GSMA

Digital Innovation for Climate-Resilient Agriculture

Using rainfall data from mobile networks for localised and scalable services

The GSMA represents the interests of mobile operators worldwide, uniting more than 750 operators with almost 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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The GSMA AgriTech Programme works towards equitable and sustainable food supply chains that empower farmers and strengthen local economies. We bring together and support the mobile industry, agricultural sector stakeholders, innovators and investors in the agritech space to launch, improve and scale impactful and commercially viable digital solutions for smallholder farmers in the developing world.

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Published
March 2021

This material was funded by UK aid from the Foreign, Commonwealth & Development Office.

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Acknowledgements

GSMA would like to acknowledge the following individuals for their contribution and support during the research for this publication

Patrick Sampao, ACRE

Farid Wangara, ACRE

Steven Crimp,
Australian National University

David Bergvinson, aWhere

Lauren Allognon, aWhere

Nathanial Peterson, Busara Center

Morgan Kabeer, Busara Center

Brian King, CGIAR

Srinath Wijayakumara,
Dialog Axiata Sri Lanka

Ari Davidov, Earth Networks

Steven Wonink, eLeaf

Eleni Vakaki, eLeaf

Daniel Paska, Ericsson

Simone Fugar, Esoko

Gordon Kotey Nikoi, Esoko

Angshujyoti Das, FarmNeed

Faisel Irshad, FarmNeed

Corjan Nolet, FutureWater

Ali Tareque, Green Delta Insurance

Israel Muchena, Hollard Insurance

Andreas Vallgren, Ignitia

Christian Reichel, International Finance Corporation

Christian Chwala, Karlsruhe Institute of Technology

Chacko Jacob, Misteo

Akinbulejo Onabolu, MTN Nigeria

Simon Schwall, OKO

Bojan Kolundzija, Oxfam Sri Lanka

Kasis Inape, Papua New Guinea National Weather Service

Owen Barder, Precision Agriculture for Development

Sam van Herwaarden, Precision Agriculture for Development

Aart Overeem, Royal Dutch Meteorological Institute (KNMI)

Arjen Vrielink, Satelligence

Abhishek Raju, SatSure

Samir Ibrahim, Sunculture

Peter Laderach, The Alliance of Bioversity International and CIAT

Steven Prager, The Alliance of Bioversity International and CIAT

Remko Uijlenhoet, TU Delft

Elizabeth Onyango, Ukulimatech

Arjan Droste, Wageningen University and Research

Stefan Ligtenberg, Weather Impact

Alice Soares, World Bank

Executive summary

1 THE NEED FOR CLIMATE RESILIENCE

The increasing volatility of weather patterns caused by climate change is posing significant challenges for smallholder farmers around the world. Agriculture is an income source for an estimated two-thirds of adults living in poverty, who typically lack the resources to maximise yields and respond effectively to production challenges, such as adverse weather conditions, crop pests and disease. There is a risk that growth in global yields could decline by up to 30 per cent by 2050, pushing up food prices and leading more people to become undernourished and food insecure.

Climate resilience refers to the ability of farmers to adapt to long-term shifts in climatic conditions, and to anticipate and take steps to mitigate the effects of extreme weather events exacerbated by climate change.

2 DIGITAL INNOVATION FOR SMALLHOLDER CLIMATE RESILIENCE

Digital climate resilience services can directly impact the resilience of smallholder farmers:

- **Weather and climate services** provide the information farmers need to adapt their practices to anticipated conditions or respond to impending extreme weather events.
- **Data-driven agricultural services** draw on a multitude of data sources to support decision making at both the macro and grassroots level.
- **Agricultural financial services**, such as credit, enable farmers to access inputs and assets to support climate-smart agricultural practices, while agricultural index insurance provides a safety net for those affected by adverse weather events.

Digital innovations, such as open satellite data, low-cost sensors, big data and machine learning, have been key enablers of digital climate resilience services. Mobile network operator (MNO) assets provide the basis for further innovation, facilitating localisation and scale-up of these services. MNO assets include network infrastructure, data from mobile networks and services, communications channels, digital services platforms, and agent networks.

3 MEASURING RAINFALL USING MOBILE NETWORKS

Reliable ground-level weather observations are key inputs to digital climate resilience services, providing more reliable data than remote sensing sources. This data is lacking in LMICs, for example, weather station coverage in Sub-Saharan Africa is eight times lower than the WMO's minimum recommended level, and six times lower in India. **Mobile networks, currently providing over 90% population coverage in most LMICs, can provide high-resolution rainfall data from commercial microwave links (CMLs), presenting a significant opportunity for MNOs to close the weather data gap.**

CMLs connect towers in a mobile network using close to the ground radio connections that are disrupted by rainfall. By capturing these disruptions, rainfall rates between connected towers can be calculated. Recent studies in tropical markets have validated this approach, confirming the potential of CML data to enable, localise and scale climate resilience services.

Executive summary

4 WHERE MNOS CAN ADD VALUE

Three services that are enabled or significantly enhanced by MNO assets are considered in more depth in this report:

- **Rainfall nowcasts**[1] draw on high resolution rainfall observations to provide hyper-local rainfall forecasts up to six hours in advance.
- **Climate-smart agri advisory (CSAA)** provides advice on agricultural activities tailored to the specific location and climatic conditions of its recipients.
- **Weather index insurance (WII)** uses weather observations to determine agricultural risk and provide pay-outs to affected policy holders.

CML data from mobile networks can enable **rainfall nowcasts** in markets lacking weather radar, forming the basis for weather data services and early warnings. MNOs can improve the resolution and scalability of **CSAA and WII** using weather observations from CML data or co-located automated weather stations (AWS), combined with farmer locations from caller- or registration- data. Existing value-added services (VAS) provide opportunities for bundling services to strengthen individual value propositions. Mobile money channels benefit **WII** by digitising transactions, reducing operating costs and increasing scalability.

5 OPPORTUNITIES FOR MNOS

CML-derived rainfall observations can form the basis for data-as-a-service (DAAS) offerings to enterprises in a variety of weather-sensitive sectors, including agriculture, utilities, extractive industries, public services and humanitarian response. The annual revenue opportunity from unprocessed CML data is estimated at up to $3m in Nigeria, $1.2m in Kenya, and $2.6m in Indonesia. Providing higher value data services such as rainfall observations and rainfall nowcasts will further increase this opportunity.

MNOs can add significant value to consortia providing data-driven agricultural services and agri digital financial services. In doing so, MNOs benefit in the short term from shared revenues, higher ARPU and customer loyalty. In the long term, strategic relationships with agri intelligence- and/or financial services- providers can be leveraged to expand service offerings.

6 RECOMMENDATIONS

MNO involvement in climate resilience services provision will depend on several considerations, unique to their specific market and strategy:

- Willingness to invest in CML data extraction and processing
- Existing strategy to provide direct-to-consumer services for the rural sector
- Potential enterprise user base for weather services in agriculture and other sectors
- Maturity of market and availability of potential partners for service creation

1 Rainfall nowcasting provides rainfall forecasts up to six hours in advance using high-resolution rainfall observations (typically radar) that are spatially extrapolated into the future.

1 The need for climate resilience and closing the weather data gap

Smallholder farmers are facing a growing number of challenges due to climate change. This section outlines recommendations to address these challenges, and identifies areas in which digital services can play a key role. It highlights the gap in surface weather observations data common in low- and middle-income countries (LMICs), and how CML data from mobile networks provides a significant opportunity for MNOs to close this gap.

An increasingly volatile climate challenges smallholder farming systems

Increasingly volatile weather patterns caused by climate change are posing significant challenges for smallholder farmers around the world. While agriculture is an income source for an estimated two-thirds of adults living in poverty,[5] they typically lack the resources to maximise yields and respond effectively to production challenges, such as adverse weather conditions, crop pests and disease. Financial services that would support these investments, such as agricultural credit, and formal safety nets like agricultural insurance, are also not available to most smallholders. It is estimated that areas exposed to extreme weather will increase by up to 44 per cent by 2050,[2] with affected areas experiencing reduced soil fertility and increased pest and disease pressures. As a result, there is a risk that growth in global yields could decline by as much as 30 per cent by 2050, driving up food prices and exposing millions more to food insecurity and hunger.

Vulnerable smallholder production

- Globally, 500 million farms are two hectares or less.[4]
- Two-thirds of adults living in poverty generate at least some of their income through agriculture.[5]
- Smallholder agriculture in LMICs is typically rainfed, including 90 per cent in sub-Saharan Africa.[6]
- Access to agricultural insurance or other formal safety nets is limited. In Sub-Saharan Africa, it is estimated that less than three per cent of smallholder farmers are insured. In Asia, 22 per cent have insurance.[7]
- Inputs such as improved seed and fertiliser are not widely accessible, keeping adoption low. For example, the adoption rate of improved maize across Africa is approximately 28 per cent.[8]

Increasingly volatile climate

- Developing countries are experiencing 20 per cent more extreme heat now than in the late 1990s.[1]
- Areas exposed to serious drought and flooding are expected to increase by up to 44 percent by 2050.[2]
- Higher temperatures reduce the amount of water available for crops by drying out air and soils, put stress on livestock, reduce labour productivity and increase pests and diseases for both livestock and crops.[3]

Increased food insecurity and livelihoods at risk

- The number of people affected by hunger has been rising since 2014. In 2019, nearly one in ten people in the world were exposed to severe levels of food insecurity,[9] in part due to climate shocks.
- Researchers estimate that climate change will depress growth in global yields by five to 30 percent by 2050.[10]
- In some African countries, yields from rainfed agriculture may have declined by as much as 50 per cent by 2020, with smallholder farmers hit hardest.[11]
- Climate change is likely to raise food prices by 20 per cent[12] for billions of low-income people.

Climate risk mitigation strategies must address smallholder production challenges and support climate adaptation

To address climate change and achieve food security, systemic changes are needed in the global food system.[13,14,15] Ensuring that smallholder farmers can become resilient to climate change while also increasing productivity will require action on several fronts (see Figure 1). Climate resilience refers to the ability of farmers to adapt to shifting climatic conditions, and anticipate and take steps to mitigate the effects of extreme weather events brought about by climate change.

Recommendations to support smallholder agriculture address both existing productivity challenges and new challenges presented by climate change. Productivity challenges need to be met with better knowledge of climate-smart practices, relevant agricultural advisory and greater availability of more productive, climate-adapted crop varieties. The resilience of smallholder farmers will depend on their ability to diversify their income streams and access safety nets, such as social security systems and agricultural insurance. Agricultural interventions should take the reality of a changing climate into account while also ensuring the most vulnerable groups are not left behind.

Advances in digital technologies are addressing these challenges by making digital services increasingly available to smallholder farmers. Digital advisory services have thrived due to the rapid penetration of mobile phones in LMICs, as well as weather and climate data that support tailored messaging to local conditions. Agricultural insurance services are reaching scale with a shift to index-based services that use data from remote sensors and other sources. Policy and donor decisions can now be informed by macroagricultural intelligence services that draw on big data and use machine learning to identify vulnerable areas and model the outcomes of interventions.

Figure 1 **Recommendations to support smallholder agriculture**[13]

1 Improve smallholder productivity

- Boost research and development of good agricultural practices.
- Expand extension services, including digital agricultural services, weather and seasonal forecasts.*
- Improve the availability of climate-adapted crop varieties.

2 Help farmers manage more variable weather and climate shocks

- Stimulate income diversification.
- Strengthen social security systems.
- Provide crop and livestock insurance.*

3 Address the challenges of the most affected and vulnerable farmers

- Improve rights and access to resources for women farmers.
- Support pastoralists with climate adaptation.
- Provide transition funds for the most-affected populations.*

4 Make climate-smart agricultural interventions

- Facilitate climate-smart decision making.*
- Support synergies between climate adaptation and mitigation.
- Adopt measures to conserve land and water resources

* Recommendation can be directly addressed through digital services

A key MNO asset, CML data from mobile networks can help close the weather observation gap in LMICs

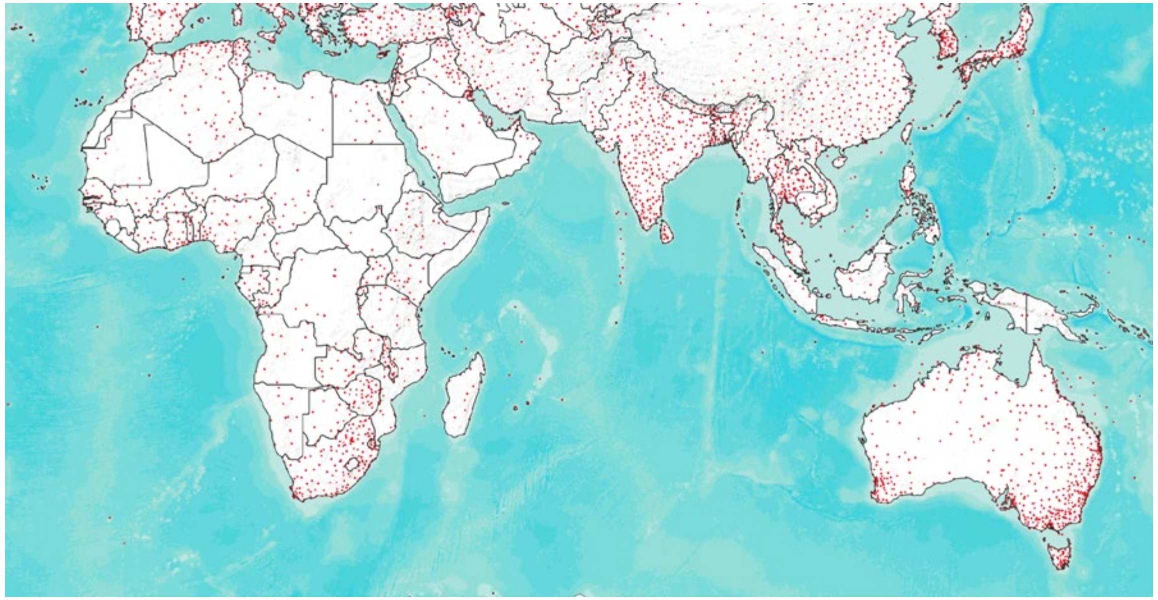
While innovations in digital technologies have helped advance digital climate resilience services, they have not yet reached their potential or achieved scale. There are several obstacles. Since weather observations are a vital part of climate-resilience services, the lack of surface weather (Figure 2) and radar observations in many LMICs hinder the creation of accurate, localised forecasts and derivative services.

CML data from mobile networks has the potential to narrow the weather observations gap. CML data provides information on the signal strength of microwave links that transfer data between mobile base stations. As it rains, this signal weakens, and these variations in signal strength can be used to calculate the intensity of rainfall.

Early CML research focused on the underlying principles of rainfall estimation and establishing a proof of principle.[17,18] Once established, numerous studies applied this principle to larger CML data sets from high-income temperate countries, such as the Netherlands,[19] where extensive data sets for validating rainfall data from CML are available. Recognising the potential of this approach in LMICs, a number of studies followed that demonstrated the validity and potential of the technique in tropical markets, the first of which was in Burkina Faso.[20]

Commercial applications of CML-based rainfall observation remain limited. US-based ClimaCell is one of the few organisations to use CML data in weather services. Ericsson is working in collaboration with the Swedish Meteorological and Hydrological Institute (SMHI) to develop CML-based services through its Ericsson One Weather Data Initiative. The GSMA is working with Wageningen University & Research (WUR), the Royal Netherlands Meteorological Institute (KNMI) and Delft University of Technology (TU Delft) to develop CML-based rainfall data services in collaboration with MNOs that can be used in the development of climate resilience services.

Figure 2 **Distribution of surface weather observations[16]**



This report examines how digital services can support climate resilience for smallholder farmers, and how these services are created and delivered. It outlines the opportunity for MNOs to employ mobile networks as rain sensors through the use of CML data. Use cases likely to benefit most from MNO involvement are highlighted, as well as business models that could support mutually beneficial partnerships to develop climate resilience services.

Methodology: This study combines insights from key informant interviews and secondary research with experience from GSMA-supported pilots

This report combines findings from secondary research (literature review) with key informant interviews (KIIs) and experience from GSMA-supported pilots.

Secondary research

- The GSMA maintains a tracker of active digital agricultural climate resilience services. These services are defined as those that have scaled beyond the pilot stage and have been active for over a year (this currently includes over 140 organisations). The tracker is a subset of the GSMA's AgriTech Services Tracker[1] (covering over 700 services as of January 2021) and is kept up to date with ongoing secondary research that draws on industry publications (e.g. The Technical Centre for Agricultural and Rural Cooperation (CTA), Global Commission on Adaptation (GCA), World Bank, World Meteorological Organization), donor and international NGO websites (CCAFs, CGAP, MercyCorps, UK Foreign, Commonwealth & Development Office), as well as snowball sampling from informant interviews. Additional sources include service provider websites, relevant case studies and semi-structured interviews (see Primary research). Geographically, the research focused on markets where the GSMA AgriTech programme has a presence: Sub-Saharan Africa, South Asia and Southeast Asia.
- Academic research was used where relevant, primarily to capture developments in rainfall estimation from CML, and included journal articles from *Science, Atmospheric Measurement Techniques and Geoscientific Model Development*.

Primary research

- Semi-structured key informant interviews (KIIs) were conducted by telephone throughout 2020 with 33 organisations, including private and public weather service providers, agricultural intelligence and advisory providers, agricultural insurance providers, agritechs, academia, international agencies and multilateral organisations. Interviewees were identified from GSMA AgriTech's climate services tracker and other secondary research sources for individuals from non-service organisations. For service providers, the goal of the interviews was to understand the scope of services offered, how the services were developed (especially data sources and analysis), the underlying business model and their roadmap for the future.
- Lessons from the GSMA's engagements with MNOs in Nigeria, Sri Lanka and Papua New Guinea inform section 2 on the use of CML data for rainfall estimation, as well as section 4, which outlines potential business models and partnerships to integrate MNO assets in climate resilience services. The GSMA's current engagements in these markets cover the technical work to create data services using CML data for rainfall estimation, and piloting the use of this data in climate resilience services. These projects will run from 2020 to 2022, funded by the UK's FCDO (Nigeria, Sri Lanka) and Australia's DFAT (Papua New Guinea), with WUR, KNMI and TU Delft as the main technical partners.
- In Sri Lanka, the GSMA, in partnership with Dialog Axiata Sri Lanka (Dialog), WUR and KNMI, collected and analysed 3.5 months of CML data to demonstrate the potential of CMLs for real-time tropical rainfall monitoring. This study represents the most extensive evaluation of CML data in tropical markets in terms of spatial and temporal coverage. The findings inform the assessment of CML data in section 2.[21]

Endnotes

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2 Digital services for smallholder climate resilience

This section highlights the range of digital services that can have a direct impact on the climate resilience of smallholder farmers. It introduces three categories of use cases that will be the focus of this report: weather and climate information services, data-driven agricultural services and agri digital financial services. Finally, it identifies the unique assets that MNOs could use to develop and deliver these services in innovative and efficient ways.

Weather and climate services, data-driven agriculture and agri digital financial services have the greatest potential to positively impact smallholder climate resilience

Digital technologies enable a range of services that can mitigate the challenges smallholder farmers face, and help agricultural value chains function better, especially in the last mile.[1] The GSMA has grouped digital agricultural solutions into three broad categories of access and five categories of use cases[2] (see Figure 3).

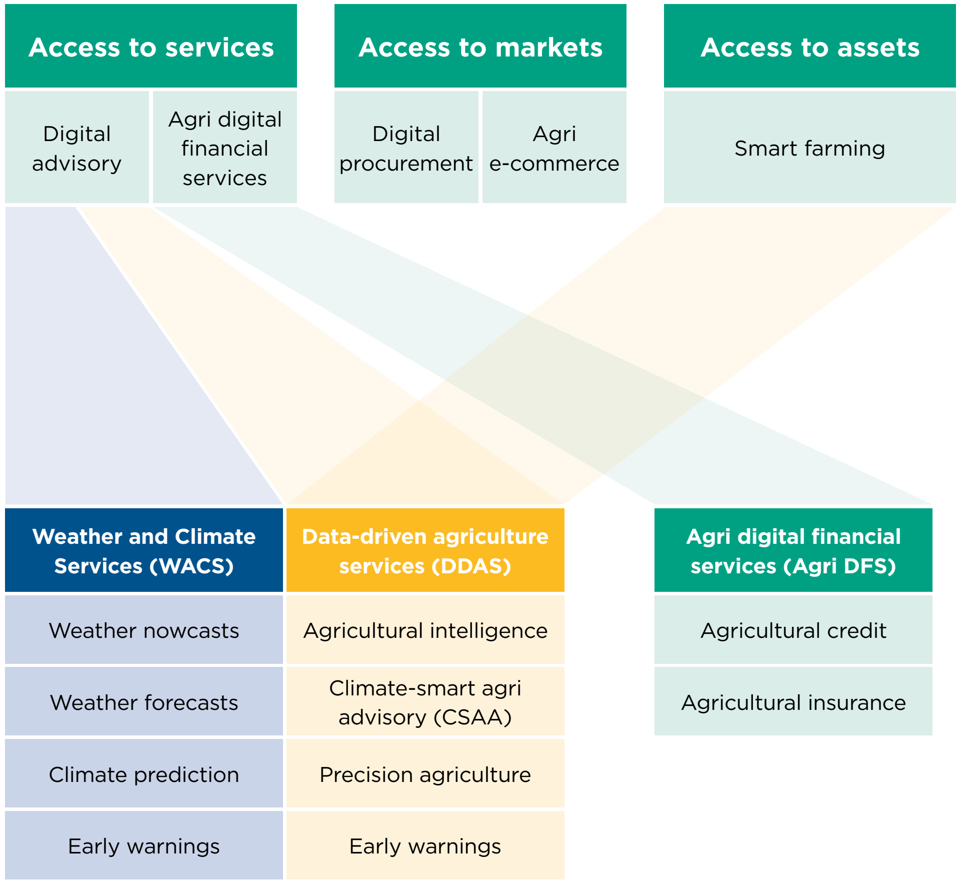
This report focuses on three categories of services that allow farmers to directly mitigate the impacts of long-term climate change, short-term climate shocks and extreme weather events: 1) weather and climate services (WACS), 2) data-driven agriculture services (DDAS) and 3) agri digital financial services (agri DFS). These services fall under the use cases of digital advisory and agri digital financial services.

Weather and climate services (WACS) are advisory services that provide valuable and actionable information to smallholder farmers on changing weather conditions. The three sub-use cases of weather nowcasting, weather forecasts and climate prediction represent services that extend further into the future, and therefore require different data sources and modelling approaches.

Data-driven agriculture services (DDAS) use localised and timely data to create information and advisory services for agricultural value chain actors. Agricultural intelligence services monitor and predict agricultural activities to support decision making for a variety of organisations. Climate-smart agri advisory builds on traditional agricultural advisory services by incorporating local and timely data to tailor advisory messages to farmers' current farm conditions. Precision agriculture uses hyperlocal data sources, such as sensors and UAV imagery, to optimise on-farm activities, and may involve elements of mechanisation, such as solar irrigation.

Agri digital financial services (Agri DFS) include agricultural credit and agricultural insurance that can help smallholder farmers become more resilient to climate change. Agricultural credit includes digitally enabled credit products that smallholders can use to access agricultural assets, inputs and services. Index insurance refers to insurance that relies on the modelling and monitoring of observable phenomena (such as rainfall) to determine insurance costs and pay-outs.

Figure 3 **Digital agriculture use cases and sub-use cases[1]**



Digital agriculture plays an important role in climate resilience, from long-term adaptation to short-term responses

Adaptation to climate change can take place when farmers are aware of the longer term shifts in climate affecting them, and have the resources to adopt practices that will maximise their productivity in this new context. Climate prediction and climate-smart agri advisory provide the information farmers need to understand climate change and the implications for local agriculture. In the medium term, seasonal weather forecasts allow farmers to select appropriate climate-adapted crops and varieties, and plan their agricultural activities.

Throughout the cropping season, weather forecasts, nowcasts and early warnings provide advance warning of adverse events, allowing farmers to **respond** to changing meteorological conditions where possible.

In the case of adverse weather events, such as droughts or heavy rainfall, insurance provides a safety net for famers to **recover** some of their production costs or lost income. Similarly, agricultural credit can be a catalyst for recovery, allowing farmers to invest in agricultural inputs for the next season after suffering losses in the last.

Agriculture contributes to climate change by producing greenhouse gas (GHG) emissions, primarily through livestock production and deforestation.[3] Agri-intelligence services can monitor land use changes, alert relevant authorities to deforestation activities[4] and allow agribusinesses to identify risk in their supply chains. Together, these services can reduce the net carbon emissions of agriculture and contribute to climate change **mitigation**. Meanwhile, agricultural credit can enable smallholder farmers to shift to more sustainable farming practices through increased access to inputs and assets, and therefore reduce the need to expand their cultivated land.

Figure 4 **The role of digital services in managing climate change**

Approaches to managing climate change	Weather and climate services (WACS)	Data-driven agriculture services (DDAS)	Agri digital financial services (Agri DFS)
LONG TERM ↑ **Mitigation**		Agricultural intelligence	Agricultural credit
Adaptation	Climate prediction Weather forecasts	Agricultural intelligence Climate-smart agri advisory Precision agriculture	Agricultural credit
Response	Weather nowcasts Early warnings (weather)	Early warnings (crop pests and disease)	
SHORT TERM **Recovery**			Agricultural insurance Agricultural credit

Weather and climate services allow smallholders to anticipate and respond to climate events and can enable adaptation to long-term climate change

Meteorological services, which include WACS, provide information and advice on the past, present and future state of the atmosphere. This includes information on temperature, rainfall, wind, cloudiness and other atmospheric variables and their influence on weather- and climate-sensitive activities and communities.[5] Depending on the timescale, different services can be used to support smallholder climate resilience. These are outlined in Figure 5 below.

WACS are typically considered public goods and are provided by National Meteorological and Hydrological Services (NMHSs). The role of NHMSs has typically been to operate a network of weather stations, produce weather forecasts for the general public and specialised forecasts for relevant sectors. As satellite and private weather data have become more available, and global forecasting models can be used as the basis for regional and local forecasts, NHMSs are slowly shifting to focus on the localisation and dissemination of forecasts for the general public and weather-dependent sectors. The increased availability of openly available satellite weather data has also fostered innovation in the private weather sector. For example, innovative forecasting techniques and delivery models are used to provide end-user services (e.g. Ignitia), and proprietary technologies are used to collect local weather data to refine forecasts (e.g. Earth Networks, ClimaCell).

Figure 5 **Temporal coverage of weather and climate services[5]**

Weather observations

Weather observations include data from numerous sources of key atmospheric variables, such as temperature, humidity, wind speed and direction and atmospheric pressure at various altitudes. This data is captured by remote sensing, weather balloon and land and marine weather stations.

Historical weather observations enable analysis of long-term weather trends, and are key inputs for financial services, such as weather index insurance actuarial models and agricultural credit risk assessments.

Weather nowcasting

Weather nowcasting provides high-resolution rainfall forecasts up to six hours in advance based on radar observations that are spatially extrapolated into the future.[6]

Nowcasts enable short-term responses that reduce the impact of climate events, such as storms and heavy rainfall.

Weather forecasts

Weather forecasts use numerical models that forecast the behaviour of atmospheric processes based on initial conditions up to one month into the future.

Forecasts enable short-term planning by agricultural value-chain actors to optimise input use and timing of agricultural activities, and to anticipate pest and disease outbreaks.

Climate predictions

Climate predictions provide an estimate of climate more than one month into the future, at seasonal, interannual or long-term timescales.

Predictions enable seasonal planning by smallholder farmers, including which crops to grow and planting/harvesting dates. Macro-level actors can identify potential issues and take mitigating measures.

Early warnings

Early warnings are predictions or forecasts of hazardous or dangerous weather conditions, such as flooding, droughts, high winds, extreme heat and cold, that pose an immediate or serious threat to life, property or livelihoods. Creating early warnings may require additional information on underlying factors (e.g. soil saturation, water levels).

Early warnings enable short-term responses to reduce the impact of climate events, both by micro-level actors, such as smallholder farmers, as well as public institutions and NGOs.

Case studies: Weather and climate services

Ignitia

Ignitia is a specialist tropical weather forecaster based in Sweden with offices in Ghana and Nigeria. iska™, the company's flagship service, provides localised daily, monthly and seasonal weather forecasts via SMS to smallholder farmers in Ghana, Nigeria, Burkina Faso, Mali and Ivory Coast.

The service relies on an advanced tropical numerical weather prediction model developed by Ignitia that draws on various data sources, including satellite data, global numerical weather prediction models and lightning detection to provide more accurate and higher resolution forecasts.

Ignitia markets their services under a subscription model. They partner with local MNOs under revenue-sharing arrangements to distribute their messages and rely on them to provide subscriber location from call detail records. Ignitia has partnered with MTN in Ghana and Ivory Coast, 9Mobile in Nigeria, and Orange in Mali and Burkina Faso. Alternatively, Ignitia works with NGOs that cover subscription costs and provide the farmer registration data they need to deliver the service.

Earth Networks

Earth Networks is a US-based private weather forecaster that provides cloud-based weather data services to a range of enterprise customers around the world, including national meteorological and hydrological services. Services include weather data APIs and dashboards, as well as decision-making support systems.

Earth Networks integrates data from global numerical weather prediction models, their own global network of weather sensors and weather observations from other sources to provide localised forecasts. Machine learning processes use local weather observations to fine-tune forecasting models to specific locations, enabling accurate local forecasting. Earth Networks partners with mobile networks to co-locate weather sensors with mobile base stations to expand their observations network.

In LMICs, Earth Networks works across the public, private and civil sectors. For example, they have a partnership with Viamo, a provider of digital advisory services, to include weather forecasts through its 3-2-1 platform in 11 countries in Africa and Asia. In the Philippines, Earth Networks has partnered with PAGASA, the public weather service provider, to install and run a nationwide weather monitoring network.

Data-driven agricultural services provide evidence-based decision-making support to agricultural stakeholders

Data-driven agricultural services (DDAS) use near real-time data sources to make predictions and provide advice on agricultural activities. These services build on conventional advisory services by considering a user's location and current local agrometeorological conditions to tailor models and advice.

As satellite observations, Internet of Things (IoT) networks and low-cost sensors have become more available, and machine learning and computing technology more advanced, there has been a proliferation of data-driven agricultural service providers around the world.

DDAS use the same approach to provide solutions to a variety of end users. By integrating data from diverse sources, from satellite imagery to soil sensors, DDAS create models of current and future agricultural activity. These models can be used for various use cases depending on the end user and available data sources (see Figure 6).

As use cases move from the macro- to micro-level, data demands increase. This is because localised sources of data, such as ground-level sensors, are needed to create farm-specific models, and farm-level data on agricultural practices is needed to tailor advisory messages.

Figure 6 **DDAS use cases**

MACRO

Agricultural intelligence

Agricultural intelligence services are data analytics solutions that integrate satellite, agronomic, weather and climate and market data, and convert this information into useful country- and value chain-level insights for government policymakers, agribusinesses and financial actors.

Services include monitoring agricultural activity, including land use, growth assessments, yield forecasting and pest and disease early warnings.

Long-term trend analysis is used to assess value chain risk and identify longer term adaptation strategies. Agricultural intelligence services also contribute valuable inputs to financial services, including risk assessments for agricultural credit and actuarial modelling and index monitoring for agricultural insurance.

Climate-smart agri advisory

CSAA provide information on agronomic best practices, pests and diseases and weather and market prices to smallholder farmers through digital channels. They draw on weather and climate forecasts, as well as spatial agronomic data such as soil maps, to tailor advisory messages to local and seasonal conditions.

These services enable smallholder farmers to maximise their agricultural production and revenues by selecting the most appropriate inputs, optimising agricultural practices, and responding to crop pests, disease and extreme weather events in a timely and effective manner.

Precision agriculture

Precision agriculture services bring intelligence and advisory services to the farm level by utilising farm-specific agronomic data, such as on-farm sensors, soil analysis and high-resolution remote sensing data from unmanned aerial vehicles (UAVs) or private satellite providers.

This shift from general to more specific data enables more tailored recommendations to optimise crop choices, input use and good agricultural practices, and ultimately maximise agricultural productivity.

MICRO

Case studies: Data-driven agriculture services

aWhere

aWhere is an agricultural intelligence provider based in the US, but operating globally. They offer a range of solutions that enable data-driven decisions on adapting to changing weather conditions on a local and global scale. Data APIs and an online platform are their core services, which provide agriculturally relevant weather conditions, historical trends, crop models and pest and disease predictions, among other information.

aWhere's weather and agronomic data can integrate with other geospatial data such as soil maps, watersheds, and livelihood zones as well as population data to provide additional insight. With historical observed data going back to 2006, aWhere's customers can analyse historical weather trends and develop crop models.

Services are provided through a freemium subscription model, allowing free access to basic data points and tiered access to the complete dataset. aWhere has subscribers in public agencies in Kenya, Uganda and Zambia that use their platforms for weather forecasting and decision making. In Kenya, they have worked with Safaricom and MercyCorp's AgriFin programme to develop a bespoke agronomic advisory service for smallholder farmers delivered as part of the DigiFarm platform. In Ghana, Esoko uses the aWhere API to access the weather data they need to provide climate-smart agronomic advice.

SunCulture

SunCulture provides solar-powered irrigation solutions to farmers in Africa from their base in Kenya. The company combines innovative hardware with Pay-As-You-Go (PAYG) financing models to make irrigation accessible to smallholder farmers. Their equipment is bundled with tailored advice and generates intelligence around customer usage through integrated IoT devices. Installation, training, and after sales support is included with their products.

They are currently building their IoT capacity to provide precision advisory services. Using Microsoft's Azure platform, they integrate usage data collected from their devices with complementary data, such as weather observations and forecasts to model how particular usage patterns result in better yields. These models will enable the provision of tailored advisory messages to customers via SMS. The addition of customer payment behaviour to this dataset enables the creation of repayment profiles, which represents highly valuable data to lenders and insurers, and allows SunCulture to develop a range of higher value productive appliances for more affluent customer segments.

SunCulture irrigation systems are marketed directly to customers through phone sales channels, regional sales and support centers, and a network of field sales agents in Kenya.

Agri digital financial services provide a safety net following adverse weather events and stimulate adoption of climate-smart inputs and assets

The traditional hurdles to financial services for smallholder farmers, mainly the high costs of assessing individual farm risk and creditworthiness, are slowly being removed as digital data sources are used to replace or approximate individual farm assessments.

In the insurance industry, index or parametric insurance is increasingly replacing indemnity models as they are proving to be more cost-effective and scalable. By relying on secondary data sources, such as weather observations for actuarial modelling, claims assessment costs are greatly reduced.

Similarly, with the increasing digitisation of payments and transactions in agricultural value chains, smallholder farmers are building financial histories that can be used for loan risk assessments and credit scoring. This significantly reduces the manual due diligence required by financial service providers to provide agricultural credit services.

Digital communication channels and mobile money services have also played a key role in facilitating financial services. As mobile phone ownership increases among smallholder farmers, mobiles can serve as both a marketing platform and payment/pay-out channel for digital financial products.

Agricultural credit

The increasing availability of digital data on farmers' economic and agronomic activity, combined with the growth of digital service delivery channels, are making formal agricultural credit services increasingly scalable to smallholder farmers.

Farmer credit scores and risk assessments can now be created using data on farm size, farmer assets and income streams, reducing or eliminating the need for face-to-face assessments (e.g. FarmDrive). Approved credit can be paid and repaid using digital vouchers or mobile money transfers, further reducing costs.

Short-term credit products give smallholder farmers access to improved inputs, such as high-yielding or drought-resistant crop varieties. Long-term loans, with payment terms built around a farmer's cash flow, can enable investment in assets that enhance productivity, such as irrigation.

Agricultural insurance

Agricultural index insurance uses digital data sources, such as automated weather stations and remote sensing data, as the basis for risk and claims assessment. This makes them cheaper and more scalable than traditional insurance that requires farm visits to assess premiums and claims.

Digital data sources typically include agriculture-related data, such as rainfall, evapotranspiration[9] or NDVI.[10] Historical indices are calculated to determine normal conditions, and pay-outs are based on deviations from those conditions.

In the face of adverse weather events, weather index insurance can make the difference between being able to replant a crop that did not germinate (e.g. due to a lack of early rains) or replace lost income at the end of an unproductive season. With insurance, farmers are able to cover their expenses and invest in the next season's crop.

Case studies: Agri digital financial services

FarmDrive

FarmDrive is a Kenyan tech start-up that specialises in credit scoring for smallholder farmers. Their services bridge the gap between smallholder farmers and financial institutions, making agricultural financing available to groups that have traditionally been excluded from the formal financial system.

FarmDrive collects information directly from farmers and combines it with relevant agronomic data, such as satellite imaging, soil analysis and weather forecasts, to assess credit risk. Credit providers can use the information provided by these models to make informed lending decisions, and use FarmDrive's digital platform to reach rural customers directly.

FarmDrive partners with financial service providers to make innovative agricultural credit products available to smallholder farmers. In Kenya, they work with Safaricom to launch DigiFarm Loans through Safaricom's mobile value-added services platform for rural customers.

Oko

Oko is a weather index insurance provider operating in Mali and Uganda. Specialising in the development of index insurance using remote sensing data, they partner with local insurance providers for underwriting. Oko markets their products directly to smallholder farmers or through other players in the agricultural value chain.

Oko uses publicly available data from the geostationary MeteoSat satellites via TAMSAT on cumulative rainfall, as well as NDVI and evapotranspiration, combined with historical yield data, where available, to create actuarial models and monitor insured risks. This provides a scalable quantification of risk and automated verification of claims and pay-outs. Insurance products are made available through apps and USSD, allowing them to be distributed to remote locations.

In Mali, Oko has partnered with MNO Orange to offer weather index insurance through Orange's USSD menu. This has created a fully digital insurance service that farmers can access and pay for using their mobile phone.

MNOs have a range of assets that enable localised and scalable climate resilience services

Digital technologies have been key enablers of innovation and service development in all three categories of climate resilience services (weather and climate services, data-driven agriculture services, and digital agricultural financial services). MNO assets, from technical infrastructure to communications channels, existing customer bases and agent networks, have the potential to support even greater innovation and scale climate resilience services.

Existing mobile network infrastructure can support the collection of local, ground-level weather observations through the use of CML data (section 2 takes an in-depth look at CML data) or by co-locating automated weather stations with mobile base stations. These observations fill a crucial gap in LMICs where weather radar and weather station networks are typically lacking. This data can be used by weather forecasters to localise global models, by DDAS providers to improve agronomic models and by insurance providers to provide agricultural insurance to previously unserved areas.

Mobile money channels enable innovative payment models, such as micropayments for asset financing (e.g. M-Kopa, SunCulture), which allow farmers to access credit products and services that were previously unattainable. For insurance, mobile money enables digital marketing and repayment of insurance policies, eliminating the need for face-to-face and cash transactions. MNOs can also help alleviate bottlenecks in user registration. Collecting Know Your Customer (KYC) and location data remains problematic for service providers, but MNOs may already have this data for their existing customers.

	Data collection	Analysis	Service design	Service delivery
Digital technology service enablers	• Automated weather stations (AWS) • Internet of things (IoT) enabled sensors • Remote sensing imagery and data (satellite, drone) • Open data sources (e.g. Africasoils.net, APHLIS.net) • Mobile data collection (e.g. ODK)	• Artificial intelligence approaches • Open-source analysis software and libraries (e.g. Python, R) • Global numerical weather models (e.g. GFS, ECMWF) • Serverless computing (e.g. Azure, AWS) • Cloud data analysis platforms (e.g. Azure FarmBeats)	• Geographic information systems (GIS) platforms • Data-as-a-service (DaaS) • Software-as-a-service (SaaS)	• Mobile aggregators (SMS/IVR) • Smartphone apps • Online platforms and services • Social media and chat • Application programming interfaces (APIs)
MNO value-add	• CML data for rainfall observations • Siting AWS with mobile base stations • Connectivity (data, IoT) • Registration data (location, KYC) • Mobile (money) usage data		• Bundling of complementary services • Mobile money enabled payments and payment models (e.g. pay-as-you-go) • Disbursement of credit via mobile money or digital vouchers	• Digital services platforms • Agent networks • Mobile delivery channels: SMS, USSD, IVR • Cell broadcast

Legend: **Data sources** **Technical infrastructure** **Marketing and distribution assets**

Endnotes

1 In agricultural value chains, the "last mile" is the web of relationships and transactions between buyers of crops, such as agribusinesses, cooperatives and intermediaries, and the farmers who produce and sell the crops.

2 GSMA (2020). Digital Agricultural Maps.

3 WRI. (2018). Creating a Sustainable Food Future.

4 GSMA (2020). Digital Dividends in Natural Resource Management.

5 WMO. (2015). Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services.

6 Wang, Y. et al. (2017). Guidelines for Nowcasting Techniques. WMO

7 Tsan, M. (2019). The Digitalisation of African Agriculture 2018–2019. CTA.

8 GSMA (2020). Agricultural insurance for smallholder farmers: Digital innovations for scale.

9 Evapotranspiration measures water loss through leaves, which is proportional to plant growth and crop yield. Evapotranspiration monitoring is done by modelling remote sensing data.

10 Normalised difference vegetation index (NDVI) quantifies the density of plant growth in a given area by measuring the reflectivity of the surface using remote sensing imagery.

11 Alley, R., Emanuel, K.A. and Zhang, F. (25 January 2019). "Advances in weather prediction", Science 363(6425), pp. 342–344.

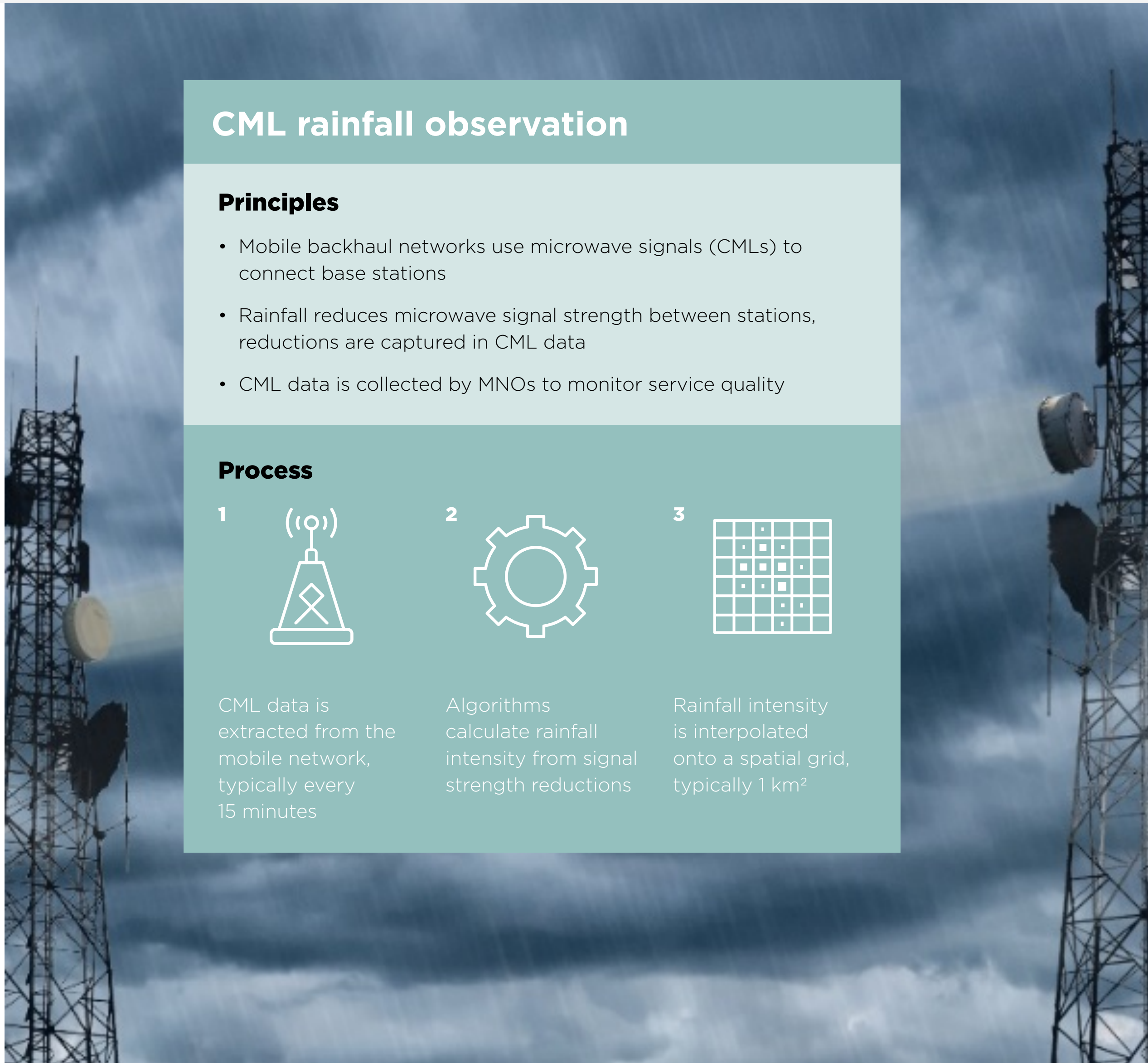
3 Measuring rainfall using mobile networks: commercial microwave links (CML) data

Existing mobile network infrastructure presents a unique opportunity to gather data that can support near real-time rainfall observations in countries with limited ground-level weather observations. This section describes the principles and potential of CML-based rainfall observation, and compares CML rainfall estimation to other precipitation data sources. It concludes by outlining the opportunity for MNOs to develop CML rainfall services through the addition of software to their network hardware.

Existing mobile communications networks can be used to observe rainfall events at high resolution by monitoring fluctuations in signal strength

Given the lack of reliable ground-level measurements, there is an opportunity for MNOs to add significant value to a range of weather monitoring and forecasting services. Recently, MNOs have begun using CMLs as virtual weather sensors to monitor and map rainfall measurements. CMLs are close-to-the ground radio connections used worldwide in cellular telecommunication backhaul networks. In telecommunications, backhauling refers to the connections and links between the core or backbone network and the small sub-networks at the edge of the network.

Along microwave links, radio signals propagate from a transmitting antenna at one mobile base station to a receiving antenna at another base station. When it rains, water absorbs and scatters these microwave signals, reducing the signal strength between the transmitting cell phone towers. By comparing signal levels to those representative of dry weather, CML data can be analysed and converted into highly accurate rainfall measurements, effectively turning the mobile network into a virtual network of rain gauges. Commercial weather companies such as ClimaCell,[1] and technology companies such as Ericsson and its Weather Data Initiative,[2] have developed their own proprietary algorithms to analyse this data and develop weather-related services. An open source algorithm, known as RAINLINK, has also been developed as part of a joint initiative between WUR and KNMI.[3]



CML rainfall observation

Principles

- Mobile backhaul networks use microwave signals (CMLs) to connect base stations
- Rainfall reduces microwave signal strength between stations, reductions are captured in CML data
- CML data is collected by MNOs to monitor service quality

Process

1. CML data is extracted from the mobile network, typically every 15 minutes
2. Algorithms calculate rainfall intensity from signal strength reductions
3. Rainfall intensity is interpolated onto a spatial grid, typically 1 km^2

Mobile networks cover over 90 per cent of the population in most LMICs, with less coverage in rural areas

Most countries in Sub-Saharan Africa, South Asia and Southeast Asia have mobile networks that cover over 86 per cent of the population (Figure 7), indicating extensive national backhaul coverage. It is estimated that by 2023, around 65 per cent of radio sites in the world will be connected by microwave (excluding Northeast Asia).[4] This means there is a significant opportunity to use CML as virtual weather sensors to monitor and map rainfall measurements.

In rural areas, network coverage is more limited as population density decreases. This is illustrated by the example of MNO Tigo in Tanzania (see Figure 8). While 95 per cent of the population in Tanzania is covered by a mobile signal, large uninhabited parts of the country are not. In rural areas, backhaul networks also typically become less dense and link lengths longer as fewer connections need to be served. However, studies have shown that lower link densities do not necessarily lower data quality because rainfall calculation algorithms use interpolation techniques that take density into account.[5] For agricultural use cases, this coverage is a significant improvement and indicates that significant agricultural areas in LMICs are covered by CML links.

Figure 7 **Percentage of population covered by mobile signal[6]**

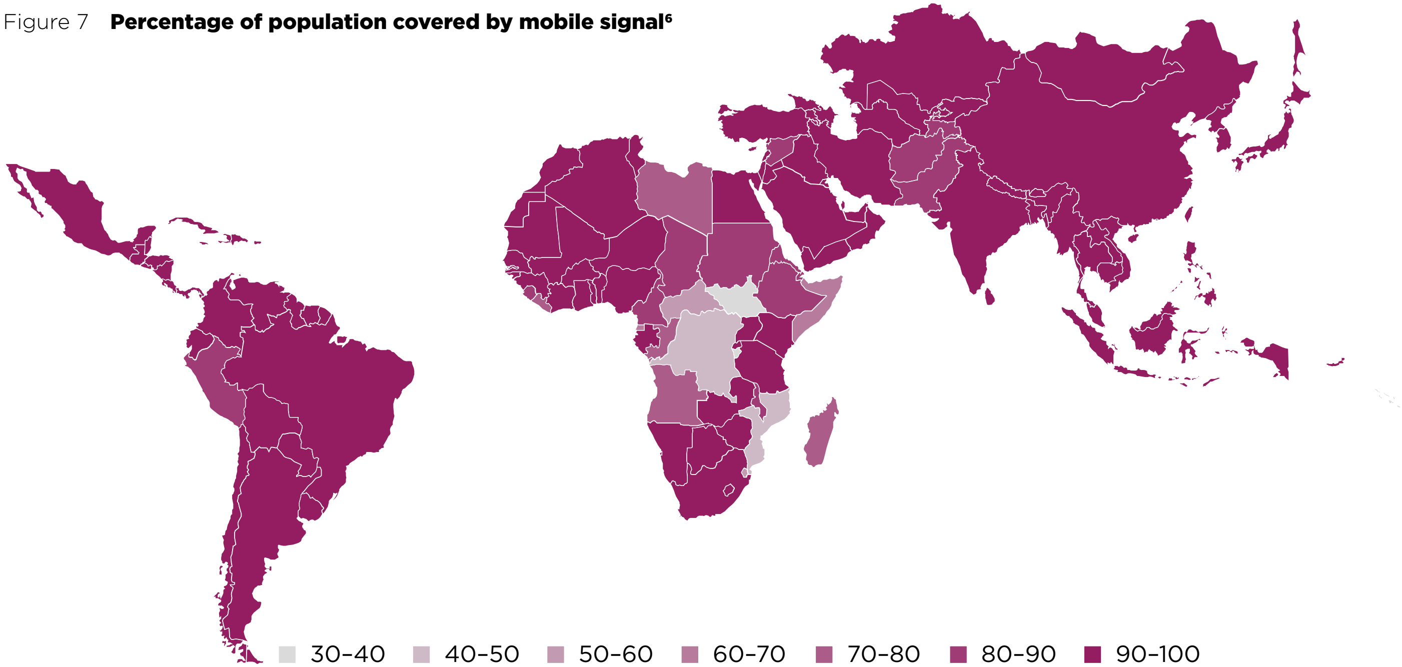
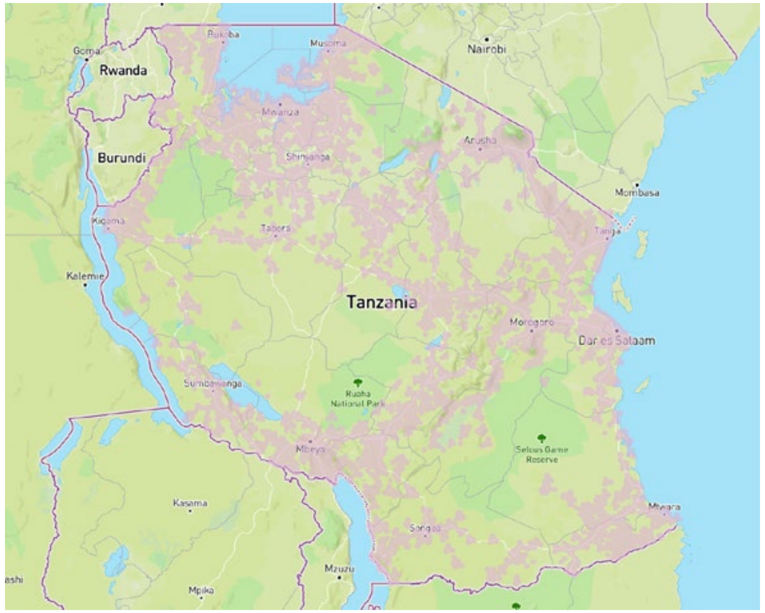


Figure 8 **Mobile network coverage of Tigo in Tanzania[4]**



CML rainfall estimates correlate strongly with daily rainfall amounts collected from official rain gauges

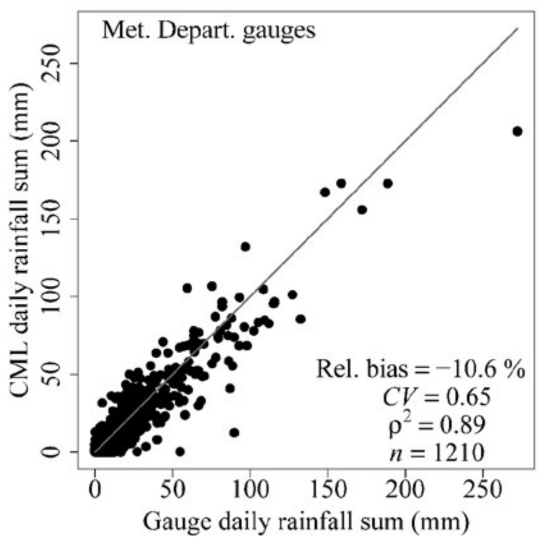
An extensive evaluation of rainfall observations produced from CMLs using the RAINLINK algorithm was conducted as part of an ongoing collaboration between Dialog, WUR, KNMI, TU Delft and the GSMA.[7]

Data was collected from both the Dialog backhaul network and from rain gauges operated by the Sri Lanka Department of Meteorology between 12 September and 31 December 2019. In total, data was collected from 2,418 link paths and 23 weather stations. CML data was collected every 15 minutes and weather station data for all stations was available at daily intervals.

The RAINLINK algorithm[8] was used to produce estimates of rainfall intensity along each CML path. These point estimates were then interpolated to produce a grid of rainfall observations at a resolution of 1 km. The values for each grid cell were added together to produce daily rainfall amounts.

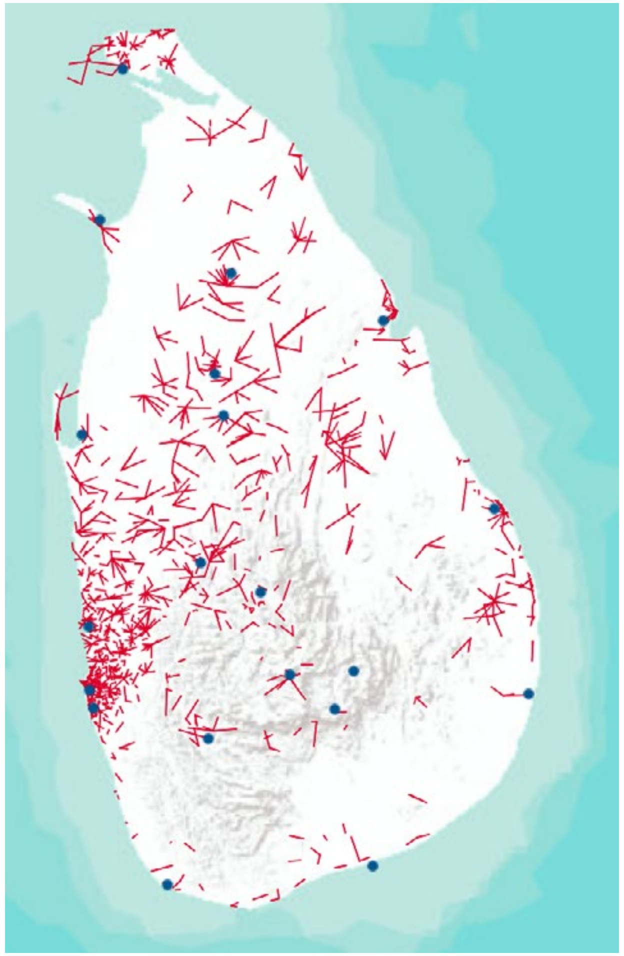
Figure 9 shows a comparison of daily rainfall amounts produced from the CML data and from the rain gauges. These values show a strong correlation, with a slight tendency of CML observations to underestimate rainfall amounts. Additional analysis that compared urban areas (with high CML density) to rural areas found no significant difference in correlation. Overall, this indicates that CMLs are a reliable data source for rainfall observation.

Figure 9 **CML comparison to rain gauges, Sri Lanka[7]**
(nearest CML on average < 5 km from rain gauge)



Each point on this scatterplot represents daily rainfall values for each location. The closest CML links are within 5 km of an official rain gauge, on average. The diagonal line represents perfect agreement between the measurements made by the rain gauges and from CML links, which would have a correlation coefficient of 1.

Figure 10 **CML vs. rain gauge distribution, Sri Lanka**



CML rainfall maps provide a higher resolution than the satellite benchmark, and can improve satellite-based models

Passing showers, Lagos, Nigeria, 6 March 2019

The NASA/JAXA co-led Global Precipitation Measurement (GPM) mission uses a constellation of satellites to produce precipitation rates for the world every 30 minutes at ~10km resolution.[9] Figure 11 shows GPM data for a rainfall event in Lagos on 3 March 2019. This data is available six hours after the event.

Using CML data from MTN Nigeria, WUR captured the same rainfall event, showing precipitation rates every 15 minutes at 1 km resolution (Figure 12). The CML-derived data also shows a greater range of rainfall intensity, indicated by the yellow areas of high intensity.

The unique characteristics of CML and satellite data are complementary and may be combined to build on each other's strengths. CML-based rainfall calculations can be improved by using satellite data to classify rain events and cover gaps in network coverage if CML density is low. CML observations, in turn, can be used to validate and improve satellite precipitation products. Improvements can be made either by merging them with satellite data or by using them as training data to improve satellite precipitation retrieval algorithms.

Figure 11 **Rainfall intensity map for Lagos, 6th March 2019 from GPM IMERG data**

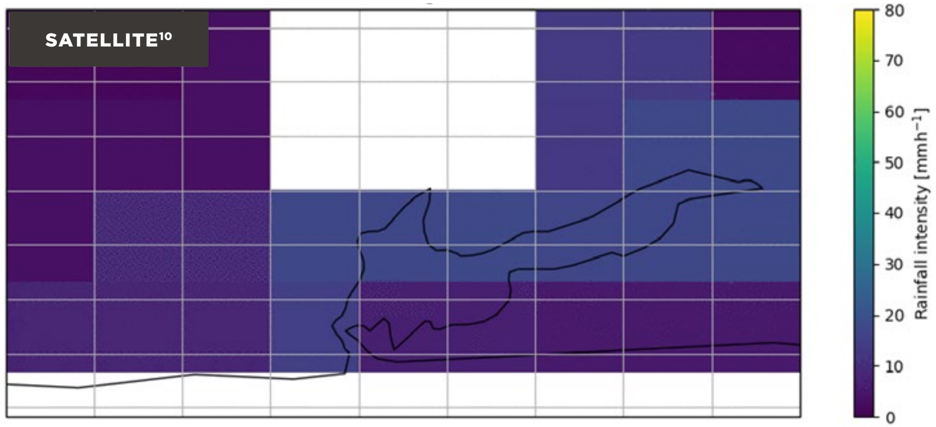
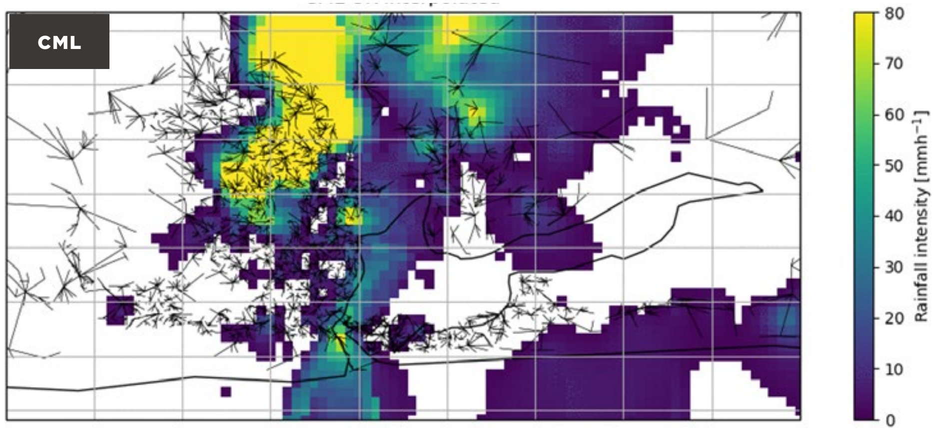


Figure 12 **Rainfall intensity map for Lagos, 6th March 2019 from MTN Nigeria's CML data**



CML rainfall observations can provide additional ground-level data to complement existing sources

Geostationary weather satellites

Geostationary satellites spin at the same rate as the earth, providing frequent imagery of the same area to help detect and forecast rapidly developing high-impact weather.[11]

Geostationary satellites are operated by numerous national space agencies to achieve global coverage.[12] Data is made publicly available online.

The frequency and resolution of data depends on the instruments used. Imagery from EUMETSAT is refreshed every 15 minutes and captured at 3 km resolution.[13] Rainfall monitoring can be conducted using statistical techniques based on cloud top temperatures[14] and benefits from calibration to surface observations.

Global Precipitation Measurement (GPM)

The GPM mission is an international collaboration co-led by NASA and JAXA to advance precipitation estimation from space for research and applications.[15]

Satellites provided by a consortium of international partners contribute measurements from a variety of sensors to GPM to generate and disseminate global precipitation products. Data is made publicly available online.

Precipitation data is available with global coverage every 30 minutes at a 10 km resolution. Data from real-time products is available approximately six hours after observation.

Weather observation stations

Weather station networks make a variety of surface observations, including temperature, rainfall and wind. They are typically operated by NMHSs and, in some cases, by private and civil sector[16] actors.

Weather station coverage in LMICs is typically low. Sub-Saharan Africa has one weather station per 26,000 km^2 – eight times lower than the WMO's minimum recommended level.[17] In India, the density is approximately one per 16,000 km^2.[13,18]

Precipitation data from automated weather stations is available in near-real time, typically at intervals of one hour. Manual weather stations provide readings every 3 hours or less.

Weather radar

Weather radar is used to track the intensity and movement of rainfall events. Weather nowcasting techniques use weather radar data to create short-term rain forecasts.

While relatively widespread in high-income countries, radar coverage in LMICs is much lower. In Sub-Saharan Africa, only Kenya, South Africa, Rwanda and Mali have functioning weather radar. In Southeast Asia, Myanmar and Thailand are the only countries with weather radar.[19]

Radar can detect rainfall events between 5 km and 200 km, and continuously rotates, creating a circular observation field with a diameter of 400 km. Radar observations are refreshed every five to 10 minutes.[20]

Commercial microwave links (CMLs)

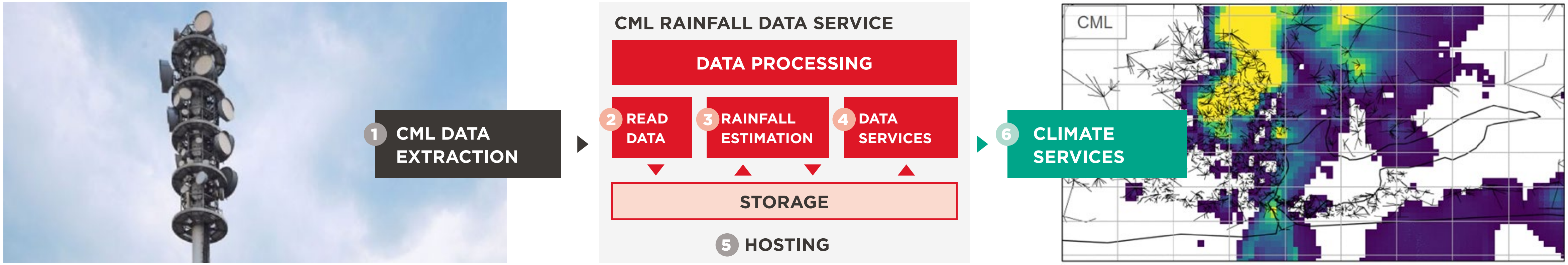
CMLs present an opportunity to measure ground-level rainfall by measuring signal reduction in microwave links that connect mobile backhaul networks.

Mobile network coverage has expanded rapidly in recent decades, and today over 90 per cent of the population in most countries are covered by a mobile signal.[21] Mobile network coverage is closely related to population density, with fewer links in rural areas.

CML data can be used to create rainfall maps at a resolution of 1 km^2.[22] The sampling frequency of CML data depends on the extraction method used. It is typically 15 minutes, but can be as frequent as one second.[23]

Opportunity for MNOs: CML rainfall data services can be created by adding a layer of software to existing mobile network infrastructure

Figure 13 **CML rainfall data service outline**



1 CML data is acquired from mobile base stations through network management software, data loggers or dedicated software services. For example, the open source pySNMPdaq service has been developed to collect CML data directly from base stations, bypassing network management software.[24]

2 CML data is handled by a number of services that facilitate the aggregation, normalisation and storage of data so that it can be processed by an algorithm into rainfall estimates.

3 There have been various approaches to converting CML data into rainfall estimates, as described in section 2. For example, RAINLINK is an open-source R package developed using an extensive dataset from the Netherlands, and can be used for this conversion.[25]

4 Once the rainfall data is available, various services can be used to make it available to end users. At the most basic, one or more APIs can be defined that allow users to request and receive data in pre-defined formats. Other data services can include map-based visualisations that allow users to view the data in real time.

5 The full software stack runs on a server that has access to the CML data and makes the rainfall estimations available to end users. This environment would need to include data security and user management services that govern access to the stored data. Potential hosts are MNOs, cloud hosting services (e.g. AWS, Microsoft Azure) or another third-party host.

6 By using the APIs and authentication keys provided by the CML rainfall data service, climate service providers can integrate the CML data source with their existing services.

Endnotes

1 Climacell: https://www.climacell.co/

2 The Weather Data Incubation Project – The Ericsson ONE Unit: https://www.ericsson.com/en/cases/2018/SMHI

3 Overeem, A., Leijnse, H. and Uijlenhoet R. (2016). "Retrieval algorithm for rainfall mapping from microwave links in a cellular communication network", Atmospheric Management Techniques 9(5), pp. 2425–2444.

4 GSMA Future Networks. (2019). Mobile Backhaul: An Overview.

5 Rios, M.F. et al. (2017). "Evaluation of Rainfall Products Derived From Satellites and Microwave Links for The Netherlands," IEEE Transactions on Geoscience and Remote Sensing, 55(12), pp. 6849–6859.

6 Indicator 9.c.1: Proportion of population covered by at least a 2G mobile network (percent); GSMA Network Coverage Maps: https://www.gsma.com/coverage/#279

7 Overeem, A. et al. (2021). "Tropical rainfall monitoring with commercial microwave links". Forthcoming publication

8 Overeem, A., Leijnse, H. and Uijlenhoet R. (2016). "Retrieval algorithm for rainfall mapping from microwave links in a cellular communication network", Atmospheric Management Techniques 9(5), pp. 2425–2444.

9 NASA's Global Precipitation Measurement Mission (GPM): https://gpm.nasa.gov/missions/GPM

10 NASA's Precipitation Data Directory: https://pmm.nasa.gov/data-access/downloads/gpm

11 EUMETSAT Meteosat Series: https://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Meteosat/index.html

12 Including NOAA (Americas), EUMETSAT (Europe, Africa), ISRO (South Asia) and JMA (Southeast Asia).

13 EUMETSAT Meteosat Series: https://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Meteosat/MeteosatDesign/index.html

14 EARS Earth Environment Monitoring – Delft. (2014). FESA Micro-Insurance: Crop Insurance Reaching Every Farmer in Africa.

15 NASA's Global Precipitation Measurement Mission (GPM): https://gpm.nasa.gov/

16 https://tahmo.org/

17 World Bank. (2 June 2015). "Creating an Atmosphere of Cooperation in Sub-Saharan Africa by Strengthening Weather, Climate and Hydrological Services".

18 Pai, D.S. et al. (January 2014). "Development of a new high spatial resolution (0.25° × 0.25°) long period (1901–2010) daily gridded rainfall data set over India and its comparison with existing data sets over the region", Mausam 65(1), pp. 1–18.

19 WMO Radar Database: https://wrd.mgm.gov.tr/Home/Wrd

20 Australian Government, Bureau of Meteorology (9 June 2017). "How does a weather radar work?"

21 Indicator 9.c.1: Proportion of population covered by at least a 2G mobile network (percent)

22 Overeem, A., Leijnse, H. and Uijlenhoet R. (2016). "Retrieval algorithm for rainfall mapping from microwave links in a cellular communication network", Atmospheric Management Techniques 9(5), pp. 2425–2444.

23 Chwala, C., Keis, F. and Kunstmann, H. (2016). "Real-time data acquisition of commercial microwave link networks for hydrometeorological applications", Atmospheric Measurement Techniques 9(3), pp. 991–999.

24 Chwala et al. 2016. Real-time data acquisition of commercial microwave link networks for hydrometeorological applications. Atmospheric Measurement Techniques

25 Overeem, A. et al. (2016). "Retrieval algorithm for rainfall mapping from microwave links in a cellular communication network", Atmospheric Management Techniques 9(5), pp. 2425–2444.

4 Digital climate resilience services: where CML rainfall data and other MNO assets add value

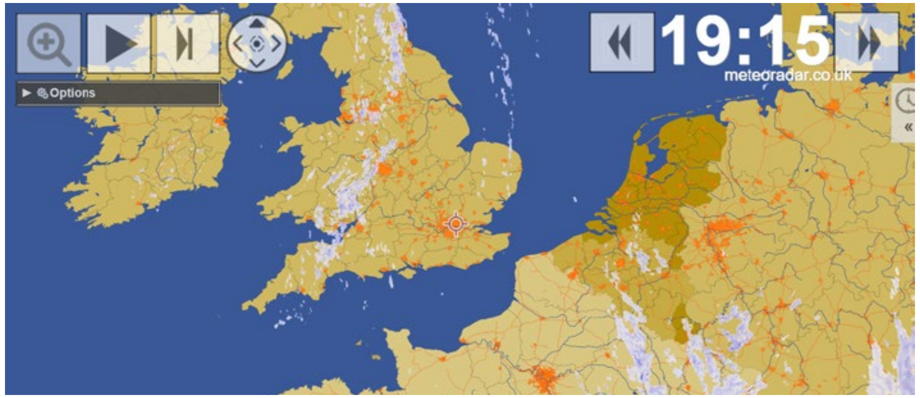
This section looks in detail at three use cases that are made possible or significantly enhanced by CML rainfall data and other MNO assets: weather nowcasting, climate-smart agricultural advisory and weather index insurance. It then lays out the steps required to create services for each use case, and the potential value add for MNOs.

Rainfall nowcasting provides high-resolution, short-term rainfall forecasts

Rainfall nowcasting provides high resolution rainfall forecasts up to six hours in advance. They are based on high-resolution rainfall observations (typically radar) that are spatially extrapolated into the future.[1] Data from the nowcasting models can be monetised to third parties through online data APIs, visualised to create end user services, such as nowcasting maps, or localised for users that receive rainfall forecasts and early warnings for their specific location.

Figure 14 shows an example of an online rainfall nowcast map for the UK and Europe by Meteoradar. The animated map visualises the movement of rainfall events for the coming three hours and allows users to zoom in to specific locations.

Figure 14 **Meteoradar's rainfall nowcasting service for Europe**[2]



Rainfall nowcasting: service creation

Data collection	Analysis	Service design	Service delivery
High-resolution rainfall observations Typically high-resolution radar quantitative precipitation estimates (QPE); 1 km grid @ 5 min CML data from MNO networks provides equally high resolution precipitation data as radar data. In LMICs, CML is likely to be the only source of precipitation at this resolution.	**Probabilistic nowcasting of rainfall fields** Statistical approaches that extrapolate past movements of precipitation fields are most commonly used, although machine learning approaches have recently begun to be explored.[2] For example, the pySTEPS initiative develops and maintains an open-source framework for nowcasting that combines various nowcasting models.[3]	**Rainfall nowcast data** Rainfall forecasts for the coming six hours are generated every time new observations are available, typically every five minutes. The data provides rainfall intensity (mm) for each cell in a spatial grid (typically 1×1 km cells). **Rainfall nowcast maps** Typically, nowcasting services visualise data as a dynamic map showing the original precipitation data and continuing it into the future.[4] **Rainfall early warnings** Nowcast data can be used to develop early warnings for heavy rainfall. When a predefined threshold for rainfall is exceeded, an alert is triggered for that area.	**Application programming interface (API)** An API makes nowcast data available to third parties in a predefined format and allows for user authentication and access control. **Online services** Web-based map services provide online platforms for viewing map data. They can be accessed through PCs or mobile devices and can be integrated in existing websites and smartphone apps. **Mobile channels (SMS, USSD, IVR)** Due to the limited bandwidth of mobile channels, they are best suited for early warnings or rainfall probabilities for specific user-defined locations.

Legend: Data sources Technical infrastructure Marketing and distribution assets

CML rainfall observations can enable rainfall nowcasting services in countries where weather radar is not available

Rainfall observations from CML data can be used as the input for weather nowcasting models.[5] In most LMICs where weather radar is not available, CML rainfall observations can be a key enabler for weather nowcasting services.

Nowcasting is an opportunity for MNOs to add value to their CML data services by building on their CML rainfall observations. Implementing this service would require a relatively small investment since the technology infrastructure required for rainfall nowcasts is similar to that for CML rainfall data services, and open-source nowcasting algorithms are now available.[6]

MNOs are well positioned to host commercial services built on nowcasting. They can use nowcasting service infrastructure to provide the API required for data access, and use their existing value-added service platforms and communications channels to deliver early rainfall warnings to consumers.

MNO value addition

Technical

- CML data from MNOs can be a key enabler of rainfall nowcasting in LMICs where radar is typically not available.
- Since no other data inputs are required, and nowcasting software is openly available, MNOs can consider hosting rainfall nowcasts, especially if they are also hosting the CML-rainfall conversion algorithm, because this would require minimal additional investment.

Commercial

- Several services can be derived from rainfall nowcasts that have distinct business models:
  - The rainfall data API allows rainfall nowcasts to be provided as a data service, in addition to the CML-derived rainfall data.
  - Web-based map services for nowcasts are commonly used in developed markets and typically rely on ad-based revenue generation.
  - Rainfall early warnings through mobile channels can be offered as part of a bundle of value-added services for both urban and rural customers.

Rainfall nowcasting: MNO value-add

Data collection	Analysis	Service design	Service delivery
High-resolution rainfall observations	Probabilistic nowcasting of rainfall fields	Rainfall nowcast data	Application programming interface (API)
		Rainfall nowcast maps	Online services
		Rainfall early warnings	Mobile channels (SMS, USSD, IVR)

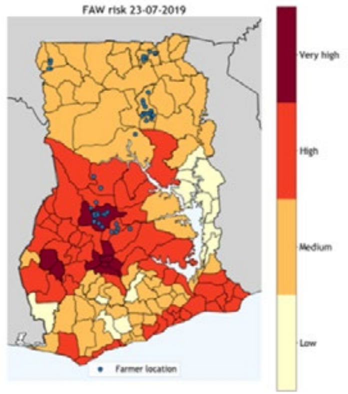
Legend: **Critical MNO value-add** (High-resolution rainfall observations) | **Incremental MNO value-add** (all other items)

Climate-smart agri advisory uses weather and location data to tailor advisory messages to farm conditions

Climate-smart agricultural advisory (CSAA) services are the first step from general agricultural advice towards advisory that is tailored to specific farms. By integrating various data sources, such as remote sensing, weather forecasts and agronomic data, these services can model current and future agricultural conditions and tailor messaging. Depending on the data available, this can include advice on what and when to plant at the start of a season, the timing of good agricultural practices throughout the season and early warnings for crop pests and disease. Producing tailored advice using algorithms or decision trees is the most scalable approach. However, many services currently rely on expert assessments of the available data to manually create advisory content.

Figure 15 **Fall armyworm early warning, Ghana**

In developing an early warning system for the fall armyworm, Weather Impact and Satelligence combined satellite imagery, weather forecasts and observational data to provide a weekly risk assessment for every district in Ghana.[7] This information is translated into local languages and communicated to farmers via voice-SMS by local agritech partner Esoko.



Climate-smart agricultural advisory: service creation

Data collection	Analysis	Service design	Service delivery
Remote sensing data Data from satellite-mounted sensors that enables monitoring of agricultural variables, including land use, crop classification, NDVI and evapotranspiration.	**Agronomic modelling** Involves the use of analytical methods, typically machine learning, to identify key variables that allow the monitoring and modelling of agricultural phenomena, such as crop growth, incidence of pest and disease and value chain risk. Having historical data is key, as it allows robust "training sets" to be created, and current and forecast data to infer current conditions and create predictions.	**Seasonal planning** Advisory provided at the start of a growing season can support decisions, such as when to plant and harvest, crop variety selection and inputs required, given the climate forecasts for a specific user location.	**Smartphone apps** Apps can provide rich advisory information reinforced by audio/visual content, and can gather information from farmers to expand and improve advisory messages.
Weather observations and forecasts Weather data sources include observations, short-term forecasts and longer term climate predictions.	**Decision support system** Typically in the format of a decision tree, decision support systems use knowledge of good agricultural practices to consider key variables, such as location, crop, growth stage and weather, to provide the most relevant advice in a particular situation.	**Short-term agricultural advisory** Advice provided over the course of a growing season on the timing and application of good agricultural practices, such as land preparation, choice and application of fertiliser and pesticides and harvesting.	**Mobile channels (SMS, IVR, USSD)** Basic mobile channels are still the most accessible for smallholder farmers. Since bandwidth for data transfer through these channels is low, localisation is important to ensure users receive the most relevant messages.
Agronomic data Agricultural data from secondary sources, including market prices, productivity, input use, soil maps and good agricultural practices.		**Early warnings** Based on agronomic models or decision support systems, triggers can be set for specific early warnings that are sent out when certain conditions are met. Risks are typically related to weather, pests and disease.	**Intermediated delivery** Field-level actors can play a key role in the delivery and interpretation of advisory messages from digital sources in contexts where they are not available to the majority of intended recipients.
Basic farm data Location, crops cultivated and mobile number are the basic data required to deliver advisory services.			

Legend: Data sources · Technical infrastructure · Marketing and distribution assets

Farmer location data and CML rainfall observations can enable localised climate-smart agri advisory

Local weather observations from CML data or AWS co-located with MNO base stations enable the creation of localised weather models. This allows them to provide valuable inputs to models for agricultural growth and the incidence of pests and disease. Since these observations are typically not available in LMICs, they can add significant value to CSAA.

Collecting basic farm data, especially location data, can be a major expense for CSAA. To provide localised advisory messages, accurate location is crucial. However, in the absence of widespread smartphone adoption (GPS) or a well-established address system, collecting a location can be a significant barrier for user registration. MNOs can help overcome this barrier by using existing registration data, or by using call detail records and location-based services to locate customers.

The technical value provided by MNOs enable services to be improved (through localised weather information) and costs to be reduced (by making it less expensive to register new users). MNOs that already serve rural populations with value-added services will also be able to market CSAA services to their existing user base, and bundle them with other service offerings. For MNOs, CSAA services can improve customer acquisition and retention (reduce churn), and generate new sources of income through revenue-sharing models.

MNO value addition

Technical	Commercial
• Weather observations from CML data or co-located AWS can provide data to enable or improve localised agronomic modelling. • By providing user data from existing value-added services, or location data obtained from call detail records, MNOs can facilitate the collection of user data required for service localisation.	• Use of MNO-owned data sources reduces operating costs • CSAA can be marketed through existing service platforms and to existing customer bases. • CSAA services can be bundled with complementary services to provide novel value propositions. • Provision of CSAA services can improve customer acquisition and retention (reduce churn) for MNOs and provide new revenue streams.

Climate-smart agricultural advisory: MNO value-add

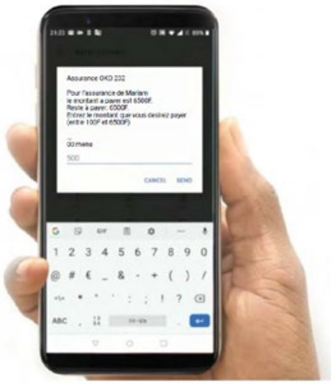
Data collection	Analysis	Service design	Service delivery
Remote sensing data	Agronomic modelling	Seasonal planning	Smartphone apps
Weather observations and forecasts	Decision support system	Short-term agricultural advisory	Mobile channels (SMS, IVR, USSD)
Agronomic data		Early warnings	Intermediated delivery
Basic farm data			

Legend
Incremental MNO value-add

Weather index insurance uses weather observations to protect smallholders from agricultural risks

Weather index insurance uses weather observations as indicators of agricultural risk. By moving away from insuring individual farms to catchment areas that share weather conditions, costs are greatly reduced and insurance becomes viable for smallholder farmers. While some traditional insurers have made the transition to index insurance, typically these services are created by technical service providers (TSPs) that specialise in the development of actuarial models and delivery of digital services. These TSPs partner with local insurers for underwriting and may create additional partnerships with MNOs, input providers and/or government agencies to bundle and distribute their services.

Figure 15 **OKO, a technical service provider, has partnered with Orange in Mali** to provide their agricultural insurance to farmers through Orange's USSD menu. This has helped them reduce operating costs and greatly expand the reach of their product. Since insurance is complex, Orange and OKO have also conducted voice SMS campaigns to educate farmers about the benefits of insurance and how it works.



Weather index insurance: service creation

Data collection

Current and historical weather observations

Observations include temperature, wind speed and precipitation from sources such as weather stations, radar and satellite. Extensive historical data are typically required to build an actuarial model.

CML data from MNO networks can provide high-resolution precipitation observations, which are a key enabler for rainfall-index insurance.

Basic farm data

Location of farm, crops cultivated and mobile number are the basic data required to deliver insurance.

MNOs can provide farmer locations from call detail records or location-based services.

Analysis

Actuarial modelling

Actuarial modelling is the analysis of the agricultural risks being covered (e.g. excess rainfall, drought, yield) to create sustainable insurance products. For each risk, historical data is required to create a reference index and thresholds at which pay-outs are triggered. This risk is then monitored throughout the insured period to determine when and where pay-outs are due.

This modelling is sometimes carried out by the insurance provider, but is also often provided by agri-intelligence companies with specialist skills to acquire, process and monitor this data.

Service design

Bundling

Index insurance is often provided as a complementary addition to an existing service or product.[8] Bundling provides additional opportunities for distribution and the development of new revenue models, and can reduce the need for customer education on insurance.

Early drought insurance was bundled with seed, with pay-outs enabling the purchase of replacement seed. Agricultural credit is often provided with insurance cover, which serves as collateral and reduces loan risk.

Mobile money integration

Mobile money can significantly reduce costs in the provision of agricultural insurance.

Pay-outs are usually digitised since mobile money account details can be collected during registration and payments triggered automatically.

Service delivery

Smartphone apps

Apps provide an opportunity to educate the user about the insurance, and allow users to register and pay the insurance premium.

Mobile channels (SMS, IVR, USSD)

Insurance is increasingly offered through SMS or USSD channels as part of larger, value-added service offerings to the agricultural sector. Benefits include customer trust and existing user bases.

Face-to-face

Face-to-face marketing channels remain important due to the complex nature of insurance and the detailed registration data required to provide insurance.

Legend: Data sources | Technical infrastructure | Marketing and distribution assets

Mobile money and digital marketing platforms can enable fully digitised index insurance services

MNOs can enable the creation of weather index insurance in contexts where adequate weather observations are not available. Mobile base stations provide opportune locations for installing automatic weather stations, while CML data can be used to provide high-resolution rainfall observations from existing network infrastructure. Both approaches would likely improve the resolution of existing weather observation sources, typically satellite or NMHS observation networks. Higher resolutions would create fewer false negatives and erroneous pay-outs, and improve the efficiency and perceived trustworthiness of the service.

Already having customer registration data, mobile money services and marketing platforms significantly reduce the costs of providing weather index insurance and achieving scale. Call detail records and location-based services can be used to infer a user's location where registration data is not available. Where available, digital services platforms can be used to market weather index insurance, leveraging the brand strength of MNOs and providing opportunities to bundle weather index insurance with complementary services, especially credit, to create stronger overall value propositions.

MNO value addition

Technical	Commercial
• Weather observations from CML data or co-located AWS can enable rainfall index insurance where other sources of data are not available, or reduce basis risk where only lower resolution data has been available. • MNOs can leverage user data from existing value-added services, as well as location data obtained from call detail records, to enabled localised services.	• Cost reductions through the use of existing registration data, mobile money services and marketing platforms for digital services. • Creation of more attractive value propositions through the bundling of complementary services.

Weather index insurance: MNO value-add

Data collection	Analysis	Service design	Service delivery
Current and historical weather observations	Actuarial modelling	Bundling	Smartphone apps
Basic farm data		Mobile money integration	Mobile channels (SMS, IVR, USSD)
			Face-to-face

Legend

Critical MNO value-add

Incremental MNO value-add

Endnotes

1 Wang, Y. et al. (2017). Guidelines for Nowcasting Techniques. WMO

2 Meteoradar, Expected rainfall next 3 hours.

3 Pulkkinen, S. et al. (2019). "Pysteps: an open-source Python library for probabilistic precipitation nowcasting (v1.0)", Geosci. Model Dev. 12, pp. 4185–4219.

4 www.meteox.com

5 Imhoff, R.O. et al. (2020). "Rainfall nowcasting using commercial microwave links", Geophysical Research Letters.

6 The pySTEPS initiative: https://pysteps.github.io/

7 Van Pelt, S. (25 July 2019). "Fall Armyworm early warning system operational in Ghana" Weather Impact.

8 GSMA (2020). Agricultural insurance for smallholder farmers: Digital innovations for scale.

5 Unlocking CML rainfall data: opportunities for MNOs and service providers

This section describes the approaches MNOs can take to contribute to climate resilience services, from commercialising CML data through data-as-a-service (DAAS) models for weather and climate service providers, to partnering with relevant consortia in the provision of data-driven agriculture services and agri digital financial services. Potential revenue streams are identified for DAAS models, and potential consortia and contributions from consortium members are outlined for partnership models.

CML rainfall data can enable and improve a range of services for agriculture and other sectors

As demonstrated in the previous section, a range of services can benefit from CML-derived rainfall data. For services such as weather nowcasting, early warnings and alerts, as well as weather index insurance, timely and high-resolution rainfall data is vital. Data-driven agricultural services can also benefit from CML rainfall data because it can provide higher resolution than other data sources.

Figure 17 **Agricultural users and economic sectors that can benefit from climate resilience services**

Service	CML value-add		Agricultural users	Other sectors	
Weather nowcasting	Service enabler		Smallholder farmers, agribusinesses, extension agencie	Aviation Public services	Extractive industries Logistics
Weather and climate forecasting		Improved accuracy and resolution	Smallholder farmers, agribusinesses, extension agencies, policymakers	Aviation Public services	Extractive industries Logistics
Early warnings and alerts	Service enabler	Improved accuracy and resolution	Smallholder farmers, agribusinesses, extension agencies	Public services Mainstream media	Humanitarian
Agricultural intelligence		Improved accuracy and resolution	Agribusinesses, commodity traders, policymakers, input providers, financial service providers		
Climate-smart agri advisory		Improved accuracy and resolution (indirect)	Smallholder farmers, extension agencies, cooperatives, agribusinesses		
Precision agriculture		Improved accuracy and resolution	Smallholder farmers, agribusinesses		
Agricultural insurance	Service enabler	Improved accuracy and resolution (indirect)	Smallholder farmers, agribusinesses, input providers, government agencies		
Agricultural credit		Improved accuracy and resolution	Smallholder farmers, agribusinesses, input providers, government agencies		

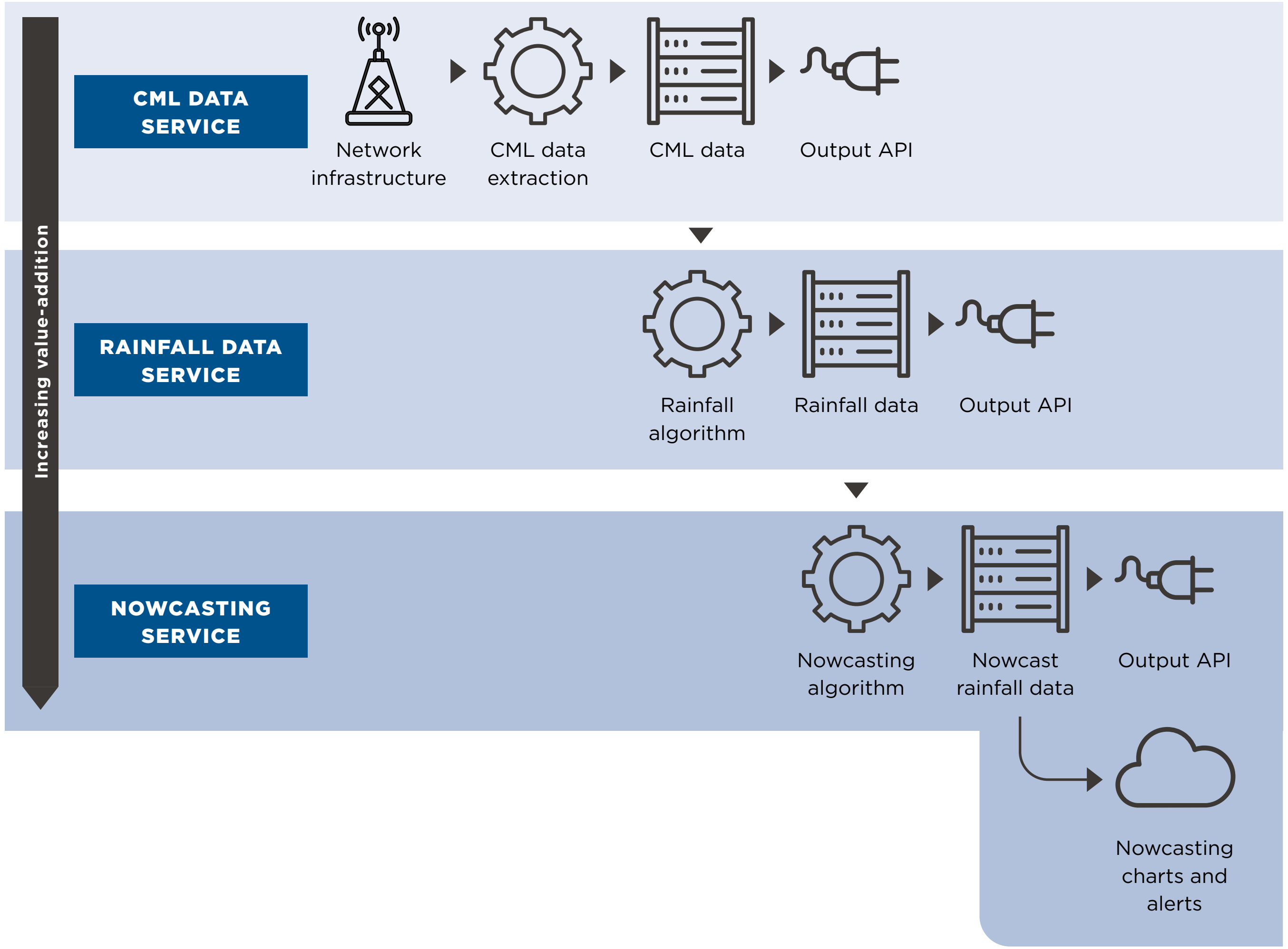
MNOs can generate additional revenue streams by offering enterprise services based on CML rainfall data

When operationalising CML data for their climate services, MNOs have the option to share raw CML data with third parties or convert it into rainfall data and nowcasts, which can offer greater value to potential enterprise users.

A raw CML data service would appeal to weather specialists and other organisations willing to do the conversion to rainfall observations in-house. Rainfall data services will be immediately valuable to a wider range of actors, including weather forecasters and agri-intelligence service providers. These services can be monetised through subscription or price per data models that provide users access to specific coverage areas and/or time intervals. Potential revenues are outlined on page 37.

Rainfall data can also be processed to create and host weather nowcasts. This can be done by using open-source nowcasting algorithms, such as pySteps, and specialist consultants to configure them for local contexts. Mainstream media outlets (broadcast and online) are potential customers since nowcasts are valuable services for the general public. They can provide the basis for extreme weather warnings, and are useful for weather-exposed sectors of the economy, such as aviation, logistics and extractive industries.

Figure 18 **Building enterprise services based on CML data**



Potential revenue opportunity of CML weather data services for MNOs: scenarios from key markets

To provide an indication of the potential revenue opportunity for MNOs, we have created several pricing scenarios based on existing data-sharing agreements in Europe. We estimate that MNOs could charge between $2 and $7 per km² per year for raw CML data services. The cost of this service in the EU is $10 per km² per year.[1] Figures 19–21 indicate the annual revenue potential based on different coverage and price scenarios. The inset maps show the network coverage of the market leader in each country[2] and informs the maximum coverage used in the revenue scenarios.

In Nigeria, this would equate to an annual revenue of between $0.55 million and $1.94 million with 30 per cent geographical coverage, between $0.12 million and $1.22 million in Kenya and between $0.38 million and $2.67 million in Indonesia. Services that provide processed data are likely to command higher prices, appeal to more users and yield higher revenues. This increase would potentially offset the additional investments required to set up and maintain the processing infrastructure for rainfall calculation and the production of rainfall nowcasts.

Figure 19 **Nigeria: Potential annual revenue from raw CML data**

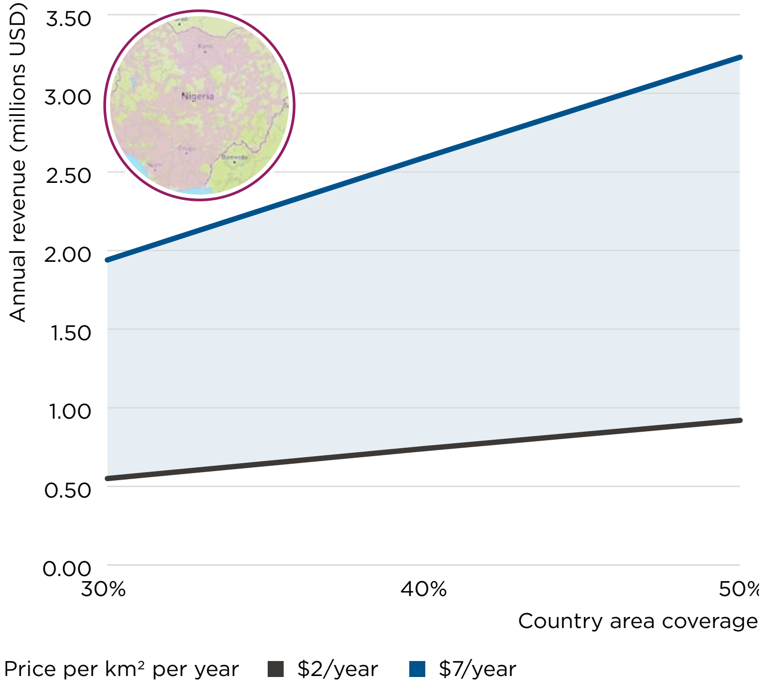


Figure 20 **Kenya: Potential annual revenue from raw CML data**

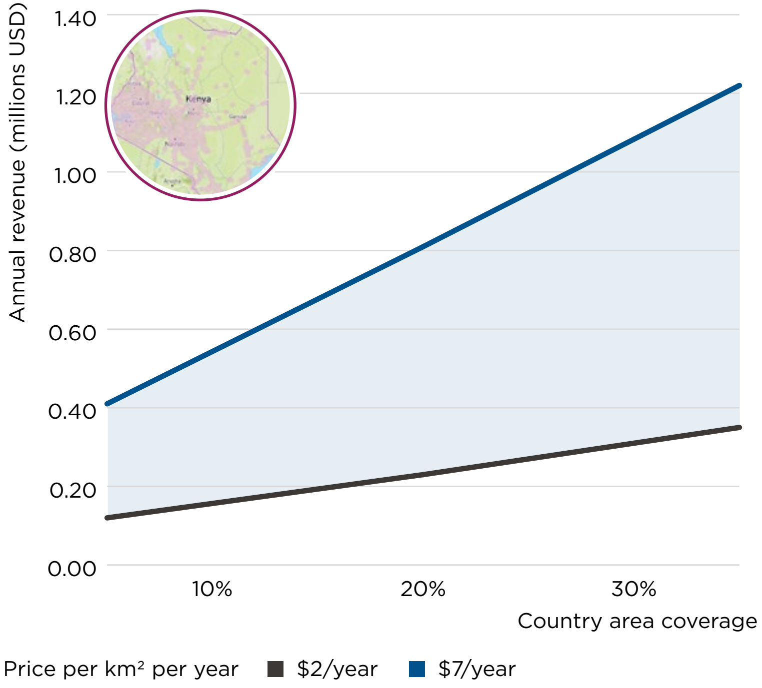
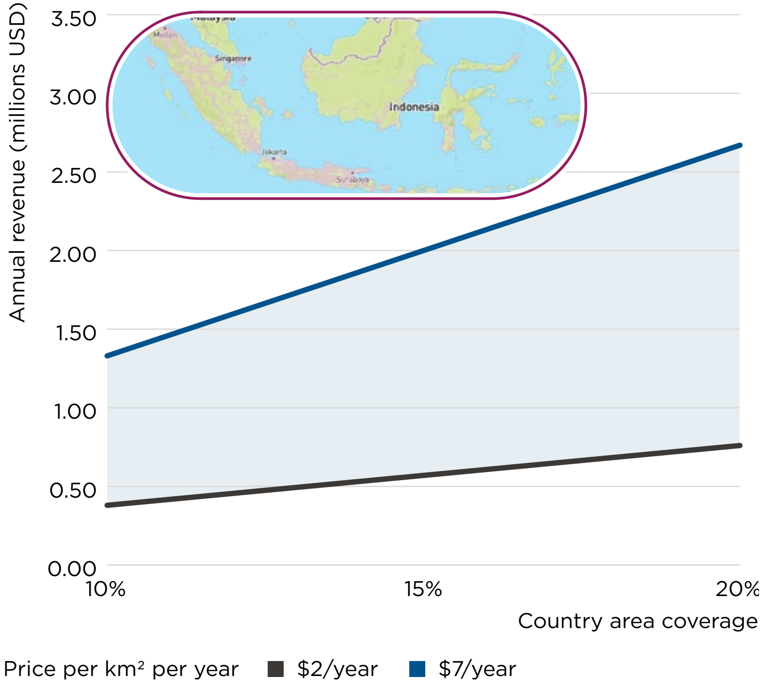


Figure 21 **Indonesia: Potential annual revenue from raw CML data**



MNOs can play a key role as a partner in B2C climate resilience services

When creating consumer-facing, data-driven agricultural advisory and financial services, weather data is one of several assets that MNOs can contribute. A partnership approach is therefore appropriate. In such partnerships, MNOs can benefit from revenue-sharing arrangements, increased ARPU from data, communications and/or mobile money usage. They can also benefit from stronger customer acquisition and retention metrics due to the services offered through the MNO's network and VAS platform.

In DDAS, **agri-intelligence providers** develop the agronomic models that provide the content for CSAA services and agricultural intelligence platforms. In agri DFS, these models can be utilised to develop and monitor indices for agricultural insurance as well as assess climate risk for agricultural credit.

In the provision of weather index insurance, **financial service providers** provide underwriting and required regulatory compliance, and may conduct the actuarial modelling required to create the insurance product. In the provision of agricultural credit, financial service providers take the lead in risk assessment. Agent networks may be used to sensitise and market the provided services.

Agritechs and agribusinesses can play an important role in distributing services and registering users. Agritechs would rely on their digital platforms while agribusinesses would leverage their purchasing networks, extension agents and connected smallholder farmers.

Figure 22 **Potential organisations and roles in the provision of data-driven agriculture services and agri digital financial services**

CLIMATE-SMART AGRI ADVISORY

MNOs
- Distribution (mobile channels, VAS platform)
- Profile data (location)
- Weather data (CML/AWS)

Agri-intelligence provider
- Agronomic modelling
- Advisory content creation

Agritech
- Service platform
- Hardware development
- Farmer profiling data

Agribusiness
- Agent network (extension, data collection)

PRECISION AGRICULTURE

MNO
- Distribution (mobile channels, VAS platform)
- Profile data (location)
- Weather data (CML/AWS)

Agritech
- Service platform
- Hardware provision (sensors, mechanisation)
- Farmer profiling data

Agritech
- Service platform
- Hardware development
- Farmer profiling data

Agribusiness
- Agent network (extension, data collection)

AGRICULTURAL INSURANCE

MNO
- Distribution (mobile channels, VAS platform)
- Profile data (location)
- Weather data (CML/AWS)
- Mobile money services

Financial service provider
- Actuarial modelling
- Index monitoring
- Agent network

Agritech
- Service platform
- Hardware development
- Farmer profiling data

Agribusiness
- Agent network (extension, data collection)

Agri-intelligence provider
- Index monitoring

AGRICULTURAL CREDIT

MNO
- Distribution (mobile channels, VAS platform)
- Profile data (location)
- Mobile money services

Financial service provider
- Credit provision
- Agent network

Agritech
- Service platform
- Hardware development
- Farmer profiling data

Agribusiness
- Credit provision
- Farmer transaction data

Agri-intelligence provider
- Climate risk assessment

Case study: The GSMA is working with MNOs during 2020–2022 to develop CML rainfall data services and pilot their use in climate resilience services

Building on successful pilot studies completed in 2019 to test the viability of using CML data to measure rainfall in tropical countries, the GSMA continues to work with Dialog Axiata Sri Lanka and MTN Nigeria, and has established an engagement with Digicel Papua New Guinea to operationalise CML rainfall estimates for use in climate resilience services.

This work involves additional research and development to evaluate and optimise the RAINLINK rainfall estimation algorithm for use in tropical climates; technical development of an automated rainfall estimation service; and a pre-pilot test of the use of CML data in a climate resilience service.

Lessons from this process will be shared in reports and academic publications, and the refined RAINLINK algorithm will remain publicly available under an open-source licence. We hope this will clarify the process and demonstrate the viability of using CML data in climate resilience services, and motivate more MNOs to invest in unlocking this valuable resource.

GSMA contribution:

Dedicated resources: mapping stakeholders, identifying best practices, brokering partnerships

Technical partners: development of rainfall estimation algorithm; development of rainfall service

MNO contribution:

CML data: six to 12 months to improve algorithm and share with climate service provider (CSP)

Commitment to pre-pilot test: CML-enabled climate resilience service in partnership with a relevant CSP

Engagement outputs:

Localised RAINLINK[3] algorithm that converts CML data into high-resolution rainfall estimates

- Published as an open-source software package.
- Extensive evaluation of the algorithm, supported by academic publications.

Evaluation of a CML-enabled climate resilience service (non-commercial pre-pilot)

- Demonstrates value of CML data in climate resilience service; first step towards the development of a commercial climate service.
- Informs the strategic direction for the development of CML-based services and partnerships.

Case study: Dialog Axiata Sri Lanka is pursuing the use of CML and AWS in weather and agriculture services

Sri Lanka is heavily affected by climate change. In 2018, it ranked sixth among countries most affected by extreme weather events due to severe monsoon rains in the southwest of the country.[5] It is estimated that nearly 87 per cent of Sri Lankans are living in areas likely to experience extreme temperatures and rainfall that will impact lives and affect livelihoods.

Dialog is Sri Lanka's leading mobile network with over 50 per cent total market share and over 15 million connections.[4] Dialog is renowned for their focus on using its network and operations for development, innovation and sustainability, and has launched a succession of digital climate and agricultural services (Figure 22).

Their digital agri-advisory service, Govi Mithuru, was launched in 2015 and has since reached 600,000 users. The service is accessible through an app or voice service by Dialog subscribers for a daily fee of Rs.1 (voice) or Rs. 2 (app) and provides advice on 25 types of crops. In addition to increasing direct revenues, the service has also driven new SIM sales and enhanced the loyalty of existing users.[6]

Recently, Dialog has co-located 35 AWS with mobile base stations to collect weather observations. They make them available as part of a suite of weather-related services to third-party users through the WeatherGuru data platform. They are also piloting rainfall index insurance in partnership with insurer Sanasa that draws on their AWS data to provide a safety net for tea farmers. Ongoing research with the GSMA and WUR is investigating the use of CML-derived rainfall estimates in the provision of index insurance to improve weather forecasting and provide climate-sensitive agricultural advisory services.

Figure 23 **Overview of Dialog's weather and agricultural services and initiatives**

2005	Launch of public Disaster Early Warning System (DEWN)
2014	Launch of DEWN v2 in collaboration with the Sri Lankan Disaster Management Centre
2015	Launch of the Govi Mithuru digital agri-advisory service
2018	Launch of WeatherGuru with Ideamart and Earth Networks
2019	Start of collaboration with the GSMA and WUR on using CML data for rainfall estimation[3]
2021	Pilot testing of rainfall index insurance for tea farmers with Sanasa; investigating use of CML data in insurance provision

Endnotes

1 GSMA (2019). Mobile technology for rural climate resilience: the role of mobile operators in bridging the data gap.

2 GSMA Network Coverage Maps: https://www.gsma.com/coverage

3 https://github.com/overeem11/RAINLINK

4 https://data.gsmaintelligence.com/data/operator-ranking

5 Eckstein, D. et al. (2020). Global Climate Risk Index 2020. Germanwatch.

6 GSMA AgriTech (25 September 2019). Rainfall monitoring through mobile technology in Sri Lanka.

6 Key findings and recommendations

Key findings

- **Advances in digital technologies, including satellite observations, artificial intelligence and mobile communications have enabled innovations in digital services that support the climate resilience of smallholder farmers in LMICs.** There are three categories of digital agriculture solutions that have the greatest potential for impact: weather and climate services, data-driven agricultural services and digital agricultural financial services.
- **Data from mobile networks and services can form key inputs to all three service types.** Weather observations from CML data or weather stations co-located with mobile base stations can enable the creation of new services or improve the resolution and/or accuracy of existing services. Farmer locations from existing registration data or call detail records can enable the localisation of service delivery. Data from mobile money services can be used to assess creditworthiness of farmers.
- **CML data has significant potential to support climate resilience services.** CML data is an available, but untapped, source of high-resolution rainfall observations that covers over 90 per cent of the population in LMICs. Recent research confirms that CML data is a reliable source for rainfall observations compared to official rain gauges, and offers better temporospatial resolution, sensitivity and timeliness than the satellite benchmark. MNOs can develop CML rainfall services by adding a layer of software to their existing mobile network infrastructure.
- **MNO's digital distribution channels and mobile money services enable innovation in service delivery.** Digital marketing platforms alongside mobile distribution channels and agent networks can be leveraged to target new services to an MNO's existing customer base. Complementary digital services can be used to create service bundles with more compelling value propositions. Mobile money services can be used to create fully digital financial services and enable innovative payment models.

Key findings

- There are three **main use cases** to which MNOs could add significant value:
  - CML data can enable the creation of **weather nowcasting services** because it provides the near real-time weather observations needed to provide high-resolution short-term forecasts. This data allows MNOs to create and deliver nowcasts independently or in partnership with weather forecasters. It could be provided either as a standalone service or enable severe weather warnings and other industry-specific services.
  - **Climate-smart agricultural advisory (CSAA)** could use local weather observations from CMLs and AWS provided by MNOs to improve the reliability and precision of their advisory messages. Using their existing user data, MNOs can support the registration of new users to the CSAA service, enabling new distribution models and reducing running costs.
  - MNOs can enable **weather index insurance** by providing weather observations through CML data or weather stations co-located with mobile base stations. Other mobile assets, such as mobile money services, user registration and location data, as well as complementary services, all present opportunities to reduce the costs of service creation and delivery, and build more compelling value propositions through service bundling.
- **The involvement of MNOs in climate resilience services has the potential to create additional revenue streams and improve business metrics** (customer acquisition and retention, ARPU) of services targeted at rural users, the general public and other economic sectors. In addition, partnering with weather forecasters, agri-intelligence providers and financial institutions can lead to strategic partnerships and even more opportunities for innovation and service creation as these fields develop.
- **The role of MNOs in the provision of climate resilience services will vary depending on the services provided.** This can range from being an independent service provider (weather nowcasting) to a data provider (CML rainfall data for weather forecasting and agriculture intelligence services), to a consortium partner (climate-smart agri advisory, precision agriculture, weather index insurance, agricultural credit).

Recommendations

MNO involvement in climate resilience services provision will depend on several considerations, unique to their specific market and strategy.

These key considerations are outlined here:

Investment

Willingness to invest in CML data extraction and processing

Unprocessed CML data services require the least investment for installation and maintenance and will appeal to weather service providers and other niche users willing to further process this data. Additional investments will enable in-house processing of the CML data to create value-added services such as rainfall and nowcasting, which appeal to a larger range of users from a variety of sectors.

CML rainfall services are likely to be the most suitable starting point in most markets as they are usable by a range of sectors and require minimal investment over unprocessed CML data services.

Strategy

Existing & strategic involvement in targeting direct-to-consumer services for the rural sector

MNOs with existing service offerings for the rural sector can leverage their existing service platform and user base to deliver B2C, as well as B2B, climate resilience services. For MNOs with a strategic objective to provide services for rural consumers, weather forecasts can form part of an initial service offering as they are relevant across agricultural value chains, maximising the potential market, while requiring minimal infrastructure and partnerships.

Business development

Potential enterprise users for weather services in agriculture and other sectors

Enterprise users in agriculture and other sectors form key user groups for weather services and provide revenue opportunities for MNOs not pursuing a rural strategy. CML data services can be offered to weather forecasters. Rainfall observations and nowcasting data represent valuable services for agribusinesses and agri-intelligence providers, as well as other sectors such as the extractive industries, logistics, and aviation.

Business model

Maturity of market and availability of potential partners

Depending on the maturity of the market, there is the opportunity to provide more complex climate resilience services such as precision agriculture (DDAS), and weather index insurance (agri DFS) services in partnership with specialist organisations.

The provision of DDAS will depend on the market-specific agricultural value chains and actors. Sustainable business models for CSAA typically depend on agribusinesses, government or civil sector subsidisation of the service, or provision to cash-crop farmers on a subscription basis.

Agri DFS will have similar prerequisites, with, in addition, the awareness and understanding of farmers of such services, as well as their ability to access them. Specialised partners are also required with the necessary expertise, and, in the case of insurance, regulatory approval to provide such services.

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