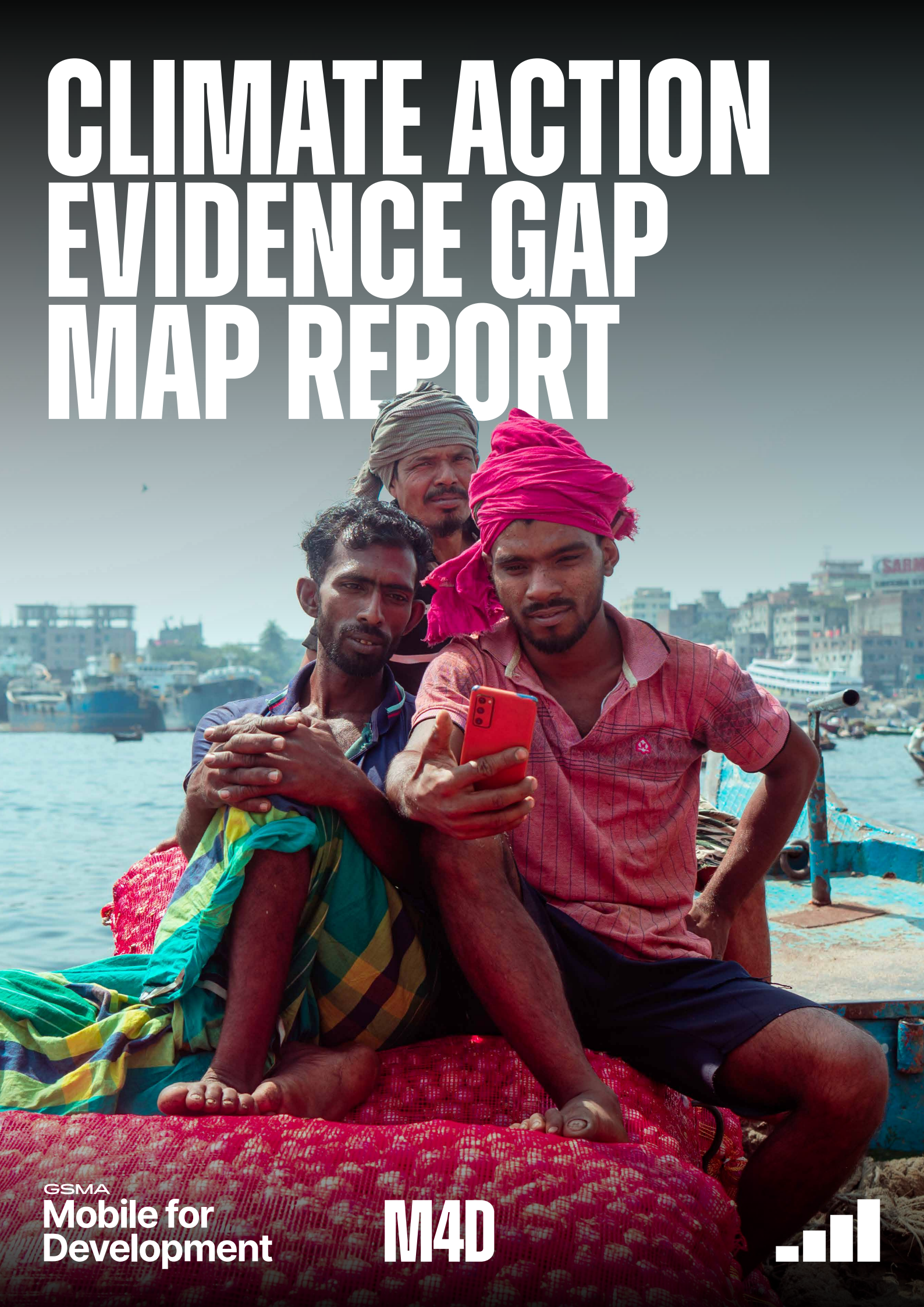
CLIMATE ACTION EVIDENCE GAP MAP REPORT



GSMA
Mobile for Development

M4D

GSMA

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

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This report has been funded by UK International Development from the UK government and is supported by the GSMA and its members. The views expressed do not necessarily reflect the UK government's official policies.

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1. INTRODUCTION



Purpose and scope of the evidence gap map

From droughts to floods and food insecurity, the impacts of climate change are intensifying for individuals and communities around the world, particularly vulnerable groups in low- and middle-income countries (LMICs) like women, smallholder farmers and the urban poor. Over the past three decades, the global community and local actors have ramped up efforts to mitigate climate change and adapt to present and future impacts. A range of technologies are proving critical to these efforts, including mobile and digital technologies, as outlined in various GSMA reports, notably *The Role of Digital and Mobile-Enabled Solutions in Addressing Climate Change*.

The GSMA Mobile for Development (M4D) team has developed an evidence gap map (EGM) to investigate and visualise the ways in which digital solutions can support climate action in LMICs. The EGM captures available and missing evidence on climate mitigation, adaptation and resilience, and sustainable resource and environmental management, among communities in Sub-Saharan Africa and South Asia.

While the benefits of mobile internet for improved climate mitigation, adaptation and resilience play an important role in the M4D programme's Theory of Change (ToC), evidence is lacking on how different population groups in different countries and regions are reaping the benefits. Having a complete picture of both the benefits and potential risks of mobile internet access will play an important role in how M4D designs its programmes. It could also make an important contribution to the mobile industry by informing future collaboration and planning, and creating a better understanding of the mobile ecosystem in LMICs and its potential role in socio-economic development.

Key research questions

The EGM addresses three key questions:

1. To what extent do digital solutions support climate mitigation, adaptation and resilience, and sustainable resource and environmental management, for people accessing mobile internet in Sub-Saharan Africa and South Asia?
2. How effective (level of contribution and extent of change – breadth of scale and depth of impact) are digital tools in improving climate mitigation, adaptation and resilience for people accessing mobile internet?
3. To what extent are digital solutions transformative in improving climate mitigation, adaptation and resilience for people accessing mobile internet?

2. METHODOLOGY



Evidence gap map process and protocol

To address these questions, a systematic review was conducted following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The process included the following steps:

Step 1: Eligibility criteria

The inclusion criteria for the systematic review were: 1) peer-reviewed journal articles; 2) studies published in English after 2015; 3) empirical research employing a qualitative, quantitative or mixed-methods approach; and 4) studies explicitly addressing mobile and digital technology, climate mitigation, adaptation and resilience, and sustainable resource and environmental management. Exclusion criteria included grey literature, theoretical papers, opinion articles and studies lacking primary data. A cut-off year of 2015 was selected, as it marks the adoption of the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement, both of which had a significant influence on global climate change research.

Step 2: Information sources and search strategy

A comprehensive literature search was conducted in Scopus, which was selected for its extensive coverage of high-quality, peer-reviewed literature across disciplines in science, technology, social sciences and humanities, providing a robust multidisciplinary dataset. TAP Room also used Scopus for its EGM study. The search was last updated on 13 November 2024.

The search terms, developed using Boolean operators and free-text keywords, followed this logic: *[mobile digital]* ***AND*** *[climate OR environment]*. The primary search strategy included the following terms:

- ***Mobile and digital technology terms:*** "mobile phone" OR "mobile* communication" OR "mobile connect*" OR "mobile device" OR "mobile computing" OR "mobile app*" OR "mobile platform" OR "mobile network" OR "mobile internet" OR "mobile data" OR "mobile money" OR "mobile payment" OR "smartphone" OR "smart device" OR "portable device" OR "WhatsApp"***AND***
- ***Climate-related terms:*** "climate change" OR "climate * mitigation" OR "climate * adaptation" OR "climate * risk" OR "climate * service" OR "climate * smart" OR "climate finance" OR "adaptive management" OR "risk assessment" OR "risk mitigation" OR "smart farming" OR "smart agriculture" OR "water management" OR "land management" OR "environmental management" OR "disaster management" OR "early warning system" OR "disaster response" OR "forestry" OR "carbon footprint" OR "carbon emission" OR "greenhouse gases" OR "biodiversity" OR "environmental conservation" OR "sustainable develop*" OR "nature-based")

This initial search yielded a total of 566 articles for screening.

Step 3:
Study selection (title and abstract screening)

Rayyan, a collaborative platform, was used for screening. To ensure reliability, each article was independently assessed by at least two of the three EGM team members. Only articles that met the following two inclusion criteria were selected: 1) explicitly mention mobile and digital technology; and 2) explicitly mention climate adaptation, resilience or risk management. Articles mentioning mobile and digital technology only in recommendations or focusing on technology development (e.g. telecoms, cybersecurity, 5G networks, algorithm modelling) were excluded. Articles focusing on climate-related topics (e.g. tree imaging, riverbank filtration systems, carbon trading) without explicit relevance to mobile or digital technology were excluded. Discrepancies were resolved through discussion. 132 articles were selected for full text screening.

Step 4:
Additional study identification (snowballing and 3ie EGM review)

To ensure thoroughness, two complementary approaches were used: snowballing techniques and reviewing EGMs developed by 3ie (International Initiative for Impact Evaluation).

Snowballing techniques were used to identify relevant studies that may not have appeared in the initial database search. This process included:

1. Manual reference screening of review articles identified in Step 3, ensuring foundational and influential works in the field were included.

2. Citation network analysis using ResearchRabbit, an AI-powered tool, to track citation patterns and identify key studies connected to those already included. This helped uncover research that aligned with the study's thematic focus but might not have been directly captured by the keyword search.

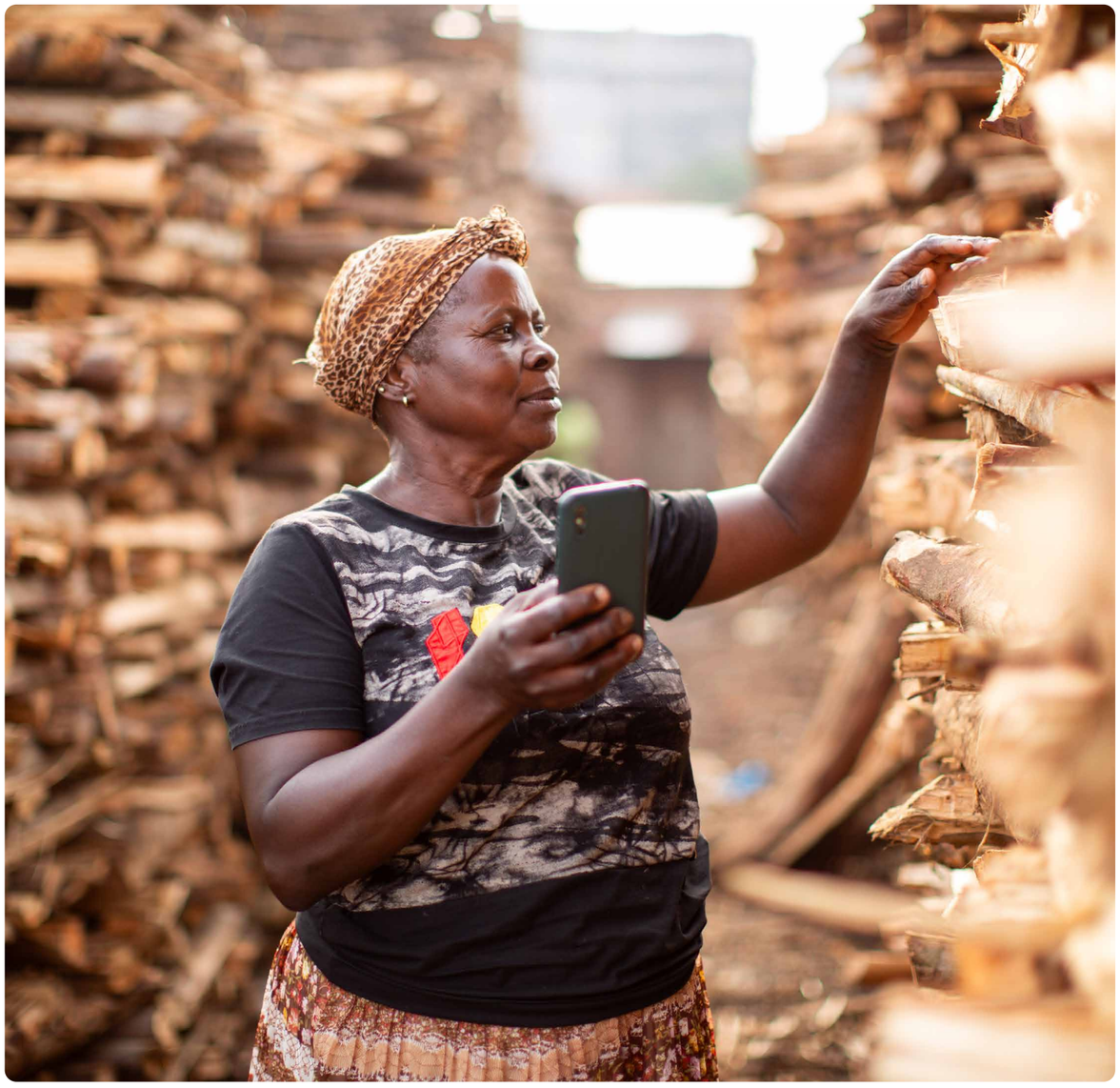
3. Google Scholar's "Related Articles" function allowed for the expansion of citation networks and helped capture studies from journals that may not be indexed in Scopus. For each method, one team member screened the first two pages of search results, selecting titles that aligned with the scope of the study. Abstracts of these articles were then assessed using the same inclusion criteria as in Steps 1 and 3. Through this approach, nine additional studies were identified for full text screening.

To expand the evidence base, the team systematically **reviewed two 3ie EGM reports** that provided structured assessments of research evidence on climate resilience and adaptation: *Building resilient societies in low- and middle-income countries* and *Land-use change and forestry programmes in low- and middle-income countries*. Both reports were screened using the inclusion criteria outlined in Steps 1 and 3. From these reports, 18 additional studies were identified for full text screening.

The final list of articles obtained through keyword search and snowballing was cross-validated to eliminate duplicates and ensure they were relevant to and coherent with the focus of the study.

Step 5:
Data extraction and synthesis

A total of 146 articles were extracted for full text analysis and coding using EPPI-Reviewer, a web-based software for analysing systematic reviews that facilitates collaborative and transparent analysis. Full text analysis resulted in the exclusion of two studies, **leaving a final total of 144 studies in the EGM**. The extracted data included four categories agreed in advance with the GSMA, which is outlined in the framework below. The extracted data was used to create an EGM visualisation using Eppi-Mapper. A narrative synthesis was conducted to summarise insights across studies, which is also found later in this document.



3. EVIDENCE GAP MAP FRAMEWORK



Outcomes

This section outlines and defines the outcome categories in the evidence gap map. These represent the changes that climate technologies may drive. These are organised on the x-axis of the EGM.

Each outcome is essentially a question: do we have evidence that a particular intervention leads to this particular change? The map then shows, for each intersection of intervention and outcome, whether strong evidence exists, weak or limited evidence exists, or whether there is a gap.

Climate finance

- **Individual access:** An individual is able to access financial resources to implement actions related to climate adaptation and/or mitigation.
- **Local collective access:** A set of actors (e.g. community-based organisation, local government) is able to access financial resources to implement actions related to climate adaptation and/or mitigation.

Climate change mitigation

- **Access to low carbon energy:** An individual or group gains or increases access to energy from renewable sources.
- **Decreased emissions:** Carbon or other greenhouse gas emissions decrease.
- **Increased emissions:** Carbon or other greenhouse gas emissions decrease.

Addressing climate vulnerabilities[1]

- **Individual or household:** A decrease in the factors that put individuals or households at risk of adverse effects of climate change, including climate variability and extremes.
- **Collective:** A decrease in the factors that put groups, communities and other collective actors at risk of adverse impacts due to climate change, including climate variability and extremes.
- **Structural:** A shift in the structural or root cause factors – economic, social, political and/or institutional – that put populations at greater risk of adverse effects of climate change, including climate variability and extremes.
- **Gender sensitive:** A shift in the gender-related factors – economic, social, political and/or institutional – that put individuals, collectives and/or populations at greater risk of adverse effects of climate change, including climate variability and extremes.

Climate change adaptation

- **Maladaptation – Individual or household:** Climate adaptations that do not address and/or inadvertently exacerbate vulnerabilities of individuals or households.
- **Maladaptation – Collective:** Climate adaptations that do not address and/or inadvertently exacerbate vulnerabilities of communities, other groups and/or institutions.

1. The United Nations Framework Convention on Climate Change (UNFCCC) defines vulnerability as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity”. (UNFCC Glossary)

- **Anticipatory – Individual or household:** Ability of individuals or households to anticipate and reduce the impact of climate variability and extremes through preparedness and planning.
- **Anticipatory – Collective:** Ability of communities, other groups and/or institutions to anticipate and reduce the impact of climate variability and extremes through preparedness and planning.
- **Absorptive – Individual or household:** Increased ability of individuals or households, due to increased skills and/or resources, to face and manage adverse climate conditions or disasters.
- **Absorptive – Collective:** Increased ability of communities and/or other groups or institutions, due to increased skills and/or resources, to face and manage adverse climate conditions or disasters.
- **Incremental – Individual or household:** Includes modest shifts in processes, decisions, actions, resources, tools, skills, etc. by individuals or households that address the manifestations of climate change they face, but do not (on their own) meaningfully address the underlying causes of their vulnerability.
- **Incremental – Collective:** Includes modest shifts in processes, decisions, actions, resources, tools, skills, etc. by communities, other groups or institutions that address the manifestations of climate change they face, but do not (on their own) meaningfully address the underlying causes of their vulnerability.
- **Resilience – Incremental:** Includes modest shifts in processes, decisions, actions, resources, tools, skills, etc. by collective actors (communities, other groups and/or institutions) that address the underlying causes of vulnerability in the system in which they are embedded.
- **Resilience – Transformational:** Includes significant shifts in processes, decisions, actions, resources, tools, skills, etc. by collective actors (communities, other groups and/or institutions) that meaningfully address the underlying causes of vulnerability in the system in which they are embedded.

Environmental and natural resources management

- **Environmental preservation/ecosystem health:** The preservation or improvement of specific ecosystems or natural resources.
- **Collective management:** Includes the processes, capacities and/or tools for local communities, other groups and/or institutions to manage their environmental and natural resources.
- **Livelihood benefits:** Individuals, households, communities and/or other groups maintain and/or improve their livelihoods directly (e.g. forestry or ecotourism) or indirectly (e.g. agriculture) related to the environment and natural resources.

Cross-cutting outcomes

- **Efficiency:** Climate actions, programmes, etc. able to maintain or increase effectiveness with fewer inputs (e.g. financial or human resources).
- **Scale:** Climate actions, programmes, etc. able to reach wider populations and/or geographies and/or higher levels of governance (e.g. national or regional).
- **Inclusiveness:** Climate actions, programmes, etc. that are more inclusive and representative of diverse populations, particularly historically marginalised groups.
- **Governance – Access to information**: Information related to climate change, finance, programmes, outcomes, etc. is more accessible to directly and indirectly affected individuals and groups.
- **Governance – Public participation:** Spaces for dialogue, coordination and decision-making related to climate change, finance, programmes, outcomes, etc. that are more accessible to directly and indirectly affected individuals and groups.
- **Governance – Accountability:** Decision-makers and power holders responsible for climate change, finance, programmes, outcomes, etc. that respond to public concerns and priorities and/or are subject to impartial oversight.



Roles and uses of mobile and digital technology

Connecting to other actors

- **Awareness:** Individuals or groups have more access to information about other relevant actors (e.g. farmers seeing profiles of other farmers, but not interacting with them).
- **Communicating:** Individuals or groups are able to connect with and communicate with other actors.
- **Coordinating, collaborating and/or co-creating:** Individuals or groups are able to communicate for the purposes of coordination, collaboration and/or co-creation.
- **Collective decision-making:** Individuals or groups are able to communicate for the purposes of collective decision-making.

Information provision

- **Individualised:** Individuals receive or have improved access to information about climate impacts, actions, programmes, resources, etc.
- **Horizontal/participatory:** Individuals or groups share information about climate impacts, actions, programmes, resources, etc.
- **Vertical:** Information that is accessed or provided by an external source (e.g. from the internet, government institution, business, etc.).

Resources/services

- **Financial:** Includes mobile money, loans and other financial services.
- **Livelihood:** Relates directly to maintaining or improving livelihoods (e.g. agricultural advisory services).
- **Public/private services:** Services including health, water, sanitation, etc. provided by a public or private entity to individuals, groups, communities, etc.
- **Ecosystem/nature:** Includes resources and/or services related to the preservation or improvement of specific ecosystems or natural resources.
- **Survival:** Resources or services related to emergency response to climate-related natural disasters.

Data generation

- **Horizontal/participatory:** Individuals or groups collectively generate information about climate impacts, actions, programmes, resources, etc. (e.g. crowdsourcing).
- **Vertical:** Individuals or groups provide information to an external actor (e.g. government institution, business, etc.).
- **Voluntary:** Individuals are aware of and agree to provide and share information.
- **Involuntary:** Individuals are unaware and/or involuntarily provide and share information (e.g. accessing mobile phone data records).

Other

- **Remote connection/monitoring:** Using the Internet of Things (IoT) to remotely monitor and control an element or system (e.g. irrigation system, home energy system).
- **Big data/machine learning:** Generating, consolidating and/or analysing large data sets, including through machine learning and AI.
- **Transparency of transactions:** Use of technology (e.g. blockchain) to ensure transparency and fidelity of electronic transactions.

Enablers and constraints to access, uptake, use and impact of mobile and digital tools and services for climate action and outcomes

Access and uptake of mobile and digital tools and services

- **Existing infrastructure/coverage:** Extent of mobile infrastructure and/or mobile service coverage
- **Access to smartphone devices:** Ability to access a smartphone device, either own or shared (e.g. family)
- **Access to mobile services:** Ability to access mobile services, including affordability
- **Age:** Age-related enablers or constraints
- **Gender:** Gender-related enablers or constraints
- **Awareness/education/training:** Enablers or constraints related to awareness, education and/or training
- **Livelihood:** Livelihood-related enablers or constraints
- **Income:** Income related-enablers or constraints
- **Social/cultural:** Social and/or cultural-related enablers or constraints
- **Institutional/governance:** Institutional and/or governance-related enablers or constraints



Use and impact of digital mobile for climate action

- **Age:** Age-related enablers or constraints
- **Gender:** Gender-related enablers or constraints
- **Awareness/education/training:** Enablers or constraints related to awareness, education and/or training
- **Livelihood:** Livelihood-related enablers or constraints
- **Income:** Income related-enablers or constraints
- **Social/cultural:** Social and/or cultural-related enablers or constraints
- **Institutional/governance:** Institutional and/or governance-related enablers or constraints
- **Economic/financial:** Economic and/or financial-related enablers or constraints

Target actors and users of mobile and digital tools and services for climate action and outcomes

Individuals

- **Men/women:** Male or female-specific users and/or targets
- **Youth/elderly/PWDs/Indigenous Peoples/ other underrepresented groups**
- **Urban/rural:** Urban or rural-specific users, targets and/or geographies
- **Coastal/arid:** Coastal or arid-specific users, targets and/or geographies
- **Environmental/natural resources-dependent groups** (forestry, fishing, etc.)

Collectives

- **Cooperatives or associations:** Collective citizen organisations by identity group, livelihood, locality, etc.
- **Communities:** Self-identifying geographically-defined communities
- **Small enterprises:** Formal or informal small businesses
- **Non-governmental organisations (NGOs):** Formal or informal non-profit/non-governmental organisations

Government

- **National:** National government actors and institutions
- **Local:** Subnational government actors and institutions
- **Programme or sector:** Public/governmental programme or service sector (e.g. health, agriculture, etc.)



4. FINDINGS



Research questions

1. *To what extent do digital solutions support climate mitigation, adaptation and resilience, and sustainable resource/environmental management, for people accessing mobile internet in Sub-Saharan Africa and South Asia?*

- The empirical evidence documented in the studies included in the EGM indicate a range of positive outcomes, primarily related to climate change adaptation. This generally holds true for studies of populations in Sub-Saharan Africa and South Asia more specifically.

- The evidence is most robust for the use of mobile and digital technologies to provide information to individuals and households from external sources or actors, for example, a government institution. There is also evidence of the use of mobile technologies for communication between individuals.

- With respect to the communication and (especially) information provision roles of mobile and digital technologies, the evidence points most strongly to climate adaptation outcomes. Specifically, outcomes related to incremental gains in anticipatory and absorptive adaptation on the part of individuals and households. There is significantly less evidence related to outcomes of strengthened collective adaptive capacities and little evidence of improved resilience overall.

- There is some evidence that directly or indirectly indicates that some climate change vulnerabilities, primarily of individuals or households (although with some evidence related to collective climate vulnerabilities), are addressed through the use of mobile and digital technologies. However, there are some studies that point to gains in adaptive capacities without evidence of whether climate vulnerabilities were identified or addressed. In general, there is not a strong or explicit emphasis on identifying, analysing and addressing climate change vulnerabilities in the literature catalogued in the EGM.

- There are a small number of studies that identify outcomes related to environmental and ecosystem health and preservation through the use of mobile technologies for communication, information generation, information provision and/or environmental services.

- This suggests that, consistent with the accompanying literature review, mobile and digital technologies on their own can contribute to incremental positive outcomes for individuals and households. There is little evidence of mobile and digital technologies being used to contribute to more holistic and systemic climate action that targets the (root) causes of the climate vulnerabilities of communities or broader population groups (i.e. transformational climate change outcomes, see the next section).

2. *How effective (level of contribution and extent of change – breadth of scale and depth of impact) are digital tools in improving climate mitigation, adaptation and resilience for people accessing mobile internet?*

- Answering this question fully would require a full systematic review of the literature included in the EGM. However, given the thin evidence for most outcomes, uses of mobile and digital technology and enabling/constraining conditions, it is unlikely that a systematic review would be possible. Or, it would produce extremely tentative findings at best.

- As mentioned, there is relatively robust evidence for specific improvements in incremental climate change adaptations (anticipatory and absorptive) on the part of individuals and households. The most common driver of improved adaptive capacity is the provision of information from an external source, often efficiently and at scale. Thus, there is relatively robust evidence of the role of mobile and digital technologies in effectively providing information to individuals and households that contribute to their ability to anticipate and/or absorb climate change shocks.

- However, the extent of change, particularly depth of impact, is difficult to determine based on the limitations of many of the studies to define and assess impacts, particularly beyond the limited duration of most research. That said, some studies do provide higher quality evidence of specific outcomes in particular contexts or conditions.

- There is much less evidence of the effectiveness of mobile and digital tools in other areas of climate change action and outcomes.

3. *To what extent are digital solutions transformative in improving climate mitigation, adaptation and resilience for people accessing mobile internet?*

- The empirical evidence catalogued in the EGM does not indicate transformative change in mitigation, adaptation and resilience for people accessing mobile internet. One partial exception is found in a study that documents the use of a mobile app for securing land tenure, although this process was mediated by social and institutional enabling and constraining factors.

- Transformational outcomes for climate change mitigation, adaptation and resilience involves systemic changes that address the root cause of climate vulnerabilities (as discussed in the accompanying literature review). This includes gender dimensions of climate vulnerability, which are absent in the EMG studies that generally underemphasise gender (as noted in the following section). The empirical evidence in the EGM studies is strongest for the use of mobile and digital technology for individual or household-specific changes, particularly in information provision to enable or strengthen anticipatory and/or absorptive capacities, as discussed above. These are positive contributions to climate change adaptation, but fall short of what is generally understood to be required for transformational change.

- Most of the empirical studies included in the EGM are relatively narrowly focused on specific technologies, their uses and resulting outcomes, rather than the more complex systems that reinforce climate vulnerability.



5. EVIDENCE GAPS



Gender

Generally, there is a lack of attention to gender in the studies and evidence catalogued in the EGM. nly 17 studies consider gender enablers or constraints on access, use and/or impact of mobile and digital technologies for climate action. Only nine studies explicitly include women as a population category. None of the studies specifically identify and assess gender-related climate vulnerabilities. Thus, there is a significant gap in the empirical evidence for the gender dimensions of mobile and digital technology for climate action.

Cutting-edge technologies

In general, there were few empirical studies of frontier technologies such as IoT, machine learning/AI and blockchain. IoT was the most studied of these technologies. Of the 11 studies included in the EGM, more than half focused on individual, household or collective absorptive adaptation capacities. Two studies assessed the use of machine learning, both to analyse photos taken by smartphones and provide insights to the user. Only one study focused on blockchain technology for climate change mitigation through peer-to-peer energy trading. None of the studies included in the EGM involved big data and machine learning/AI, despite growing literature in this area.

The likely explanation is that the vast majority of existing studies of frontier technologies for climate action focus on models or prototypes rather than empirical evidence of use and outcomes, which may take several years to carry out and publish in the academic literature. Thus, we can expect that such evidence will grow in the coming years, although likely with some of the same limitations observed in the current literature in the EGM.

Mobile and digital technologies used in broader, more holistic climate action strategies

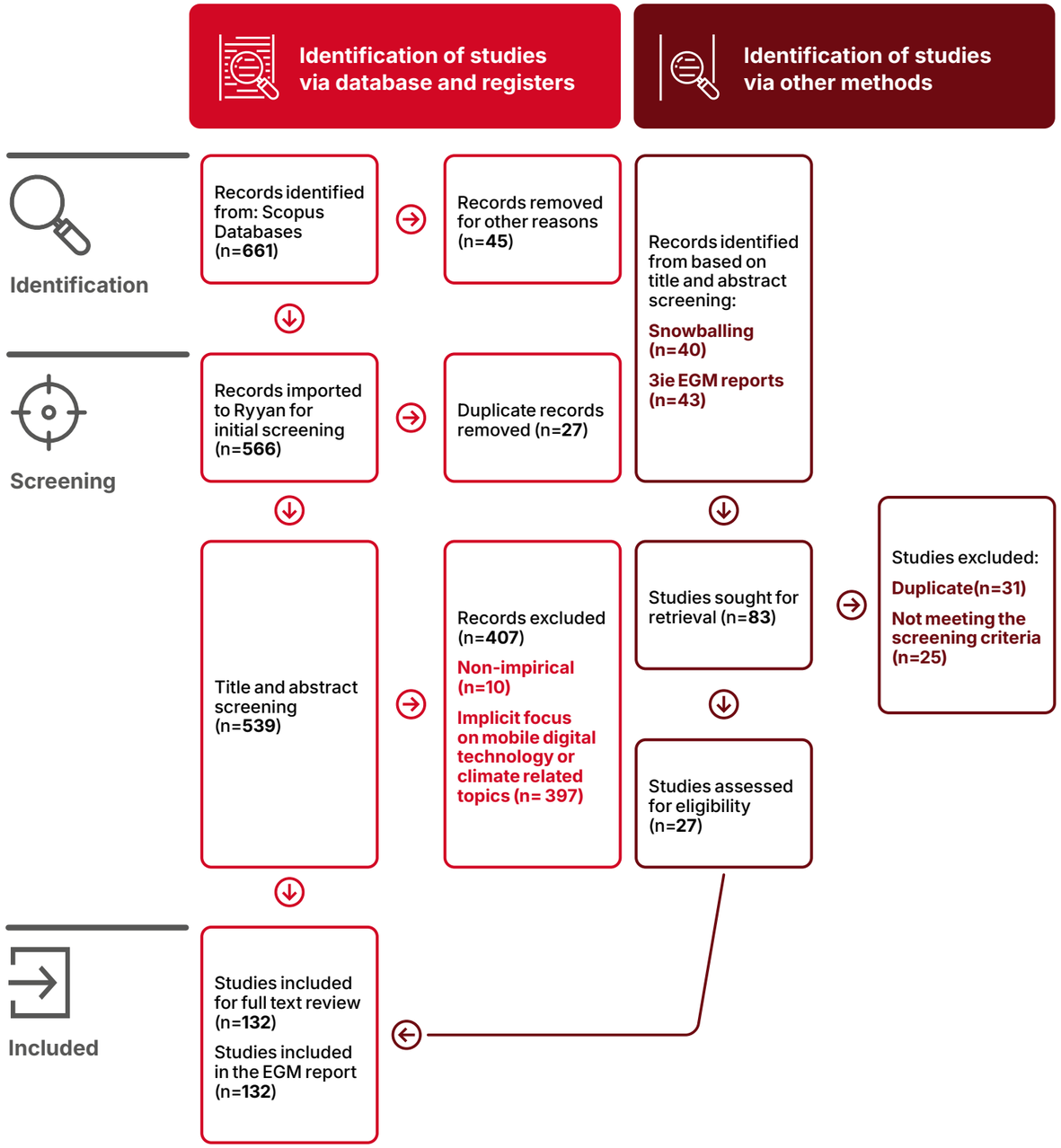
Most of the studies in the EGM focus specifically and narrowly on a particular technology, population and outcome, with some attention to enabling and constraining factors and other considerations. However, relatively few studies look at the everyday uses of mobile and digital technologies in the context of climate change. Even fewer studies examine mobile and digital technology as one tool in a broader climate action toolkit. Or, in other words, how mobile and digital technologies are being leveraged in more holistic climate action strategies.

Broader evidence on climate action, including that included in the accompanying literature review, emphasises the need for such holistic strategies for meaningful climate change outcomes. This reflects a technology/solution-centric approach in much of the included empirical literature, rather than a broader perspective on the systems in which technologies are being used in the context of climate change. The lack of such perspectives in the empirical literature constitutes a significant knowledge gap in how mobile and digital technologies are most often used and how they can contribute most effectively to positive climate change outcomes.



ANNEX 1

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) process



Source: Page, MJ, et al. (2020). "The PRISMA 2020 statement: an updated guideline for reporting systematic reviews". *The BMJ*. 372:n71.

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