood and impact.[69] It is also estimated that by 2050, 5.4 billion people will live in the 59 countries experiencing high or extreme water stress.[70] The need to focus on water solutions and management must be urgently considered by governments and businesses in most LMICs. With growing populations and increasing pressure on water resources, cities are particularly vulnerable. The Cape Town water crisis of 2018 shows that municipalities need to be proactive to manage systems and encourage behavioural change, while still understanding that many are underserved when it comes to access to clean water.

- **Managing non-revenue water:** Non-revenue water (NRW) is lost to leakage, theft or inaccurate meters – a growing challenge for climate change adaptation, particularly for municipalities and water utilities managing the impacts of climate change and the declining availability of water. If utilities treat water that is not being delivered/paid for, the cost of each litre used is ultimately higher. Mobile and digital technologies are helping to digitise processes that have shown a clear reduction in NRW for many utilities, such as meter reading, billing, payments and complaint management systems. Digitisation has helped increase revenue and investments in more climate-resilient infrastructure, which is critical as climate variability increases.
- **Mobile payment services:** Mobile payment services are saving utility customers time and money by providing a secure channel to pay for water at a fair and set price. For service providers, mobile payments enable regular and, in some cases, increased revenue collection (see the Wonderkid example in Box 8 below) and lower administrative costs. Digital services can also help utilities manage and maintain water infrastructure. This was demonstrated by an entry to the FCDO Dreampipe Challenge prize, which created a system for residents to report water leaks through either a dedicated WhatsApp number or an app on their phone.[71]

Box 8

Digital solutions to climate change: Wonderkid's water payment solution, Kenya

Wonderkid, a GSMA M4D Utilities Innovation Fund grantee, has developed a suite of mobile tools for water utilities in Kenya to adapt and scale a complaint management, self-meter reading and payment system for users, in partnership with Safaricom's M-Pesa. The project resulted in a 28 per cent increase in revenue collection and an eight per cent increase in revenues billed for the utility.[72] Wonderkid currently serves over 40 water utilities across Africa.

- **PAYG water models:** The mobile-enabled PAYG model is being replicated across several sectors, from clean cooking to irrigation, sanitation and water. For instance, CityTaps has developed a water utility subscriber management solution that combines a smart, prepaid water meter with an integrated software management system (CTCloud) to process PAYG payments through mobile money. The GSMA M4D Utilities Innovation Fund has awarded CityTaps a grant to launch smart prepaid water meters in Niamey, Niger, in partnership with the local water utility, Société d'Exploitation des Eaux du Niger (SEEN) and Orange Niger. Over the course of the grant, CityTaps helped improve SEEN's revenue collection by 100 per cent in the part of the network where CityTaps is deployed.
- **Water resource management:** There are other innovative solutions that are helping to optimise water resource management for local conditions. For example, SunCulture in Kenya, a GSMA M4D Utilities Innovation Fund grantee, sells solar-powered water pumps using M2M technology, and is now rolling out IoT-enabled systems that use soil and weather data to optimise pump activity.[73] Another example is Fundifix,[74] supported by the Oxford University led REACH programme, who use GSM-enabled sensor technology for smart monitoring of rural water supply infrastructure in Kenya.

68 UNFCCC (2006). Technologies for Adaptation to Climate Change.
69 World Economic Forum (2020). The Global Risks Report 2020. Insight Report. 15th Edition.
70 IEP (2020). Ecological Threat Register 2020.
71 Gould, C. and Brown, C. (November 2019). The Dreampipe Challenge: Reducing Water Losses in Low-income Countries. Final Evaluation Summary. Itad.
72 GSMA Mobile for Development Utilities (2019). Mobile for Development Utilities Annual Report: Intelligent Utilities for All.
73 Ibid.
74 Fundifix. https://fundifix.co.ke/

THEME 7

Adaptation and resilience: disaster preparedness and response

Many aspects of human life are vulnerable to the impacts of climate change. Increasingly, humanitarian response is focused on reducing risk, improving preparedness and strengthening emergency response to the multiple humanitarian impacts of climate change. In areas under stress, climate change is leaving people unable to support themselves,[75] and it is increasingly recognised as contributing to forced displacement, adding to or worsening the threats faced by displaced populations.[76] In addition, the spectre of sea level rise over the coming century and beyond casts doubt on the long-term viability of hundreds of thousands of coastal cities and settlements around the world.

Extreme weather events are occurring more frequently and contributing to more severe droughts, flooding, high winds and wildfire, all of which increase the risk of landslides and erosion, and cause loss of life and property damage.[77] In the past decade, 83 per cent of disasters triggered by natural hazards were caused by extreme weather and climate-related events, such as floods, storms and heatwaves, and killed over 410,000 people.[78]

Communities affected by armed conflict are also disproportionately impacted by climate change. Humanitarian needs intensify when people are displaced, food production is affected and healthcare systems are weakened.[79] Rising temperatures can also increase health risks, such as cholera, malaria and dengue fever, for communities already affected by humanitarian crises.[80]

Digital solutions can help make communities more resilient, both in urban and rural settings. They can also play a critical role in providing early warnings for disasters or other major stresses, such as localised heatwaves and flooding. They also have an important role in urban planning, especially in LMICs where reliable data may not exist and data gathering can be very expensive. Mobile call detail records (CDR) could go a long way towards bridging this gap. CDR data can be broadly separated into four categories – population dynamics, mobility, social networks and socio-demographics[81] – and can be applied to urban planning strategies that support greater resilience. For example, by making planning decisions based on the concentration or movement of people at certain times in a typical 24-hour period. Data ethics and privacy are important considerations in this context.

Box 9

Digital solutions to climate change: Flowminder's analysis for mobile operator data for international development

Flowminder is a non-profit foundation that specialises in the analysis of anonymised mobile phone data, CDR, satellite imagery and household survey data for humanitarian and international development purposes. Flowminder seeks to improve access to mobility data to support better decision making by humanitarian actors. To scale these insights, Flowminder enables mobile operators and others to produce relevant data and analyses.

In 2017 Flowminder was a recipient of a GSMA Mobile for Humanitarian Innovation Fund grant, to support the development of FlowKit, an open source suite of software tools that enable the secure access and analysis of de-identified mobile network subscribers' mobility patterns and network usage. Flowminder worked with Vodafone Ghana and Digicel Haiti to install FlowKit, enabling useful data outputs to be generated by the MNOs (which in a crisis would be provided to humanitarian responders) in less than three days, a reduction from the average of eleven days that this has taken on average in previous responses. Analysis of such data outputs will help humanitarian responders to understand where best to target relief efforts in the aftermath future crises.

75 Brown, O. (2008). Migration and Climate Change. IOM Migration Research Series No. 31.
76 UNHCR (n.d.). Climate Change and Disaster Displacement.
77 IPCC (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (Field, C.B., et al., eds.).
78 IFRC (2020). World Disasters.
79 ICRC (9 July 2020), "ICRC report: Climate change and conflict are a cruel combo that stalk the world's most vulnerable". News Release.
80 Wahlström, M. (n.d.). "Before the Next Disaster Strikes: The Humanitarian Impact of Climate Change", UN Chronicle.
81 Dujardin, S., et al. (2020). "Mobile Phone Data for Urban Climate Change Adaptation: Reviewing Applications, Opportunities and Key Challenges", Sustainability, Vol. 12, Issue 1.

- **Resilient telecoms infrastructure:** This is another important aspect of disaster preparedness and response, especially given that mobile networks and the connectivity they provide can be a lifeline for those affected by natural disasters and other humanitarian emergencies. In 2015, the GSMA launched the Humanitarian Connectivity Charter[82] to strengthen the preparedness and resilience of mobile networks and facilitate better coordination with the humanitarian sector. Over 150 mobile operators operating in over 100 countries are signatories to the Charter,[83] which has had a direct impact on improving access to communication and information for those affected by crisis, reducing loss of life and supporting humanitarian response. One notable example is Globe in the Philippines. Since 2014, the company has been evaluating the potential impacts of climate risks, including strong typhoons, floods and drought. Mobile network towers are now built to be flood resistant and can withstand wind speeds of up to 350 km/hour. To enhance their climate readiness, Globe frequently updates their business continuity plan (BCP) to include response procedures to extreme weather events and preferred local partners to help reinstall electricity and water supplies.

- **Early warning systems:** Early warning systems (EWS) is an area in which mobile solutions can have a transformational impact. An effective public warning system (PWS) is an essential part of an effective EWS, and can reduce loss of life by alerting and warning a population of an imminent disaster, such as a tsunami, typhoon or hurricane. A cell broadcast system (CBS) has several advantages over SMS, including the ability to display a message on a handset with no user interaction and sound a distinct warning tone on a device. This also has the advantage of not contributing to network congestion.[84] Multisector partnerships, including mobile operators, disaster management authorities and an enabling regulatory environment are key to a successful EWS.[85] Digital solutions can also be used to monitor and identify threats that subsequently lead to a public warning. These include better river flow observations, localised heat measurements and glacial lake monitoring.

Box 10

Digital solutions to climate change: Early warning system, Peru

An effective EWS can add precious minutes in the event of landslides and flooding. In Chosica, Peru, an EWS analyses photos and data from sensors and cameras installed on houses to track rainfall data and soil saturation levels. The municipality receives updates from the EWS and can immediately notify community leaders via SMS, who can then alert their community to start the evacuation process.[86]

- **Post-disaster resilience:** Mobile solutions can also be used to rapidly gather information on an unfolding disaster situation and improve rapid responses, which benefit from additional data and knowledge. One example is digital volunteerism, whereby volunteers working remotely from anywhere in the world can help process and prioritise crowdsourced information received from people involved in a disaster to an SMS or app-based helpline.[87] Then, frontier technologies, such as satellite and drone capabilities, can be linked with AI to process images. This can be particularly effective in conflict-affected states where it is less viable to operate on the ground.

82 The Humanitarian Connectivity Charter.
83 GSMA Mobile for Humanitarian Innovation (2020). Building a Resilient Industry: How Mobile Network Operators Prepare for and Respond to Natural Disasters.
84 GSMA (2013). Mobile Network Public Warning Systems and the Rise of Cell-Broadcast.
85 GSMA (2015). Disaster Response: DEWN – Disaster Emergency Warning Network.
86 ITU (2017). Case Studies of Turning Digital Technology Innovation into Climate Action Report.
87 For more, see: Meier, P. (2015). Digital Humanitarians: How Big Data is Changing the Face of Humanitarian Response.

As climate change gives rise to more frequent and extreme weather events, it is not only disaster response that must be scaled up, but also early action by societies and individuals. It is increasingly acknowledged that cash assistance (versus traditional in-kind aid) can be a more dignified and effective way to help affected populations rebuild or protect their livelihoods, as it empowers people to determine their own needs and how best to meet them.[88] Humanitarian agencies are increasingly using mobile money to deliver cash and voucher assistance (CVA) in emergencies,[89] and cash transfers through mobile money can also help households and businesses prepare for and recover from shocks, such as flooding or longer term stresses, such as prolonged drought.

Box 11

Digital solutions to climate change: Cash transfers by the World Food Programme via MTN, Ghana

In northern Ghana, where climatic patterns are similar to the Sahel belt, the World Food Programme (WFP) has introduced an asset creation programme that makes mobile money transfers during the dry season for farming communities to build communal infrastructure to store water (fish ponds, dams and small wells). Farmers in the region also receive cash to alleviate food insecurity.

- **Supporting livelihoods:** On average, over 20 million people are displaced every year for climate-related reasons. A 2018 World Bank report estimates that by 2050, over 143 million people in Sub-Saharan Africa, South Asia and Latin America alone (or 55 per cent of the global population) will be forced to move to escape the impacts of climate change.[90] Another study has found that the three countries with the greatest risk of mass displacement are Pakistan, Ethiopia and Iran.[91] Digital solutions can also help provide employment and income to people affected by disaster. With an internet connection and mobile device, tablet or laptop, displaced persons with relevant skills and access to opportunities can continue to engage in work. This is likely to become an increasingly important coping strategy. In addition to "gig" work via informal digital platforms, apps such as LevelApp in Uganda provide digital work opportunities to refugees in the form of data annotation microtasks. Users earn supplementary income by tagging images and data sets on their mobile phone.[92]

88 GSMA (2014). Disaster Response: Mobile Money for the Displaced.
89 GSMA Mobile for Humanitarian Innovation (4 December 2019). Navigating the Shift to Digital Humanitarian Assistance: Lessons from the International Rescue Committee's Experience.
90 Rigaud, K., et al. (2018). Groundswell: Preparing for Internal Climate Migration.
91 IEP (2020). Ecological Threat Register 2020.
92 See Refunite's LevelApp website: www.levelapp.net

2.4 Digital solutions that can help improve the delivery of climate finance

As discussed in the previous section, the global transition to a low-carbon economy requires a range of climate mitigation and adaptation technologies, including innovative ones. Many of these technologies can be enabled by climate finance.[93]

Total tracked climate finance has been growing, and surpassed half a trillion US dollars in 2018. Private finance, which reached USD 326 billion on average annually in 2017–18, continues to account for the majority (around 56 per cent) of climate finance, 85 per cent of which flowed to renewable energy, 14 per cent to low-carbon transport and less than one per cent to all other subsectors.[94] There is therefore currently very little private sector climate finance investment in climate adaptation and resilience. This is due to the difficulty of converting resilience-created value into commercial value. As such, the bulk of adaptation- and resilience-related climate finance is public, and the Green Climate Fund – the world's largest climate related vertical fund – aims for a 50-50 percent split.[95]

While climate finance has reached record levels, it still falls far short of what is needed under a 1.5˚C scenario, which requires vast decarbonisation efforts. Estimates of the investment required to achieve this low-carbon transition range from $1.6 trillion to $3.8 trillion annually between 2016 and 2050 for supply-side energy system investments alone.[96] According to the UNEP Adaptation Gap Report – 2020 the annual adaptation costs in developing countries are currently in the range of US$70 billion, with the expectation of reaching US$140–300 billion in 2030 and US$280–500 billion in 2050. On the contrary, UNEP also estimates that despite an increase in finance available for adaptation, given the pace of climate change and impacts, the adaptation finance gap is not narrowing as a result of current efforts.[97]

Mobile-enabled technologies have the potential to transform climate finance in two major ways:

- By **measuring and monitoring technologies and the impact of climate finance** projects in an inexpensive, accurate and expedient manner. This capability is often missing from climate finance projects and is a major barrier to investment in climate technologies, as a lack of monitoring, impact measurement and accountability erodes investor confidence.
- By catalysing **innovative business models, including those that enable climate finance** to be disbursed to large numbers of beneficiaries in remote areas, and support activities related to geographically disbursed programmes (e.g. ecosystem services projects). One way this can be achieved is through a combination of e-wallets, mobile money and digital identity solutions.

93 Climate finance refers to "local, national or transnational financing – drawn from public, private, and alternative (such as philanthropic) sources of financing – that seeks to support mitigation and adaptation actions that will address climate change." See UNFCCC, Introduction to Climate Finance.
94 Clark, A., et al. (2019). Global Landscape of Climate Finance 2019. Climate Policy Initiative.
95 See the Green Climate Fund website: www.greenclimate.fund
96 IPCC (2018). Global Warming of 1.5 Degrees. IPCC Special Report.
97 UNEP (January 2021). UNEP Adaptation Gap Report 2020.

Mobile networks and impact monitoring of climate finance

Investment in, and implementation of, climate mitigation, resilience and adaptation solutions in LMICs are often constrained by high investment barriers and high levels of uncertainty, particularly for innovative and unproven technologies and business models. A similar level of uncertainty surrounds climate technologies and business models that have been proven in one region or country, but are still being introduced to new markets.

Mobile-enabled solutions can help provide this service. By supporting the monitoring and verification of climate finance activities, these solutions can remove one of the most important hurdles to widespread implementation of climate technologies. The following is a breakdown of some of the impacts mobile-connected digital technologies can have on the monitoring of climate finance projects and technologies.

1 Automated and streamlined MRV-compliant impact monitoring systems

Such systems combine the accuracy of traditional monitoring, results and verification (MRV) systems with the speed and connectivity of mobile networks. Even without considering IoT sensors and smartphones, mobile networks with relatively simple mobile phones can provide a wide range of relevant parameter measurements. These include geotagging with accurate global positioning information, date and time stamping and the ability to take photos and notes. The use of smartphones and tablets for data and information collection and continuous connection to the cloud (when available) would streamline monitoring even further. Finally, IoT capabilities can automate climate finance monitoring systems, even for some types of complex and geographically distributed programs. Monitoring systems have made progress in this area in the last decade. An early example is the mobile-based monitoring system for the Efficient Cook Stove Programme: Kenya.[98] At the time it was designed in 2011, it was considered one of the most forward thinking and technologically advanced monitoring systems of a distributed programme. Many more innovative approaches have since surpassed it.

2 Impact monitoring platforms based on blockchain and distributed ledger technology

The verification stage of the MRV approach to performance monitoring usually involves conducting quality assurance and ensuring the veracity of the data to protect against fraud or malpractice. Blockchain, the underlying technology that supports bitcoin and other cryptocurrencies, and distributed ledger technology (DLT), decentralises the process of accounting for and verifying changes in stored information across a network of computers. All changes to the ledger are recorded and verified across multiple "nodes" in the network. As a result, the risk of fraud from changing the values of recorded data decreases to a level that may make the verification stage redundant. Such a development can significantly simplify the monitoring process, and reduce the time and cost of verification.

98 See CDM documentation on the Efficient Cook Stove Programme: Kenya.

Box 12

Digital solutions for climate finance: the use of blockchain by GainForest

GainForest uses smart contracts to incentivise small-scale Amazonian farmers to preserve the rainforest. Farmer "caretakers" receive rewards for preserving patches of rainforest over a three- to six-month period. The reward is crowdfunded by private individuals or institutional donors, and the size is determined by the difficulty of preserving the particular piece of land.[99] Blockchain enables pledged money to be unlocked by communities when they reach certain milestones, such as specific areas of trees still being in a pristine state one year or two years later.

Box 13

Mobile money and green financial inclusion

Mobile money services have been instrumental in enabling financial inclusion by ensuring access to money, savings, credit, insurance, remittances and government transfers. A blog by the GSMA Mobile Money programme discusses the role of mobile money in green financial inclusion and elaborates different use cases, such as mobile money-enabled insurance services for smallholder farmers or government-to-person (G2P) payments that help build resilience to climate change in LMICs. For instance, in Fiji and the Philippines, mobile money-enabled G2P payments have been used successfully to reach vulnerable populations in the aftermath of extreme climate events, and to disburse transfers to individuals helping to clear roads, buildings, schools and hospitals.[100] The PAYG models used for energy, water, cooking and irrigation services (see section 2.3) also use mobile money, elucidating the role of mobile money in green financial inclusion and supporting climate change mitigation and adaptation. It is therefore imperative that regulators and the mobile industry alike integrate climate action as part of their vision for financial inclusion, while continuing to leverage the transformative power of digital financial services.[101]

99 See the GainForest website: https://gainforest.app/#/
100 Lopez, M. (18 December 2019). "Making the Connection between Mobile Money and Climate Change", Mobile for Development Blog.
101 Ibid.



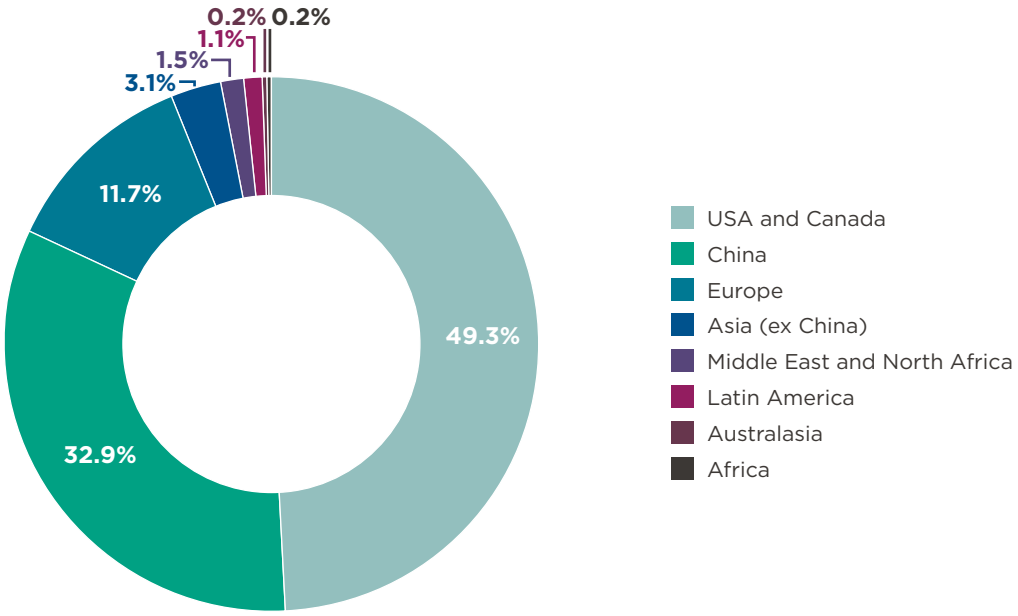
3 Conclusion and considerations

This report has demonstrated the impactful and often transformational role of mobile-enabled digital solutions in addressing the climate challenge. Often working in tandem with frontier technologies, such as AI, blockchain and IoT, digital solutions can help mitigate GHG emissions, enable individuals and businesses to adapt to changing climatic conditions and boost resilience to climate-induced shocks and stresses. However, to prevent catastrophic climate changes, the transition to low-carbon solutions must happen quickly and at scale.

According to the PwC report, *The State of Climate Tech 2020*,[102] between 2013 and 2019, $60 billion in early-stage capital was invested globally in start-ups tackling the net-zero challenge. However, just under five per cent of this investment came from Asia (excluding China), Africa and Latin America (Figure 7). The report found that climate tech[103] related to mobility and transport, heavy industry and GHG capture and storage are the fastest growing segments, followed by food, agriculture, land use, built environment, energy and climate and Earth data generation. Bengaluru in India is the only city in an LMIC to become a climate tech start-up investment hub outside of China.

Figure 8

Climate tech investments by region and top 10 climate tech investment hubs



	Startup HQ	Funding raised
	San Francisco Bay Area, United States	$11.7bn
	Shanghai, China	$7.5bn
	Beijing, China	$6.6bn
	Los Angeles, United States	$3.5bn
	Boston, United States	$2.1bn
	Guangzhou, China	$1.2bn
	Hangzhou, China	$1.0bn
	Berlin, Germany	$930m
	Bengaluru, India	$870m

Source: PwC, *The State of Climate Tech 2020*

102 PwC (23 September 2020). Climate tech investment grows at five times the venture capital market rate over seven years. Press release.
103 Climate tech is defined as an umbrella of solutions to reduce GHG emissions across energy, transport, the built environment, industrial processes and food and land use; in addition to shifts towards less resource-intensive business models, or carbon-removal technologies.

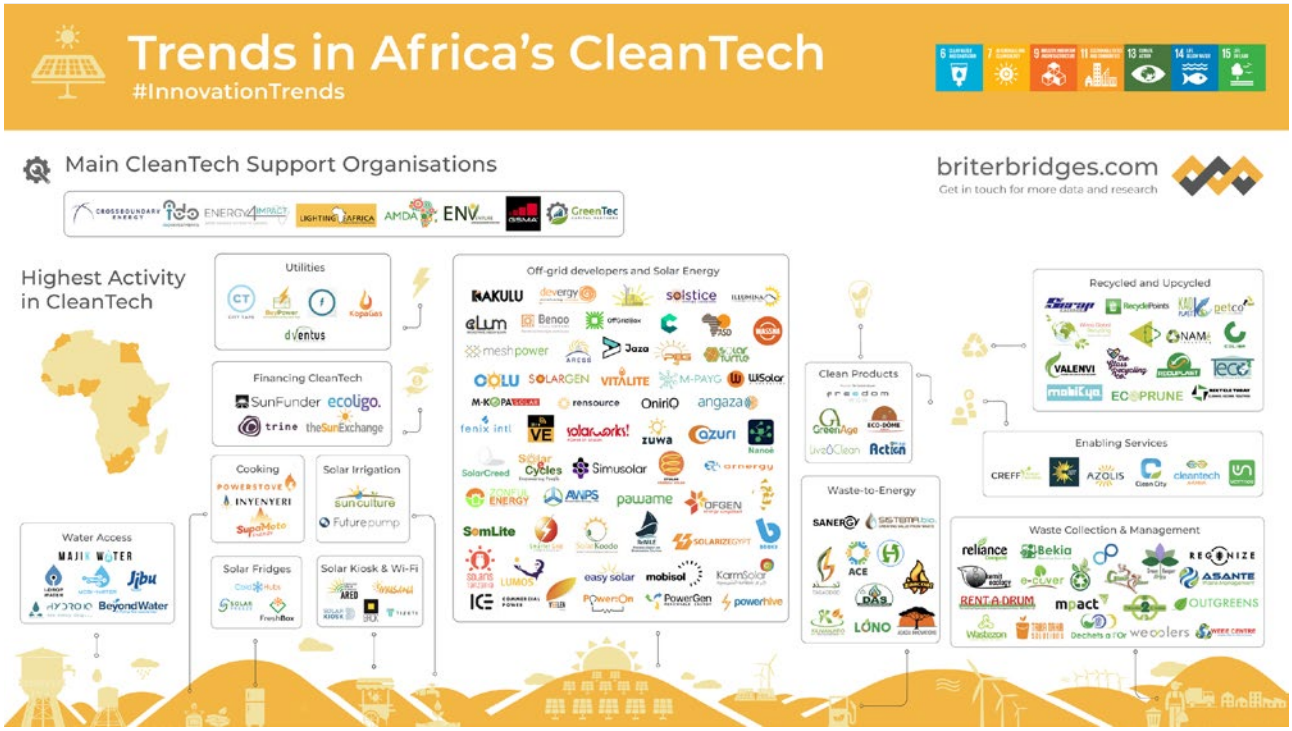
Considerations for innovators and investors

Our expert interviews revealed many underlying challenges for climate tech start-ups and the investor community in LMICs. Although energy-centric deals have seen uptake, (see Figure 9 for a snapshot of Africa), early-stage funding for broader climate tech solutions is still a challenge. In addition to the physical and digital infrastructure, literacy and content-related challenges, there is a lack of patient capital – much needed to test these solutions in LMICs. Since most research and development for climate tech solutions happens in HICs, this creates implementation challenges in local LMIC contexts. Moreover, climate tech intersects multiple industry sectors, each regulated differently in different geographies, posing further challenges for investors and innovators to understand, navigate and meaningfully use regulatory frameworks to develop and implement digital solutions for climate action.

For investors, it is important to recognise that some commercial opportunities for digital solutions may not initially appear to be directly related to climate change. For example, B2C producer-to-customer grocery delivery that can reduce food waste at scale, or shared transport platforms that facilitate shared minibus services on demand. Additional support is needed for SMEs and the "missing middle" to access funding, financing and scalable business development in LMICs. The presence of climate-focused incubators and accelerators, and greater collaboration between universities, private sector organisations and government agencies, can help create a strong pipeline of talent and opportunities to support these initiatives.

Figure 9

CleanTech trends in Africa



Source: Briter Bridges

Conceptualising, designing and engaging with products and solutions with and for local communities, including vulnerable or traditionally marginalised groups affected by climate change, is a key consideration for entrepreneurs, start-ups and established tech companies working in climate tech. In LMICs, it is important to create digital solutions that are context-specific, tailored to the needs and realities of the users and can be used both online and offline and accessed with a range of devices, including low-tech devices like feature phones.

Tech solutions aiming at optimising agri-value chains, improving water resilience, supporting the use of clean energy and others have been trialled and used in the LMICs for many years. But the climate or environmental impact of the roll-out of such services has not been well documented. It can be argued that this is partly because not all of these solutions were developed using a climate lens or with a clear-cut climatic or environmental objective. It is important for tech innovators to apply this climate lens to raise awareness of climate challenges amongst the tech and start-up community; to increase their exposure to relevant, real-world climate mitigation, adaptation and resilience; and to create triple-bottom-line business frameworks and models for climate action.

Considerations for mobile operators

The mobile industry is a relatively small, but growing, contributor to greenhouse gas emissions. The industry will be impacted by the effects of climate change in the following ways, as explained in the GSMA's Climate Action handbook:[104]

- Changes in customers' behaviour and demand for more durable and energy efficient products and services from mobile industry
- Demand for green innovation by private companies and public entities which are increasingly looking to mobile operators to help them reduce their emissions by making broader and smarter use of connectivity to optimise their operations.
- Increasing intensity and frequency of extreme weather events could cause financial risks linked to damaged network infrastructure
- Changes in regulation from governments in terms of reporting of emissions, carbon taxes and emissions trading programmes
- Increasing demand from investors to demonstrate resilience to the impact of climate change but also offer solutions to rising temperatures.
- Reputational risk of not being seen as part of the solution to climate change

COVID-19 has made it clear that mobile and digital technologies have had a profound impact on societies across the globe. By mitigating their own emissions, supporting other companies and industry sectors to reduce their emissions and ensuring mobile infrastructure is resilient to extreme weather,[105] the mobile sector will play a central role in addressing global climate change. Through the enablement effect, mobile operators can act as a catalyst for how other sectors can decarbonise and support climate resilience.

It is important that the mobile industry continues to increase investments in the sustainability and resilience of communities in their markets, as it will help to drive sustained business growth. The industry must also support innovators in areas that could have a major impact on climate change mitigation and resilience, for example, through access to data, partnerships and co-development of solutions or mentoring and incubator/accelerator programmes. There is an urgent need for strong partnerships between the mobile industry, governments, investors and innovators to drive climate action at the scale required to meet the Paris Agreement objectives.

104 GSMA (2019). Climate Action Handbook.
105 GSMA Mobile for Humanitarian Innovation (2020). Building a Resilient Industry: How Mobile Network Operators Prepare for and Respond to Natural Disasters.



Annex

Assessing potential interventions to enhance digital solutions

The GSMA M4D programme conducted research to understand the current and potential role of mobile and digital technologies in addressing climate change issues in LMICs. The objective of this research was to build consensus and understanding among tech stakeholders (including mobile operators) of the commercial opportunities available in climate and environmental innovation.

Following research and interviews with experts from across climate mitigation and adaptation fields in LMICs, a scoring and filtering process was undertaken to identify high-potential intervention themes. A long list of potential interventions was completed and then narrowed down to a short list by scoring:

i. The potential scale of GHG emissions mitigation or the scale of adaptation/resilience impact; and

ii. The extent to which mobile-enabled solutions offer transformational change.

Intervention themes that failed to score highly against these criteria were omitted. The resulting 18 intervention themes are shown in Table 2.

To help define the best type of support that GSMA could provide, the shortlisted interventions were then assessed against an additional set of criteria:

i. What are the levels of maturity for each intervention area, including public and private investment and proven technologies and solutions?

ii. Which sectors have greatest potential for mobile-enabled monetisation at scale?

iii. What and how strong are the potential development impact (SDG) spill-overs, such as health or environmental benefits?

iv. What is the role of partnerships between mobile operators and other stakeholders to deliver solutions?

This approach to assessing areas of potential support ensured that high-impact areas not particularly well suited to a commercial private sector approach, such as early warning systems, were not discounted. The outcome of this process is summarised in Table 3.

These 18 interventions covered one or more of the seven themes explained in this report namely clean energy and energy efficiency; transport, mobility and logistics; natural resource management and forestry; agriculture; managing water solutions; waste management and circular economy solutions; disaster preparedness and response. It should be noted that many of the intervention themes are still broad and include many possible areas of digital interventions. For example, “transport and mobility” could include digital services for ride sharing and on-demand minibus services; integrated transport service information, journey planning and fare payment; and encouraging uptake of EVs via information on charging points or battery swapping. Similarly, urban planning and individual climate awareness cut across the more than one of the seven themes. All these interventions are at different stages of maturity in different country contexts, and have different potential for mobile monetisation.

Which high-impact solutions should be supported?

Table 2 includes the 18 thematic areas shortlisted from an assessment of likely intervention areas and the scale of the impact of GHG mitigation, adaptation and resilience solutions.

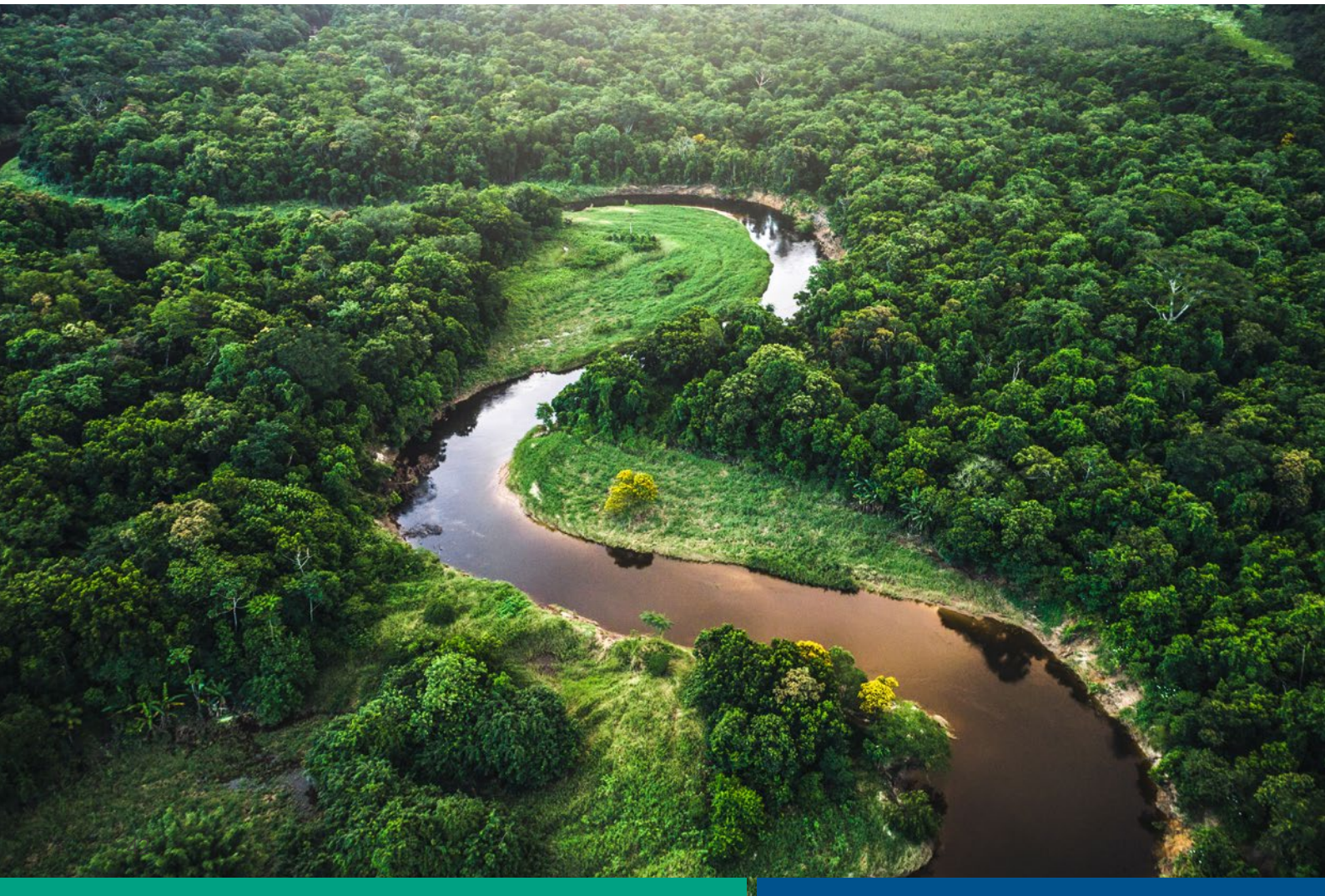
Table 2

18 high-potential thematic areas in which digital solutions can address the climate challenge

Description of intervention areas	Scale of impact of GHG mitigation or adaptation and resilience	Transformational role of mobile-enabled solutions
Energy Mitigation		
PAYG solutions to enable household or business access to clean energy, battery storage or cooking technologies, and linkage to productive energy use.	Decentralised renewable sources help reduce the need for fossil fuel generation. PAYG solar and storage can also displace diesel generators, which are responsible for the same amount of GHG emissions as 700 to 1,000 coal-fired power stations in LMICs.	Mobile has a vital role in linking service providers to customers, changing consumer behaviour and providing incentives, and facilitating monthly payments via mobile money.
Energy Mitigation		
Digital services to enable energy efficiency and demand response via smart metering of homes, industry, businesses and offices, connect to IoT, etc.	Reduced usage and mechanisms to flatten peak demand for energy generation have a significant impact on reducing GHG emissions from fossil fuel energy generation.	Mobile-based solutions are an enabling interface, linking IoT-connected devices together and to the smart meter, along with mobile money for bill payments.
Agriculture Mitigation, Adaptation & Resilience		
Digital solutions in logistics and supply chain efficiency and integration (such as access to chilled storage, producer-to-market solutions, home grocery delivery, etc.).	Reducing food/produce waste is a major driver of GHG mitigation, supported by reduced transport emissions. Digital solutions can also greatly improve the resilience of value chains, as experienced during COVID-19.	Mobile is an enabler, helping to link producers to markets more efficiently, and provide platforms for marketplace services, including payment, aggregation and allocation. Significant scope for accountability and traceability to be incorporated via blockchain, etc.
Agriculture Mitigation, Adaptation & Resilience		
Digital tools that enable more climate-smart/resource-efficient farming, including to help farmers respond to less reliable rainfall and weather patterns; to identify crop disease or other crop or livestock-related problems; and suggest mitigating actions and support climate-smart agricultural value chains.	Climate-smart agriculture is predicted to be a major driver of GHG emissions mitigation. Agriculture is also on the front line of climate change impacts and can greatly benefit from a range of more resilient approaches.	Central role for mobile-enabled services that draw on mobile money and AI (machine learning) in particular. Mobile also enables enhanced monitoring, diagnostics, and predictive and prescriptive functionality to improve agricultural production, resource allocation and management and reduce post-harvest losses.
Agriculture Adaptation & Resilience		
Provision of livestock management and remote veterinary services. Could include geotagging of nomadic livestock herds using GPS or integration of migration patterns with real-time water and pasture resource mapping.	Such a system can be used in several ways, including cross-border animal health systems, epidemic early warning systems and drought early warning systems.	Central role for mobile-enabled services depending on connectivity in remote areas for tracking and monitoring. Potential use of network-connected veterinary measurement devices (IoT).
NRM (including forests) Mitigation		
Integrated digital solutions to measure, report and verify avoided deforestation and sustainable resource management, linked to payments for ecosystem services (PES), especially for local residents and indigenous communities.	Forest conservation is extremely important for mitigation. Forests are also vital to maintaining biodiversity and resilience, including by reducing the likelihood of flooding during heavy rainfall events.	Central role for mobile as an interface and mobile money for payments, awareness raising and community based NRM

Description of intervention areas	Scale of impact of GHG mitigation or adaptation and resilience	Transformational role of mobile-enabled solutions
NRM (including forests) Mitigation		
Gamification initiatives that channel financial resources to NRM or afforestation programmes, often linked to use of mobile money services (e.g. Ant Forest, China).	Afforestation and restoration of natural resources is extremely important for mitigation and resilience.	Central role for mobile as the interface to incentivise behaviour and facilitate calls to action and payments.
NRM (including forests) Mitigation		
Digital solutions (including awareness, information, market linkage opportunities) to catalyse sustainable livelihoods in high natural resource value areas (forests, watersheds, coastal and marine zones) or buffer zones, helping to reduce activities or livelihoods that are destructive to natural habitat.	Forest conservation, afforestation and restoration of natural resources, are extremely important for mitigation and resilience.	Role of mobile is central to providing solutions at scale to recently connected populations. It also has a role in improving communication, access to resources and community based NRM
Transport & Mobility Mitigation		
Digital information, platforms and tools to facilitate greater, more efficient and convenient use of public or informal transit services, ride sharing, micro-mobility and uptake of EVs.	Public transit and shared mobility is an extremely important mitigation factor, helping to reduce the mode share of private vehicles.	Central role for mobile as an enabler, particularly for people on the move. Use of AI and other frontier technologies. as part of solutions. Central role for mobile as the interface and mobile money for payments and public advocacy.
Water supply Adaptation & Resilience		
Digital solutions for integrated water management to improve the efficiency of revenue collection and improve management of water resources and infrastructure, helping to reduce losses and provide more reliable, resilient and inclusive services.	Due to climate change, access to clean water is becoming an increasingly critical challenge for many communities in LMICs. Improving water resource management and access is critical for adaptation and resilience.	Central role for mobile as the interface and mobile money for payments, behaviour change and incentivisation.
Solid waste management Mitigation, Adaptation & Resilience		
Digital circular economy solutions across general waste management and plastic waste management value chains (collection, transport, processing, reselling, etc.).	Waste management is an important part of mitigating GHG emissions, particularly related to organic content, so segregation of waste is a vital component. Waste management also enhances resilience, as plastic waste and other items often block drainage systems and make flooding worse.	Mobile-enabled solutions have great potential to improve waste management value chains, providing value to each actor in the chain, such as enabling greater access to information on supply and demand for waste plastics.
Wastewater management Mitigation, Adaptation & Resilience		
Digital solutions to improve the efficiency and security of wastewater collection and management.	Poorly managed wastewater poses significant public health risks during increasingly frequent flooding, and proper management greatly improves resilience to disease. Innovative wastewater treatment can also reduce GHG emissions, but the impact is less.	GSMA M4D Utilities studies have shown strong potential for mobile-enabled commercialisation at scale.
Data-driven urban planning Mitigation, Adaptation & Resilience		
Urban planning solutions that draw on call detail records (CDR) and other mobile-related big data to understand locations and movements of residents and other factors.	Mitigation can be greatly enhanced by urban planning that minimises the need for private vehicle use. A pillar of disaster resilience is often well-planned communities, drawing on hazard mapping and vulnerability assessments.	Mobile is an enabler for resource allocation, spatial mapping and community monitoring.
Disaster risk reduction Adaptation & Resilience		
Mobile-based early warning systems linked to better observations provided by digital systems and sensors (e.g. of localised heat, landslides, river flow or storm surges).	Early warning systems are critical for disaster resilience, helping residents to identify threats, evacuate and prepare.	Mobile needed for GPS and satellite images, as well as local reporting and communication on the ground (by local population), to make it as efficient as possible.

Description of intervention areas	Scale of impact of GHG mitigation or adaptation and resilience	Transformational role of mobile-enabled solutions
Disaster risk reduction Adaptation & Resilience		
Post-disaster vulnerability and damage assessment, identifying the need for urgent assistance and potential loss and damage, including through digital volunteerism.	Resilience also depends on rapid response, which can be aided by well-defined systems to bring technology and volunteers together to help identify and respond to needs as soon as a disaster strikes.	Digital volunteerism facilitated by mobile and digital technology. It could also be facilitated via a larger digital platform related to mobile money, humanitarian aid, community management, etc.
Disaster risk reduction Adaptation & Resilience		
Role of mobile-enabled insurance for individuals and businesses in agriculture and other sectors to cover losses from disasters and enable faster recovery and avoidance of poverty traps.	Insurance strengthens resilience considerably by allowing customers to avoid a poverty trap that may be caused by loss of income or damage to assets or property.	Mobile solutions are likely to be key via mobile money platforms, consumer awareness, digital identity, analytics and reporting, etc.
Disaster risk reduction Adaptation & Resilience		
Digital cash transfer solutions to help vulnerable citizens cope with shocks and stresses, especially in remote areas.	Cash transfers enable more resilient livelihoods and local economies and faster post-disaster recovery.	This can be greatly enhanced via mobile, particularly in terms of transparency, speed, accessibility and efficiency.
Individual climate awareness Mitigation		
Apps that promote low-carbon lifestyle information and advice, including through gamification and competition between users.	Such solutions can raise significant awareness of how personal actions can help to reduce GHG emissions, as well as provide motivation to take practical actions. Personal changes multiplied by millions of individuals can lead to transformational reduction in GHG emissions.	Central role for mobile as the interface for public advocacy, consumer awareness, payments and behaviour monetisation.



Assessment of maturity, commercial potential and the role of partnerships

The results of the assessment of additional factors for each shortlisted intervention are included in Table 3. These include the maturity of the sector, including public investment and overseas development assistance (ODA); the potential for commercialisation via mobile solutions; and the role of partnerships, including for mobile operators.

Table 3

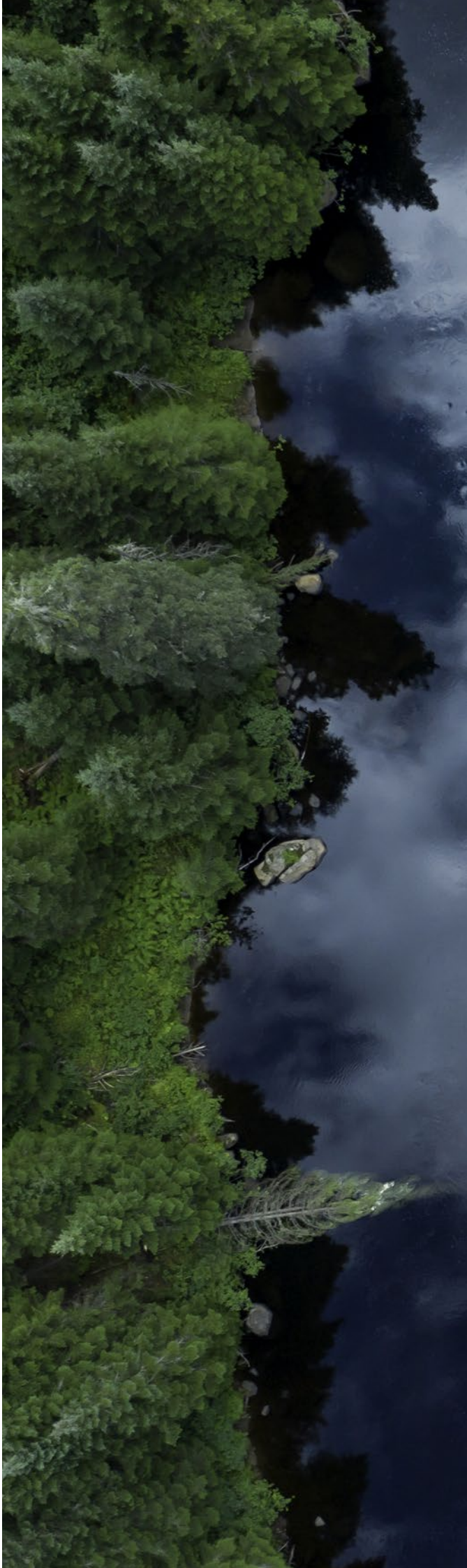
Assessment of maturity, commercial potential and the role of partnerships in the 18 high-potential intervention areas

Description of intervention areas	Maturity: Assessment of investment in sector	Potential for mobile monetisation	Role of partnerships
Energy Mitigation			
PAYG solutions to enable household or business access to clean energy, battery storage or cooking technologies, and linkages to productive energy use.	High	High for specific groups, due to proven business models	Business partnerships are essential. There is a growing trend and high potential for software start-ups to partner with corporates that provide the infrastructure. Strong role for mobile operators to support PAYG partnerships.
Energy Mitigation			
Digital services to enable energy efficiency and demand response via smart metering of homes, industry, businesses and offices, connections to IoT, etc.	Moderate	High. Regional differences, but the topic is gaining interest everywhere.	Business partnerships are essential. There is a growing trend and high potential for start-ups that provide the software to partner with corporates that provide the infrastructure or services. Analytics partnerships are of particular interest. Strong role for mobile operators in relation to smart grids and IoT for smart energy efficiency solutions.
Agriculture Mitigation, Adaptation & Resilience			
Digital solutions in logistics and supply chain efficiency and integration (such as access to chilled storage, producer-to-market solutions, home grocery delivery, etc.).	Moderate	High	Business partnerships are essential. There is a growing trend and high potential for start-ups that provide the software to partner with corporates that provide the infrastructure or services. Data analytics partnerships to support better logistics, etc. are of particular interest.
Agriculture Mitigation, Adaptation & Resilience			
Digital tools that enable more climate-smart/resource-efficient farming, including to help farmers respond to less reliable rainfall and weather patterns; to identify crop disease or other crop or livestock-related problems; suggest mitigating actions; and support climate-smart agricultural value chains.	Low to Moderate	High	There are many interagency, NGO and public-private partnerships (PPPs) and government investments. Strong role for mobile operators to promote and support solutions, as well as benefit from increased data use and revenue.
Agriculture Adaptation & Resilience			
Provision of livestock management and remote veterinary services. Could include geotagging of nomadic livestock herds using GPS or integration of migration patterns with real-time water and pasture resource mapping.	Low to Moderate	Medium	There are many NGOs and government investments. Strong role for mobile operators to promote and support solutions.

Description of intervention areas	Maturity: Assessment of investment in sector	Potential for mobile monetisation	Role of partnerships
NRM (including forests) Mitigation			
Integrated digital solutions to measure, report and verify avoided deforestation and sustainable resource management linked to PES, especially for local residents and indigenous communities.	Low to Moderate	Moderate (region specific)	There are many opportunities for PPPs and co-financing projects. For example, the Global Environment Facility (GEF) has pioneered the development of mechanisms that reward good stewardship of natural resources, including the structuring of PES schemes.
NRM (including forests) Mitigation			
Gamification initiatives that channel financial resources to NRM or afforestation programmes, often linked to the use of mobile money services (e.g. Ant Forest, China).	Moderate to High	Medium – CSR-centric	Significant incentive for building marketplace partnerships via payment gateways, including possible role for mobile operators. PPPs enable greater advocacy and impact monitoring.
NRM (including forests) Mitigation			
Digital solutions (including awareness, information, market linkage opportunities) to catalyse sustainable livelihoods in high natural resource value areas (forests, watersheds, coastal and marine zones) or buffer zones, helping to reduce activities or livelihoods that are destructive to natural habitat.	Low to Moderate	Moderate (region specific)	Partnership likely necessary between a private company or MNO and an NGO or IGO, research or donor agency.
Transport & Mobility Mitigation			
Digital information, platforms and tools to facilitate greater and more efficient and convenient use of public or informal transit services, ride sharing and uptake of EVs.	High	Moderate due to lack of commercial opportunities. More evidence needed to explore the use of payments seems to be a promising area though government regulations, political will and willingness to pay.	High potential for PPPs with ride share aligned with governments' smart and clean cities initiatives and "green zones". Growing opportunities for partnerships with schools, including electric bus fleets. The key for govtech start-ups is to design business models around existing popular payment tools, such as M-Pesa in Kenya or Alipay in China. The marriage between govtech for public services and fintech is critical. PPPs are also key for public transit services.
Water supply Adaptation & Resilience			
Integrated water management digital solutions to improve the efficiency of revenue collection and better manage water resources and infrastructure, helping to reduce losses and provide more reliable, resilient and inclusive services.	Moderate	Low. But B2B/B2G solutions are more likely to attract them than decentralised customer-facing solutions.	Public-private collaborations between government, utilities and start-ups are important. Possible role for mobile operators to support digital solutions and strong opportunities to scale.
Solid waste management Mitigation, Adaptation & Resilience			
Digital circular economy solutions across general waste management and plastic waste management value chains (collection, transport, processing, reselling, etc.).	Moderate	Moderate. Potential in optimising value chains and digitising informal work-streams linked to waste management. MNO interest in plastics, in line with their sustainability agendas.	Public-private collaborations between government, utilities and start-ups are important.
Wastewater and faecal sludge management Mitigation, Adaptation and Resilience			
Digital solutions to improve the efficiency and security of wastewater and faecal sludge collection and management.	Moderate	Moderate. Potential in partnering with mobile operators to explore value in supporting logistics-based solutions.	Public-private collaborations between government, utilities and start-ups are important.

Description of intervention areas	Maturity: Assessment of investment in sector	Potential for mobile monetisation	Role of partnerships
Data-driven urban planning Mitigation, Adaptation & Resilience			
Urban planning solutions that draw on CDR and other mobile-related big data to understand locations and movements of residents and other factors.	Low	Moderate. Sensitivities around data sharing lead to highly selective partnerships.	This sector is primarily dominated by public sector initiatives and PPPs. Role for mobile operators to share or sell relevant anonymised data to contribute to big data analytics that guide urban planning and management.
Disaster risk reduction Adaptation & Resilience			
Mobile-based early warning systems, linked to better observations provided by digital systems and sensors (e.g. of localised heat, landslides, river flow or storm surges).	Low	Moderate. Region specific and time specific (dependent on natural disaster cycle).	Universities and development agencies play a key role in research and development in partnership with governments. Private sector engagement at this stage is vital to assist in developing and managing innovative EWS at lower costs.
Disaster risk reduction Adaptation & Resilience			
Post-disaster vulnerability and damage assessment, identifying the need for urgent assistance and potential loss and damage, including through digital volunteerism.	Low	Low	Public-private collaborations between government, NGOs, corporates and start-ups are important.
Disaster risk reduction Adaptation & Resilience			
Role of mobile-enabled insurance for individuals and businesses in agriculture and other sectors, to cover losses from disasters and enable faster recovery and avoidance of poverty traps.	High	High	Corporate insurance partnerships, along with innovation labs within more mature or heavily funded regional tech companies, are critical for specific market penetration.
Disaster risk reduction Adaptation & Resilience			
Digital cash transfer solutions to help vulnerable citizens cope with shocks and stresses, especially in remote areas.	Moderate	High	Public-private collaborations between government, NGOs, development agencies and the private sector are important.
Individual climate awareness Mitigation			
Apps that promote low-carbon lifestyle information and advice, including through gamification and competition between users.	Moderate	Low to moderate	Strong incentive for building marketplace partnerships via payment gateways. PPPs are important for advocating and monitoring the cause.

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