GSMA

Measuring the Impact of Digital Innovation on Climate Resilience in Cities

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GSMA

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Introduction



As climate-related stresses intensify, building climate resilience in urban contexts has become increasingly urgent. Nearly 60% of the global population lives in cities, a figure that is expected to reach 70% by 2050.[1] Many urban dwellers—particularly those in informal settlements—face heightened vulnerabilities due to insecure housing, inadequate infrastructure and limited access to essential services such as clean water, energy and healthcare. These challenges are even more pronounced in secondary cities in low- and middle-income countries (LMICs), where rapid urbanisation, governance constraints and financial limitations make resilience-building complex.

Digital solutions offer promising pathways to enhance climate resilience by improving access to information, optimising resource management and strengthening early warning systems (EWS). Tools such as mobile alerts, geospatial platforms and Internet of Things (IoT)-based infrastructure monitoring can help governments, institutions and households[2] anticipate, prepare for and respond to climate risks. However, despite increasing investment in digital solutions, their impact on household-level climate resilience remains underexplored.

Understanding the role of digital solutions in driving meaningful climate resilience outcomes is essential. Without robust monitoring and evaluation frameworks, it is difficult to identify best practices, scale effective interventions, or ensure equitable access across diverse urban populations. This gap in evidence affects our ability to address the unique challenges of intermediary cities and invest in high-impact innovations. Furthermore, as climate change, urbanisation and technology rapidly evolve, so too must our approaches to learning and adaptation.

Current literature on climate resilience emphasises theoretical frameworks and indices for planning, with limited frameworks and tools for measuring the effects of interventions on climate resilience, especially in cities or at the household level. Themes pertaining to the measurement of climate resilience centre on assessing the ability of digital innovations to effectively build anticipatory, adaptative and absorptive capacities with a multi-sector approach to resilience outcomes. This capacity is measured through indicators of infrastructural, social, economic and environmental factors, as well as governance. Measuring these capacities also needs to account for specific exposures and vulnerabilities faced by populations in cities in LMICs, with a focus on ensuring equity.

By examining the intersection of digital innovation and urban climate resilience, this analysis aims to identify how we can measure the impact of digital tools that support climate adaptation and recovery in vulnerable communities. This analysis suggests that focusing on households will provide the best unit of analysis for understanding the effects of digital innovations on building climate resilience capacities.

1. UN-Habitat. (2022). World Cities Report 2022. Envisaging the Future of Cities.

2. OECD definition: "Either an individual person or a group of persons who live together under the same housing arrangement and who combine to provide themselves with food and possibly other essentials of living."

How digital innovations impact climate resilience in cities



Digital innovations play a crucial role in enhancing climate resilience in cities by empowering individuals, communities and city governments with innovative tools and data-driven solutions. They facilitate efficient resource management, improve infrastructure resilience, and enhance communication and collaboration, strengthening the capacity of cities to adapt to, mitigate and withstand the impacts of climate change.

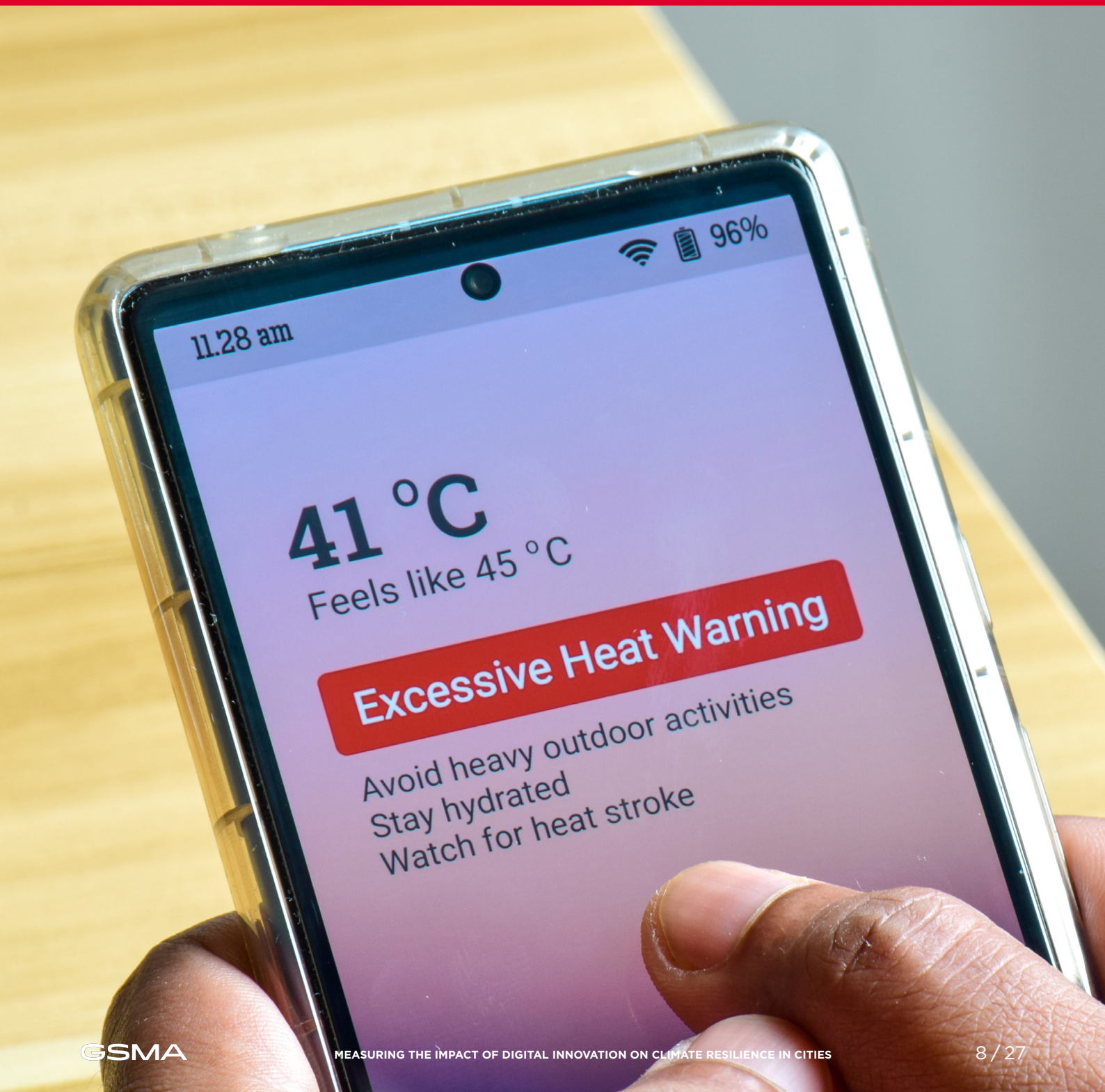
At the city level, digital solutions can enhance climate resilience through improved infrastructure management and data-driven decision-making. For example, smart meters and sensors can optimise resource allocation, reduce energy consumption, and enable EWS for extreme weather events. These technologies help cities adapt to climate change by preparing for and mitigating its effects.

At the community level, digital solutions can foster collaboration, knowledge sharing and access to information, enabling communities to actively participate in climate resilience initiatives. Mobile technologies also provide channels for communication during emergencies, facilitating rapid response and coordination among community members. By strengthening community organisation and information dissemination, digital solutions enhance the ability of communities to anticipate, absorb, recover and adapt to climate change impacts. They also present communities with the tools to monitor and report environmental changes, contributing to localised decarbonisation and nature-positive solutions.

At the household and individual level, digital solutions empower individuals with personalised information and tools for climate adaptation and recovery. Access to real-time weather information, EWS, and climate advisory services through mobile devices enables individuals to make informed decisions to protect their livelihoods and well-being. Digital platforms can also facilitate access to financial resources, insurance mechanisms and credit, strengthening the capacity of individuals to cope with and recover from climate-related shocks.



Understanding our impact on household climate resilience



Designing and evaluating digital tools with the needs of end-users in mind is essential. Centring individuals or households ensures that digital solutions are technically robust, equitable, accessible and contextually relevant. Urban households, particularly those in vulnerable communities, face diverse challenges such as limited digital literacy, language barriers and resource constraints. Urban households are the most vulnerable to the effects of climate change on their quality of life and livelihoods. While much of the literature focuses on the development of climate resilience at the city level, centring households provides insights into the real-world impact of innovations in digital solutions across diverse settings. Individuals and households are at the forefront of adapting and absorbing, and thus need to be both part of the solution and considered as the unit of change.

The GSMA is interested in growing the body of knowledge on the social impact of digital startups. However, without situating household or individual level changes within a broader framework of measurement and value, it will be challenging to understand the social impact being made, including both the intended and unintended consequences.

A robust Monitoring, Evaluation and Learning (MEL) framework is essential to ensure that climate resilience-building interventions in urban contexts are effective, equitable and adaptable over time. MEL provides a structured approach to assess whether initiatives are meeting their goals, identify areas for improvement, and adapt strategies to dynamic urban realities. As highlighted by the World Bank's Resilient Cities initiative,[4] MEL fosters accountability and inclusivity, ensuring that the perspectives and needs of urban households are centred in resilience efforts. A MEL framework facilitates learning by asking questions around effectiveness and worth, which are essential when working in emerging areas such as digital innovation. Developing MEL frameworks and approaches aids in understanding what is working, what is not, and where to invest time and resources.

> **. . . the assessment of resilience is fraught with complexity: both the definition of resilience and the methodologies used to measure it are heavily contested. Confounding factors, such as what mix of indicators to choose, which systems and scale of analysis to apply, and how to recognise the context-specific nature of resilience each muddy the waters.[3]**
>
> Cumming *et al.* 2005

Most current approaches to measuring climate resilience in cities incorporate quantitative and qualitative metrics to create an index or scorecard to track progress and to plan interventions. These approaches incorporate metrics ranging from investments in resilient infrastructure to assessing the social capital of communities. Only the Resilience Assessment Benchmarking and Impact Toolkit (RABIT) Handbook[5] looks specifically at the role of information and communication technologies (ICT) in urban climate resilience, although other frameworks incorporate elements of digital solutions. Few measure changes at the household level, and those that do are not focused on digital innovations.

3. Jones. L., & Tanner, T. (2015). Measuring 'Subjective Resilience': Using Peoples' Perceptions to Quantify Household Resilience. SSRN Electronic Journal.
4. World Bank. Monitoring, Evaluation and Learning Framework (English). Washington, D.C.: World Bank Group.
5. Ospina, A.V., & Heeks, R. (2016). Resilience Assessment Benchmarking and Impact Toolkit (RABIT) Implementation Handbook. NICCD.

The following are key considerations for MEL in measuring climate resilience:

1. The critical role of human, social, and financial capacity-building, including access to information and decision-making at the household level.
2. The need to link measurement to a systems approach by designing frameworks across sectors for a holistic understanding of households within a city ecosystem.
3. The importance of MEL as an approach to understanding how different solutions bring about outcomes based on improved well-being after a climate stress or shock.
4. The value of applying an intersectional lens to measurement frameworks, given the cross-sectoral nature of climate resilience interventions, by combining methodologies from across the social sciences.
5. The necessity of including beneficiaries in MEL processes to ensure a contextualised and specific understanding of vulnerabilities and effects.
6. The importance of considering changing urban contexts in MEL approaches, along with the continual maintenance of effects.

One novel approach is to measure 'subjective resilience.' This is the idea that households have individual needs, take specific action to adapt and build resilience, and can describe the changes either in their own households or within the community. These are the individual's assessment of their own livelihoods, capacities and well-being. Measuring subjective resilience will require both quantitative lines of inquiry and costly and time-intensive qualitative data collection to gain the richest data.[6]



6. Jones. L., & Tanner, T. (2015). Measuring 'Subjective Resilience': Using Peoples' Perceptions to Quantify Household Resilience. SSRN Electronic Journal.

How to measure climate resilience in urban centres



There is no single way to measure climate resilience in cities. Each toolkit or scorecard emphases different actors and outcomes in the short- and medium-term. However, some key insights from the literature have emerged:

- **Target audience:** There is a clear emphasis on tools for local governments, national responses and increasingly, communities, reflecting their crucial role in urban resilience. Practitioners and strategists also have access to tailored toolkits such as RABIT.
- **Methodological diversity:** Methodologies range from diagnostic approaches (e.g. the UN-Habitat CRPT or City-RAP tool)[7] to mixed-method assessments (RABIT, the US EPA tool),[8] and big data analysis (e.g. mobile big data, GSMA), reflecting the complexity of resilience approaches and measurement. Many of these combine diagnostic, planning and measurement into the same tool.
- **Mixed methods:** Most methodologies employ both qualitative and quantitative data.
- **Level of analysis:** While many assessments focus on the city-wide level, some also examine community-level dynamics (e.g. RABIT, CRMC[9]). They can include individual or household level indicators, but are most often a way to understand change at the community level. The BRiCS Consortium have divided their impact measurement into area communities and participant communities to better understand the direct and indirect impact of climate resilience building activities.[10]
- **Indicators at beneficiary level:** In many tools, indicators at the individual level are focused on formal economies and land use. In the case of intermediary cities, adapting these to informal settings will be crucial. Where EWS and other anticipatory action is happening, many tools look at risk reduction at the community level, but rarely in cities or at the individual level.
- **Indicators:** Indicators vary but commonly include infrastructural, social, economic and environmental factors, as well as governance and capacity.



7. UN-Habitat. (2018). City Resilience Proofing Tool.
8. US EPA. (2018). Evaluating Urban Resilience to Climate Change: A Multi-Sector Approach.
9. Zurich Climate Resilience Alliance, (2013) Climate Resilience Measurement for Communities
10. Toplic, L. (2022). Digital for Climate Adaptation and Resilience of Vulnerable Communities. NetHope.

Table 1
Comparing adaptive capacities between rural and urban contexts

Category	Rural context	Urban context
Key climate risks	Droughts, flooding, soil degradation, crop failures, heat stress	Heatwaves, flooding, water scarcity, infrastructure failures, pollution
Types of adaptive capacities	— Natural capital (land, water resources, biodiversity) — Social capital (community cohesion, indigenous knowledge) — Livelihood diversification (agriculture, pastoralism, small trade)	— Infrastructure resilience (housing, transport, utilities) — Economic adaptability (job flexibility, access to financial services) — Institutional support (municipal planning, social protection)
Vulnerabilities	— High dependence on natural resources — Limited access to formal markets and services — Poor connectivity and isolation from decision-making	— High population density and informal settlements — Overstressed infrastructure and basic services — Economic inequality and precarious livelihoods
Governance and institutions	— Traditional/local governance structures — Limited presence of government agencies — Reliance on community-driven adaptation	— Formal government institutions (municipalities, utility providers) — More access to policy frameworks and climate action plans — Greater reliance on public services
Digital solution uptake	— Lower internet/mobile penetration — Reliance on radio, SMS-based alerts and community networks — Limited access to real-time climate information	— Higher smartphone and internet access — Greater use of apps, digital payments and real-time climate monitoring — Integration of smart technologies (e.g., IoT for air quality, energy grids)
Measurement indicators	— Percentage of households with diversified income sources — Access to climate-resilient seeds, farming techniques or irrigation — Participation in community-based disaster preparedness — Mobile ownership and access to climate information	— Percentage of households with climate-proofed housing — Access to emergency services and financial support — Adoption of energy-efficient and water-saving technologies — Use of digital financial tools for climate adaptation (e.g. microinsurance)
Social and economic resilience	— Strength of informal safety nets (kinship, barter systems) — Migration as a coping strategy — Localised food security measures	— Job flexibility and access to employment alternatives — Social protection schemes (e.g. urban cash transfer programmes) — Household financial savings and insurance uptake
Infrastructure and services	— Access to climate-resilient roads, electricity and irrigation — Availability of climate-smart storage and transportation for goods	— Strength of transport networks and household infrastructure — Access to reliable energy, water and sanitation systems — EWS for heatwaves, floods and air pollution
Data collection methods	— Household surveys, participatory rural appraisals — Satellite imagery for land use and agricultural monitoring — SMS-based self-reporting systems	— Mobile and sensor data for climate exposure — Urban household surveys and administrative data — Crowdsourced data from digital platforms (e.g., heat mapping, air quality sensors)

Key themes to consider when measuring impact in urban climate resilience



To effectively measure the impact of digital solutions on climate resilience in urban areas, we must focus on holistic, equity-centred and data-driven approaches. There are four key areas of focus at the household/individual level:

1 Building capacities through digital innovation

In both rural and urban contexts, different types of digital solutions will address the broad range of climate resilience outcomes of interest. In the short- and medium-term, these innovations will likely be aimed at fostering certain capacities for climate resilience, with the longer-term impact being seen only once a climate disruption has occurred. For example:

- EWS (Anticipate): Assess the access and adoption (short-term outcomes) and effectiveness (long-term outcome) of mobile-based alerts for extreme weather events.
- Climate-smart financial services (Absorb): Measure the adoption (short term) and impact (long term) of mobile money, insurance and credit services that help households recover from climate shocks.
- Smart infrastructure and IoT (Adapt): Track the role of digital technologies in improving energy efficiency, water management, and air quality as part of a change in capacities (short and long term, in the context of the most vulnerable).
- Data-driven decision-making: Evaluate how digital platforms (e.g. artificial intelligence (AI), big data) support urban planning and disaster preparedness (short term), and how these changes impact on households (long term).

Fostering and measuring climate resilience should recognise that each household displays different risks and vulnerabilities. These can either be thought of in aggregate, as a community, or at the household level. Given the nuances in household risks, measuring changes in climate resilience runs the risk of missing solutions that will not fit a proportion of households and might even increase their risk, e.g. having access to finance/loans. See Table 1 for the differences between urban and rural household capacities and vulnerabilities.

2 Ensuring no one is left behind

- Access and inclusion metrics: Analyse who benefits most from digital climate solutions, ensuring marginalised groups (women, low-income communities, people with disabilities) are not excluded.
- Affordability and digital literacy: Examine barriers to technology adoption, such as cost and skills gaps and the extent these gaps are closed through the digital solution.
- Localised and community-led solutions: Consider whether solutions are co-created with local communities, and if they have cultural and contextual relevance.

3 Addressing uniqiue urban challenges in LMICs

— Infrastructure and connectivity: Measure digital access and infrastructure gaps in informal settlements and low-income neighbourhoods, and how digital solutions (and digital financial inclusion) are plugging the gaps.

— Resilience in the informal economy: Since many urban dwellers in LMICs work informally, evaluate how digital tools help them adapt to climate risks (e.g. extreme heat, flooding), with a longer-term assessment on how households have been able to maintain their livelihoods after a climate shock.

— Public-private collaboration: Track how mobile network operators (MNOs), governments and NGOs coordinate efforts to enhance resilience within informal settlements or migrant households.

4 Assessing vulnerability at the household level

— Household climate adaptation strategies: Assess whether individuals or households use digital tools to make climate-resilient choices (e.g. accessing financial aid, modifying housing).

— Health and well-being: Measure how digital solutions mitigate climate-related health risks, particularly for vulnerable populations (e.g. elderly, pregnant women). This could include mitigating infectious disease risks, or climate phenomena such as heatwaves.

— Behavioural change: Evaluate shifts in climate-conscious behaviours, such as energy efficiency, waste reduction and sustainable transport adoption. This might be more pertinent at the mitigation level.[11]



11. See: https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-for-development/climatetech/greenglossary/. Accessed 13 March 2025.

Using digital solutions to build climate resilience in urban contexts and in cities



Digital solutions contribute to climate resilience in diverse ways, addressing different aspects of adaptation, early warning, financial protection and recovery. To measure their impact, a clear causal chain or theory of change must be established that links digital interventions to climate resilience outcomes. This includes identifying how these solutions enhance individual, household and community capacities—such as access to timely climate information, financial preparedness, or improved decision-making—and how these capacities translate into reduced vulnerability and better coping mechanisms (absorptive capacities) when climate shocks occur.

Given the challenges LMICs face, a key focus of measurement should be on equity, particularly in intermediary cities of LMICs where climate risks disproportionately affect marginalised populations. Digital innovations must be assessed for their overall effectiveness, accessibility and inclusivity, ensuring that the most vulnerable benefit.

As with most digital solutions, short-term result areas of access and adoption measures remain central to understanding how change happens for beneficiaries of digital solutions. This sits within a chain of results, as seen in Figure 1.

Figure 1
Illustrative causal chain for digital solutions in building climate resilience



A brief examination of the causal chain assumes that users can access the digital platform, that it ameliorates a problem for them or suits their contextual needs (relevance), and that this leads to a series of new capacities. In the literature, these capacities can be divided into economic, infrastructure, community and social, and governance,[12] and categorised as adaptive, absorptive or transformative.[13] They are also integral to households being able to prepare for and absorb climate stressors and shocks. Given the sphere of control of the GSMA Innovation Fund, it may be that measurement ends with the intermediate outcomes (strengthened capacities).

In this case, the goal of the Innovation Fund, and thus MEL metrics, will be to build the capacities required to build climate resilience, not the resilience itself. The idea of resilience is that when a climate event occurs, households are better able to cope without a loss in well-being (financial, health, livelihood, housing, etc.). Capacities are the intermediate outcome, with use of these capacities (i.e. climate resilience) being the long-term outcome.

Therefore, at a medium- to long-term outcome level, we would look for how households are using the capacities built by the digital solutions to anticipate, prepare for, and absorb/recover from climate shocks. Measurable changes could

12. UNDP. (n.d.). Community Based Resilience Analysis (CoBRA) Conceptual Framework and Methodology.
13. Mercy Corps. (2019). Our resilience approach to relief, recovery and development.

be understood as a range of multi-sectoral changes in household well-being, e.g. the ability to maintain a livelihood after a climate shock, health outcomes from reduced heat exposure or access to clean drinking water, or improved safety (e.g. the number of people able to remain in their home during and after a shock). To assess impact, data on how these changes in climate resilience led to improvements (or at least decline) in well-being should be collected.

Longitudinal impact tracking is essential to assess whether digital innovations lead to sustained improvements in resilience over time, and to ensure that investments are yielding cost-effective results.[14] Many digital tools yield tangible benefits only when a climate shock occurs, meaning short-term assessments may capture only intermediate outcomes, such as increased knowledge, improved financial preparedness or strengthened social networks. These capacities are crucial precursors to resilience, but they must be tracked over time to understand whether they lead to sustained improvements in households' ability to withstand and recover from climate-related stresses.

Additional considerations for measurement

Interoperability and scalability should be prioritised to determine if solutions can be adapted across diverse urban contexts while maintaining effectiveness.[15] As policymakers and regulators play a crucial role in shaping enabling environments for digital resilience, evaluating the influence of digital innovations on policy and governance can provide insights into systemic change.[16] Furthermore, ensuring that digital solutions align with local needs requires an inclusive, multi-stakeholder approach, fostering collaboration between MNOs, governments and community organisations.[17]

The Resilience Assessment Benchmarking and Impact Toolkit (RABIT)

The RABIT Toolkit offers a valuable framework for assessing urban climate resilience by identifying nine key attributes: robustness, self-organisation, learning, redundancy, rapidity, scale, diversity, flexibility and equality. By focusing on these attributes, stakeholders can assess the adaptability and scalability of digital solutions, ensuring they remain effective across diverse urban contexts.[18]

The Toolkit can be adapted to assess the impact of digital solutions at the household level by applying its nine resilience attributes to individual and household-level experiences. For example, robustness can be evaluated by measuring whether households using digital financial services (e.g. mobile money, climate insurance) recover more quickly from climate shocks. Self-organisation can be assessed by tracking how digital platforms enable collective action within communities, such as peer-to-peer support networks for disaster preparedness.

14. Dhanani, Q., Niavas, S., Fischer, G. et al. (2024) New Measures of Success for Climate Adaptation and Resilience. BCG.
15. ITU. (2021). Digital Transformation for Cities and Communities. Outcome Document.
16. World Bank. (2024). Digital Progress and Trends Report 2023.
17. Njoroge, B. et al. (2024). Co-Designing Urban Futures: Innovation and partnerships for improved service delivery in intermediary cities. GSMA.
18. Ospina, A.V., & Heeks, R. (2016). Resilience Assessment Benchmarking and Impact Toolkit (RABIT) Implementation Handbook. NICCD.

How the GSMA can centre households when demonstrating the impact of startups



The GSMA Innovation Fund grantees offer B2B, B2C and B2G digital solutions. A framework is required to accurately measure the direct bearing those digital solutions have on individuals or households. For example, an EWS would fit into the MEL measurement framework (Table 2) as a B2G solution that also has a direct impact on communities and households.

MEL framework for digital solutions in climate resilience

To develop a cohesive measurement framework, a set of guiding questions that are applicable to households and digital offerings for climate resilience is needed. These questions build on existing measures for digital startups, and include anticipatory, adaptive and absorptive capacities. To answer the questions posed, an MEL framework must create a mix of qualitative and quantitative indicators. Many organisations group indicators together to create indices or scorecards—at adaptive, absorptive and systems levels—to measure the aggregated effect of changes on resilience. In Table 2, the indicators for capacities would need to be tailored to the type of digital solution and the intended impact on resilience.

Learning and adaptation

- **Feedback loops and iterative design:** Regularly share findings with users and incorporate their suggestions into system updates or refinements.
- **Scaling insights:** Use MEL results to scale innovation, ensuring adaptations for diverse urban contexts of intermediary cities and vulnerable groups, e.g. are startups focused on informal townships? Do they want to scale to other townships/larger populations?

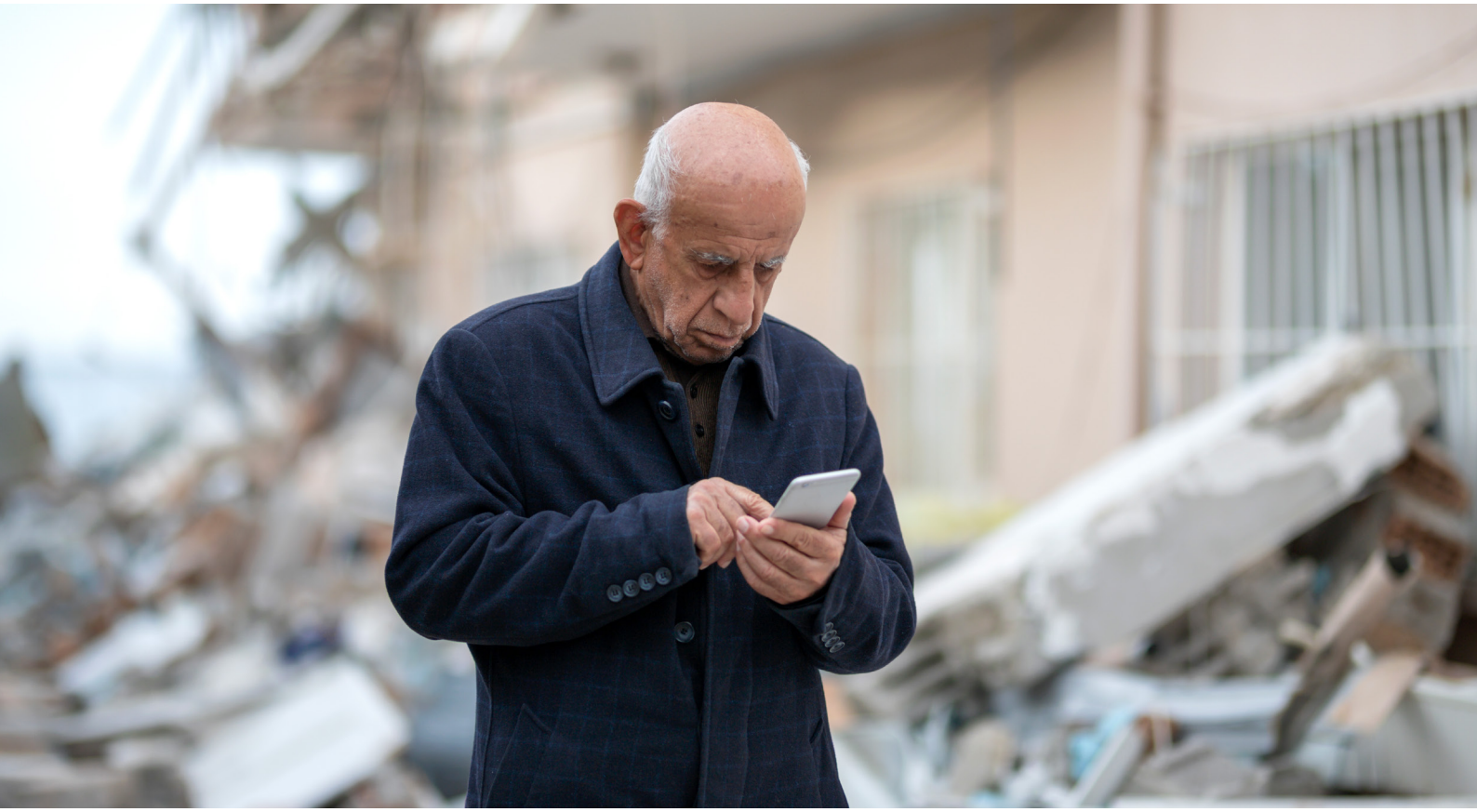


Table 2
Indicative MEL framework

MEL questions	Illustrative indicators	Example data collection method
Result area: Access and adoption		
Are digital solutions accessible to marginalised groups (e.g. women, low-income households, people with disabilities, informal workers)?	— Percentage of households with access to the digital solution	**User analytics and surveys:** — Leverage digital tools to track app usage patterns and trends
What barriers (e.g. digital literacy, affordability, connectivity) limit adoption?	— Number of active users across different demographics (e.g. gender, income levels)	**User analytics and surveys:** — Periodically survey users to assess satisfaction, barriers and social impact (capacities, use in resilience)
Result area: Usability and relevance		
Do beneficiaries (individuals or households) find the digital solution easy to use and understand? **How well does the solution address their specific resilience needs (e.g. flood alerts, resource mapping)?**	— User satisfaction scores (via surveys) — Frequency and type of features used	**Participatory data collection:** — Conduct focus groups with users to understand their experiences, challenges, and suggestions — Use community-led mapping or co-creation workshops to evaluate the digital platform/tool's relevance and effectiveness
Result area: Capacities for climate resilience		
How does the digital solution build an adaptive or absorptive capacity for households?	— Strength of urban neighbourhood support networks for preparedness and response — Economic capacities, e.g. use of mobile savings platforms or digital lending — Physical and infrastructure, e.g. EWS — Social and institutional capacities, e.g. use of mobile apps, USSD, or digital dashboards to access relief aid, disaster response or climate adaptation programmes — Knowledge and skills, e.g. digital literacy training for climate resilience — Governance capacity, e.g. participation in digital participatory governance platforms	**Capacity index (see RABIT Handbook).** **Case studies:** — Document stories of individual households or communities showcasing how the digital solution has improved their climate resilience
Result area: Impact on resilience		
Did the beneficiaries use the digital solution to anticipate, adapt or absorb climate shocks?	— Reduction in response time to climate events (e.g. evacuation after flood warnings)	— Scorecards — Outcome mapping
What measurable changes (e.g. reduced losses, quicker recovery times, improved resource management) have occurred as a result of using the digital solution?	— Changes in livelihood stability post-disaster — Reduction in displacement after a disaster	— Most significant change Geospatial/ Remote sensing Quasi-experiment methods
Result area: Equity and inclusivity		
Who benefits most and least from the digital solution? Are there ways to improve the social impact of the solution within a commercially sustainable framework?	— Distribution of users by demographic group	**Equity audits:** — Analyse data for disparities in usage and benefits — Interview underrepresented groups to identify barriers to adoption
Are community voices, especially those of vulnerable groups, integrated into its design and feedback processes?	— Differentiated effects by location within a city	— Participatory data collection methods

GSMA Examples:

The nature, quality and accessibility of digital services has significant implications for some of the most important determinants for productive, liveable and resilient cities. Examples of different types of mobile or digital solutions include:

- Anticipating: **Komunidad** | Philippines | Typhoon EWS
- Adapting: **Koolboks** | Nigeria | Pay-As-You-Go (PAYG) solar-powered refrigerators for commercial use by MSME traders

Table 3
Illustrative indicators for Komunidad (EWS in the Philippines)

Result area	Quantitative indicators	Qualitative indicators
Access and adoption	Percentage of households with access to the EWS (via mobile alerts, sirens, radio, etc.) Percentage of households in low-income areas with access to the EWS (especially given digital access challenges)	Barriers to access/receiving warnings
Usability and relevance	Percentage of households that can correctly interpret warning messages	Users rate their satisfaction with the kinds of warnings, their accessibility and how it can improve
Capacities for climate resilience	Percentage of people aware of the nearest evacuation route and safe location Number of local EWS committees or community-led initiatives established and maintained	People have trained evacuation drills Levels of trust in the EWS
Impact on resilience (Use)	Percentage of people who evacuate promptly when warnings are issued	Unintended consequences
Equity and inclusivity	Injuries avoided Critical infrastructure protected	Perceived resilience. How people integrate the EWS into their habits and maintenance of their livelihoods, health, education and housing

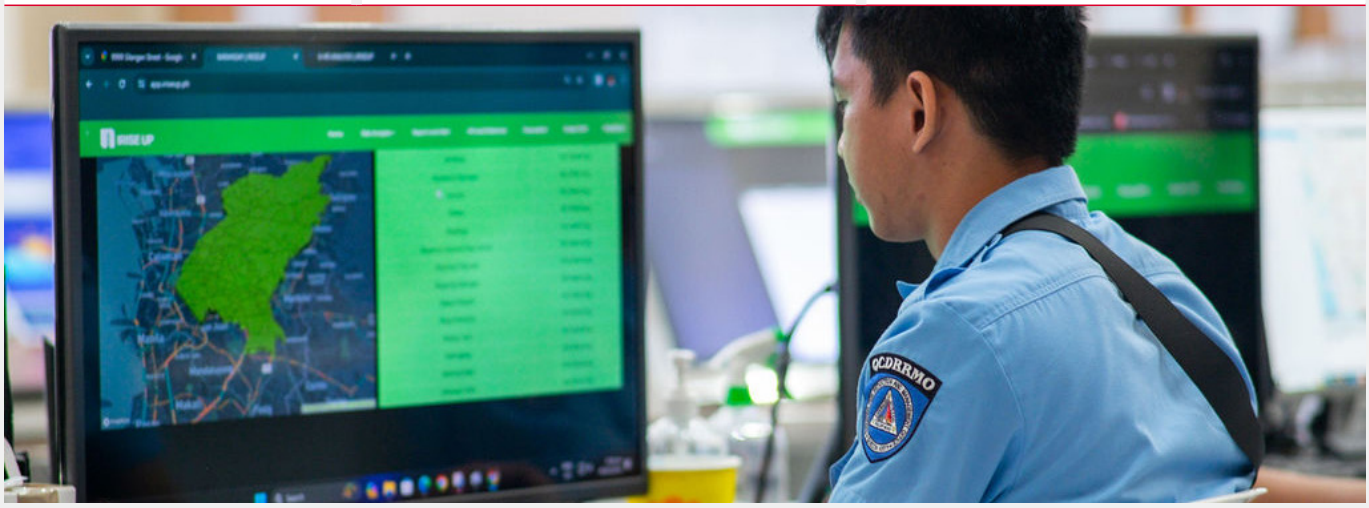


Table 4
Illustrative indicators for Koolboks (PAYG solar-powered refrigerators for commercial use by MSME traders in Nigeria)

Result area	Quantitative indicators	Qualitative indicators
Access and adoption	Number of households and businesses adopting the PAYG financing model Percentage of users from underserved demographics, such as women-owned businesses or unbanked populations Percentage of units installed in off-grid or energy-insecure communities (i.e. informal settlements)	Barriers to accessing Koolboks
Usability and relevance	Percentage of households that can use Koolboks for longer than 12 months	Users rate their satisfaction with service, product, accessibility and how they can improve
Capacities for climate resilience	Increase in income for small businesses utilising Koolboks solutions	Perceived resilience Changes in percived resilience as a result of using Koolboks products eg. effects of having access to continued power and refrigeration and discussion of how this led to improved wellbeing after a climate shock (or during an ongoin climate stress)
Impact on resilience (Use)	Improvement in local food supply stability during climate-related disruptions Continuation of livelihood during climate disruption	
Equity and inclusivity	Enhanced capacity of communities to maintain essential services during power outages	



Opportunities, challenges and limitations



As the GSMA deepens its focus on climate resilience in cities, there is a key opportunity to shift the perspective to prioritise the impact of digital solutions at the household level and to further investigate different levels of social impact. While much of the current discourse focuses on city-wide planning and municipal services, there remains a gap in understanding how digital innovations directly shape the ability of urban households to anticipate, absorb and recover from climate shocks. To bridge this gap, the GSMA Mobile for Development team can explore new approaches to measurement, ensuring that individuals or households remain central to climate resilience-building efforts.

One opportunity lies in refining methodologies to capture the long-term impact of digital solutions. Longitudinal studies can track key resilience indicators over time, providing insights into how different types of digital solutions—whether focused on EWS, water management, or energy access—contribute to sustained adaptation. Participatory research methods could also play a role by involving urban residents in data collection and analysis, fostering a sense of ownership over resilience strategies and potentially informing B2B product design. Additionally, integrating big data sources—such as app usage patterns, IoT sensor data, and satellite imagery—could create more comprehensive insights into household resilience. While such an approach would require significant investment, it could be incorporated into future funding rounds or city-level initiatives.

However, several challenges remain. The digital divide continues to be a barrier, with disparities in internet access, device ownership, and digital literacy limiting the reach of certain solutions. Local contexts also matter. Solutions must respect linguistic, cultural, and gender dynamics, particularly in regions where women may have limited decision-making power. In intermediary cities, fragmented governance structures and data scarcity further complicate efforts to track and scale digital interventions. Additionally, ensuring compliance with evolving data privacy regulations is critical, particularly when working with vulnerable communities.

A broader strategic challenge lies in aligning the GSMA's investment approach with emerging thinking on urban climate resilience. The current GSMA Innovation Fund grantee portfolio does not fully reflect the need to centre household beneficiaries in climate adaptation strategies. Moving forward, the GSMA must ensure that future investments prioritise solutions that not only enhance urban infrastructure but also empower communities and individuals to build resilience from the ground up. Strengthening impact measurement, fostering inclusive research methods, and refining the role of digital innovations in climate resilience-building will be key to making meaningful progress in this space.

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