Research Brief

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Sustainable WASH Systems Learning Partnership

Maintenance Approaches to Improve the Sustainability of Rural Water Supplies

January 2020

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Introduction

The United Nations proclaimed 1981 to 1990 the International Drinking Water Supply and Sanitation Decade. One outcome was the widespread installation of water supply infrastructure, particularly hand pumps, to increase water access in rural communities of developing countries. Community-based management was widely adopted to promote participatory approaches that leverage local knowledge and decentralize responsibility to the community level. In the decades following, evidence showed poor planning and implementation strategies left nearly a third of hand pumps non-functional. Within the last 10 years, an emerging paradigm shift is transitioning the rural water sector from infrastructure delivery to a service delivery approach (Lockwood and Smits, 2011; Smits, 2014). Numerous studies have sought to understand the factors that most influence the sustainability of rural water supply services. This understanding has led to the development of maintenance approaches, both reactive and preventive, that seek to improve functionality rates and maintain reliable continuity of rural community water services. This document reviews literature about the factors influencing the sustainability of rural water services, and the emerging maintenance approaches seeking to address these factors and improve service reliability.

Factors Influencing the Sustainability of Rural Water Service Delivery

A variety of interacting factors make the delivery of sustainable rural water services a complex challenge. Studies have applied various sustainability assessments to identify and evaluate these factors (Borja-Vega et al., 2017; Cronk and Bartram, 2017; Foster, 2013; Giné and Pérez-Foguet, 2008; Kativhu et al., 2017; Kwangware et al., 2014; Lockwood et al., 2003; Madrigal et al., 2011; Martin et al., 2017). Though it is difficult to draw cross-study conclusions given differences in study methodology and geographical and cultural contexts, there are recognized, common factors that influence the sustainability of rural water service delivery:

- Capacity, accountability, and willingness of governments to provide and finance post-construction support
- Capacity and accountability of community-based management by community water committees — particularly the ability to enforce tariff collection
- Willingness and ability of water users to pay tariffs
- Availability of reliable maintenance resources, including spare parts and mechanics

Government Capacity for Post-Construction Support

Communities typically depend on government intervention to maintain and rehabilitate installed infrastructure, especially when alternative maintenance services are unavailable. However, a variety of sub-factors affect a government's ability to provide post-construction support:

- **Monitoring**: The information governments have to prioritize and conduct repairs is reliant on the availability of adequate data on the status of water point functionality and monitoring capacity (Jiménez and Pérez-Foguet, 2010).
- **Technical capacity**: The availability of government-backed technically skilled personnel is essential to oversee and provide maintenance support (RWSN, 2015).
- **Policy and regulatory oversight**: To establish an environment where well-maintained water points are the expectation of the government, and political conflicts of interest do not lead to an imbalance in the allocation of resources and support among communities, appropriate policies and regulation are needed (Jiménez and Pérez-Foguet, 2010; RWSN, 2015).
- **Government-led incentive programs**: When linked to monitoring data, government-led incentive programs that reward operators with small cash grants for reliable performance have resulted in reliable service delivery (The World Bank, 2017).

Capacity of Community Water Committees

Over the past 30 years, the community-based management model sought to empower communities to own the operation and maintenance of their water points. The goal was to leverage the expertise of local mechanics for more frequent repairs and avoid the delays of government-initiated maintenance services. By engaging communities in the planning and development of projects, the expectation was they would have more incentive to keep their water points operating in good condition, and the consistent supply would encourage regular user payments supporting continued functionality and improvements in service. However, while studies found community involvement in planning and management-related decision-making contributes to positive sustainability outcomes, taking on more complex technical roles does not (Marks et al., 2014). Limited technical capacity among communities necessitates external support and professionalization of technical tasks (Chowns, 2015; Marks et al., 2014). Furthermore, water committees are often unable to collect enough funds to pay for maintenance and repairs fully. Cited reasons include a lack of trust in water committees due to misuse of money, and a lack of payment enforcement by committees (Chowns, 2015; van den Broek and Brown, 2015). However, the inability to cover costs raises a broader question regarding the different levels of subsidies required to ensure sustained services.

Water User Payments

There are several factors found to influence payments by water users. Reliable and fast maintenance and repair services are necessary to secure regular user payments. But payments are subject to demand, and the availability of alternative nearby water sources reduces incentives for payment (Koehler et al., 2015). Seasonality also affects user payments, as rains provide alternative water sources (Foster and Hope, 2016). Water quality can also impact user payments, not only due to perceived aesthetic quality but also when water characteristics such as pH or salinity contribute to the corrosion of water points, ultimately leading to the more frequent need for repairs (Ibid.). The productive use of water, such as raising livestock or small-scale irrigation, can improve the likelihood of user payments as water access contributes to income generation (Ibid.). Pay-as-you-fetch (PAYF) approaches, where users make payments upon collection on a per volume (e.g., 20 L jerrycan) basis, generate more income per volume than flat fees collected periodically (e.g., per week or month) (Foster and Hope, 2017). Periodic flat fee collection can also be difficult when households live far away from water points. However, higher PAYF rates may exclude households who choose free alternative sources that are potentially unimproved (Ibid.). Mobile money may be a way to reduce payment barriers related to household distance. Evidence shows mobile water payments are not exclusive to wealthier users, allow for both cost and time savings when compared to traditional payments through banks, and improve timeliness of water payments among users, making mobile money particularly valuable in regions where banking services are distant and expensive (Foster et al., 2012; Hope et al., 2011). There is also some evidence of water payments being made through the informal economy, where users make non-monetary payments with time and labor or non-cash goods such as rice, corn, or chickens (Behnke et al., 2017). However, the viability of non-monetary payments for professionalized maintenance approaches is not well understood.

Maintenance Provision

Studies have investigated the factors necessary to provide reliable maintenance services for rural water systems. Access to spare parts is essential for maintenance, but a lack of consistent spare parts supply has left communities with few options when a breakdown occurs (Baumann and Danert, 2008; Chowns, 2015; Harvey and Reed, 2006; van Beers, 2001). Although studies have identified a community's inability to pay for parts as a barrier to maintenance services, there is also evidence that markets exist for high-quality professional maintenance services, without which communities are left with the task of recognizing and diagnosing hardware problems (Kleemeier and Narkevic, 2010; Klug et al., 2018). Furthermore, while regulatory support is necessary for successful private sector maintenance provision, it need not be a prerequisite for successful pilot endeavors (Kleemeier and Narkevic, 2010). Professionalized maintenance services may alleviate the responsibility placed on communities from the community-based management model and improve the reliability of water services. Performance-based contracts have been proposed as a mechanism to shift incentives, where mechanics are no longer paid by the number of breakdowns repaired, but by the uptime of reliably functioning water points (Harvey, 2017; Katuva et al., 2016). Sensor technology may help expedite the repair and maintenance process by monitoring water point usage and functionality rates, triggering faster response, and objectively quantifying downtime as a performance metric (Nagel et al., 2015; Thomson and Koehler, 2016).

Maintenance Approaches

Knowledge of the factors and sub-factors affecting sustainable water service delivery (e.g., monitoring, technical capacity, regulatory oversight, incentives, fee collection, and spare parts availability) has led to the design of innovative maintenance approaches that seek to reduce water point failures while changing the system[1] they operate within. Approaches to maintenance provision are different across contexts but are aligned in their goal to improve and sustain service levels and water point functionality rates. Their typologies vary based on the use of corrective, proactive, or guaranteed service approaches (Lockwood, 2019), yet subsidized service delivery is a common element. Some of the emerging approaches are described here. In addition, a complementary report to this brief details a comparative study of these and other maintenance approaches. Conducted by Lockwood (2019), the study was commissioned by IRC Ethiopia and financed through the United States Agency for International Development (USAID) Sustainable WASH Systems Learning Partnership (SWS).

FundiFix

The FundiFix (Katuva et al., 2016; REACH, 2016) model is focused on maintaining existing rural water infrastructure in Kenya through a guaranteed-service approach based on insurance logic, where communities and schools pay a portion of the direct operating costs and scale reduces risk. Local Maintenance Service Providers (MSPs) have initially been established in rural areas of two counties, Kwale and Kitui, as independent social enterprises: Kwale Handpump Services Ltd. and Miambani Ltd., respectively. Each MSP, comprised of trusted local technicians and entrepreneurs provided with tools, training, equipment, and office space, sets up annual performance-based contracts with community water user committees and schools. As of June 2019, approximately 75,000 people are served through maintenance services for 112 hand pumps and 24 piped schemes. Communities sign up for annual contracts for each water point and make monthly payments by mobile phone transfers. Contracts require maintenance work to be completed within 3 days for hand pumps and 5 days for piped schemes, or communities receive the next month's service for free. The respective local or county governments are parties to the agreements with the responsibility for asset replacement and major repairs. In the case of piped schemes, the local government agrees to be responsible for major rehabilitation and

[1] The **system** is defined as being comprised of actors (consumers, public institutions, private sector, civil society, etc.) and factors (financial, institutional, social, and regulatory factors, asset management, service delivery models, etc.) and the dynamic interrelationships among them, all of which influence rural water service delivery.

infrastructure extensions and replacement. When equipment must be procured through the government, additional time is granted for repairs. In addition to communication with water committees, smart monitoring data from hand pump sensors are also used to inform the MSP of system conditions, and any repair needs that may arise. User payments are insufficient to fully cover the cost of maintenance service provision in the FundiFix model, so a Water Service Maintenance Trust Fund also supplements funding for MSPs. The Trust Fund currently receives money from private donors with the long-term goal of leveraging county government public financing to subsidize universal maintenance service delivery. Performance metrics from smart monitoring sensors are sent to the board of trustees who share the information with donors, enabling results-based funding.

Safe Water Network

The Safe Water Network model, currently employed in Ghana and India, uses a market-based approach to deliver safe water to communities. Safe Water Network identifies a local water source, tests for contaminants, and provides the capital expenditure for the construction of treatment systems, known as Safe Water Stations (Safe Water Network, 2019a, 2019b). Local community members are hired and trained on the operation and maintenance of the stations, as well as bookkeeping and reporting practices. These local employees are responsible for the stations' day-to-day operation and functionality. Water is sold to community members through two avenues: water ATMs where users pay at the collection point, and through delivery to households or third-party retailers. User fees are set high enough to cover the full operating and routine maintenance costs. Unit costs are higher than alternative models but pay for higher water quality as well. Educational programs and marketing campaigns are used to establish and grow the consumer base. Centralized technical support is provided by locally trained and hired engineers, geographically proximate to clusters of Safe Water Stations. This technical support includes direct assistance, training services, and comprehensive manuals, toolkits, and marketing messaging. Remote monitoring provides 24/7 data collection via satellite to operators who can proactively maintain systems before larger issues arise. Water quality protocols for field testing ensure Safe Water Stations meet World Health Organization drinking water standards. There is also a focus on supply chain strengthening through collaborative efforts with local government, water suppliers, technicians, marketers, and entrepreneurs. Key performance indicators include:

- Coverage of operating and maintenance costs by the generated revenue from user fees,
- Accumulation of financial reserves for future maintenance,
- Less than 5 percent downtime,
- Household participation of 75 percent, and
- Meet or exceed national drinking water standards.

Vergnet Hydro – UDUMA Project

Vergnet Hydro is a French pump manufacturer focused on serving rural communities. Over the years, the company has tried various approaches to providing maintenance service, including using revenue generated from piped schemes to fund the maintenance of hand pumps, and providing warranties where communities paid an annual fee to receive maintenance and repair services (Kleemeier, 2010). However, the inability to secure consistent payments from water committees undermined the viability of these approaches. Recently, the company established the UDUMA Mali Project (Barbotte and van der Wilk, 2017). In this model, UDUMA has been contracted by the local government to rehabilitate, operate, and maintain 1,400 pumps for 15 years, with a maximum downtime of 72 hours per incident. UDUMA operates under concession and affermage contracts, where the government is responsible for the capital investment (Deal and Furey, 2019; Lockwood, 2019), while Vergnet Hydro is financing 40 percent of the project, including rehabilitation, operation, and maintenance (Barbotte and van der Wilk, 2017). Water tariffs are set in accordance with local authorities, and pump caretakers and local mechanics are hired and paid a percentage of the sales revenue (UDUMA, 2019). An electronic, cashless payment system is used, and payments are based on the volume of water collected.

Water for Good

Water for Good focuses on ending water poverty in the Central African Republic (CAR) by 2030 (Water for Good, 2017). To increase water point density, the organization drills wells and installs protective cement slabs and hand pumps. So far, 650 new wells were drilled, over 900 rehabilitated, and maintenance was provided to 1,400 hand pumps serving 500,000 to 600,000 people across the country. Rehabilitation and maintenance work is performed by local Water for Good water service technicians, while drilling is done through contracts with a locally owned, well-drilling business. Water for Good financially supports all aspects of this model, from installation to maintenance. The organization's maintenance approach follows a proactive supply-driven circuit rider model (Lockwood, 2019). This involves four maintenance teams consisting of two technicians driving in trucks along an assigned, pre-determined route, along which they maintain about 300 wells. On average, each water point is visited twice per year. In late 2017, Water for Good added two motorcycle-based teams to supplement truck-based circuit rider teams and cover areas with higher water point density with a blend of preventive and responsive repair in the cities of Berberati and Bangui. Each water point has an ID tag, and technicians complete iPad-based reports using iFormBuilder, launched in 2011. The electronic reporting provides verification of well location via time-stamped GPS data and photo verification. Maintenance reports detail the pump status, well age, the total number of maintenance visits, parts used, estimated water usage per person, and time needed to access water. Technicians also record self-reported data on community population statistics and the number of water users for each pump. Water for Good uses radio programming to provide messaging on water and hygiene habits. They are currently providing maintenance services in 9 of 16 prefectures in CAR, at an annual cost of $450,000 (2018) (Lockwood, 2019). The majority of Water for Good funding comes through grants and contributions, with 1 to 2 percent coming from program service revenue.

Whave

Whave's model for rural water service delivery comprises public-private partnerships developed through workshops and meetings with local governments in Uganda (Harvey, 2017; Harvey et al., 2015). Established in 2011, Whave is a Ugandan social enterprise with two roles: (1) an advisory body, advocating for systems that address the prevalence of inadequate rural water service delivery, and (2) a prototype rural water utility. In the first role, Whave advocates for practical regulatory structures and development of local governance capacity in setting maintenance tariffs, performance-contracting maintenance providers, and coordinating investors to follow maintenance protocols, including the promotion of Build-Operate-Transfer arrangements (Lockwood, 2019). In the second role, Whave operates as a guaranteed service provider. As such, Whave contracts technicians who are members of local hand pump mechanics associations, with performance-based payments to follow preventive maintenance schedules, utilize quality-controlled stocks of materials, and undertake responsive repairs. It signs preventive maintenance agreements with community water committees and assures the functionality of water supply in exchange for monthly payments. Whave works with local government to develop a range of options for water user maintenance payments based on local conditions. Some of these arrangements include users paying by subscription, irrespective of volume consumed, and pay-for-volume hybrid options that combine subscription and volume-based payments (Harvey, 2019). Whave currently provides services to over 400 hand pumps serving 150,000 people in six districts across Uganda and has an overall strategy of transitioning from hand pump supply to rural piped water.

Concluding Remarks

The studies identifying sustainability factors for rural water supply have created a breadth of knowledge now being applied by organizations to test different maintenance approaches. There is a recognition that focusing solely on reactive repairs and infrastructure expansion is insufficient and unsustainable. This understanding has led to comprehensive maintenance models that build local capacity, foster consistent user payments through quality service, use monitoring to inform proactive maintenance, and reward continual functionality to incentivize maintenance. Though these approaches are still nascent, they have demonstrated the potential to improve the sustainability of rural water supply; however, their long-term success is dependent on the support of local governing bodies and appropriate policies recognizing the role of maintenance provision in water service sustainability. Although these approaches are still largely subsidized (McNicholl et al., 2019), they are piloting possible solutions to some of the problems seen with community-based management. Achieving universal sustainably managed water access is a complex challenge requiring a holistic systems perspective of the several interacting factors that influence reliable service delivery. As water service models continue to develop, not only recognizing, but effectively managing these interacting factors will be imperative.

Acknowledgments

This research brief was prepared by Pranav Chintalapati, with valuable contributions from SWS colleagues Harold Lockwood of AguaConsult, Karl Linden of University of Colorado Boulder, Cliff Nyaga of FundiFix, Adam Harvey of Whave, and Adrienne Lane of Water for Good. Additional thanks to Elizabeth Jordan and Ella Lazarte of USAID for review and feedback. An annex containing summaries of the literature referenced in this brief is available upon request.

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About the Sustainable WASH Systems Learning Partnership:

The Sustainable WASH Systems Learning Partnership is a global United States Agency for International Development (USAID) cooperative agreement to identify locally-driven solutions to the challenge of developing robust local systems capable of sustaining water, sanitation, and hygiene (WASH) service delivery.

This report is made possible by the generous support of the American people through USAID under the terms of the Cooperative Agreement AID-OAA-A-16-00075. The contents are the responsibility of the Sustainable WASH Systems Learning Partnership and do not necessarily reflect the views of USAID or the United States Government.

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