Africa Water Enterprises

Using IoT to monitor and introduce pre-payment for remote water stands in The Gambia

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The **Mobile for Development Utilities Programme** improves access to basic energy, water and sanitation services in underserved communities using mobile technology and infrastructure. Our work encompasses any energy, water and sanitation service provided to a community, which includes a mobile component, whether it is voice, SMS, USSD, Machine-to-Machine, NFC, a mobile operator's agent network or tower infrastructure. We aim to seize the opportunity, leveraging mobile technology and infrastructure to enhance access to affordable and reliable energy, clean and safe water and sanitation services in underserved communities. The GSMA Mobile for Development Utilities Programme receives support from the UK Government.

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Africa Water Enterprises is a UK-based charity that in partnership with eWATER, a technology provider, harness mobile and solar technologies to develop affordable and sustainable water systems in Africa. eWATERtaps are GSM-monitored taps that dispense water when users present their NFC eWATERtag, which stores their prepaid water credit. Founded in 2013, they have installed over 100 eWATERtaps in The Gambia and are expanding to work in Tanzania and Senegal.

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GSMA Mobile for Development Utilities Seed Grant 2015-2017

Introducing IoT for monitoring and pre-payment for remote water stands in The Gambia

USE OF MOBILE

Mobile Services
Mobile App

M2M
connectivity

AWE installed eWATERtaps on rural solar pumps in the Gambia and established a pre-paid bill collection system with an app that agents used to transfer cash to credit on customers' NFC tokens. M2M connectivity enabled real-time monitoring and responsive maintenance, financed through collected funds, to address the issue of broken water systems.

AWE installed **100** eWATERtaps in **7** villages in the Gambia, improving water for over **9,000** people.

PROJECT OUTCOMES

1985 NFC tags were registered, for a total estimated water usage of 3.2 million liters of water in May 2017.

52 taps transmitted data via GSM-enabled M2M and were monitored via the eWATERcare cloud management system.

Pre-paid bill collection through NFC tags led to 100% revenue collection in six rural villages.

KEY PROJECT LESSONS

M2M connectivity and pre-paid bill collection improves maintenance and revenue collection.

Community education and local support is critical for adoption of new technology and services.

In selecting the right type of mobile connection for M2M between LoRa versus GSM, connectivity and costs should be considered thoroughly.

AWE is trialling version two of the tap in Tanzania, delivering water to over **5000** people. Since the grant, AWE has established eWATERpay as a limited company.

Project overview

Africa Water Enterprises (AWE) was awarded a grant from the GSMA Mobile for Development Utilities programme to install 100 eWATERtaps in The Gambia. The eWATER system managed water distribution and bill collection to improve revenues and fix broken water points, a persistent problem arising from a lack of information and funds for repairs. Previously, water taps in rural areas were managed by village water committees that collected fees manually and maintained the taps. The collections were not systematic and often not recorded, and this human error led to financial losses, the water pumps not being serviced regularly and few funds for repairs.

The project began in April 2016 when taps were installed in three villages in the upcountry of The Gambia: Brikama Ba, Jarreng and Jafai Koto. By June 2017, a total of 100 taps had been installed, including in four other villages: Kerr Lien, Brufut, Jappineh and Jallenbarah.[1] AWE indicates the taps have improved water services for over 9,000 people.

Sixty-eight of the eWATERtaps were machine-to-machine (M2M) connected, which enabled the company to monitor the taps over GSM networks, triggering responsive maintenance and repairs and providing insights into customer behaviour. eWATER tested two methods of connecting the taps through M2M connectivity, initially LoRa[2] and later GSM connectivity, which it switched to exclusively because of cost and connectivity considerations. Due to resource constraints, not all 100 taps were connected and, of the 68 connected taps, not all reported data consistently due to connectivity issues. In April 2017, 52 taps were reporting data via GSM connectivity.

Bill collection was managed through a contactless pay-per-use system based on offline Near Field Communication (NFC) tags, on which customers loaded water credit via an agent with an app. Funds were used to finance repairs and maintenance.

Following the grant project, AWE has been trialling the newest version of the tap in Tanzania and eWATERpay has become a limited company.

1. The World Bank estimates the total population of The Gambia at 2.039 million (2016). Accurate village population numbers are difficult to find, but it is estimated that the Janjanbureh district, where these villages are located, has a total population of 126,910.
2. Long-range, low-power wireless platforms

Business model and use of mobile channels

Business model

In The Gambia, AWE initially refurbished the villages' broken water systems. In most cases, this was a simple fix to the pipe systems or solar pump, which supplied water to a tank that customers accessed through a single tap. Once repaired, the water systems were retrofitted with eWATERtaps. The funds collected through the eWATERpay system were sent to an eWATER account, which received a percentage as revenue on water sales, and the remaining funds went to AWE to pay local partners for ongoing maintenance and operation of the taps. As this was a pilot, the business case was not completely fulfilled as there were more costs associated with tap installation than expected and AWE did not take any revenues. The projected break-even point for the operation to become commercially sustainable was forecasted at 1,000 installed taps.

Service design and use of mobile channels

The eWATERtap is a low-power solar device that turns on a water supply and dispenses water. The system, built by eWATER to manage water distribution and revenue collection, has three main attributes that enable more robust operation and management of rural water supplies:

1. **Contactless pay-per-use system:**

- Water credit is purchased and added to an NFC tag via the eWATERapp through village resellers at the price of 0.5 dalasi (USD 0.01) for 20 litres.
- eWATER contracted seven agents to sell eWATERcredit to the communities, making eight per cent commission on the transactions. Agents were trained to use mobile money to sell water credit by purchasing bulk water credit via eWATER's mobile app (Figure 1_1) and touching a tag to the NFC-enabled mobile phone (Figure 1_2). However, as mobile money adoption is still nascent in The Gambia and there are significant barriers to use, including a very limited mobile money agent network, only one agent regularly used mobile money.
- Once loaded with credit, the tag operates the eWATERtap using NFC technology to dispense water when it is touched to the tap (Figure 1_3).
- The eWATERtap connects to eWATERcare, AWE's backend platform via the GSM network, enabling data to be captured on functionality, flow rates and sales, and providing real-time monitoring of the system.

2. **The Internet of Things (IoT) cloud management:** Taps are connected to a cloud-based management system via the GPRS communications system through the local mobile network. The cloud system and dashboard are hosted by Amazon Web Services and managed by eWATER. This connectivity allows the tap to communicate with central account management and read the credit available on each token and how much water can be purchased. The cloud-based monitoring system also allows for remote monitoring of tap operations and sends notifications of any breakdowns, avoiding the lengthy downtime that comes from maintenance issues not being reported.
- **Service-level agreements with local contractors/private franchisees** for maintenance and tap repair in the event of downtime. The pre-payments for water credit are held in a bank account by AWE and, through the connected taps and updates from villagers, AWE is made aware of tap issues and can send a local contractor/private franchisee to fix the issue.

FIGURE 1

eWATER's contactless pay-per-use system

1

2

3

Lessons from the project

1 eWATER technology improved revenue collection and ongoing maintenance for rural water services.

Before AWE installed eWATERtaps, village water committees often hired tap attendants to collect water payments and paid committee members to collect fees, record transactions and deposit funds. This system is ripe for human error and fraud and introduces unnecessary costs. It also made it very difficult to monitor payment collection and losses due to non-revenue water or fraud.

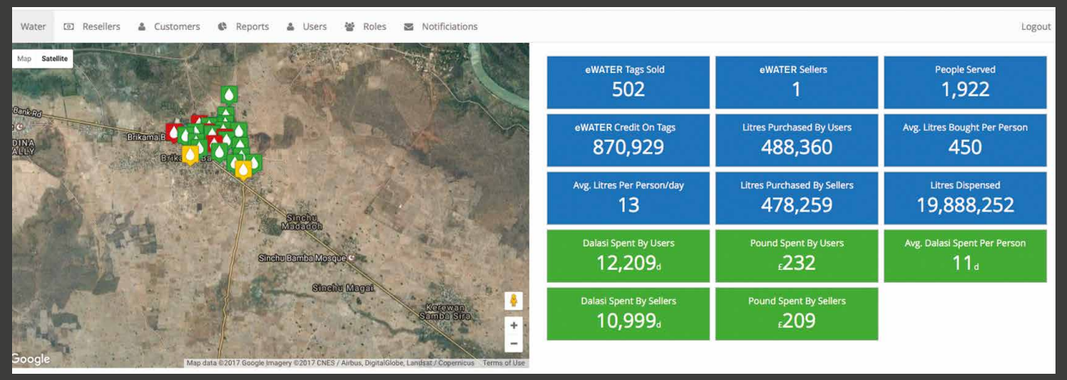
The pre-payment process resulted in 100 per cent payment collection, as end users paid for all the water that was distributed. It is not certain what the payment collection rates were before the taps were installed, due to the lack of transparency and accountability, but anecdotal evidence from the water attendants suggests it was between 25 and 50 per cent. A pre-payment system created an equitable system in which status, relationships or income did not affect access to water. AWE reported that each household, on average, spends USD 6.40 (GMD 307) per month on water, or six per cent of their income on average.

The eWATERtap also helped to improve monitoring and maintenance of the water points. The tap produces its own data as it records and transmits the amount of water purchased and distributed via M2M connectivity. Real-time monitoring through the digital system reduced the costs associated with employing attendants, as well as the risk of fraud. The eWATERcare dashboard (see Figure 2) is monitored by the eWATER administrative team based in Banjul, who can observe information on functionality, flow rates and sales in real time and can alert local maintenance engineers when they notice unusual behaviour. The system significantly lowered repair time, as maintenance work could be carried out within hours of a server alert.

eWATER reports that before the pilot, 65 of the 79 new solar pumps or piped networks they surveyed in The Gambia were either broken or not functioning to capacity. Although the pilot did not yield significant data, qualitative information suggests that maintenance rates on solar pumps made water access significantly more reliable.

FIGURE 2

Dashboard view of Brikama Ba village



Green taps are functional Yellow are not reporting Red are non-functional

FIGURE 3: EXAMPLE OF A BROKEN HAND PUMP

2 Community education and local support is critical for adoption of new technology and services

The high numbers of broken solar water pumps across The Gambia led to low levels of trust among community members, who reported being wary of trusting yet another water system using new technology. Having a local team based in The Gambia assured communities there would be someone they could contact and hold accountable if there were any issues, and gave the eWATER system a sense of legitimacy.

Demand for the eWATER system was mainly through word of mouth, with villages eventually approaching eWATER for installations. A certain amount of community education was required before installation, as the benefits of the water taps were not always clearly understood. In Jafai Koto, a health workshop was conducted in February 2017 to teach the importance of drinking, washing and cooking with clean water from the eWATERtaps. Support from local elders and other influential community members was sought prior to the workshop. Based on data collected from the taps, water usage increased from 5 to 7 litres per person per day to 12 to 15 litres per person per day the following week, and has remained high since.

A key finding from the qualitative study was that the majority of users were female, and were not comfortable making mobile payment themselves because of low levels of digital literacy and confidence. They reported preferring to send their children or other members of their household to top-up credit. It became clear that extensive community education, targeted specifically at women, was necessary for more inclusive use of the tap and, in particular, to roll out the eWATERapp for customers to top-up credit themselves.

Despite these challenges, the eWATER system generated important socio-economic benefits for users. With the traditional taps, water was only available when the village water committee turned on the water and when the tap attendant was working, typically a couple of hours a day. Customers often had to wait in long queues and sometimes the water was shut off by the time it was their turn.

With the new system, water was always on and available 24 hours a day, wait times were reduced and there was a set water tariff, creating a more equitable system. In addition, qualitative evidence showed the tap helped to strengthen ties between women, as several customers reported borrowing tags from each other when their credit ran out. Finally, customers particularly appreciated the health benefits of having access to clean water.

"At night, we can't go to the well but we can go to the tap. With your tag, you can take water, that's why it's important."
– eWATER CUSTOMER AT JAFAI KOTO

"Men are the ones who pay, but women go to collect the water and bring it home. In our area there is solidarity. Even if one of us does not have credit, someone will lend her tag because it is a matter of health."
– eWATER CUSTOMER FROM JAFAI KOTO

3 When selecting the type of mobile connection for M2M (LoRa versus GSM) connectivity and costs should be carefully considered

The type of mobile connectivity selected for an M2M connection depends on several factors, including GSM network coverage, density of connected devices, cost constraints and plans for scale. Initially, eWATERpay developed LoRa networks to connect the taps to the eWATERcare cloud platform, but subsequently decided to implement GSM connectivity.

GSM (2G/3G): Cellular M2M enables the coordination of various machines, devices and appliances connected to the internet through 2G and 3G networks. The vast majority of M2M devices in operation today use 2G networks (77 per cent of cellular M2M connections in 2014).[3]

LoRa (Long Range) is a Low Power Wide Area (LPWA) technology often used for building IoT networks. It uses unlicensed radio spectrum in the Industrial, Scientific and Medical (ISM) bands to enable low-power, wide-area communication between remote sensors and gateways connected to the network. The LoRa technology enables public or multi-tenant networks to connect multiple applications to the same network infrastructure.

Initially, eWATERpay developed LoRa networks to connect its 170 taps to the eWATERcare cloud platform. It was selected because of its hub-and-spoke model, which is considered more appropriate given The Gambia's low levels of 3G coverage. In this case, four individual taps would transmit data via LoRa communication to one tap in the area designated as the hub. The hub then sent all the data from the four taps to the eWATERcare cloud via the 2G network. The connectivity range of each tap was only about 500 metres, so the taps either had to be in close proximity or the central hub would have to be elevated on a mast to improve connectivity.

Ultimately, the LoRa prototype had several challenges that did not make it possible to connect all the taps. Transmission required a clear line of sight from tap to hub, which meant the central hub had to be elevated, creating several installation issues. Maintenance of the LoRa devices, which had been purchased off the shelf rather than customised, also became a major challenge. In terms of data costs, there were no advantages to using LoRa, as the same amount of data flows regardless of whether it is aggregated through a LoRa star network or a point-to-point network of 2G devices.

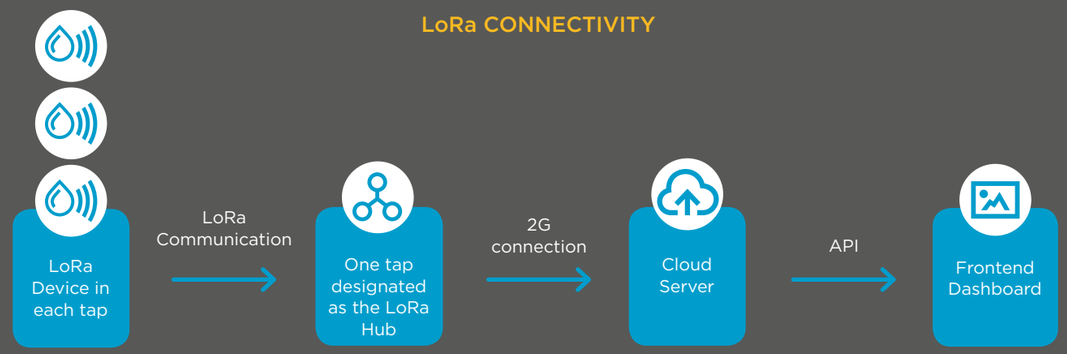
To address these challenges, in August 2016, eWATERpay decided to switch to GSM connectivity for M2M, adding the functionality to directly transmit data from each tap to the cloud server (Figure 4). eWATERpay found that low-bandwidth 2G connectivity was sufficient for the transmission, as 2G coverage was more widespread in rural Gambia than eWATERpay had expected. A GSMA Intelligence study found that 2G connectivity can support the requirements of most devices used for remote monitoring.[3] In addition, while the cost per unit of GSM cellular boards was higher than the LoRa units (estimated at USD 50 per cellular board and USD 20 per LoRa hub and spoke), the cellular boards had lower installation and maintenance costs because they did not require line of sight. The 2G GSM connectivity was therefore a far simpler system to install and maintain and was considered the best solution.

3. GSMA Intelligence, 2015, "Global cellular M2M technology forecasts and assumptions", https://www.gsmaintelligence.com/research/2015/03/global-cellular-m2m-technology-forecasts-and-assumptions/498/.

To implement GSM, eWATERpay tested a solution from ESEYE, an Amazon Web Services (AWS) Advanced Technology Partner for IoT competency.[4] With this method, each tap was fitted with an ESEYE AnyNet Secure SIM card (an international roaming SIM), which sends data on each tap over the 2G cellular network directly to the eWATERcare app. The benefit of the international roaming SIM was better connectivity; at times it picked up a stronger signal from networks in nearby Senegal. After testing the technology on a few taps, it demonstrated good results that could be scaled affordably.

FIGURE 4

Comparing LoRa and GSM connectivity for M2M



4. Amazon Web Services, 2017, "eWATER Case Study", https://aws.amazon.com/solutions/case-studies/ewater/.

FIGURE 5

LoRa Hub (left) and GSM tap (right)

Progress since the end of the grant and future plans

Since the end of the GSMA grant, eWATERpay has become a limited company and has been iteratively developing the eWATERtap. This trial and testing has enabled eWATERpay to identify key issues and necessary features to add. With additional funding from DFID's Frontier Technology Livestreaming programme, eWATERtap (v2) was developed. eWATERpay reports this tap has been successfully delivering water to over 5,000 people in two villages in Tanzania since June 2017.

The improvements include:

- Tap hardware upgrades to increase water flow rates;
- The use of proprietary NFC tags with magnets to ensure the tag is held firmly in place on its own;
- All taps are fully GSM-enabled IoT using Amazon Web Service, Bluetooth and LoRa support to ensure that 12 months of data buffering is included, no data is lost and connectivity can be based on what is appropriate given the local context;
- Full remote monitoring of device environmental data (temperature, humidity, light and battery voltage);
- Tamper alerts; and
- Customers can purchase credit top-ups directly at the tap via the NFC and IoT interface, in addition to the current method via an agent with a smartphone app.

The benefits to the user and eWATERpay customers:

- It is much easier to buy credit using cash or mobile money from feature phones OR from an agent;
- Taps are more reliable and resilient; and
- Less time is spent waiting to fill a bucket.

Future plans

Other technology products in the pipeline include an urban pre-payment tap and 'eWater sense' to provide real-time monitoring of other aspects of the water system, including cleanliness, leakage and reservoir status.

eWATER is currently working with partners in several countries to deliver benefits beyond The Gambia and Tanzania, and is actively looking for partners throughout the developing world to help scale the product globally.

Recommendations

FOR WATER SERVICE PROVIDERS

Community education is critical when introducing new technology. To facilitate smooth introduction of a new technology-driven water service, ensure time and effort is given to meet with the community to explain the tap, how it works and what they are gaining in terms of access, improvements to health and potentially lower water tariffs.

Choosing the right connectivity technology is crucial. When introducing a new technology, be sure to consider all the aspects and potential impacts of implementation. When implementing M2M on decentralised devices in a rural setting, keep in mind that GSM provides higher connectivity levels and a simpler data flow system than other types of non-GSM connectivity, and can therefore ensure more reliable results.

When it comes to developing an IoT solution, an iterative design process is essential. The GSMA M4D Utilities team recently published an IoT guide based largely on work with Eseye and other Innovation Fund grantees.[5] The three recommendations for service providers are to:

- **Build fast, fail fast –** eWATER was able to trial the LoRa technology and quickly decide it was not the right technology.
- **Test prototypes early in targeted locations –** testing in the upcountry of The Gambia introduced unexpected challenges despite thorough testing in the UK on 2G networks. Operating in hard-to-reach, underserved locations will affect the development journey.
- **Bring in external IoT specialists and have the right in-house capabilities –** eWATER had sufficient in-house capabilities to set up the LoRa network, but when it came to other alternatives, Eseye provided a bespoke solution that could be tested within a few weeks.

FOR THE MOBILE ECOSYSTEM

There is an emerging opportunity to collaborate with water service providers to develop new use cases for mobile money adoption and use. In The Gambia, mobile money use is still extremely nascent, especially in the upcountry area. The use of mobile money was limited during the project, with only shopkeepers and eWATER staff using it. However, this raised awareness of mobile money in the villages and, in the next iteration of the eWATERtap, consumers can buy water credit directly through mobile money on their feature phones. Payment for water services can therefore be a way for MNOs to expand mobile money services into rural areas.

5. GSMA Mobile for Development Utilities, 2017, "The IoT development journey for utility enterprises in emerging markets", https://www.gsma.com/mobilefordevelopment/programme/m4dutilities/the-iot-development-journey-for-utility-enterprises-in-emerging-markets.

Appendix

Methodology

All data used in this case study is primary data, and data sources include:

- An in-person quantitative baseline survey conducted in August 2016 in two villages, with a sample size of 20 households.
- Operational monitoring data from March to June 2017, using data from the eWATERcare dashboard.
- An independent third-party qualitative evaluation, conducted by a research agency based in Senegal, consisting of four in-depth interviews with water resellers and tap operators and two focus group discussions with eight participants each. These took place in Jafa Koto and Jarrang villages.

The research methods and data gathered are as robust as possible, but are not intended to be part of an exhaustive, academic study. Rather, we have taken a pragmatic approach to recording the impact of the mobile service on the beneficiaries, capturing early-stage data and insights to help GSMA grantees improve their business performance, and generating knowledge for GSMA and the wider mobile ecosystem on the business case for using mobile innovations for energy, water and sanitation services. With this, we recognise some limitations of the data: capacity and budget constraints mean that most field data relies mainly on self-reported responses by users/ beneficiaries; the sample sizes are statistically significant where possible, but statistical analysis has not been applied.

For more information on the Mobile for Development Utilities programme visit:
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