CASE STUDY

TAHMO

Leveraging commercial microwave link data to develop flood early warning systems

COUNTRY:
Ghana

PROBLEM ADDRESSED:
Lack of effective monitoring tools and data ahead of flooding events, leaving communities in flood-prone urban areas at high risk

TECHNOLOGY USED:
Commercial microwave links (CML), Internet of Things (IoT), web and mobile platforms including interactive voice response (IVR), SMS and WhatsApp

KEY PARTNERS:
AT Ghana (formerly AirtelTigo), MTN Ghana, National Disaster Management Organisation (NADMO), Ghana Meteorological Agency (GMet) and Farmerline Ghana Ltd

BUSINESS MODEL:
Not-for-profit, providing data free to government, communities and academia, with commercial users paying a fee for access

FIND OUT MORE: www.tahmo.org

The GSMA Innovation Fund for Anticipatory Humanitarian Action supported TAHMO to establish a flood early warning system in Aboabo, an urban suburb of Ghana that is increasingly vulnerable to severe flooding. TAHMO integrated various digital technologies in the system, including leveraging commercial microwave links from mobile masts to monitor rainfall data, alongside IoT-enabled sensors to provide hydro-meteorological data. The project applied a citizen science approach, with local smartphone users capturing videos that were used to interpret river flow data. Communities in Aboabo received flood early warning alerts via accessible mobile channels, including SMS, IVR and WhatsApp, improving safety and building resilience for residents and local authorities.

GSMA Innovation Fund for Anticipatory Humanitarian Action

Tahmo Project Outcomes October 2023 – March 2025

4,2k
People received early warning flood alerts via IVR and SMS

7
Citizen scientists collected water-level data with their phones

2
MNO partnerships created to access CML data

12
TAHMO stations installed – 5 weather stations (each with attached soil moisture sensors) and 7 hydrological sensors placed at drain sites

$2.58 million
Additional investment unlocked from other sources during the GSMA grant period

GSMA
Mobile for Development

About TAHMO

The Trans-African Hydro-Meteorological Observatory (TAHMO) is a not-for-profit organisation that provides institutional weather and climate data across Sub-Saharan Africa. TAHMO operates a network of more than 600 hydro-meteorological stations in 23 African countries. It provides an innovative rainfall product that combines ground data, commercial microwave links and satellite data for accurate and timely information that forms the basis for flood early warning systems (EWS).

> "Telecommunications companies see their masts as communication receivers and transmitters, but we see these as rain gauges."
>
> **– Professor Nick van de Giesen, TAHMO Co-Founder**

The GSMA Innovation Fund

TAHMO was one of the organisations supported by the GSMA Innovation Fund for Anticipatory Humanitarian Action, launched in 2022. This initiative was funded by the UK Foreign, Commonwealth & Development Office (FCDO) and was supported by the GSMA and its members.

The Fund backed solutions that leverage mobile digital technology to help anticipate potential humanitarian impacts and enable effective early response. By focusing on the important theme of anticipatory action, the Fund contributes towards the minimisation of humanitarian impacts and the improvement of preparedness in the face of sudden-onset crises.

The project

Urban flooding has been a frequent occurrence in Ghana, often leading to the destruction of property and loss of life. The Aboabo community, a suburb of Kumasi located in the transitional forest zone of Ghana, has become particularly vulnerable to the devastating effects of flooding due its location along the Aboabo River, exponential population growth, rapid urbanisation and the impacts of climate change.

Tailored early warning systems are often not available for at-risk communities in smaller cities. This can be due to several factors, including the need for specialised, real-time monitoring equipment which is expensive, as well as a long and complex chain of communication, from monitoring and forecasting to response. The human resources required to maintain these systems are also costly.

TAHMO received funding from the GSMA Innovation Fund for Anticipatory Humanitarian Action to develop a Flood Early Warning System (FEWS). TAHMO integrated various digital technologies in the system, including CML data from mobile masts to monitor rainfall and IoT-enabled sensors to provide hydro-meteorological data – a modular structure that used numerous data sources. TAHMO partnered with mobile network operator (MNO) AT Ghana during the grant, and later MTN Ghana, to leverage CML data for rainfall monitoring.

During rainfall events, wireless CML signals are weakened, disrupting signal strength. By analysing these signal variations, TAHMO can accurately calculate rainfall intensity in real time.

The project applied a citizen science approach, with local smartphone users capturing videos that were used to interpret river flow data. To disseminate weather-related alerts to communities, a platform was created in partnership with the organisation Farmerline, enabling early warning and advisory messages to be sent via a variety of mobile-enabled channels, including SMS, IVR, WhatsApp and online.

Commercial microwave links[1]

Increasingly, MNOs around the world are teaming up with third parties like universities, tech firms and weather organisations to share rainfall information collected from their networks.

Mobile base stations are connected by backhaul networks that distribute data throughout the mobile network. This network is comprised of fibre optic cables or wireless connections using microwave radio frequencies.

When it rains, these wireless CMLs are disrupted, weakening the signal at the receiving device. By monitoring these changes, experts can estimate how much rain is falling. This information helps create detailed maps showing rainfall intensity, especially in locations where detailed weather observations are lacking.

Key project activities

GSMA Mobile for Development

Project activities

Flood early warning system created with NADMO and other partners

TAHMO worked with the National Disaster Management Organisation (NADMO) and other partners to identify priority flood-prone areas and optimal sensor locations, including upstream points feeding into Aboabo's drains. A co-creation process with community members and key stakeholders (including NADMO, Farmerline, the Hydrological Services Department and others) ensured the system design reflected local realities. These sessions introduced the project, gathered community input and tailored the service to reduce the impacts of flooding on people's lives. Sensor placement was also informed by local knowledge of microclimates and water flow, with NADMO validating locations to ensure actionable outputs.

Development of the FEWS dashboard

The development of the Flood Early Warning System dashboard was a crucial step in raising awareness and improving preparedness in flood-prone areas. The dashboard was designed to monitor water levels, precipitation and other weather variables (such as temperature and wind speed) at the locations where stations had been installed. IoT-enabled sensors at these stations provide real-time data to help predict potential flooding, enabling timely alerts and responses.

During the development process, there were setbacks due to hydrological station malfunctions and installation delays. These challenges temporarily slowed progress, but once all stations were fully operational the dashboard functioned effectively.

Stakeholder training on mobile-enabled services

Five workshops were conducted to provide training on how the FEWS functioned and its importance to communities. Stakeholders in attendance included NADMO, the Ghana Meteorological Agency (GMet), citizen scientists and community members. Participants at the workshops were introduced to the weather and hydro stations that had been installed and their functions. Citizen scientists were trained on data collection and how to clean sensors.

Development of the dissemination platform

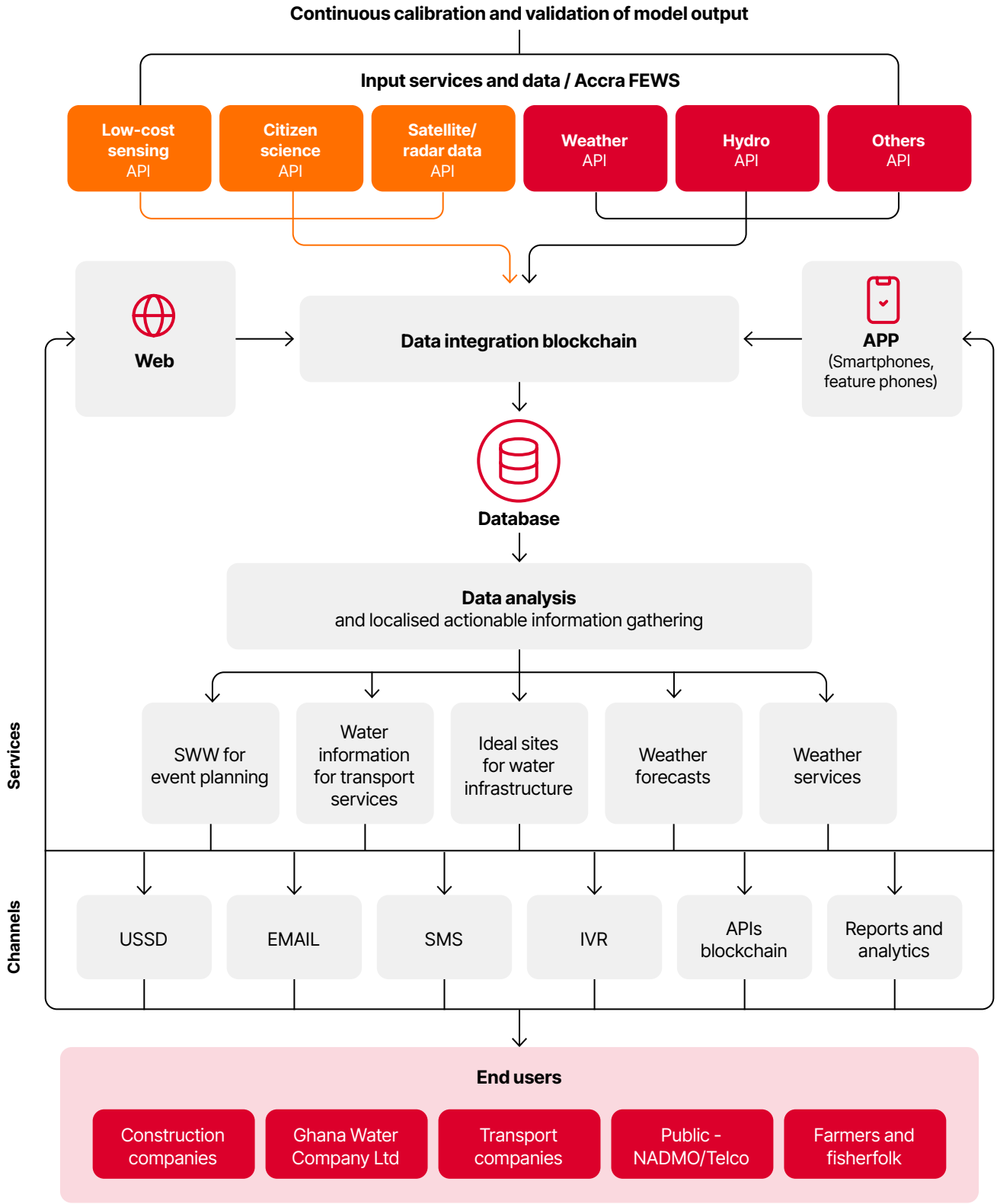
Farmerline, a longstanding TAHMO partner, led the development of the dissemination platform, building on earlier collaborations. Once installations were complete, TAHMO and Farmerline convened workshops with community members and partners to co-create how alerts would be shared. Together they determined the most effective formats and languages for the service, with Asante Twi identified as the dominant choice in Aboabo, while also allowing users to select alternative languages. These sessions ensured messages were well understood, culturally appropriate and accessible through multiple channels (SMS, IVR, WhatsApp, web and mobile).

Enhanced community engagement for service enrolment

Farmerline assisted with the onboarding of community residents and project stakeholders. TAHMO initially gathered a small pilot group of community members, conducting co-creation workshops with them to ensure early warning messages met their needs and those of the wider community in Aboabo. Encouraging the broader community to enrol for the service involved working with the pilot group as champions to advocate for the service, alongside enumerators, Farmerline, NADMO staff and community leaders to expand outreach and registration across the community (see Lesson 2). Information captured for onboarding included the individual's name, phone number, preferred language, location and time for message to be received, while following data privacy regulations (GDPR and local regulations).

How the solution works

TAHMO's Flood Early Warning System



Project outcomes and lessons

Outcome 1:

TAHMO established an effective flood early warning system in partnership with key public and private organisations

TAHMO's strong partnerships with key public institutions and private-sector players were central to the project's success and ability to scale. Two key public-sector partners were GMet and NADMO. NADMO is the national institution responsible for flood response in Ghana, and GMet is the mandated institution responsible for issuing weather alerts and warnings across the country. Without GMet, it is illegal to disseminate weather alerts through any official channel, making them a critical partner in the design, implementation and sustainability of the FEWS system. By partnering with NADMO and GMet, TAHMO gained the ability and legitimacy to share flood forecasts to people in the Aboabo communities.

The success of TAHMO's FEWS project was also the result of strategic partnerships with private-sector players, notably MNOs. This included AT Ghana, as well as MTN Ghana – a new partnership for TAHMO. These partnerships and collaborations to acquire CML data were crucial, as the project aimed to establish the first operational CML data pipeline for rainfall retrieval for climate services.

Establishing these partnerships with public and private organisations was no easy feat, requiring trust and perseverance and the identification of beneficial outcomes for all parties. TAHMO was the crucial link between national institutions mandated to provide flood-related early warnings and MNOs that have the technological capabilities to predict and disseminate flood information.

Lesson 1:

Stronger relationships with MNOs enabled a shift from hindcasting to nowcasting

At the outset of the project, AT Ghana was unable to provide regular operational access to CML data (i.e. every 15 minutes). Instead, data was being shared with TAHMO a few days later. While this was still useful for TAHMO to combine with data collected to validate past rainfall events and improve flood modelling (hindcasting), the real value of CML data is when it is used in real time for nowcasting and forecasting. TAHMO has made significant progress and now nearly has operational CML data from AT Ghana for predicting flood hazards.

TAHMO applied this lesson when approaching MTN to ensure it could have an operational, real time feed of CML data via an application programming interface (API) – not just for Aboabo, but for the whole of Ghana. TAHMO's prior experience with AT Ghana helped MTN understand exactly what was needed, and how to format the data in a way that makes it easy to use and most effective for the FEWS. TAHMO noted that the support and guidance they received from the GSMA to engage with MNOs in Ghana were extremely valuable. It helped achieve the project's objectives and ensure the project activities were sustainable beyond the grant funding.

Outcome 2:

More than 4,000 people in Aboabo received flood early warning alerts, improving safety and strengthening the resilience of residents and local authorities

By integrating CML data in its modular FEWS, TAHMO improved the accuracy of rainfall monitoring and enabled the timely dissemination of weather alerts to more than 4,000 residents in Aboabo. They received critical information and guidance via accessible communication channels, including SMS and IVR.

By equipping urban areas with reliable early warning systems, TAHMO's project has improved safety and strengthened the resilience of residents and local authorities. In flood-prone informal settlements of Aboabo, access to early flood warnings allowed residents and local authorities to take preventive action, thereby reducing damage to critical infrastructure, homes and roads. By delivering real-time, actionable climate risk data, the system protects lives and assets while supporting anticipatory action and long-term resilience planning.

"TAHMO and Farmerline consistently provide us with timely weather information and guidance, which we use to educate community members. This includes not only explaining the weather forecasts but also offering practical advice on what actions to take upon receiving the information, helping communities make informed decisions and improve their resilience."

– Ernest Yaw Amoah, NADMO Director

Lesson 2:

Face-to-face community engagement was instrumental for service enrolment

Initially, it was expected that the FEWS would generate users by word of mouth through peer networks and relationships. However, it became clear that community visits to explain the service and its benefits to individuals face to face were extremely effective and necessary for high levels of enrolment. Extra resources were therefore invested in community engagement. Working with a pilot group of users as champions to advocate for the service also enhanced trust, encouraging service enrolment.

Lesson 3:

Reaching diverse users requires multiple dissemination channels

TAHMO found that some of the most difficult aspects of the FEWS were the communication and dissemination activities, particularly ensuring that messages were tailored to local needs and reached users with a range of literacy levels and types of mobile phones. Partnering with Farmerline, who had almost a decade of experience with inclusive dissemination activities, ensured that this critical aspect of early warning was carried out effectively. Disseminating information via multiple mobile channels (SMS, IVR, web and apps) improved accessibility for a range of audiences, ensuring locally relevant information was delivered via the most appropriate channel and tailored to user needs.

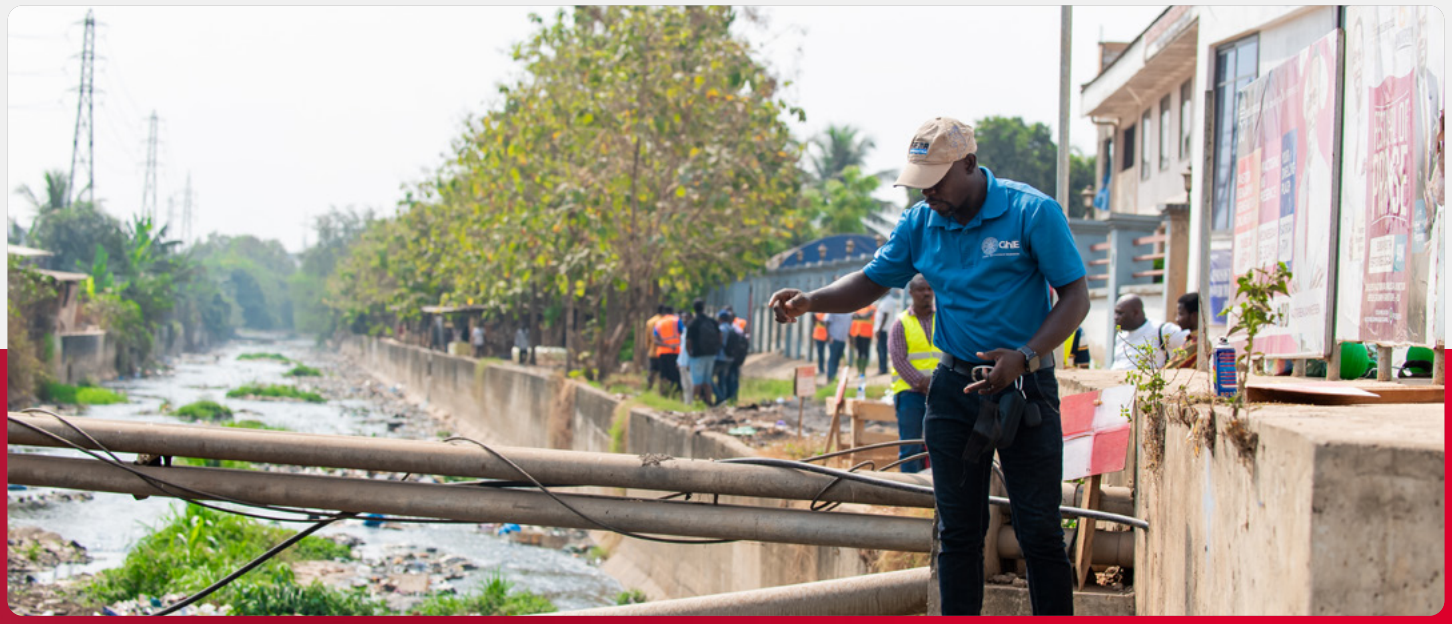
"Since December, we have been disseminating weather information to users via SMS, using AI technology and API integration to tailor and automate the messaging. One of the most widely used formats is voice recordings, which are typically sent in the morning for maximum relevance and accessibility. We deliver messages in multiple local languages, including Hausa, English, Daug Bani, and others, ensuring inclusivity and better understanding by each individual user, aligning with their preferences and daily routines."

– Mary Afenyo, Farmerline Climate Service Disseminator

Outcome 3:
Community involvement in citizen science created a sense of local ownership, building trust and accuracy

Taking a citizen science approach enabled data collection at the community level. Seven local residents were trained to collect river flow data, maintain weather stations and provide regular updates on flood events. This real-time feedback helped validate technical data against lived community experiences, ensuring alerts and forecasts reflected actual local conditions. By contributing in this way, citizen scientists not only improved data accuracy but also strengthened the link between communities and authorities, creating a trusted information chain. Now, this model is a core element of TAHMO's projects given its ability to foster ownership, contextualise data and support timely action.

> "I have learnt how to collect data for surveys and share it with TAHMO and NADMO on behalf of my community. This skill has enabled me to contribute valuable local information that supports weather forecasting, disaster preparedness, and informed decision-making."
>
> **– Rukaija, Citizen scientist**



Lesson 4:
Co-creation of climate services is critical for uptake and response

A series of co-creation workshops with a pilot group of end users (around 30 people) were organised to better understand their needs and ensure early warning messages were timely, clear and actionable.

Monitoring activities also played a key role in community engagement and service adoption. Regular discussions with project beneficiaries allowed the team to clarify the purpose and expected outcomes of the project, helping community members understand, accept and identify with the intervention. This sense of ownership strengthened their commitment to the project and reinforced its sustainability by fostering trust and collaboration.

Lesson 5:
Station maintenance and accurate data are critical to the long-term effectiveness of the FEWS

With both hydrological and weather stations, regular maintenance is essential to ensure reliable data. Issues such as clogged rain gauges can compromise accuracy, making routine checks and timely servicing vital. TAHMO technicians are scheduled to visit each station at least twice a year, while trained community hosts handle simple maintenance tasks in between. These partnerships help keep stations in good condition and ensure consistent data quality. TAHMO also found that taking a modular approach to data sources (combining observations from ground stations, CML data, radar and satellites) meant that warnings could still be issued even if one data stream was temporarily unavailable, making the FEWS even more robust.

What's next for TAHMO?

Scaling up

The FEWS has been designed to be scalable from the outset, with a modular system that can have multiple data sets and cover new locations added over time. While the service is currently available to the Aboabo community, TAHMO intends to expand project activities to other parts of Kumasi and the country at large, building on its relationships with AT Ghana, MTN Ghana, GMet and NADMO, which will make scaling up much easier.

Sustainability

TAHMO has developed a sustainable business model for future growth. At present, most users are not accustomed to paying for early warning services, often underestimating the value of accurate forecasts. Through this project, TAHMO aims to demonstrate the growing risks of floods and other disasters, helping communities recognise the importance of reliable warnings for safeguarding lives, property and livelihoods. The long-term plan is to build demand so that users see the value of subscribing to these services for their own safety and security. In parallel, TAHMO is in discussions with MTN and AT Ghana to explore how MNOs can integrate and disseminate anticipatory action information via their platforms, opening a path to financial viability and co-developed products that strengthen resilience.

A challenge remains the readiness of investors to commit resources, as FEWS still rely on grants and donor-funded projects. Hazard and disaster risk management services are often perceived as public goods and expected to be provided for free, despite the significant investments required. To address these challenges and support future growth, TAHMO is developing a project proposal to secure funding to scale its operations to Kenya, Zambia and other parts of Ghana.

UK International Development
Partnership | Progress | Prosperity

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

GSMA Mobile for Development

GSMA Head Office
1 Angel Lane, London,
EC4R 3AB, United Kingdom
gsma.com