Smart Water Systems

Final Technical Report to
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April, 2011

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1 Executive summary

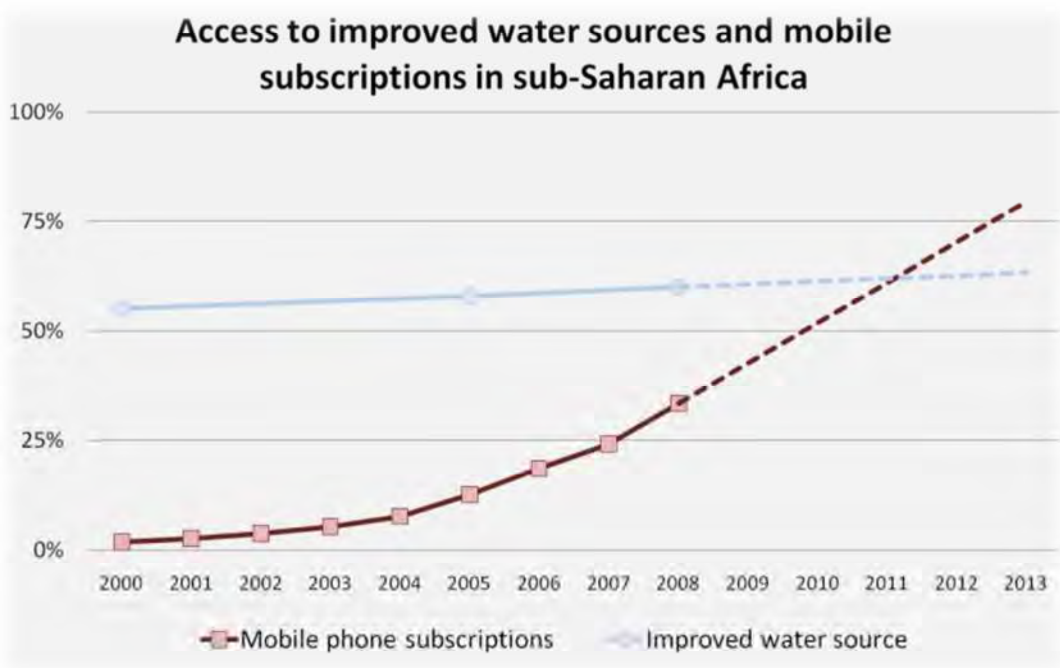
The global mobile communications revolution presents new opportunities to address water security and poverty reduction challenges. In Africa, the number of people within range of a GSM signal has already overtaken the number with an improved water supply, and by 2012 the number with a mobile subscription will pass this same benchmark. In India, the number of mobile subscriptions is twice the number of individual piped water connections. These milestones mark a new technological era which can transform the way water services are paid for, operated and regulated with the prospect of reducing the multi-billion dollar water service financing gap, crowding-in investment and lessening the fiscal burden, particularly for low-income countries. Mobile banking is already increasing financial access amongst low-income groups with emerging opportunities for innovative saving and payment applications in the water service sector. Smart water metering is rapidly being deployed across the industrialized world, and offers an untapped opportunity to address systemic operational inefficiencies in developing regions and to govern water resource use and allocation more effectively at scale. Based on a global literature review and proof-of-concept fieldwork in Kenya and Zambia, we find compelling evidence that the confluence of mobile network coverage expansion, wide-spread mobile phone ownership, innovative mobile banking applications and smart metering technologies offer new, effective, low-cost and inclusive pathways to water security and poverty reduction.

Smart Water Systems (SWS) present a new approach to promote water security with uncertain but significant future risks from population growth, hydrological variability and extreme events, and intensifying water allocation demands across water supply, agriculture, industry and ecosystems. Strategic and transparent water resource decision making is central for water security to be achieved. This is in turn contingent upon the accurate, timely and reliable collection and communication of information relating to water abstractions and use, and the primary resource base. With mobile networks expanding globally across national territories, SWS offer a mechanism to capture and communicate data on water resources through hydro-informatic systems on abstraction from surface water and groundwater, soil moisture content, storage levels and network leaks or theft. Within a new architecture of accurate, integrated and timely water resource data, water risks can be reduced and water security enhanced.

For water service utilities the SWS approach can break the downward spiral of poor operational and financial performance. Globally, the financial investment in new and existing water supply services between 2005-2030 is estimated at an unfathomable USD22 trillion. By coupling mobile banking and smart water metering, SWS can create a secure, transparent and low-cost flow of funds and information between consumer, water service provider and delivery system. By driving down water payment transaction costs, revenue collection will increase and administrative costs will be reduced. By identifying and reducing non-revenue water losses, greater financial efficiency will be achieved along with cost savings and resource conservation from more effective maintenance and investment in piped network systems. In doing so, smart solutions can disrupt the spiral of decline characterised by poorly maintained infrastructure, irregular supplies, low levels of customer dissatisfaction and commensurate bill payment. The SWS approach can lead to more sustainable water services reducing financial losses to permit an accelerated expansion of formal water services to connect the poor and other excluded groups.

SWS also has the potential to unlock innovative business models for serving both the urban and rural poor. Communicating water consumption data and electronic payments across large distances and many endpoints can help resolve the enduring challenges that prevent the poor from accessing more sustainable water services. Household connections fees and monthly bills can be made more affordable for the poor by enabling flexible installment payments that accommodate irregular household cash flows via mobile phones and automated meters. Mobile banking and smart metering can pave the way for cashless standpipes that avoid middlemen and their profit margins that currently cost the urban poor in Africa around USD650m every year. Barriers to rural water supply sustainability can also be tackled with remote monitoring and mobile banking opening up scales of management as alternatives to a community management paradigm that continues to meet with mixed success.

By generating accurate and reliable data, SWS deployed at scale can drive a step change in water sector accountability and transparency, thereby improving governance, reducing risk and ultimately creating a new business case for water sector investment. Partnerships across mobile network operators, water service providers, regulators and investors will be needed to realize the full potential of SWS and catalyse further innovations. These alliances offer complementary benefits that are both commercial and developmental in nature. Bold thinking and innovative partnerships are now required to drive these technological advances to achieve water security and poverty reduction.



2 Project overview

2.1 Aims and approach

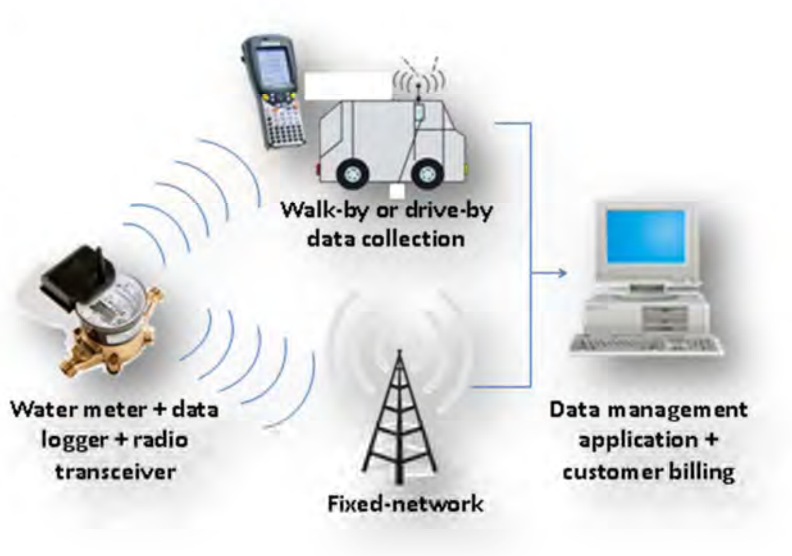
The aim of the project was to examine the generic case for smart water systems (SWS). This work has been undertaken via two work streams over the period October 2010 to March 2011. First, a global desk-based review of smart metering and mobile banking systems has been undertaken to determine the applicability and feasibility of SWS to a developing country context. Second, proof-of-concept workshops with key stakeholders have been convened in Lusaka, Nairobi and London to critically examine and debate the case for SWS. Key findings from these work streams are summarized here and further outputs can be found in the appendices.

2.2 Desk-based review

2.2.1 Smart water metering

Smart water metering refers to a system that measures water consumption or abstraction and communicates that information in an automated fashion for monitoring and billing purposes. Smart meters differ from conventional meters in that they measure consumption in greater detail and transmit that information back to the service provider without the need for manual readings.

Smart metering systems can be configured in many ways, and when broadly defined, the term includes both Automated Meter Reading (AMR) and Advanced Metering Infrastructure (AMI) systems. AMR refers to any system that allows automated collection of meter reads (usually by radio transmission), without the need for physical inspection. AMI is used to describe a system that involves two-way communication with a water meter. That is, water consumption information is transmitted to utilities, whilst utilities can in turn issue commands to water meters to undertake specific functions. Over the last decade, most smart water meter deployments around the world have been AMR systems, however due to their additional functionality, the industry is starting to shift towards AMI and 'smart grid' solutions. Regardless of the configuration, all smart metering systems consist of three main elements: (a) measurement; (b) communication; (c) software application.



Smart water metering is experiencing strong growth throughout the industrialized world with annual growth projections varying between 8% and 13% until 2016. By 2014 smart meters are expected to account for 50% of the global water meter market, with a market size of around USD800 million. Thus far smart water metering projects have been undertaken mainly in Europe and North America. According to Pike Research, these two regions account for 89% of the global smart water market in terms of module shipments. Projects vary greatly in size from small rural towns with less than 1000 connections to large cities such as New York and Mumbai which serve up to 1 million connections. Over the past decade Boston, District of Columbia, Cincinnati, Philadelphia, Atlanta, Chicago and Detroit have all undertaken major AMR projects. Large projects are also currently underway in New York, Kuwait, Malta and Toronto. Whilst smart water meter deployments have been concentrated in developed regions, recent projects in Mumbai and Dar es Salaam indicate developing countries may figure more prominently in the coming years. Similarly, smart metering companies are beginning to tailor products to emerging market needs, such as Elster's smart standpipe solution.

Smart water metering offers a range of benefits when compared to conventional water metering. These include:

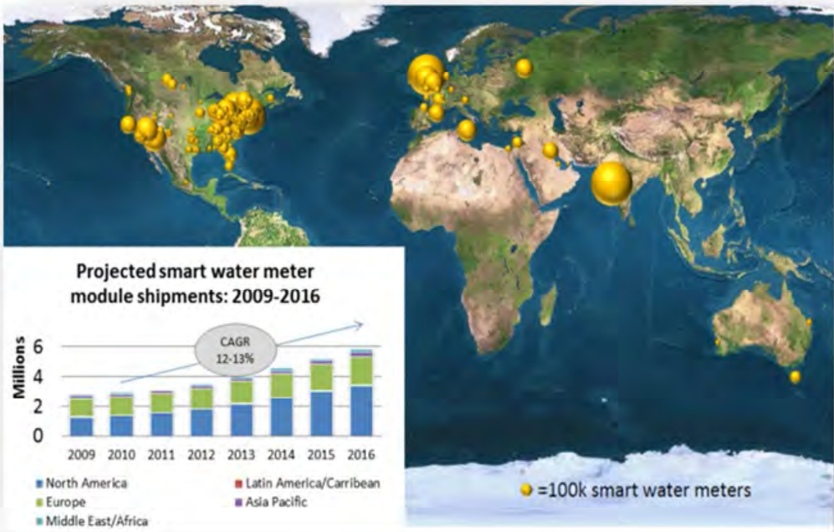
- Faster and more efficient meter reading
- Theft and leak detection
- Greater billing accuracy
- Enabling a flexible tariff structure
- Increased read frequency, resulting in improved debt collection
- Ability to remotely monitor resource use

Case study: Smart water meters in District of Columbia, USA

The fixed-network AMR system implemented by District of Columbia Water and Sewer Authority in 2002 provides a good example of the possible dividends a smart water metering intervention can yield. Reported benefits included reductions in non-revenue water (36% to 22%), increase in revenue by 7% (through debt reduction), reduction in meter reading costs ($4.15 per metre to <$1), reduction in costs relating to complaint investigation (50% lower) and customer call centre services (36% lower), 20 less field vehicles required, and 106,000 litres of fuel saved every year.

There is of course an incremental investment required to deploy a smart water metering system. In addition to the meter modules, upfront cost items include communications infrastructure, data management applications and a range of additional technology to support the large volume of data, middleware and messaging software that may be needed to handle communications between applications and alerts to and from field devices. This upfront cost stands as a barrier to smart water meter undertakings, as evidenced by the fact cost recovery/measurable return on investment

(46%) and up-front utility expenses (42%) were considered by North American utility managers to be the major constraint in implementing such projects. Per unit metering costs vary greatly and depend on project scale, pre-existing infrastructure and type of technology deployed. Whilst the many different permutations limit the validity of general estimates, costs of projects undertaken in North America over the last decade have tended to fall between $US150 and $US300 per installed module (including installation, communications infrastructure and application costs). Indicative unit costs for a smart meter compared to an analogue ('dumb') meter are in the order of USD30 and USD60, respectively. In terms of payback periods or returns on investment, of the few figures that have been publicly quoted, payback periods in North American and Australian cases have tended to be in the range of 3 to 15 years.



2.2.2 Mobile banking in the water sector

Mobile banking (m-banking) is a system that enables money transfers to and from an electronic wallet accessible via a mobile phone. Physical cash withdrawals and deposits are facilitated via a network of agents, which is substantially cheaper to establish than traditional bank branches. M-banking therefore has greater ability to extend the reach of financial services to poor and unbanked households.

Having launched M-PESA in 2007, the Kenyan mobile network operator Safaricom is the global m-banking leader, with more than 13 million users and 22,000 retail agents. Motivated by Safaricom' success, an additional 94 m-banking services have since been launched across the globe, with almost half of these in Africa.

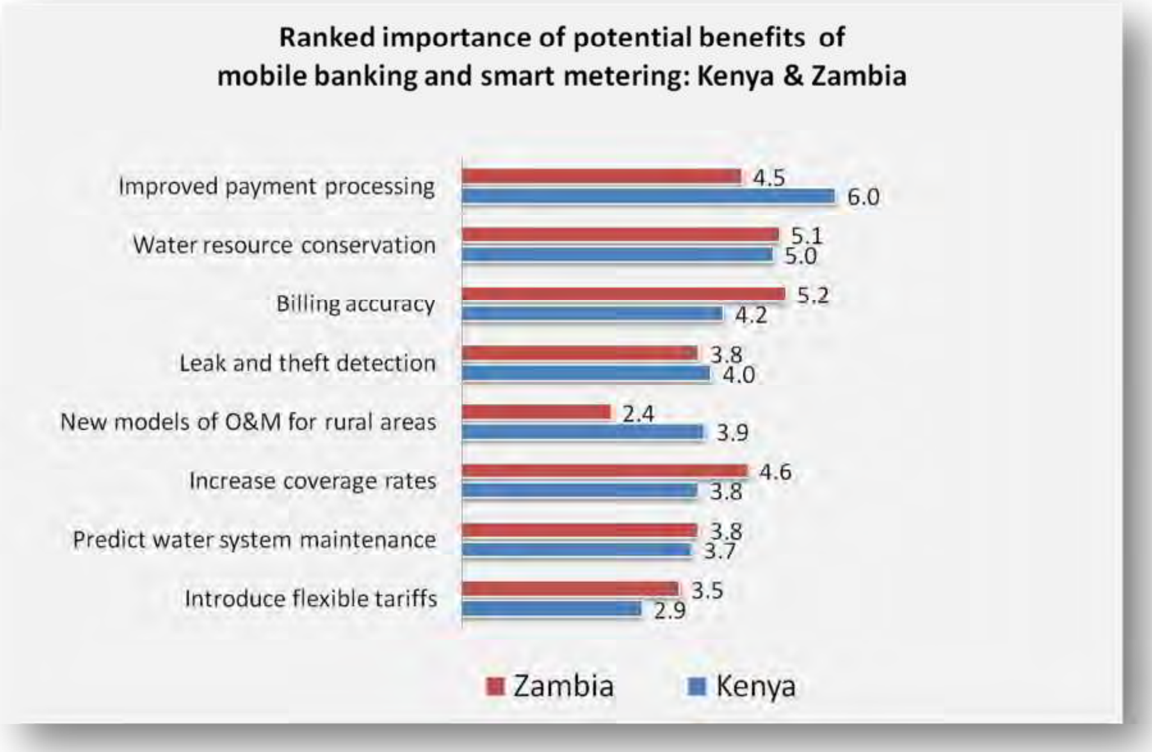
Mobile bill payments are a common feature amongst m-banking transaction services, and present an important way in which m-banking providers can achieve the transaction volumes they need to get a return on their upfront investment. Given traditional modes of water bill payment often pose high transaction costs for customers and utilities, mobile bill payments also offer mutual benefits for utilities and customers. As a result, water service providers across Kenya, Ghana, Tanzania, Zambia, Rwanda and Uganda have all introduced the mobile bill payment option.

Case study: M-PESA water payments in Kiamumbi, Kenya

The Kiamumbi Water Trust (KWT) established an M-PESA bill pay system in December 2010, enabling 550 households to settle their monthly water bills via mobile phone. Demand for this option arose due to the inconvenience and cost associated with the traditional mode of water bill payment. Because of security issues, KWT could not accept cash payments on their premises, meaning customers had to settle their bills at the nearest bank – an undertaking which involved a 40 minute round trip costing US$0.50 and the opportunity cost of waiting around one hour in a bank queue. A final trip would then be made to deposit the bank slip at the KWT offices, whereupon a receipt would be issued, and the amount manually entered into a billing database. In the first month, 42% of customers had transitioned to the mobile payment channel, rising to 59% by month four.

Workshops

Workshops to critically examine and debate the case for SWS were held in Zambia, Kenya and UK. Both workshops in Lusaka (December 2010) and Nairobi (January 2011) were attended by more than 30 senior stakeholders representing key government ministries, water service providers, water service regulators, donors, mobile network operators, banks and other non-government organisations. Attendees explored the opportunities and constraints of SWS, with keys outputs captured using both qualitative and quantitative methods. A final meeting was held in London (March 2011) to evaluate the concept of SWS and the future prospects for a global partnership. As with Lusaka and Nairobi, senior figures from industry, government, donors and research bodies were in attendance.



2.3 The case for SWS: opportunities and challenges

SWS offer a range of potential benefits for both water services and water resource management. First, SWS can help disrupt a water service's downward cycle of poor operational performance and weak financial base, by way of increased revenue collection, reduction of non-revenue water (leaks and illegal connections), and more efficient payment processing. Second, the low-cost collection and communication of consumption and payment data in electronic form paves the way for alternative models for urban standpipe supplies, rural water operation and maintenance, and more generally, flexible payment arrangements to serve the poor. Third, a greater understanding of the water resource base, and abstractions, can facilitate strategic water resource decision-making. In addition, the secure nature of electronic payments and consumption data is likely to increase accountability and transparency across the water sector.

2.3.1 Urban water supply

Sustainable urban water service delivery is undermined by weak operational performance linked to a growing financial deficit. For example, in Africa the current funding gap to meet the water access MDG is USD9.3 billion per year. Bridging this gap requires new approaches to full cost recovery which tackle low service coverage rates, low collection efficiency, high non-revenue water and inequitable tariffs. For example, households without an individual piped connection currently pay three to four times more for water from public standpipes.

SWS offer great potential to reduce operational efficiencies of urban water services that are estimated to cost African water utilities around USD1 billion a year. First, by making water bill payments more convenient for customers, revenue collection levels are likely to improve. Second, administrative costs can be reduced by the utility. Third, with the ability to accurately locate and measure non-revenue water (NRW), those with illegal connections can be converted to paying customers. At the same time, leaks can be located and repaired, thus reducing pumping and treatment costs and promoting water conservation.

There are therefore three key aspects to the urban water supply opportunities for SWS:

- **Smart metering**, could reduce the inefficiencies in water supply systems with smart meters a) remotely detecting leaks and illegal connections b) increasing billing accuracy to promote payments that reflect consumption, c) improving data management to introduce smart tariffs, and d) prevent corrupt practices relating to meter reading and illegal connections
- **Mobile banking** provides a platform for innovative mobile payment/saving and billing solutions which can a) reduce transaction costs and opportunity costs of water bill payments, b) increase collection efficiencies, c) create secure payment systems, and d) improve customer relations and satisfaction
- **Standpipe management models** that incorporate smart metering and mobile banking would enable cashless and secure water point, whereby the unconnected poor could directly benefit from social tariffs and the utility could enjoy an increased revenue base. Smart technology would also allow for standpipe performance monitoring, regulation and accurate data to guide cost-effective water point expansion, such as in informal settlements.

Case study: Operational inefficiencies in Kenya and Zambia

The barriers to urban water service cost recovery were readily apparent in the focus countries. The revenue collected in urban Kenya and Zambia amounts to 83% and 86% of the total billed amount respectively. This means Kenyan water service providers fail to collect over US$14m from billed water delivery every year, whilst Zambian utilities annually fail to collect US$13m. Similarly, NRW in Kenya is valued at US$81m a year, whilst in Zambia it is US$61m per year. The NRW levels in both countries (49% in Kenya and 44% in Zambia) are over twice the industry benchmark of 20%.

2.3.2 *Rural water supply*

Sustaining rural water supplies in Sub-Saharan Africa remains an enduring challenge. Estimates suggest a third of the continent's handpumps are non-functional, and the number of rural Africans lacking access to improved water supplies has actually grown from 238m in 1990 to 278m in 2008. There is therefore an urgent need to reconsider the current community management model and develop alternative approaches to managing rural water supply operation and maintenance

Mobile banking and water point monitoring innovations provide an exciting opportunity to remove existing scalar constraints and unlock new models of rural water supply management. Existing mobile infrastructure could dramatically enhance rural sector accountability and transparency by providing the platform for innovative technical, financial, and institutional solutions:

- **Technical** innovations that measure water use on daily time-steps and relay packets of data to a central database to a) alert water point failure and trigger response, b) integrate into m-payment/billing models, c) establish and monitor new Service Level Agreements and performance-based contracts with private-sector Rural Water Service Providers, and d) provide a national database of water points, volumetric use and performance metrics to improve sector transparency and accountability.
- **Financial** innovations that leverage mobile banking innovations for new billing and payment models that respond to a) seasonal cash-flow economies, b) existing m-remittances from urban to rural areas, c) saving constraints of the poor, d) weaknesses in community financial management capacity, e) financial transparency and accountability, and f) increasing service levels (i.e. productive use supplies) where demand exists.
- **Institutional** innovations which can explore supra-community-based management systems and introduce an appropriate regulatory framework with rural-specific performance metrics to monitor and evaluate rural WSPs, and to create incentives for private sector actors to invest in new and sustainable rural water supply models.

Case study: Grundfos LIFELINK, Kenya

Danish pump manufacturer Grundfos has rolled out an innovative off-grid water scheme to twelve peri-urban and rural communities in Kenya. By integrating mobile payments and smart metering into a 'LIFELINK' water dispensing system, Grundfos has enabled a cashless arrangement which is remotely monitored and avoids the need for third-party operation. On average, each installation produces around 3 cubic meters of water a day, the entirety of which is paid for with mobile money. Early evidence suggests this system is generating a range of economic, agricultural and health benefits. Whilst the capital expenditure requirement may restrict the speed at which this particular off-grid configuration might be scaled-up, it demonstrates the potential for smart technologies to open up new business models for water provision. If connected to a piped network, a similar approach could make for a more sustainable standpipe service, and reinvigorate the incentives water service providers need to expand waterpoint coverage.

2.3.3 Water resource management

Water security may only be achieved where there is accurate, timely and reliable data of water abstractions and use that affect the physical quantity and quality of surface water and groundwater systems among competing sectors.

- **Unlocking scale** – global under-investment in basic hydrological monitoring has promoted parsimonious modeling based on imperfect data sets. Smart metering technology that can relay packets of surface water measurements or groundwater abstractions has scalar independence where automated and centrally managed.
- **Real-time response** – mobile communications permit the harmonisation of distant hydrological points to facilitate real-time decision-making and permit pre-emptive responses.
- **Water governance** – with improved information and communication systems to collate basic water use data, more accountable and transparent decision-making is likely to improve a) understanding of dynamic water use patterns, b) predictive capacity to identify and mitigate systems under pressure, c) objective information to shape negotiations where resource allocation is required, and d) mitigate expenditures where failure is predicted resulting in significant or irreversible damage to society, growth or ecosystems.

2.3.4 Constraints and challenges

Whilst SWS offer great potential to address many of the barriers to sustainable water management, the desk-based review and in-country workshops uncovered an array of constraints that need to be navigated and overcome. These include:

- Access to and cost of capital investment
- Security threats to both physical assets and data
- Mobile phone penetration levels
- Mobile network coverage in rural areas
- Mobile payment tariffs

2.4 Communications

The SWS website was established early January 2011 (see http://owfp.ouce.ox.ac.uk/was/smart-water-systems.php). Within the first three months, the page was visited by 410 unique viewers, across 37 countries. The workshops in Zambia and Kenya also attracted local media interest. An interview with two team members featured on Zambian national television, whilst coverage of the workshop was included in key national newspapers in both countries.

DAILY NATION

Researchers seek ways to improve water supply using mobile phones

STANDARD Panorama

Science / Environment / Health

Water Services

Kenya to get smarter at water management

SWS may offer the potential to improve the lives of millions willing to pay for the water that they use

2.5 Next steps

2.5.1 *M-Water: a global partnership for water security*

As a result of this first project phase, an action-oriented programme of work has emerged, dubbed ‘M-Water’. This new label is in recognition of the pivotal role existing mobile infrastructure is likely to play in smart metering and mobile banking innovations. M-Water seeks to harness the transformative potential of mobile communications to achieve water security and improve the coverage, reliability and affordability of water services for the urban and rural poor. We aim to develop an international, interdisciplinary and multi-sectoral partnership to achieve three objectives: a) to develop and pilot innovative ideas and initiatives; b) to evaluate and monitor initiatives to determine developmental impacts, and c) to provide a global platform to share and debate new initiatives to drive pro-poor policy change at scale.

2.5.2 *Pilot implementation*

Partner organizations in both Zambia and Kenya have committed to pilot implementation as part of the M-Water programme. In Zambia, partners include the Ministry of Energy and Water Development, Lusaka Water and Sewerage Company, UNICEF-Zambia and Airtel. Kenyan partners include the Water Services Regulatory Board, Water Resources Management Authority, and Tana Water Services Board. Support letters can be found in the Appendix to this report.

3 Appendices *(see project website)*

3.1 Lusaka workshop presentation, key benefit analysis, participant list

3.2 Nairobi workshop presentation, key benefit analysis, participant list

3.3 London workshop presentation

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