Experiences with Remote Data Collection: Using Mobile Phones and PCs for Monitoring Delivery of Rural Water Services in Uganda

Authors

Joseph Abisa[1], Peter Magara[2] and Peter Wakholi[3] .

Abstract

Mobile Phones for improved Water access (M4W) is a multi-stakeholder collaborative initiative aimed at reducing downtime and improving Operations and Maintenance (O&M) support system in Uganda. It was launched in October 2011 in 8 districts including: Arua, Kasese, Kyenjojo, Masindi, Amuria, Lira and Katakwi.

Approximately 20% of water systems in Uganda do not function at all, or operate behind design expectations. One of the problems contributing to non-functionality of rural water sources is the time lag between the identification of faults and the rehabilitation. The M4W initiative aims at providing up to date information on rural water sources, thereby benefiting the water user by enabling the information of a broken water point to lead to prompt repair of the same water source. Over 8,000 water points including shallow wells, deep boreholes, protected springs and public taps are currently being monitored using the M4W initiative.

Since October 2011, the M4W initiative has provided feature phones to the Hand Pump Mechanics (HPMs) and Community Development Officers/Health Assistants (CDO/HAs) to enable entering, uploading and approval of data. The system also consists of a module referred to as the District Water Information Management System (DWIMS) that enables DWOs to manage the operational processes of water point functionality via an internet link. Other stakeholders and the public are able to access data and information on the M4W website. Information on functionality, location and management is also presented using Google maps.

Using the M4W technology 5,779 out of 8,844 (65%) water points have been visited and data have been collected from them in the 8 districts to date. This means the system has therefore been used to map 65% of the water sources in the pilot districts. Out of the 5,779 water points that have been mapped, a total of 4,810 water points (83%) were found to be functional which compares well with the national average of 82%. Out of the

[1] Research Officer (IRC/Triple-S Uganda). Email: jabisa@triple-s-ug.org Mobile: +256 759 767 241.

[2] National Learning Facilitator (IRC/Triple-S Uganda). Email: pmagara@triple-s-ug.org Mobile: +256 750 563 920.

[3] Lecturer Makerere University SCIT and Principal Investigator, M4Water Project. Email: peterokhisa@gmail.com Mobile: +256 775 144 070.

5,779 water points that have so far been visited, 968 (17%) were found to be non functional. Furthermore, 921 water points in 7 districts were found not to have Water User Committees. Close to 500 water sources captured in the M4W system were not in the WATSUP database. The process of implementing the system also created an opportunity for district personnel to undergo training thereby enhancing their ability to perform. The system has further empowered the water users to report faults in water points which has improved functionality. The system currently provides information useful for learning, advocacy and resource mobilisation purposes among the stakeholders which will eventually permit replication to other districts. Action research on the system has increased ownership of the water sources by the communities, offering more opportunities for sustainability of the initiative.

Key words
Mobile phones, improved water access, functionality, rural water, M4W system, operations and maintenance.

Introduction and purpose

Mobile Phones for improved Water access (M4W) is an initiative of International Water and Sanitation Centre (IRC)/Triple-S, The Netherlands Development Organisation (SNV), Makerere University College of Computing and Information Science and WaterAid, in partnership with the Ministry of Water and Environment (MWE), to improve functionality of rural drinking water sources. It aims at reducing downtime and improving Operations and Maintenance (O&M) support systems. The initiative is currently being used in three ways including: collecting information about the management and functionality, reporting faults, assessment and repair information, and collecting sanitation information on the water point. Launched in October 2011, the M4W initiative is being implemented in 8 districts in Uganda including: Arua, Kasese, Kyenjojo, Masindi, Amuria, Lira and Katakwi. Details of the initiative can be viewed at: http://m4water.org/

Stakeholder roles in monitoring and supporting rural water service delivery

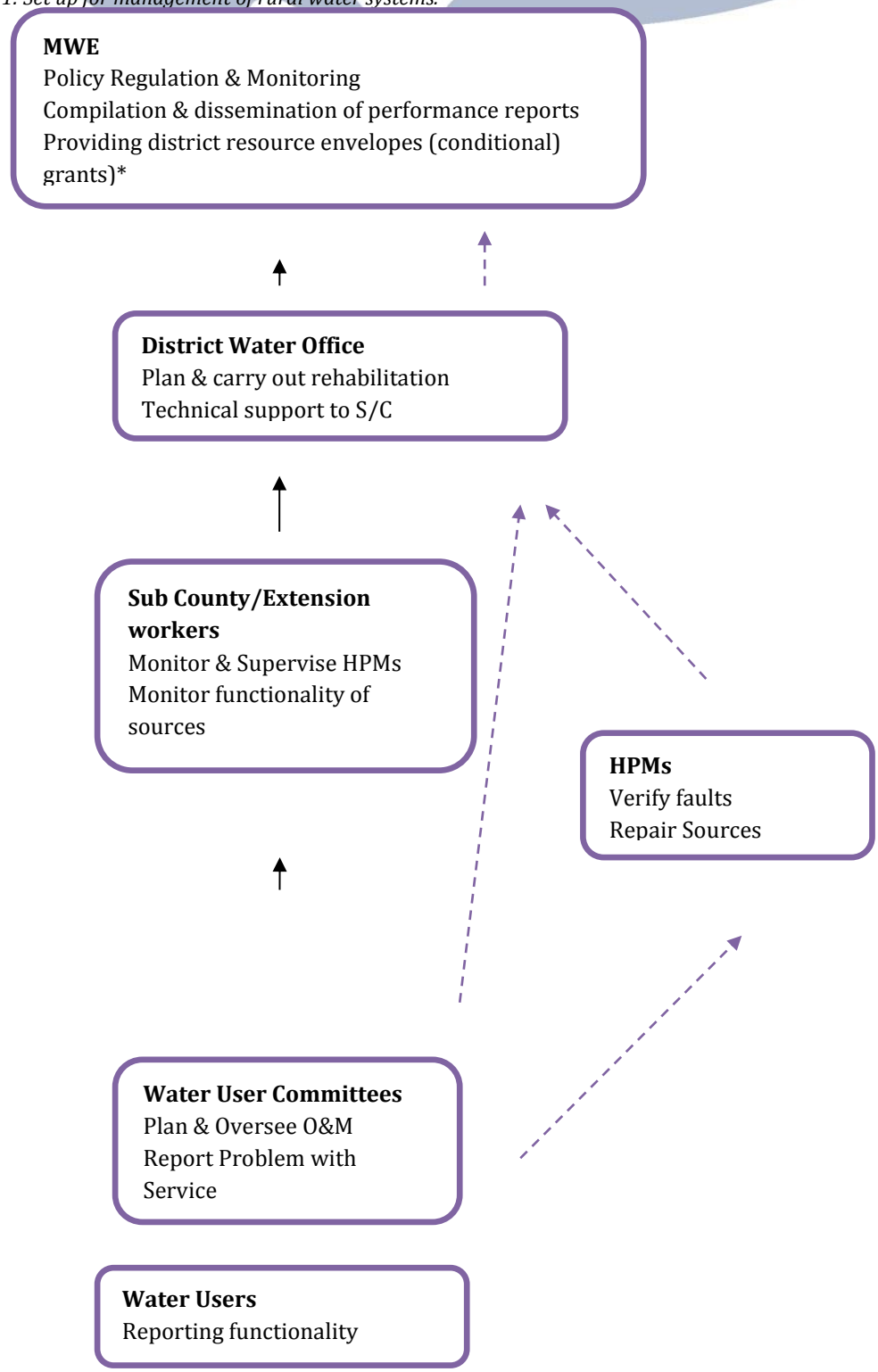
Figure 1 shows the management of WASH programmes in Uganda. At the Local governance level, these programmes are managed by the District Water Officer (DWO) who works with the Community Development Officers (CDO) and Health Assistants (HA) based at the sub county level to ensure that there are adequate water, sanitation and hygiene programmes. In order to achieve this, communities are engaged through Water User Committees (WUC) that comprise of six people who manage the water source and report any malfunctions to the relevant authorities. In addition, the WUCs collect regular contributions from community members that are used for minor repairs and maintenance of the water source. Hand Pump Mechanics are individuals (none government officers) based at the districts which are piloting the M4W initiative, who have been recruited, trained and given mobile phones for monitoring the functionality of rural water sources. They now operate under Community Based Organisations

known as Hand Pump Mechanics Associations (HPMAs). Each sub county in the district has at least 2 Hand Pump Mechanics.

The operation and maintenance framework (MWE 2004) stipulates roles of the different stakeholders involved in the rural water service delivery under the Community Based Maintenance System. In Figure 1 the straight arrows show the current reporting and information flow mechanism under the CBMS while the dotted arrows show the reporting system that is used under the M4W initiative.

The water user level is the main point for measuring service delivery performance since this is where the actual service occurs. In the current set up of CBMS in Uganda, users report issues with the water service to the Water User Committees (WUCs). The WUCs then report to the sub county hand pump mechanics if they have the contact or to the sub county that then sends a mechanic to verify the fault and repair the system. However, several studies have shown that most WUCs do not have contacts for sub county HPMs (MWE 2011). Though the option of contacting the HPM directly seems more efficient, there is no means to verify whether the assessment of the fault reported is actually done since no documentation is available on HPM assessments at the sub county level. The district water office is the final reference point at the decentralised level.

Figure 1: Set up for management of rural water systems.



The prime purpose of this paper is to present the methodology used, results and achievements from the M4W system since its launch in October 2011 in improving functionality of the water sources. The paper also presents other unique features of the system which include: use of government structures, flexibility, low costs and ability to monitor at the local levels, yet report at the national levels.

Context

Studies from different parts of Africa show that between 30% and 40% of water systems in the continent either do not function at all, or operate significantly below design expectations (Uganda country Study Report 2011). Approximately 20% of water systems in Uganda do not function at all, or operate significantly behind design expectations with failure rate high for hand pump based technologies (MWE 2010). One of the key challenges contributing to non-functionality of rural water sources is the time lag between the identification of faults and the rehabilitation (IRC 2012). In Uganda, while the development of new physical infrastructure would be a solution for improving the rural water supply, government continues to face challenges in providing new rural water infrastructure. This means people in rural areas still face various problems in accessing safe and reliable water for use.

Figure 2: a broken borehole in Borboro east parish, lira district.

The M4W initiative is meant to benefit the water user by enabling the information of a broken water point to lead to repair of the same water source. Over 8,000 water points are currently being monitored under the M4W initiative. These include: shallow wells, deep boreholes, protected springs and public taps. The initiative seeks to provide real time data on performance of rural water systems and trigger response to non functional sources. Data on the Government of Uganda's Water Atlas 2010 was collected in 2009 for example, but only published about 2 years later, rendering information on some of the water sources obsolete and outdated. The M4W initiative was therefore launched in October 2011 to, among others: improve efficiency in reporting faults, trigger action for response to non-functional sources, and improve efficiency in updating District and National Information Systems.

Uniqueness of the System

The M4W initiative is unique in that it utilises government structures both at national and at the district levels. The District Water Officers (DWOs), Health Assistants (HAs)

and Technical Support Units (TSUs) are all actively involved in the implementation of the initiative within their respective districts. This therefore provides an opportunity for monitoring at water sources at community level yet report at the national level, something which has not been tried out before in the country. Unlike other mobile phone and web based technologies like the FLOW (in Ghana) and Daraja, the monitoring component of the M4W system tracks the same indicators that are captured by Government (WATSUP), therefore providing a useful tool for monitoring the delivery of water services at the local levels and updating the Districts Water Management Information Systems (DWMIS). Community participation in reporting faults also offers a good foundation for the sustainability and ownership of the initiative.

Methods

Since October 2011, the M4W initiative has provided Java-enabled telephone handsets (approx. 40 USD each) to the Hand Pump Mechanics (HPMs) and Community Development Officers/Health Assistants (CDO/HAs) to allow entering, uploading and approval of data. In this section we provide technical details on the design of the system, the roll out and data collection process, and finally the challenges faced and how they were overcome.

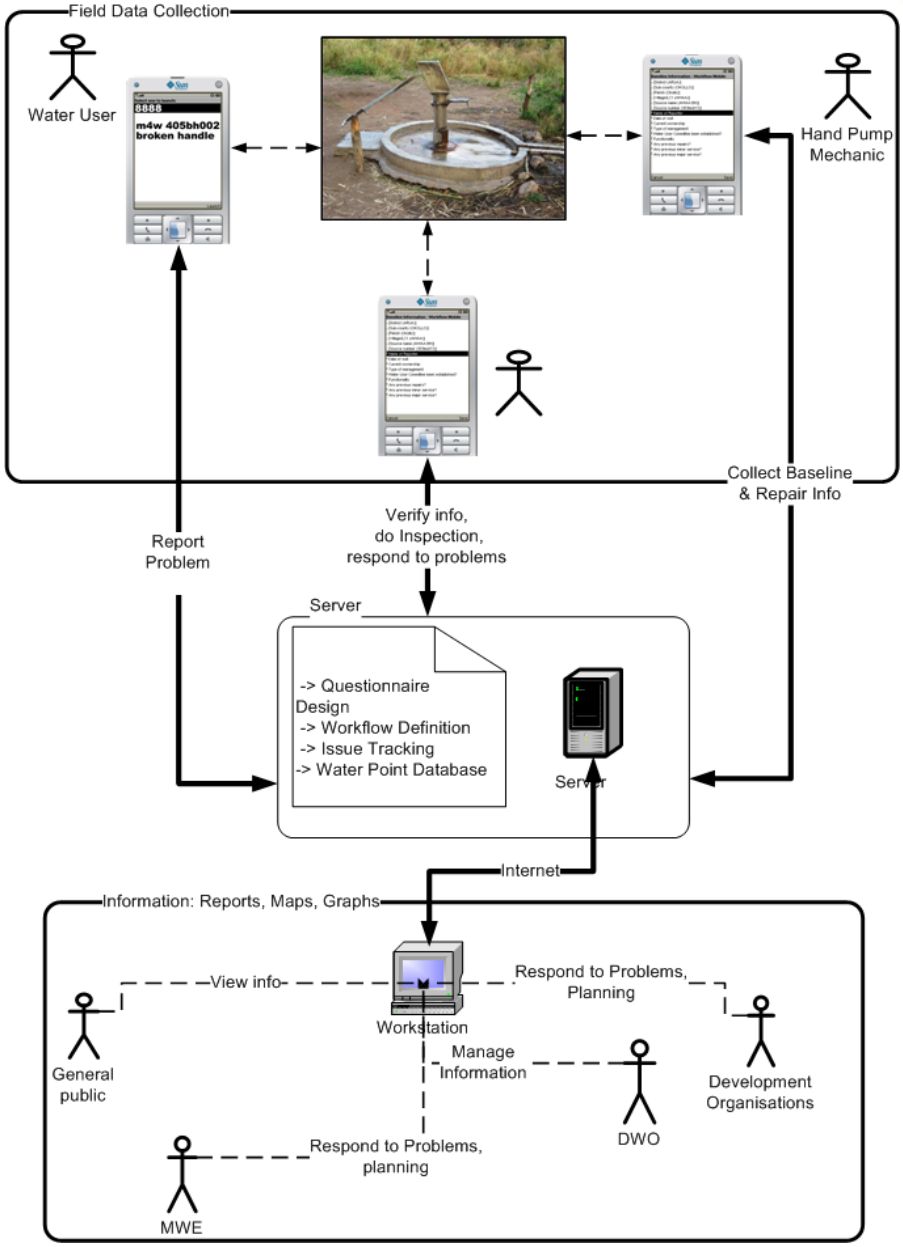
Design of the M4W system

The M4W system has been designed as a generic data collection and management system that uses multiple technology platforms (personal computers and mobile) and provides information to various stakeholders at local, district and national levels.

Figure 3 provides an overview of the system. The forms for data collection are defined on the web-based server which runs the OpenXdata system (openXdata). The associated processes for data collection, e.g. collection and review of data and reporting and responding to faults are configured using the YAWL workflow management system (van der Aalst, Aldred et al. 2004). Forms that are designed are rendered on the mobile phone with the relevant logic to enable users to fill in only sections that are relevant and select appropriate responses.

The phones used for this project are Nokia 110, Nokia 111 and Nokia C101 which are the cheapest feature phones on the market – costing approximately 40 USD. The system also consists of a module referred to as the District Water Information Management System (DWIMS) that enables DWOs to manage the operational processes of water point functionality via an internet link. Other stakeholders and the public are able to access information on the M4W website (M4W 2012). Information on functionality, location and management is presented using Google maps.

Figure 3: architectural design of the m4w system.



How the m4w system works

How the system functions for the user

If there is a problem with the water point e.g. a borehole has a broken pump, a care taker of the water source or any other community member can send a text message to code 8888 i.e. ***(m4w->water source ID->problem->8888)***. The system alerts the responsible HPM who then goes to assess the magnitude of the problem and advises the community of the costs of repair (in case of minor repairs) or he may inform the district (in case of major repairs). The user is therefore able to report a fault and have the broken water point repaired with minimal movements.

Hand Pump Mechanics are individuals (non-government officers) based at the districts which are piloting the M4W initiative, who have been recruited, trained and given

mobile phones for monitoring the functionality of rural water sources. They now operate under Community Based Organisations known as Hand Pump Mechanics Associations (HPMAs). Each sub county in the district has at least 2 Hand Pump mechanics managing, on average, 150 water sources.

Management of faults

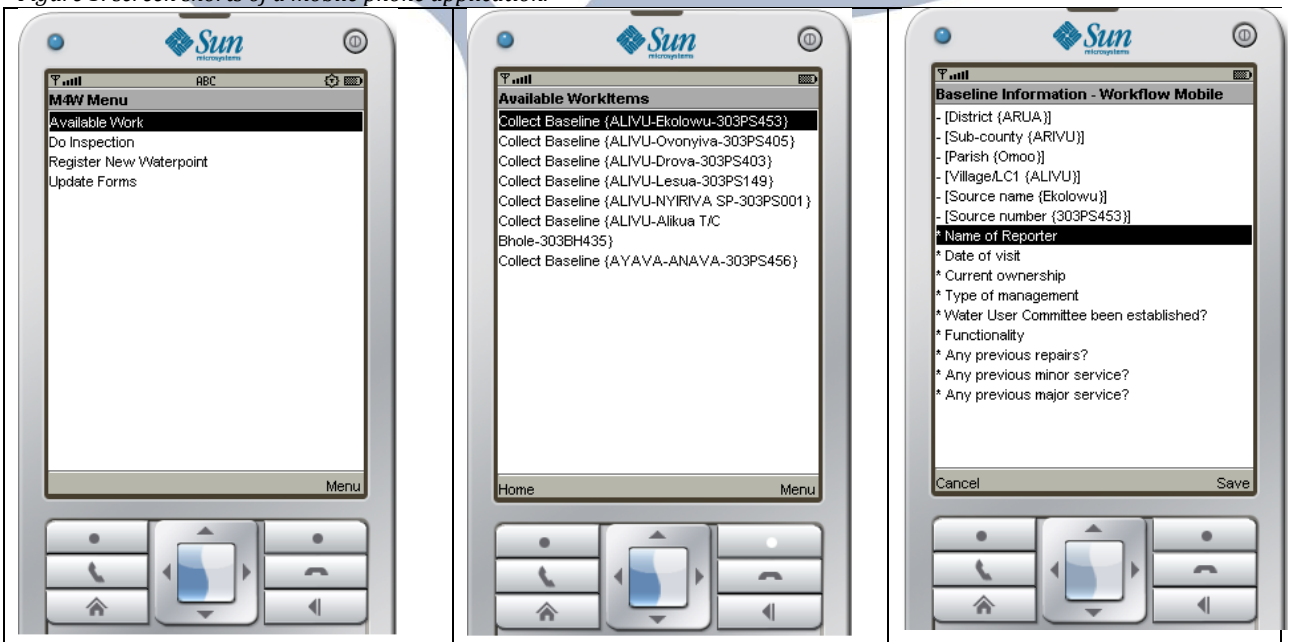
When a user identifies an issue with the source, he or she sends a text message to SMS Code 8888, indicating the source identification number. Once the system receives the notification, it generates an SMS which is sent to the relevant HPM's phone. Upon receiving the information, the HPM is expected to go to the source to do analysis and to advise the community on the necessary action. Each fault attended to by the HPM is reported to the system, whether or not it was triggered by the HPM.

Monitoring data

Monitoring data is collected by the district in a snapshot of time. The project enables collection using mobile phones based on current datasets from Ugandan Ministry of Water and Environment (MWE) Water supply database (WATSUP). The data collection processes are similar to the existing local government procedures where data is collected by the HPM and approved at the sub county before it is stored as a record. Current information on water points is collected by HPMs. A HPM is assigned the work by the DWO with just a click on the DWMIS. This work is delivered to the mobile phone of the HPM who completes the form and sends information via a mobile phone (MTN) network. An SMS message is then automatically sent to the Extension worker who approves it and a record is saved in the database. This process ensures that the DWMIS is kept up to date. Once information has been reviewed and uploaded, the record is modified in the database and archived. This process is illustrated using the YAWL process model in Figure 4.

Figure 4: baseline data collection process.

Figure 5: screen shorts of a mobile phone application.

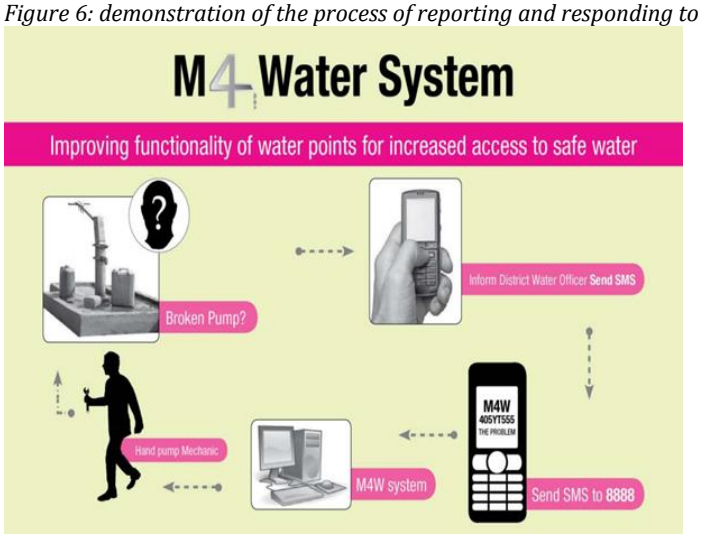


(a) Checking for work	(b) Selecting a work item	(c) Completing a task

Reporting of faults by the Community

A member of the community or any member of the public can report a fault by sending a coded SMS with the identification (ID) of the water source and problem to code 8888. The system creates a ticket which triggers the HPM and DWO to take action. HPMs are able to report about the assessments and repairs undertaken as demonstrated in Figure 5. All water sources are being mapped and assigned unique identifiers. Once faulty water sources are reported, SMS notifications are sent to responsible stakeholders. Furthermore, status of water points can be viewed for particular locations in the form of reports.

Figure 6: demonstration of the process of reporting and responding to a fault under the m4w system.



Collection of sanitation information

Health Assistants (HAs) are able to carry out inspections and send information to the system. When collecting information, a HA needs to specify the ID of the water source. The information collected is based on the MWE guidelines for Inspection. The status of water points can be viewed in the DWMIS.

Data analysis and information sharing

The M4W system collects three types of data including: monitoring data, data on the reported faults and sanitation data. This information is kept in a central database that provides different access rights to various stakeholders. Through the M4W website, information about location, functionality and management of sources is displayed on the map. If a water point ticket has been created, it can be viewed on the map, together with supporting information about progress on repairs. Once the source has been fixed, it is taken off the map. Other stakeholders are able to download data from the website using comma delimited format (CSV). This data may be exported to other data analysis software such as SPSS or STATA and analysis performed on specific indicators of interest. This can then be presented in tables and graphs depending on the nature of audience for which it is meant and the purpose.

The information is also presented in different formats including briefing notes, fact sheets, and monitoring reports. Sharing of information is done with other implementing stakeholders, government and other NGOs in the water sector.

Table1: Baseline Progress On M4w System Since Oct 2011.

No. of water points expected	**No. of water points located**	**Percentage located**
8,844	5,779	65.34
No. of water points located	**No. of water points functional**	**Percentage functional**
5,779	4,810	83.23
No. of water points located	**No. of water points non functional**	**Percentage non functional**
5,779	968	16.75
No. of water points located	**No. with no WUC**	**Percentage with no WUC**
5,779	921	15.94

The information is also presented in different formats including briefing notes, fact sheets, and monitoring reports. Sharing of information is done with other implementing

stakeholders, government and other NGOs in the water sector. The information from the system is also shared during the District Coordination and planning forums.

Achievements (also what is working well)

The following can be attributed as achievements of the M4W project. It is anticipated that greater impact will be achieved when the system is mainstreamed by MWE and more community engagement and sensitisation of reporting done.

Between October 2011 and Nov 2012, a baseline study was conducted in the seven pilot districts to establish the functionality of sources, water user committees and the state of operations and maintenance. Findings from the system reveal that 4,797 out of 8,844 (54%) water points in the 7 districts are currently being monitored using the M4W technology.

Additionally, 3,951 out of the 4,797 water points (82%) were found to be functioning. This compares well with the National average of 82%. On the other hand, 921 water points of the 4,797 water points were found not to have water user committees. Close to 500 water sources captured in the M4W system were not in the WATSUP database.

The implementation of the M4W system provided an opportunity for the different categories of district and other personnel to be trained. All the CDOs, HAs and the HPMs in target districts were trained and provided with mobile phones.

The M4W initiative has provided opportunity for water users to report on broken water points. To date, 85 reports have been transmitted through the system and have triggered HPMs to conduct assessments of water points within 3 days from receipt of reports. HPMs have also repaired at least 70% of the 85 water sources that were reported to be faulty through the system.

The M4W system is currently generating information that is used by the different stakeholders for learning, advocacy and resource mobilisation. HPMs in one of the pilot districts (Kabarole) used M4W data to conduct assessments of 22 non functional sources in 5 sub counties and prepared a proposal to repair the water sources that was shared with the DWO and other development partners.

Additionally, the M4W consortium, in partnership with the liaison office of MWE, has established the Management Information Systems (MIS) working group to coordinate different sector monitoring initiatives. The consortium has used the group to share lessons on how M4W can be used to update District Information Management Systems. Currently, MWE is in the process of incorporating the M4W initiative in their work processes to roll out a nation-wide system.

The system also offers opportunities for action research which increases ownership of the water sources by the communities. Furthermore, HPMs and their target communities are now known to each other. Previously, community members did not know which mechanic was responsible for which area. But since the HPMs have been

personally involved in the source mapping exercise, they have been able to introduce themselves to the communities in their areas of jurisdiction.

Low costs of collecting the required data. Uganda has approximately 1,400 sub counties and 144,000 water sources. The total cost of providing mobile phones to these sub counties would be 140,000 USD. Considering these phones get damaged/lost, one would have to factor in 20% (28,000) annually to replace them. Additional costs including data collection at approximately 1USD/Source (total 144,000 USD), management of the system (30,000 USD/year). This would translate to approximately 342,000 USD – excluding training and any other operational costs. Subsequent costs for annual data collection amount to 202,000 USD making annual updates of the water database a viable option. This contrasts with the amount spent by the MWE in the last Water Atlas Update (previously done 10 years ago) estimated at about 1,000,000 USD.

Table 2: the costs of implementation of the system.

Component	**Cost drivers**	**Examples**	**Estimates**
Phone hardware, handset devices	Type of handset being used, wear and tear	Nokia/Symbian, Ideos/Android	Low (<=40USD) and viable for volume deployment
Software license or service subscription fees	Opensource Vs Proprietary	LAMP, Unix, Linux, Windows	All open source so no license costs
Training, Support & Consulting	Handset complexity, Tools complexity, Skills requirements	Training workshops, local champions, System admin, Devt support from Mak	1 MIS admin@2M/month, 1 database Admin@2M/month
Data Transmission	Internet connection, SMS	SMS Data/IP: GPRS, Edge, 3G, 4G	National agreements for toll free SMS line. Cost per data upload 2UGX
Locally hosted Data Centres and Server Hardware	Local IT personnel Lack of power & reliable infrastructure	Local SMS Gateways, database servers, Line of business,	Cost per month for server approximately 200 USD

Costs for nationwide deployment

Hardware costs @ 280,000 for 1,400 sub county – 392M
Insurance 10% of hardware– 39.2M/Year
Training – MWE incorporate in Programmes
Data collection – 2K@144,000 sources – 288M
Support – 5M/Month = 60M/Year
Consulting – Consortium to continue looking for funds for full development
Data transmission – None

Data Centre – 500,000/Month = 6M/Year
Total Projected for initial deployment - 785.2M
Recurrent Costs Subsequent - 115.2/Year

What is not working well

One of challenges being experienced relates to the limited use of information and data being generated by the M4W system both at national and decentralised levels. There is still need to build the capacity of the District Water Officers to mine and utilise the data generated for their reporting purposes.

At the time of launching the M4W initiative in October 2011, all the water sources drawn from the 7 participating districts were properly labelled with unique identifiers which contained the district code and the source number of the water point and the code to which a message can be sent (in case of a fault). However, over time, most of these identifiers have either fallen off from the water sources or have completely faded out, rendering the writings on them invisible to the care takers and water users. This, in a way, is increasingly complicating the process of utilising the M4W system for reporting faults, since the care taker or water user may not know the source number to enable them to complete the process of sending the message in case of any fault with the water source. This is, however, being addressed by reinstalling the identifiers on all the water sources.

Network & system technology related problems have also been experienced in a number of the piloting districts. For instance, the code 8888 to which the message to report a fault is sent sometimes fails to function thereby rendering the water users helpless since they are not able to report during this time. The Systems Administrator has, however, held discussions with the network operators to resolve this challenge.

Some of the mobile phones that were initially distributed to the HPMs and HAs have gotten lost and for others, the batteries are dead. The costs of repairing and replacing such phones are becoming a liability to the project.

Limited follow up by districts (DWOs, DHO, HIs)

In Uganda, the District Health Officers (DHOs) are key government officials handling all health related issues at the district level. However, in most of the M4W piloting districts, the DHOs have limited or no interest in the M4W initiative. This therefore calls for retraining and sensitisation of district personnel about the relevance of the M4W initiative.

Another challenge with the implementation of the system is the limited number of HPMs allocated to particular water sources in the piloting districts. There are only 2 HPMs per sub county. A sub county can have, on average, 90 water points. It becomes difficult for the HPMs to manage all the water sources in their allocated sub counties, with the limited funding that they receive.

Conclusions

The M4W initiative is a real potential for creating a national monitoring system for functionality of the rural water sources since it uses the existing government structures for collecting data at the local (community) level yet reports it at the national level. The system currently provides timely and up to date information on performance of rural water services which is also useful in updating the National and District Management Information Systems (DWMIS). While greater impact is anticipated after the system has been mainstreamed by MWE, the current achievements so far registered are enhancing the functionality of rural water sources in Uganda.

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