ETM

ENGINEERING & TECHNOLOGY MANAGEMENT

Using mobile-enabled data to improve water availability and service delivery in developing countries – A literature and program application review

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Abstract

Many global organizations and governments continue to invest billions of dollars in development projects in developing countries, with a lot of such money going into water and sanitation projects. The return on investment however is difficult to ascertain given that a lot of these projects and installations are broken down in no time after they are carried out. For example, the most prevalent mode of supplying water in rural sub-Saharan Africa is through handpumps, with about 60,000 of such handpumps installed in Africa annually. It is however estimated that a third of these handpumps are non-functional at any one time. The result is a myriad of issues including, but not limited to costs of repair, health and environmental challenges, and simply a waste of billions of invested money and resources. While methods of data capture and analysis such as occasional surveys and spot checks to ascertain levels of operation and functionality have sometimes been useful, a new school of thought which proposes the use of mobile-enabled data to capture and analyze operational performance of rural water supply projects presents an interesting dimension in global development efforts. This paper presents a literature review of some of the efforts aimed at promoting the use of mobile-enabled data to improve water availability and service delivery. The factors that have influence on the functionality and sustainability of rural water supply projects are also highlighted from the review while making a case for the use of mobile-enabled data as a more credible alternative for the sustainable management of rural water supply projects.

Introduction

The issue of rural water service delivery has been studied for a very long time and efforts have been made to improve service delivery over the years. While admittedly strides have been made and continue to be made, it will be far from right to assume that solutions to the numerous challenges that plague rural water service delivery are anywhere in sight. Most researchers in this field admit there is no ‘blueprint’ for sustainability in rural water supply [1] especially given the complexity of such projects and therefore there is no ‘one size fit all’ approach. However numerous studies exist that point to the challenges that plague rural water service delivery, and therefore provide a starting point to address these challenges. One of such challenges is the absence of real-time data to monitor and improve service delivery especially as and when those challenges emerge. For example, while handpumps are the most prevalent mode of supplying water in rural sub-Saharan Africa, it is estimated that about a third of these handpumps are non-functional at any one time [2]. A number of reasons may be attributabed to this, but the fundamental issue remains that the inability to monitor some of these handpumps in real time makes it near impossible to ascertain exactly what is happening at every point in time. This makes a strong case for the use of mobile-enabled data on these projects, given that in the least this can provide information on the status of these projects. It is in light of this that efforts on the parts of some researchers in approaching the issue from this angle is welcome news in that it provides whole new dimensions and perspectives on rural development projects.

Literature Review

There are about 275 million rural people in Africa without improved water services [3]. Countless efforts are made day in and day out to provide improved water services to these people and others all over the world, and they are not without challenges. To translate these efforts into measurable and empirical results, and subsequently lead to institutional transformations requires improvements to the reliability of the methods by which water is delivered. A comprehensive study by Foster [4] investigated the predictors of sustainability for community-managed handpumps in in sub-Saharan Africa. In his three country analysis of data on 25,000 handpumps from Liberia, Sierra Leone and

Uganda, he investigated risk factors that had significant effects on non-functionality across all three countries. His findings concluded that apart from system age, distance from district/county capital and an absence of user fee collection, other variables were found to have significant associations with functionality status. Some of these included well type, handpump type, regular servicing, funding organization, spare parts proximity and availability of a handpump mechanic. The study confirmed views that a range of factors determine the sustainability or otherwise of community-managed handpumps and therefore reaffirm the notion that a lot more is required to evaluate ways by which handpump water supplies can be managed.

A number of studies have employed the use of mobile-enabled data and have come up with some interesting results. There are variations to this approach of using mobile-enabled data to improve water availability and service delivery and a number of institutions, notably Portland State University's SWEETLab, University of California at Berkeley, the London School of Hygiene and Tropical Medicine, and the University of Oxford [5] are leading efforts in this regard. Oxford/RFL and Thomas et al. [6][7] succinctly describe the architecture, hardware and technology for this approach to remote instrumented monitoring of global development programs and also describe their application in some projects. In a 12-month study in rural Kenya, near real-time mobile enabled data was adopted to test a new pump maintenance service model through the use of a 'smart handpump' which comprised of a transmitter with an accelerometer that generated pump usage data that could be sent over a mobile phone network [3]. The transmitters enabled measurement of parameters such as handpump usage and corresponding volumetric water use as well as a surveillance of maintenance service delivery and pump down-time. These provided information for decisions such as setting water charges based on usage, guiding performance-based maintenance contracts, and planning of infrastructure and investments in a bid to improve accountability.

In a study on a Mercy Corps water, sanitation and hygiene program in Indonesia, Thomas and Mattson [8] demonstrated that instrumented monitoring systems had the ability to provide institutions with the capacity to measure both impact and behavioral change in their programs. In the study, instruments were installed to directly monitor hand washing and latrine use a year after the implementation of a program that installed hand washing stations and latrines at a number of sites. For this particular program, a public health evaluation using traditional survey methods was carried out as well and reviewed in conjunction with data from the instrumented monitoring. The authors suggested that in spite of limitations with instrumented monitoring such as difficulty in discriminating details in behavior, cellular data costs, and complexity of analysis methods, a combination of instrumented monitoring and traditional evaluation methods can go a long way to provide objective quantifiable data to enhance various programs.

Thomas et al. [9] evaluated the impact of remotely reporting electronic sensors on the use of water filters and cookstoves in Rwanda through the collection of data from households using both monthly surveys and direct observations as well as sensor-equipped filters and cookstoves. Among other things, the use of sensors on the water filters provided objective data such as the quantity of water that households treated at home and the consistency of use of the filters. Furthermore, results from the sensors reinforced the tendency of surveys and direct observations to exaggerate households' compliance with environmental interventions.

Implications for development projects

The emerging evidence from mobile-enabled monitoring of rural water services delivery provides a basis for assessing performance and impact of these projects as against the often employed traditional methods. Granted that there are variations in these mobile-enabled approaches [10], the overarching goal of obtaining more credible and quantifiable metrics to track the performance of these projects makes a compelling case for this approach. As evidenced from the literature, a multiplicity of factors may be at play in terms the determinants of sustainability of these projects making it difficult to ensure project deliverables are attained. While mobile-enabled methods in and of themselves may not be a panacea for solving all the problems of rural water service delivery, the preponderance of evidence suggests they might offer more favorable options especially when used in conjunction with the typical traditional methods of monitoring and evaluating these projects. Furthermore, the use of this approach might even transcend their intended purposes and even address more pressing issues such as petty corruption which has bedeviled a great number of sub-Saharan African countries. As suggested by Krolikowski [11] in his study on mobile-enabled payment methods and petty corruption in urban water provision in Tanzania, the ability of mobile-enabled methods in reducing information asymmetries and enhancement of financial management practices such as provision of transparent payment data can go a long way to curb petty corruption in water services delivery.

To suggest that mobile-enabled approaches to water service delivery are not without their own challenges will be disingenuous. For example, well-functioning water systems might not necessarily be what users implicitly desire in terms of performance, although this might not be flagged by monitoring systems as non-functionality. Also, there might be instances where failures might not be detected or incomplete pictures of system performance might be painted due to one reason or the other [12]. Finally, the use of mobile-enabled methods will ultimately generate volumes of data that sense has to be made out of. The timeliness of the data and the ability to carry out quality and meaningful analyses is the only way to ensure that the data generated will prove useful in making decisions.

Project application

The mobile-enabled approach described is intended for use in a project in five counties in Kenya to support sustainable and resilient livelihoods through the improvement of water availability and service delivery to people, livestock, and pasture in Kenya's arid lands. These areas are characterized by high poverty rates, chronic food and water insecurity and low access to basic services. Strategic objectives expected to underpin this project to guide its success include the hypothesis that strong county institutions are required as a pre-condition for long-term sustainability and community empowerment. It is intended therefore that the project will enhance coordination and integration of development programs across sectors, enhance private sector participation in water, sanitation and hygiene (WASH) to increase investment, and empower communities with knowledge and ability to exercise rights and responsibilities for water resources. While the project is multifaceted in nature, a strong component will be the utilization of data and Information and Communication Technology (ICT) tools for improved decision making.

In this regard, sensors are expected to be installed on all water points to provide unique real time insight into the success of the program's approach. The adoption of a Monitoring and Evaluation (M&E) mechanism that will create a value chain that continuously collects data in real time is expected to go a long way to support policy making and better project monitoring. Furthermore, it is expected that data gathered will be shared with relevant stakeholders such as the government, funding and implementing organizations in a bid to provide insights and market intelligence for private business development.

Conclusion

The complexity of rural water service delivery projects makes it nearly impossible to assign a common or even a set of reasons for the failures or deficiencies in any one project. Various factors are always at play, ranging from poverty levels, geographic considerations, user group location relative to resource location, rules of access and use and a host of others. What might portend challenges for a project in one jurisdiction might not necessarily present the same challenges in another. Nonetheless, similarities exist across board given that the methods and models of provision of these rural water delivery services have a number of similarities. Having a way of ensuring constant feedback through real-time data is one sure way to monitor and make improvements to projects as and when challenges emerge.

The integration of mobile-enabled data and other methods of instrumented monitoring of rural water service delivery, though an emerging concept is already causing radical transformations in development projects the world over. As Thomas [5] argues, the improved feedback that instrumented monitoring offers has the potential to offer valuable insights into the impacts and benefits of global poverty reduction interventions.

References

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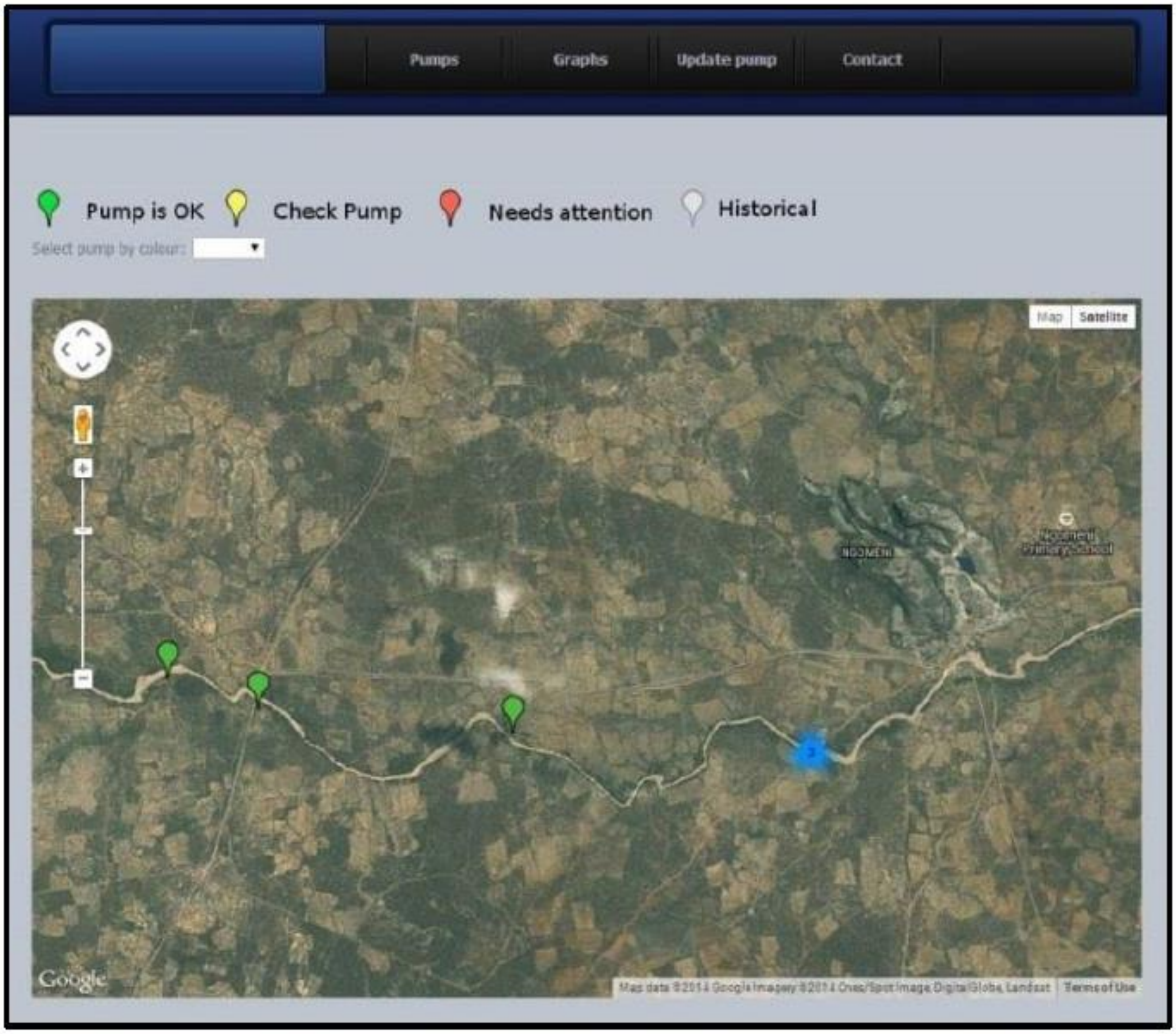
Appendix

Appendix A-1: Prevalence of water point characteristics and associated nonfunctionality rates (Source: Foster, 2013)

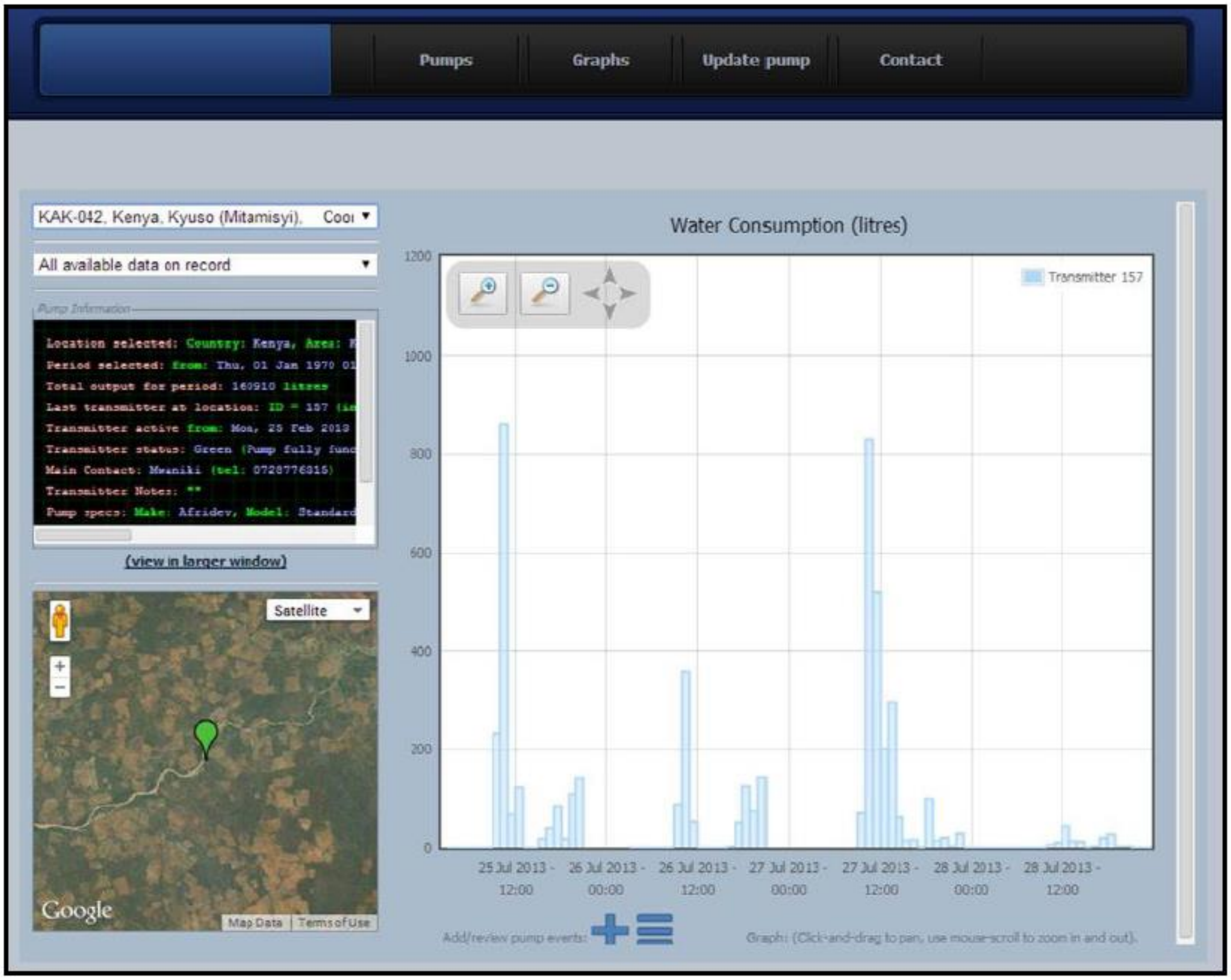
Prevalence of Water Point Characteristics and Associated Nonfunctionality Rates							
		Liberia (n=4480)		Sierra Leone (n=5448)		Uganda (n=15133)	
	variables	cases (%)	NFR[a]	cases (%)	NFR[a]	cases (%)	NFR[a]
system age (years)	1	14.7	11.4	20.1	11.2	14.2	11.3
	2	16.7	13.4	18.6	13.1	16.2	14.4
	3	17.1	17.6	12.8	17.3	15.9	15.5
	4	19.1	21.7	11.2	21.5	12	20.3
	5	15	22.1	9.5	21.7	11.4	22.2
	6	13.5	20.6	9.1	23.3	11.9	24.5
	7	2.9	23.5	8.9	26.7	9.7	26.8
	8	1	36.2	9.7	20.6	8.7	25
welltype[b]	borehole	12.9	16.8	14.2	15.8	54	13.9
	shallow/hand-dugwell	87.1	18.5	85.8	18.2	46	25.1
handpump type	Afridev	91	18.2	4.3	16.5		
	IndiaMkII	5.4	15.6	72	18.6		
	Kardia	0.6	16	16.2	13.5		
	Inkar			3	17.8		
	Other	2.9	25.8	4.5	24.3		
funding organization	government					62.1	19.1
	localgovt.					39	22.4
	national govt.					23.1	13.6
	NGO					31.5	20.3
	other					5.5	11.7
implementing/installing organization[c]	privategovernment	2.5	14.2	14.4	22.9	0.9	14.7
	NGO	81.4	18.4	69.1	16.1		
	private	3	13.3	2.9	18.1		
	other	13.1	18.9	13.7	21.6		
trained committee	yes					70.7	17.8
	no					29.3	22
regular committee meetings	yes					41.3	10.6
	no					58.7	25
no. of committee members	0					7	33.4
	1−3					1.7	28.2
	4−5					13.6	24.2
	6−7					37.5	17.5
	8+					40.3	15.9
women in key committee positions	yes					73.3	17
	no					26.7	24.7
revenue collection	yes	78.1	17.1	23.3	11.8	55.6	11
	reactivepayment	49	15.7	17.8	11.9		
	advancepayment	29.1	19.5	5.4	11.5		
	no	21.9	22.2	76.7	19.7	44.4	29.1
regular servicing	yes					47.3	11.1
	no					52.7	26.2
mechanic available	yes			49.4	13.1		
	no			50.6	22.6		
distance to spare parts	incommunity			16.7	11.6		
	<20miles			25.7	16.3		
	>20miles			57.6	20.4		
perceived water quality	good	83.1	14.7	85.9	14.2		
	poor	160[d]	32.6	10.5[e]	32.1		
rainfall season	dry	76	19.9			78.4	18
	wet	24	12.9			21.6	22.7
distance from administrative capital of county/district (km)[f]	0−10	18.3	14.8	22.4	12.9	20.7	16.9
	10−20	18.5	17.4	18.4	17.2	32.1	18
	20−30	22.8	14.8	18.1	20.8	23.5	18.1
	30−40	12.5	17	17.3	20.3	11.1	21.5
	40+	27.8	24.5	23.8	19.1	12.2	25.2
district/county handpump density	0−0.2	66	18.8	62.2	17.8	19	19.5
	02−0.4	19.5	19.7	33.7	18.8	43	19
	0.4+	14.5	13.6	4.2	12.3	38	18.9
total		**100**	**18.2**	**100**	**17.9**	**100**	**19.1**

[a]NFR = nonfunctionality rate. [b]In Uganda, well types were differentiated by depth – shallow wells are less than 30m deep, and boreholes are greater than 30m deep. In Liberia and Sierra Leone, well types were differentiated by whether or not they were hand-dug. [c]Variable relates to implementing organization in Sierra Leone and installing organization in Liberia. [d]0.9% of water points had unknown quality. [e]3.6% of water points had unknown quality. [f]0.4% of water points in Uganda did not have reliable GPS coordinates.

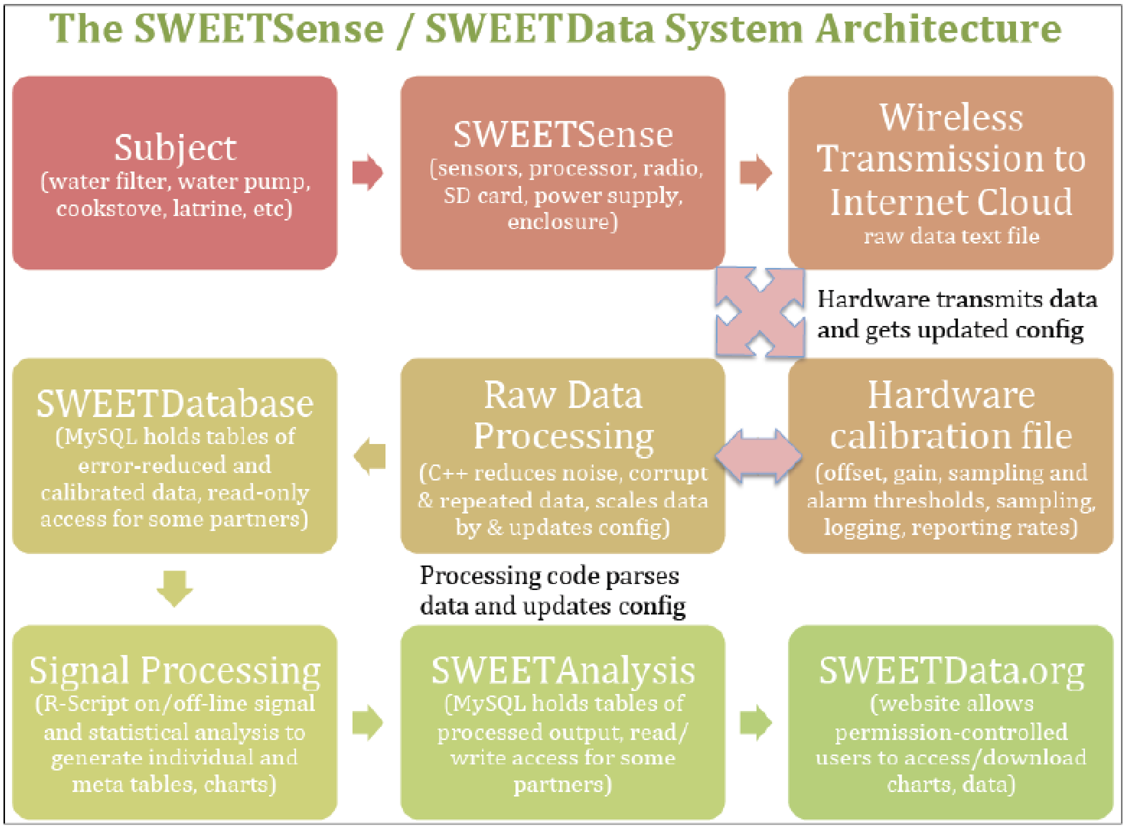
Appendix A-2: An interactive map representing integration of status of pump into a website (Source: Oxford/RFL, 2014)



Appendix A-3: Graph indicating pump output and history, usage patterns and potential failures (Source: Oxford/RFL, 2014)



Appendix A-4: The SWEETSense/SWEETData System Architecture (Source: Thomas et al., 2013)



Appendix A-5: Water filter adoption, daily uses, daily water treated, and volume treated per event as reported by survey and recorded by sensor for all available data, subset of data in the three RCT villages, and among sensor data with direct household pairings to surveys (Source: Thomas et al., 2013)

	filter use[a]		number of filter uses per day			mean volume treated per day (L)			mean volume treated per event (L)[b]			Wilcox rank sum test for mean volume per day		
	%	*n*	value	SD	*n*	value	SD	*n*	value	SD	*n*	*p*-value	median diff.	95% CI
all EHO surveys (15 villages)	96.5	1634	1.32	0.62	1600	5.05	1.13	1219	8.13	1.93	1542	0.49	0	0.00:0.00[c]
RCT EHO surveys (3 villages)	95.7	257	1.25	0.59	249	5.05	0.56	160	8.38	1.81	237	row above compares all surveys to RCT surveys; row below compares RCT surveys to sensors		
RCT sensor data (3 villages)	90.2	82	0.83	1.03	82	3.80	4.26	82	4.67	0.95	628	<0.0001	2.30	−1.94:2.83[d]

[a]Survey: Ratio of households reporting treating their water with provided filter. Sensor: At least 6 L of water treated during installation period. [b]Surveys: Reported filling container size among standard sizes (excludes "other size" and does not apply outlier analysis). Exceeds input bucket volume, indicating that, on average, individuals are reporting filling the input bucket completely. Sensors: Consideration of all detected events across households combined. [c]Compares survey data from RCT to overall program. Indicates that reported daily water treated in RCT households is not significantly different from that in overall program. [d]Compares sensor recorded daily use to survey reported. Indicates that reported daily water volume treated is significantly higher than sensor-recorded volumes, on average by approximately 2.3 L.