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Citation Details

Thomas, E.A. (2013), 'Improving global impact: How the integration of remotely reporting sensors in water projects may demonstrate and enhance positive change', GWF Discussion Paper 1349, Global Water Forum, Canberra, Australia.

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Improving global impact: How the integration of remotely reporting sensors in water projects may demonstrate and enhance positive change

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Discussion Paper 1349

December 2013

This article argues that improved feedback on the actual impact of development programs may ensure the success of poverty reduction interventions such as water filters, water pumps, latrines, and cookstoves.

The Global Water Forum publishes discussion papers to share the insights and knowledge contained within our online articles. The articles are contributed by experts in the field and provide: original academic research; unique, informed insights and arguments; evaluations of water policies and projects; as well as concise overviews and explanations of complex topics. We encourage our readers to engage in discussion with our contributing authors through the GWF website.

Keywords: feedback, development, interventions, success, poverty, water pumps

Globally, water related interventions that integrate technological feedback mechanisms may help improve impact and enhance local,

regional, and global cooperation in addressing water related challenges.

Surveys and other common methods for assessing program performance are known to have shortcomings. Surveys often overestimate adoption rates due to reporting bias where the participant is trying to please the surveyor, or recall bias where the participant does not remember the information correctly. These effects have been demonstrated between observations and surveys of water storage, hand washing¹, and sanitation behavior². Additionally, it is known that the act of surveying can itself impact later behavior³. Structured observation, an alternative to relying on reported behavior in response to surveys, has also been shown to cause reactivity in the target population⁴.

Suggested Citation: Thomas, E.A. (2013), 'Improving global impact: How the integration of remotely reporting sensors in water projects may demonstrate and enhance positive change', GWF Discussion Paper 1349, Global Water Forum, Canberra, Australia. Available online at: <http://www.globalwaterforum.org/2013/12/01/improving-global-impact-how-the-integration-of-remotely-reporting-sensors-in-water-projects-may-demonstrate-and-enhance-positive-change/>

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Finally, the subjectivity of the outcome studied can highly influence reporting bias⁵.

Water programs may benefit from improved techniques that allow funders, implementers, governments and recipients to monitor and respond to the quality of these programs. Cellular reporting sensors may provide feedback on the sustainability of interventions in developing communities, improving on survey data and infrequent spot checks to assess performance. The rapid growth of cellular telephone and data coverage globally, the lowering cost of electronics, and the increased power and capabilities of the Internet cloud all converge to make electronic monitoring feasible in this context. We recently have measured water filter use with sensors against survey methods of measuring product usage, and have found much better resolution⁶.

The use of instrumentation to provide feedback on development programs is not entirely new, though it is still largely confined to research applications. Several other organizations are contributing to this push, including work conducted at the University of California at Berkeley and the associated Berkeley Air Monitoring Group on indoor air pollution instrumentation including a particle monitor⁷, a stove temperature data logger⁸, a hand-pump motion monitor with remote reporting developed at the University of

Oxford⁹, and a passive latrine use monitor for sanitation studies developed by the University of California at Berkeley and the London School of Hygiene and Tropical Medicine⁴. There are also organizations that are currently using cell-phone based surveys and internet based visualization for data collection and communication from the field (Akvo/Water for People FLOW, World Bank WSP, mWater, mWash). These platforms largely rely on person-based data collection.

We believe that water program implementers may soon recognize an economic incentive in using remote monitoring technologies. For example, remote monitoring of water pumps has the potential to reduce system downtime, reduce the number of visits to a village that currently is part of a traditional circuit-rider model for manually monitored pumps, and thereby reduce the cost per liter of water delivered. In real terms, this may save critical operations and maintenance dollars by reducing site visits, while improving data collection, increasing the quality of data, and improving overall project accountability to donors.

Recently, our team was awarded a grant from the GSM Association and the UK Department for International Development, in partnership with Living Water International (LWI), to deploy our sensors across nearly all of LWI's

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handpump installations in Rwanda, integrate the sensor data with smartphone based technician notification and repair records, and disseminate the information online and near-time to the program, beneficiaries, the government, and out to funders.

This CellPump Project is designed to demonstrate the use of sensors in global water programs on an operational scale, 200 water pumps in Rwanda, targeting a 50% reduction in water pump failure. The sensors add roughly 10% in overall program cost, while targeting an increase in cost effectiveness of nearly 27%. The sensors may be able to reduce, over a six year budget, the per person cost of water delivery from over \$150 to less than \$70.

The instrumentation used in this project was developed at Portland State University, and previously validated within a distribution of household water filters and clean cook stoves in Rwanda⁶. Design criteria for the sensor development included a low-power, low-cost, user-friendly hardware instrument to measure the performance and use of various development projects and relay this data directly to the internet for international dissemination. To meet the design criteria, key features were realized including distributed processing between hardware and the internet cloud, and remote automated recalibration and reconfiguration¹⁰.

To date, hundreds of these sensors have been deployed in over a dozen configurations in remote and harsh environments on four continents, providing a robust data set for extensive failure-mode analysis and product improvement across the hardware, firmware, and data management platforms. Each technology to be monitored is fitted with a unique sensor configuration using an identical hardware backbone and is separately validated in laboratory and field testing, with the resultant signal processing algorithm applied across all deployments of the same sensor type.

Improved feedback on the actual impact of development programs may ensure the success of poverty reduction interventions, like water filters, water pumps, latrines, and cookstoves. Rather than infrequent data collection, more continuous feedback may improve community partnerships through continuous engagement and improved responsiveness. We hope to enable greater cooperation in these programs by separating evidence from advocacy.

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References

1. Manun'Ebo, M., Cousens, S., Haggerty, P., Kalengaie, M., Ashworth, A., & Kirkwood, B. (1997). Measuring hygiene practices: a comparison of questionnaires with direct observations in rural Zaïre. *Tropical Medicine and International Health*, 2 (11), 1015-1021.
2. Stanton, B., Clemens, J., A. K., & Rahman, M. (1987). Twenty-four hour recall, knowledge-attitude-practice questionnaires, and direct observations of sanitary practices: a comparative study. *Bulletin of the World Health Organization*, 65 (2), 217-222.
3. Zwane, A., Zinman, J., Dusen, E., Pariente, W., Null, C., Miguel, E., et al. (2011). Being surveyed can change later behavior and related parameter estimates. *Proceedings of the National Academy of Sciences*, 108 (5), 1821-1826.
4. Clasen, T., Fabini, D., Boisson, S., Taneja, J., Song, J., Aichinger, E., et al. (2012). Making Sanitation Count: Developing and Testing a Device for Assessing Latrine Use in Low-Income Settings. *Environmental Science and Technology*, 46 (6), 3295-3303.
5. Wood, L., Egger, M., Glud, L., Schulz, K., Juni, P., Altman, D., et al. (2008). Empirical evidence of bias in treatment effect estimates in controlled trials with different interventions and outcomes: meta-epidemiological study. *BMJ*, 336:601.
6. Thomas, E., Barstow, C., Rosa, G., Majorin, F., Clasen, T. (2013). Use of Remotely Reporting Electronic Sensors for Assessing Use of Water Filters and Cookstoves in Rwanda. *Environmental Science and Technology* (accepted).
7. Chowdhury, Z., Edwards, R., Johnson, M., Shields, K., Allen, T., Zanuz, E., et al. (2007). An inexpensive light-scattering particle monitor: field validation. *Journal of Environmental Monitoring*, 9, 1099-1106.
8. Mercado, I. (2012). Temperature dataloggers as stove use monitors (SUMs): Field Methods and Signal Analysis. *Biomass and Bioenergy*.
9. Thomson, P., Hope, R., & Foster, T. (2012). GSM-enabled remote monitoring of rural handpumps: a proof of concept study. *Journal of Hydroinformatics*.
10. Thomas, E.; Zumr, Z.; Graf, J.; Wick, C.; McCellan J.; Iman, Z.; Barstow, C.; Spiller, K.; Fleming, M., Remotely Accessible Instrumented Monitoring of Global Development Programs: Technology Development and Validation. *Sustainability*, 2013, 5 (8); DOI 10.3390/su5083288.

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provide a means for discussion of important issues that receive less attention than they deserve. To reach these goals, the GWF seeks to: present fact and evidence-based insights; make the results of academic research freely available to those outside of academia; investigate a broad range of issues within water management; and, provide a more in-depth analysis than is commonly found in public media.

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