WATER PROGRAMME

SMITH SCHOOL OF ENTERPRISE AND THE ENVIRONMENT

UNIVERSITY OF OXFORD

Financial Sustainability for Universal Rural Water Services - Evidence from Kyuso, Kenya

August 2015

RURAL FOCUS LTD.

Engineering and Development Consultants

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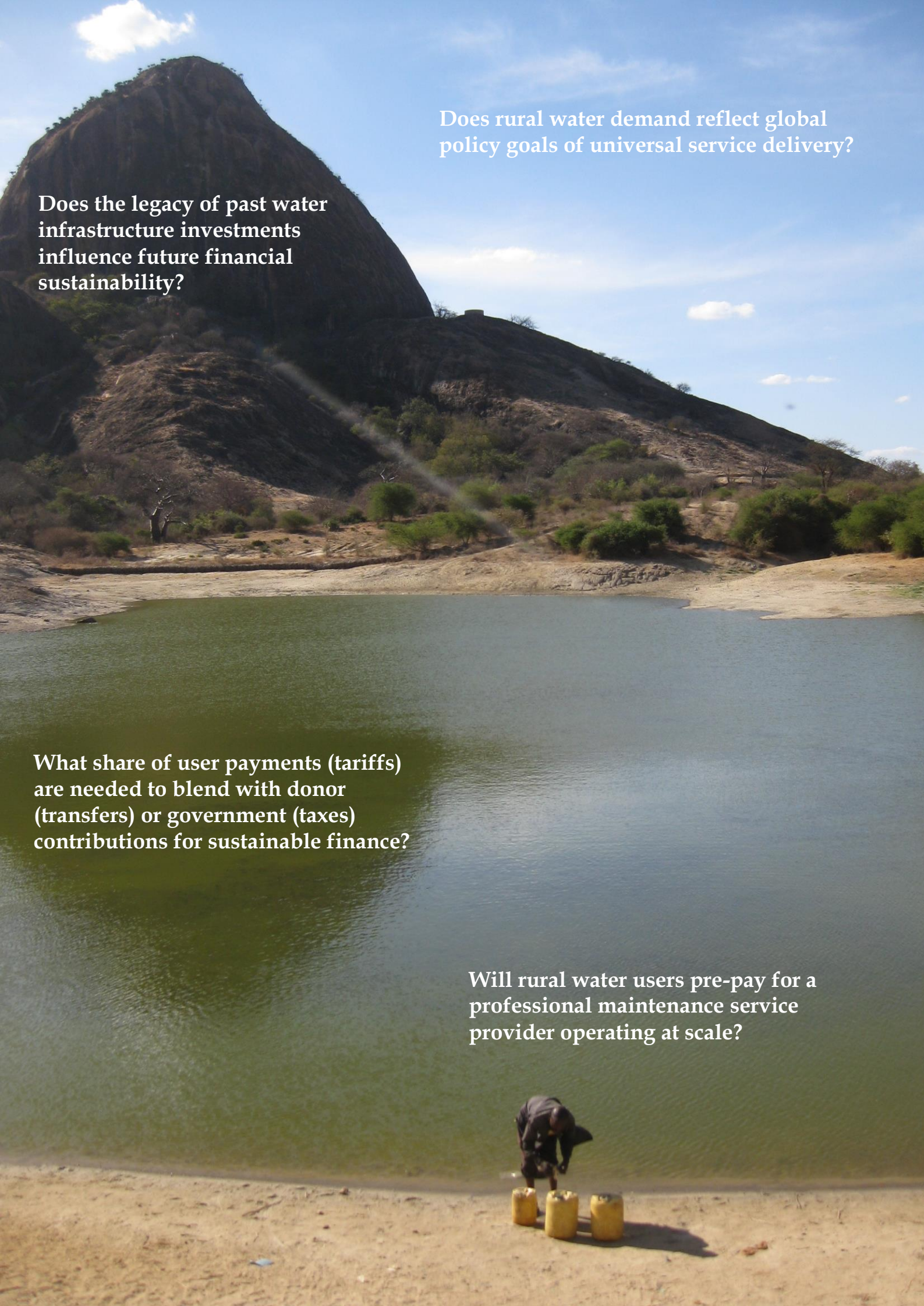
Does rural water demand reflect global policy goals of universal service delivery?
Does the legacy of past water infrastructure investments influence future financial sustainability?
What share of user payments (tariffs) are needed to blend with donor (transfers) or government (taxes) contributions for sustainable finance?
Will rural water users pre-pay for a professional maintenance service provider operating at scale?

Rainfall patterns shift rural water demand from improved (dry season) to unimproved (wet season) sources requiring new policy thinking.

Unit costs of water delivery are 2-4 times lower for handpumps with high reliability but uncertain water quality compared to kiosks.

Handpumps supply more water than any other source but with an order of magnitude less revenue than a piped water scheme.

Donor funds (transfers) to the FundiFix, handpump maintenance service is 14% of government (taxes) contributions to a piped water scheme providing less water. Rural water users pay (tariffs) around one third of local operational costs.

One third of rural handpumps join the FundiFix, pre-payment maintenance service with 89% revenue collection.

Poor well construction, saline groundwater or competing supplies explain community decisions not to join the FundiFix service.

Smith School Water Programme

The Smith School Water Programme aims to understand and address water-related risks to economic growth, human development and environmental management. A problem-based and interdisciplinary approach focuses on designing, testing and implementing new tools, technologies and models. Current projects are making science, policy and practice advances in the areas of urban utility finance, rural water institutions, groundwater risk management, smart river management, and mobile-enabled water technologies. Two themes guide the programme: (1) Water Security, Growth and Development and (2) Smart Water Systems.

The Water Programme works in partnership with the School of Geography and the Environment, Department of Engineering Science, Skoll Centre for Social Entrepreneurship and the wider Oxford Water Network with over 100 faculty and researchers working globally on water science and policy challenges across climate systems, economics, ecosystems, energy, engineering, food systems, hydrology, law, politics, policy and public health.

The programme is currently funded with over £17 million of competitive grants won from UK research councils (ESRC, NERC), DFID, UNICEF, John Fell Fund and the Skoll Centre for Social Entrepreneurship. Past donors include OECD, World Bank and the Gates Foundation. Enterprise partners in the programme include global leaders in the extractives industry, beverages/food sector, insurance, mobile network operators, and wireless technology and semi-conductor industries.

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Executive Summary

Financial sustainability is a necessary but often forgotten condition to advance global goals of universal, reliable, safe and affordable water service delivery. This working paper presents initial results from the second phase of the 'smart handpumps' pilot in Kyuso, Kenya, with the aim to design and test a mobile-enabled, pre-payment model. The FundiFix model is described and contextualised in a study area where handpumps supply water alongside often competing water kiosks provided by government or donors under differing management models. Key findings reveal:

- **Financial analysis** indicates the local unit cost of handpump operation and maintenance is two to four times less than water supplied from kiosks despite higher availability throughout the year. Rural water tariffs are around one third of costs (handpumps, kiosks) with government support (here 'taxes') higher for kiosks than the donor 'transfer' to launch the FundiFix model.
- **Institutional analysis** reveals no coordinated management of water infrastructure. A legacy of government, donor and NGO investments in water infrastructure have failed to build local institutions at the right scale and with limited accountability to maintain and monitor services over time.
- **Rural water demand** is influenced by rainfall events which shifts water use from improved water infrastructure (kiosks, handpumps) in the dry season to unimproved sources in the wet season. Pipeline kiosks generate 10 times the revenue of the FundiFix handpump maintenance service (n=22) but supply less water than the total handpump portfolio (n=66).

Recommendations identify pathways to universal rural water services by specifying a range of interconnecting conditions for: (a) institutional coordination and investment, and (b) improved monitoring systems.

Table of Contents

1. Finance Forgotten?

In 2014 we presented evidence in the 'Rights to Results' report of how mobile-enabled monitoring of rural handpumps could support dramatic improvements in water service reliability in Kyuso, Kenya. An order of magnitude improvement (27 days to less than 3 days) represented progress in the operational corner of the '*operational-financial-institutional*' triangle that we argue is a necessary condition for sustainably delivering universal drinking water supplies. Exploratory work on financial sustainability concluded that user payments are contingent on service delivery based on communities' experience of the one-year, free trial of the professional maintenance service model. This report advances work on financial sustainability by testing a mobile pre-payment system with a registered private operator (FundiFix Ltd.), which takes up the communities' stated preferences for an external, performance-based service.

Financial sustainability is a necessary but often forgotten condition for sustainable water services. The OECD has promoted a '3T' model recognising the three dominant flows of finance to the sector: (1) Tariffs (user payments), (2) Taxes (government subsidies), and (3) Transfers (donor support). Global evidence indicates that water services in even the wealthiest, industrialised economies often depend on some government subsidy; developing countries have a much lower share of tariffs and therefore depend on a blend of taxes or transfers varying by political, economic or social conditions. Where users pay nothing, by default or design, water users are hostage to changing donor priorities or shifting politics. While low and variable income groups are least able to pay unaffordable tariffs, the reality is they often pay significantly more when they are not included in a regulated and inclusive water service sector.

There is an urgent need for novel and replicable financial models that work for the poor and excluded. In rural Africa, the situation is most acute despite positive global water access trends meeting 'improved drinking water access' targets with significant growth in rural Africa from 34 per cent to 56 per cent between 1990 and 2015. However, Africa represents the slowest progress and lowest increase in access globally with a rural person four times more likely to have unimproved water than an urban resident. With piped water inching up from 4 per cent to 5 per cent in rural Africa in the same period, handpumps will remain a critical infrastructure in the short term with the rural population expected to double to just under one billion by 2050.

Institutions also matter. Information is essential to improve institutional design and performance. We proposed a 'closed loop' model in the 'Rights to Results' report and here we focus on the local operational scale conducting a water audit of other water supplies available in the study area. Alternative water supplies are known to be a key determinant of user demand and payment. Earlier we found the geographic density of handpumps unsurprisingly influencing payment levels; many and closely located pumps significantly reduce payment behaviour compared to single or twinned handpumps. We explore in more depth how the legacy of water infrastructure investments can influence the future sustainability of rural water services by considering a range of other water supplies from kiosks supplied by surface or groundwater, which are managed under differing modalities with differing outcomes.

2. The FundiFix Model

2.1 Model rationale

The 'FundiFix Model' pays homage to local and skilled mechanics ('fundis' in Swahili) and focuses on performance metrics, which means in this context repairing handpump failures fast. Exploiting Africa's expanding mobile network architecture it is powered by information flows from 'smart handpumps' and financial flows using a robust mobile payment system supported by the open access platforms of M-PESA and Frontline SMS.

A defining feature and potential limitation of the model is it is a 'Maintenance Service Provider' (MSP) not a 'Water Service Provider' (WSP). Five considerations inform this approach:

- MSPs repair infrastructure within agreed conditions and are not responsible for poor installation or changing environmental conditions, in the short term. The latter reflect the historical legacy of faulty or incompetent installations (e.g. drilling, lining, depth or manual digging) or variable water quality from natural (e.g. salinity, fluoride, heavy metals) or societal pollution (e.g. human or animal excreta). MSPs would operate at a defined but supra-communal scale promoting sustainability and accountability.
- WSPs in many countries would be liable for asset management and safe water quality provision, which would either lead to 'cherry-picking' systems (e.g. non-inclusive, likely to exclude the poor and vulnerable) or place an unreasonable burden of risk on the local private sector for the past mistakes of government, donors or communities. MSPs can monitor water quality metrics but in cases of health risks the burden for action would be with mandated government agencies.
- MSPs can expand beyond handpumps to other waterpoint infrastructure such as surface piped systems, submersible pumps or kiosks. Economies of scale would promote financial sustainability and inclusive water services. However, the need for additional financial flows from taxes or transfers would ensure accountability and performance bringing MSPs into a transparent regulatory domain flexible to differing country norms and standards.
- Communities are able to voluntarily join or leave a MSP contract based on agreed performance criteria. User tariffs (community, school, clinics) would be a necessary condition to lever performance-based financial flows from taxes or transfers. The blend of the 3Ts would inevitably vary.
- Water regulators, government and donors can monitor and evaluate performance based on the transparent flow of information, both operational and financial, improving sector accountability and progress.

2.2 FundiFix Ltd., Kyuso

In Kyuso, FundiFix Ltd. has been legally registered as a Maintenance Service Provider for handpumps and other infrastructure. The model is based on four key building blocks:

1. **Remote automated monitoring** occurs through transmitters fitted to pump handles that monitor movement (usage and functionality) and send data to a central server via SMS. The status of handpumps in the system can be remotely monitored via internet. This is essential for validation of repairs and information sharing in remote rural areas, keeping the service accountable to government, donors and other stakeholders.
2. Providing a **professional service** is linked to performance-based contracts. If a repair takes longer than three days, communities receive a free month of service, so building in penalties for poor performance (see below).

3. In the model, regular **prepaid user contributions** are made through M-PESA, and registered users (up to ten community and committee members) are sent notifications of payment and reminders via SMS. This provides a mechanism for financial flows from rural water users to the maintenance service provider, one element of **sustainable finance** (tariffs).
4. **Unit of analysis**. Each handpump is managed differently related to group size, water demand, access rules, alternative water sources and other factors. The decision was made to collect a 'community payment' rather than individual payments as the latter would have increased the complexity and transaction costs of the service.

2.3 How the model works

The model operates in a sequenced and structured programme over a period of one to two years:

- **Community trust**
  A free trial of the MSP builds trust before a contract is signed. In Kyuso, it was found that the establishment of a physical office with local staff was well-received by communities and government.
- **Affordable tariff**
  Observed handpump usage data allow variable tariffs to be designed with provision for regular, low or special cases. Most communities fall in the former; low users are monitored with a reduced tariff; and 'special' cases, including schools, clinics or other facilities, may use handpumps and should be monitored as a minimum with a reduced rate. The latter provide a basis for government support through 'taxes'.
- **Payment feedback**
  A feedback loop of payment and performance is essential, here using the open-source M-PESA and FrontlineSMS platforms. Up to ten community members split between water committee members and non-members are registered on FrontlineSMS to receive monthly messages on payment and performance data, plus paper receipts for transparency to build community confidence.
- **Performance monitoring**
  FundiFix is responsible for fixing any 'normal' repair in three days. A range of performance metrics are reported in the 'Rights to Results' report, including unit cost of water produced (USD/m^3, precentage downtime, operational efficiency etc.).

Box 1: The Contract

The maintenance service covers **"Normal repair services"**, only covering normal wear and tear, up to an annual maximum value and excluding theft, vandalism and dry wells.

A **"Notice Period"** of several months is included, meaning that if a monthly payment is missed, communities will still be covered by the service for a period of time. This flexibility allows for the seasonal nature of cashflows in rural areas, for example advance payments can be made when money is available.

"Normal repair duration" specifies the maximum time between a fault being reported and the repair being carried out, in this case three days. The service provider faces a penalty if this is exceeded.

Community responsibilities include:

- Reporting all faults to FundiFix immediately
- Providing basic manual labour during repairs
- Providing drainage and security for the pump
- Making regular payments using M-PESA

FundiFix responsibilities include:

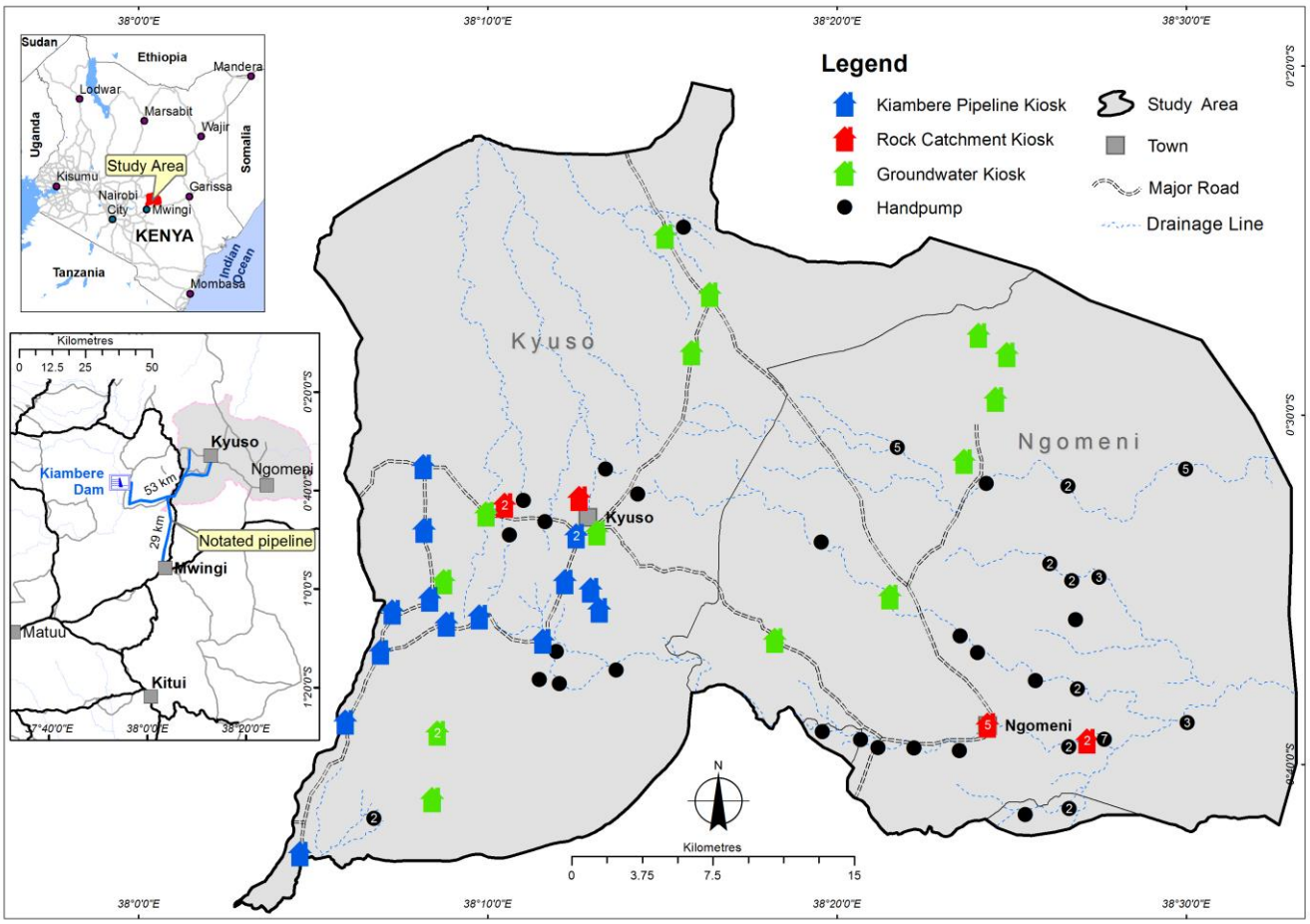
- Providing Normal Repair Services with the Normal Repair Duration
- Giving one month of service free of charge if the Repair Duration exceeds three days
- Keep a log of repairs
- Log and notify the registered users of payments

3. Study site and Methodology

3.1. Study Site

Kyuso Sub-County is situated in the north of Kitui County and 267km north-east of Nairobi (38° 10′ E, 0° 35′ S; 660-880m elevation; 2,446 km²) with a population of 50,766. The population is almost entirely rural (99%) with two out of three households classified as 'poor'. Average rainfall in the period 1961 to 2006 is 774 mm with increasing variation in decadal rainfall patterns during both the long rains (mean = 250 mm; March-May) and short rains (mean = 426 mm; October-December). Temperatures range from 14° to 34° with February and September marking increasingly severe and extended dry periods. Livelihood systems are largely agro-pastoral with cattle and goat husbandry combined with low-value, rain-fed agriculture (maize, beans) on small plots (<1 hectare). Households rely on casual labour and remittances for most of their cash income. Over half of the 512 water points (54%) are unimproved (streams, unprotected shallow wells, earth dams)[1] and most are seasonal. In the dry season (July-September and February) people rely heavily on year-round sources such as the Kiambere pipeline, deep boreholes and many handpumps making the functionality and reliability of these sources critical for water supply.

Figure 1. Study location by water sources (April, 2015)



[1] *Rural Water Point Atlas Kyuso District* (2011). Tanathi Water Services Board.

3.2. Methodology

3.2.1 Sampling Frame

As illustrated in Figure 1 a total of 66 handpumps are distributed unevenly across the study area. All voluntarily joined the free maintenance trial in 2013 and were invited to participate in the transition to a pre-paid system from January 2015. Given knowledge of a variety of other 'improved' water sources (kiosks and small pipe systems) in the area a water audit of this infrastructure was conducted between April-May 2015 by local enumerators in the local language (Kamba) following training and piloting. No attempt was made to audit 'unimproved' water sources such as rivers, ponds or household dug wells, though it is known these are used by local residents.

A sample of water users at each kiosk was interviewed along with a process of snowball interviewing. Key individuals or institutions that emerged in the audit were requested to complete a simple survey following ethical procedures approved by Oxford University Central University Research Ethics Committee and a research permit approved by the Government of Kenya's National Council for Science and Technology.

3.2.2 Operational data

Consistent with the earlier 'Rights to Results' report, standard operational data were recorded on call-in date of repair, repair date, service visits, spare parts used, transport costs, labour costs and information costs. These data were entered on a simple excel spreadsheet.

Transmitters are installed on subscribing handpumps where network coverage exists and monitored on the earlier reported graphical user interface. Changes in usage are monitored with the right for FundiFix to change the tariff band up or down based on higher or lower usage.

3.2.3 Financial data

Ethical considerations led to the careful design of the collection, storage and management of community payments. All payments were first acknowledged by the FrontlineSMS system and paper receipts were made available at the local office. In some cases communities chose to pay via a local M-PESA agent, which required the FundiFix team to confirm directly with the community and triangulate via the agent. Additional training and support is helping these communities pay directly to avoid potential confusion and simplify the procedure.

On receipt of the payments funds are held in the M-PESA account. All project expenditure is audited by RFL Ltd. and checked by Oxford University.

FrontlineSMS is used for sending reminders and receipts. Financial data is also collected and analysed, with a careful distinction between local costs associated with running the service and research costs associated with the research project. In this working paper, data is analysed for the first six months of operation (February to July 2015).

3.2.4 Water Audit

In April 2015 a water audit was carried out working in collaboration with the Kyuso Sub-County Water Ministry to assess water services from small piped systems in the area, including a) Kiambere Pipeline kiosks, b) kiosks supplied by submersible groundwater pumps, and c) rock catchment kiosks.

Forty-three kiosks were identified and data collected on operational, financial and institutional elements from primary water users and management authorities by means of:

1. A survey of 93 people on water use behaviour, who were willing to be interviewed from 24 different kiosks;
2. Institutional and operational data elicited from semi-structured interviews with kiosk attendants, management committees and key informants (n=29);
3. Financial and operational data of volumetric and financial records from kiosk attendants, management committees and water service providers.

The audit identified 18 piped systems (one large, 17 small) supplying 43 kiosks in the study area. The kiosks were classified as (1) functional, (2) functional but not in use (where infrastructure is sound, but no water available; or out of use for the wet season) or (3) non-functional (where the kiosk was not able to deliver water because of breakdown in any part of the system), based on observation and discussion with the attendant if present or local community members.

Two local enumerators interviewed 2-5 users for each functional kiosk, and nearby residents who confirmed they were users of non-functional or not-in-use kiosks, selected at random. Only adults were asked to participate in the survey, and willingness to participate was determined after explanation of the survey and an assurance of confidentiality of all information given.

Interviewees confirmed their willingness to participate orally and were assured of confidential and voluntary nature of the study. In total 17 kiosk attendants, 10 committee members, 2 Kiambere Mwingi Water and Sanitation Company (KIMWASCO) staff (Kiosks Supervisor and the Managing Director) and the Sub-County Water Officer were interviewed. Interview notes were typed up, checked for accuracy by both interviewers and coded for relevant themes using NVivo 10 software.

3.3 Study Limitations

We are aware of a number of limitations that may restrict the findings of the study and their wider applicability, including:

- Financial and volumetric data for kiosks were not always available or not recorded, particularly groundwater kiosks;
- Volumetric data were also limited by the absence or non-functioning of water meters;
- Environmental and technical data on installation of infrastructure by government, local NGOs or donors were not available;
- Water quality testing at kiosks was not conducted to triangulate the user perceptions reported;
- Handpump usage and operational data are only available for 2013 due to the end of one study period (DFID) and a seven-month gap before new funding was secured (UNICEF). Transmitters were only installed after communities joined the scheme;
- The Water Audit was designed with the support of the local government, mechanics and communities but with no central records of waterpoint installation it may not be complete;
- The Oxford/RFL team have been working continuously in Kyuso since 2012 and the significant improvements in operational performance for handpumps may upwardly bias findings for community sign-up and revenue efficiency.

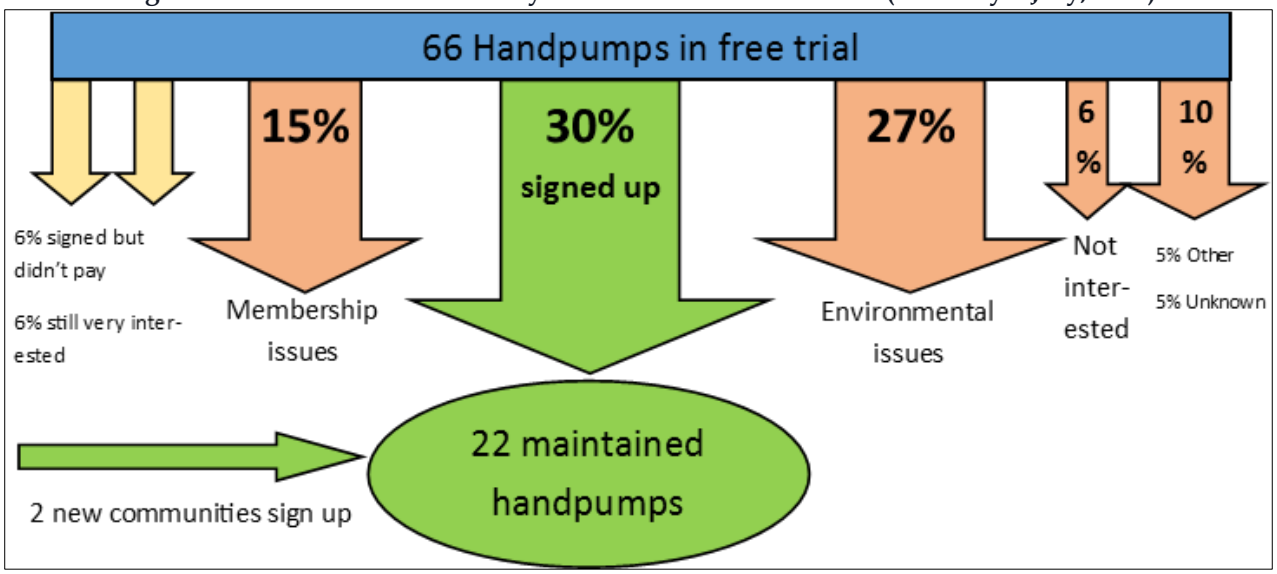
4. Results of FundiFix Launch

4.1 Community enrolment

Baseline analysis evaluated if the communities were likely to enrol for the FundiFix service via multiple focus group rounds of all communities and a sample of water user preferences was modelled against competing alternatives of payment mode, frequency and amount. According to the focus groups the majority (89%) would commit to a pre-payment maintenance service after the pilot, and the baseline survey found no payment modality (mobile, pay-as-you-go, regular) as satisfactory despite strong demand for an external maintenance service provider.

Launch results from the first six months fall between the interview optimism and the modelling pessimism. Just under one in three (30%) of communities have registered and are paying regular monthly payments with 89 per cent revenue efficiency. This period corresponds with the period before the dry season (June-October) when enrolment may increase though this should be tempered with environmental issues discussed below. Affordability of the proposed tariff system was not a major constraint.

Figure 2. Evaluation of community enrolment in FundiFix Ltd. (February – July, 2015)



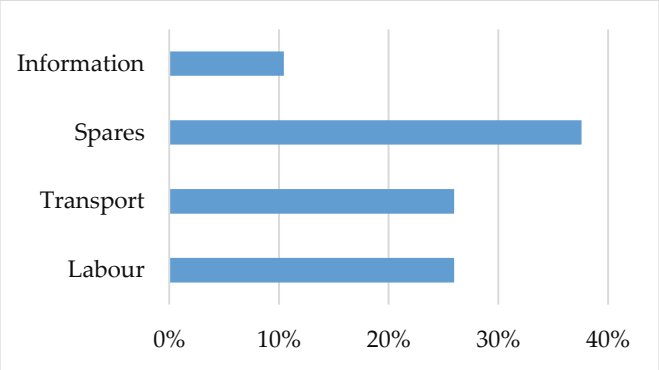
Environmental issues were the principal reason for non-enrolment (27%). Unsatisfactory water quality, particularly high salinity, collapsed well or groundwater declining were frequently cited by communities. Handpump maintenance is not their main concern, rather the water resource itself, with some planning to dig a new well elsewhere. In response, the Sub-County government has been motivated to try and rehabilitate some of the handpumps which had collapsed, now that there is an available maintenance service from FundiFix.

Membership issues were the second major reason (15% of total) for non-enrolment. Interviews identified poor organisation, lack of agreement between members and leaders, or waiting for committee elections as constraints to enrolment. None of these communities had previously been paying on a monthly basis, with most (58%) paying only when the pump breaks, and some not paying anything. This underlines the challenge of changing to a new payment modality, and building consensus among members. Although FundiFix currently uses a monthly payment model, there is some flexibility within the system (six month notice period), and a choice of payment modalities can be considered to best fit user preferences.

Institutional arrangements also emerged for some communities (6%) as they were privately owned, or had no members to contribute to the fees. Other reasons (5%) included a problem with land ownership and access, and a pump needing parts that are not stocked. Only one case indicated that the price was too high, where the owner had some repair skills and planned to carry out repairs himself.

Other communities (12%) remain interested in the FundiFix services, and half of these had signed up but not gone on to pay the registration fee. Seasonal factors such as the failure of rains in December 2014 and the impact of this on changing priorities and re-directing household income to food provision should be considered.

Figure 3. Share of FundiFix maintenance costs (Feb-Jun 2015



4.2 Operational performance

Between February and June 2015, FundiFix made 56 repairs to 18 handpumps (range: 0-17; mean = 3; median = 2). All but two repairs were made within three days, with an average downtime per repair of 1.1 days. Delays were caused by insecurity (livestock and human conflict) and waiting for water level to subside before the community could desilt a well, and were not outside of contractual obligations.

Performance is skewed by nearly half of the repairs (48%) attending to two handpumps: the first had not been part of the free trial, is deep and heavily-used and required replacement of several parts, and the second, had a rusted cylinder, which was causing rapid wearing-out of the U-seals. Pooling risk at scale underlies the economic logic of the FundiFix model and most insurance schemes. The flip-side is that just under a fifth of handpumps (18%) did not require any repairs during the time period.

One community withdrew from the service, having not fully paid the sign-up fee, or any monthly fee for the 6-month notice period. This was cited as a problem with the resource (water level in the well too low), and the availability of alternative sources nearby. All repairs were carried out by one fundi (pump mechanic), using a motorbike provided by the Sub-County water office.

4.3 Financial performance

89% revenue collection in first 6 months

Income in the first six months was USD 1,057 with 72 per cent in monthly payments, and 28 per cent in registration fees[2]. This represents 89 per cent collection efficiency, down from 96 per cent in the first quarter. Overdue payments are followed up using the FrontlineSMS software, allowing a number of community members to be reminded by SMS, as well as personal phone calls or visits where possible. Some late or non-payments are due to the lack of an M-PESA agent to deposit the money or the distance to access this. Other communities state they have not collected all the money from the members. Still other communities have management issues now that the accountability loopholes are closed. Income is lower than expected due to lower sign-up numbers.

Expenditure over the first five months of operation (February-June), the local costs of running the maintenance service (transport, labour, spare parts and information) was USD 2,156. The relative proportions are shown in Figure 3. These figures do not include overheads such as office rental, utilities, support staff and consumables, some of which are related to the research programme.

[2] An exchange rate of 1 USD = 100 KES is used throughout.

Payment behaviour identifies the number of communities in arrears as of end of July, per payment band. Most of the communities in arrears (71%) are in in the low-use payment band. Based on data from focus group discussions, 71 per cent of groups in arrears had not previously made regular payments. Of those not in arrears, only 17 per cent had not paid previously.

5. Not seeing the pumps for the pipes?

The previous section considered handpump water supplies and the FundiFix model without consideration of competing or complementary water supply infrastructure. Many studies have demonstrated alternative water supplies are a key determinant of rural water demand including a seminal report by a World Bank team on rural water demand in Africa over twenty years ago. Given the low uptake by communities of a significantly improved handpump maintenance service we present results of a 'Water Audit' that details alternative, improved water supplies. We discuss infrastructure and institutional performance with the results of water service provision disaggregated by a) sufficient, b) safe, c) physical accessibility and d) affordability in recognition of the Government of Kenya's constitutional commitment to realising the Human Right to Water.

5.1 Institutional arrangements

Surface water and groundwater supply the main water infrastructure alternatives in the study area (Table 1, Figure 1):

- **Surface water**
  - Kiambere pipeline managed by Kiambere Mwingi Water and Sanitation Company (KIMWASCO) has 15 kiosks. KIMWASCO is a public water supplier with water supplied from the Kiambere dam on the Tana River and pumped to Mwingi and Kyuso;
  - Four rock catchments collect and store rainwater distributed in ten kiosks. Major infrastructure investment and rehabilitation was financed by a multilateral donor.
- **Groundwater**
  - 12 submersible pumps supply 17 kiosks. Many of the kiosks were installed by one bilateral donor or a local religious charity;
  - 66 handpumps supply communities who commonly dug their own wells with the handpump financed by a mixture of local or international NGOs, or the government.

The Kiambere pipeline managed by KIMWASCO supplies water to 70+ kiosks as well as private connections in the wider area. They are overseen by the Kitui County Ministry of Agriculture, Water and Irrigation, and are mandated to distribute water and maintain the distribution assets. The small piped systems (boreholes and rock catchments) are managed by local management committees that are elected by the community, assuming responsibility for providing the water service and assets after construction and commissioning. Handpumps are managed by communities with infrastructure assets unclear in terms of ownership and routine maintenance being the responsibility of the community.

There is wide variation on the role of the Sub-County in operation and maintenance for the different systems. At one end of the spectrum a committee may rely on the Sub-County for all repairs, servicing and rehabilitation. At the other a committee may not seek any support from the Sub-County (in this case, the committee had the support of an external partner). Most turn to the Sub-County for assistance when there is a technical problem beyond the ability of their usual local mechanic or electrician who carries out basic repairs (repairing burst pipes, generator maintenance etc.). If the committee has funds available they may be able to come to an arrangement with the Sub-County and pay for parts and labour. If they have no funds available then the Sub-County can assist them in submitting a request for support to the County Government which can take several months; the Sub-County has no funds available to spend at its own discretion.

> *"It broke down in April 2014 and was repaired in March 2015. The reason is because there was no money so the committee wrote a proposal to the County Government. In the end no money was given but a fundi [mechanic] was sent."*

The legal definition of who owns the infrastructure and land is crucial to a discussion of who has responsibility for maintaining and operating those assets. When asked who was responsible for repairs to the system, water users gave a variety of answers, including the committee, the service provider, the Sub-county water office, community members themselves and even one response that the Member of the County Assembly (MCA) was responsible. Asking committee members themselves revealed a similar range of answers. In answer to the question "who owns the infrastructure?" the following answers were given: the community, a community-based organization (CBO), the primary school, KIMWASCO, the Sub-County government. In one case, a private benefactor had constructed the borehole and handed it over to the community but without the official paperwork. Several committees are still paying off loans for the purchase of the land.

In order to understand the ownership arrangements we must look back at the commissioning process. After construction is complete, according to the Sub-County, "*there is a 'handing over' to the community and it becomes their property*". Other requirements are that "*there must be a committee with a chairman who is a bit literate. They should be registered as a legal entity.*" If the committee needs training, this is provided by the Sub-County, including follow-up and advice, for example in tariff-setting.

However, once committees are in place, there is little oversight or regulation. The Sub-County Water Office lacks the mandate to enforce or ensure good management stating that we "*…talk with them, tell them what they are supposed to do to manage well. We make things clear. We advise them and hope they will do better next time. We don't go as far as prosecution. We leave it to the chiefs and the administration.*" We did find evidence of Members of County Assembly (MCAs) and Chiefs involved in auditing committee accounts and pushing for committee elections, but this occurs only as a last resort when the system has been broken for some time and the need for action is critical. Regulation and oversight seems to take place more successfully in systems managed by the water service provider, for example kiosk attendants being prosecuted for shortfalls in income, private connections being prosecuted for selling water.

5.2 Operational performance by service level

As noted, not all data are available nor are we able to consistently report across the same years. In the absence of better data, we recognise these caveats but also the rare ability to compare equivalent metrics across multiple water service providers in a defined area of rural Africa. Three key points emerge which are expanded upon further below:

1. Handpumps supply the majority of the area with highest operational performance;
2. Rock catchments are more often than not non-functional with an unknown user base;
3. Submersible pumps are non-functional over two in five days taking almost two months to repair.

Infrastructure (source)	Waterpoints	Estimated total users	Non-functional	Mean downtime per failure	Maintenance Provider
Kiambere Pipeline (surface)	1 (15 kiosks)	5,700	27%	9 days	KIMWASCO
Rock Catchments (surface)	4 (10 kiosks)	>300	90%	5 days	CBM/County
Submersible pumps (groundwater)	12 (17 kiosks)	5,000	44%	57 days	CBM/County
Handpumps (groundwater)	66	13,000	2%*	< 3 days	Fundifix Ltd.
Total	***108***	***c. 24,000***	***2-90%***	***3-365 days***	

* Functionality rate of handpumps relates to handpumps maintained by FundiFix in 2013.

Table 1. Water infrastructure performance by service level

5.1.1 Sufficient

This characteristic of a water supply relates to its availability, in terms of volume and time, i.e. consistently and in sufficient quantity. An added dimension that should be considered is the predictability of when water is available.

For groundwater kiosks (in the 12-month period from March 2014-February 2015) available records from five committees show that on average water was available for 22 days for each functional month (42% of months had no water due to either no data, long-term breakdown or not in use due to low demand during the rainy season). The worst-performing system had water available only 22 per cent of days per year, while the highest-performing system achieved 71 per cent of days with water available. This corresponds with the survey data which show that boreholes were more likely to have longer breakdowns.

For Kiambere pipeline kiosks (where eight records were available for a 12-month period), kiosks showed a similar variability with water available from 18-67 per cent of days over the year. Water supply to the pipeline was rationed due to the capacity of the system, being pumped to storage tanks in the Kyuso area only on Mondays and Thursdays each week. Availability is therefore determined by the volume of the storage tanks vs. demand. At peak times of year stored volumes are exhausted before the next round of pumping. If the system is out of action for urgent repair or maintenance on either of these days, then storage capacity is already exhausted and customers will have to seek alternative sources for a minimum of three days.

All but one of the rock catchment kiosks were non-functional. As the source is surface water, users can access this directly when the piped system is not in use although at significant risk to their safety due to the steep gradients of the catchments. Some of the reservoirs are seasonal only, so sufficient quantities are not available all year round.

On average, kiosk downtime per breakdown ranged from five days (rock catchment) to 57 days (groundwater kiosks). 81 per cent of breakdowns in the past year were due to burst or blocked pipes (44%), problems with fuel/electricity supply or generator (19%) or water availability

(17%). Of the remaining breakdown events, problems with the borehole and vandalism caused much longer downtimes.

5.1.2 Safe

Although water quality testing was not within the scope of this study, user perception of the safety of water for drinking was evaluated. Kiambere pipeline supplies, which are chlorinated, is thought to be safer than groundwater kiosks and both are thought to be safer than the catchment (untreated surface water), which follows the expected risk levels for these sources. Handpumps have high-perceived drinking safety though one in three users claims to treat the water, if drinking.

Table 2. User perceptions of water quality and treatment behaviour by water infrastructure

Infrastructure	% of users who say water is safe to drink	% of users who treat water from this source
Kiambere kiosks	100	16
Handpumps*	86	32
Groundwater kiosks	54	14
Rock catchment kiosks	27	93

* data from baseline survey (n=118 users from 15 handpumps)

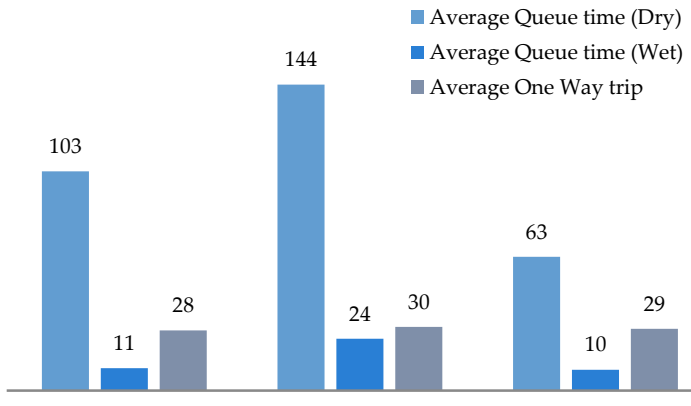
At six of thirteen groundwater kiosks the water was reported to have high salinity, and was not used for drinking or sometimes cooking. It was however preferred for livestock watering. All of the three boreholes that were not in use due to low demand in the wet season had high salinity, with users preferring to fetch non-saline water from shallow wells or surface sources while these were available, even where this costs significantly more.

5.1.3 Physically accessible

Travel time is used as a proxy measure for distance. Results from the user survey show that the average one way trip time stayed relatively constant across kiosks at 28-30 minutes for a one-way trip, regardless of the source.

Seasonal queuing times showed that there is much higher demand in the dry season (63-144 minutes queue time vs. 10-24 in the wet season), and that people queue for longer at the pipeline kiosks.

Figure 4. Average queuing and travel time to waterpoints in Kvuso (minutes)



5.1.4 Affordable

The lowest tariff charged was USD 1 per m^3 (2 KES per 20 litres) and the highest was USD 2.5 per m^3 (5 KES per 20 litres). Kiosk users were asked which sources they use when the kiosk is not functioning and how much they pay. Results show that almost a third pay for water from other sources, and that prices can be up to USD 8 per m^3 for vended water or USD 5-6 per m^3 for private wells or scoop holes in riverbeds. Rainwater and surface water were generally free sources.

The criteria of affordability will depend on household income and expenditure. In the study, the average annual household expenditure was found to be USD 1,840. Based on reported volumes collected in dry and wet seasons (assuming six months of each per year), 67 per cent of households would spend less than 5 per cent of annual income on water at the lower tariff (USD 1 per m^3). This implies for one third of households, the lower tariff may not be affordable, and may partially explain why free water sources are preferred when available. Although few

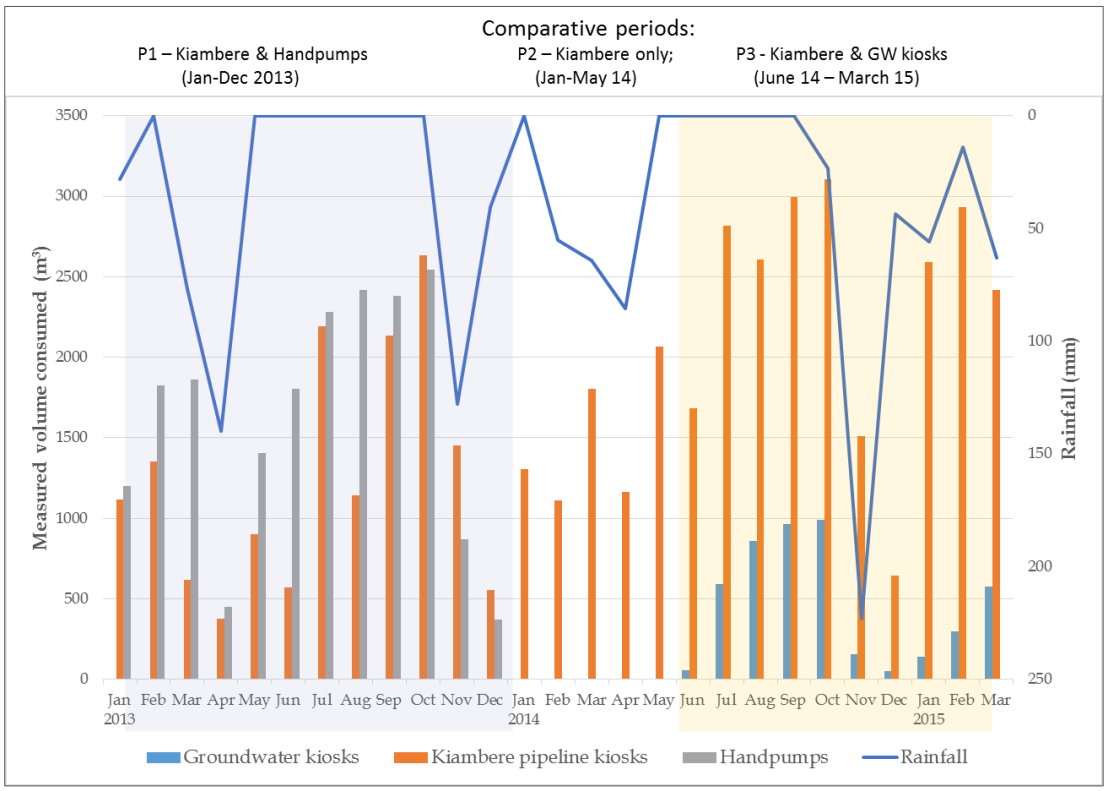
of the water systems surveyed would meet the universal access criteria, user satisfaction was high, with 77 per cent of pipeline kiosk users, 63 per cent of borehole kiosk users and 53 per cent of catchment users satisfied or very satisfied with the service provided.

5.3. Seasonal demand and rainfall

Comparing volumetric water consumption by infrastructure and rainfall highlights three key results:

1. **Water consumption mirrors rainfall patterns** - peak demand is in July to October, with a gradual increase from a December minimum. Demand may lag behind rainfall, as it takes time for infiltration into the shallow groundwater supplies that are one of the main alternative sources.
2. **Handpumps are the major water source** – assuming year-on-year figures are comparable, handpumps are the main water source followed by the Kiambere kiosks and then groundwater kiosks. Rock catchment kiosks are often broken with no volumetric data.
3. **Water infrastructure investments alone will not deliver universal water services** – a major implication of the data is that people shift from improved water infrastructure to unimproved water sources in higher rainfall periods. However, we do not fully understand what cost, convenience or taste factors influence behaviour in Kyuso. What is also known in Kyuso is that productive uses, particularly livestock, are a dominant factor of water infrastructure demand. We do not know the share of water allocated to people and livestock in the peak dry months. This raises major policy questions on strategies to the goal of universal service delivery.

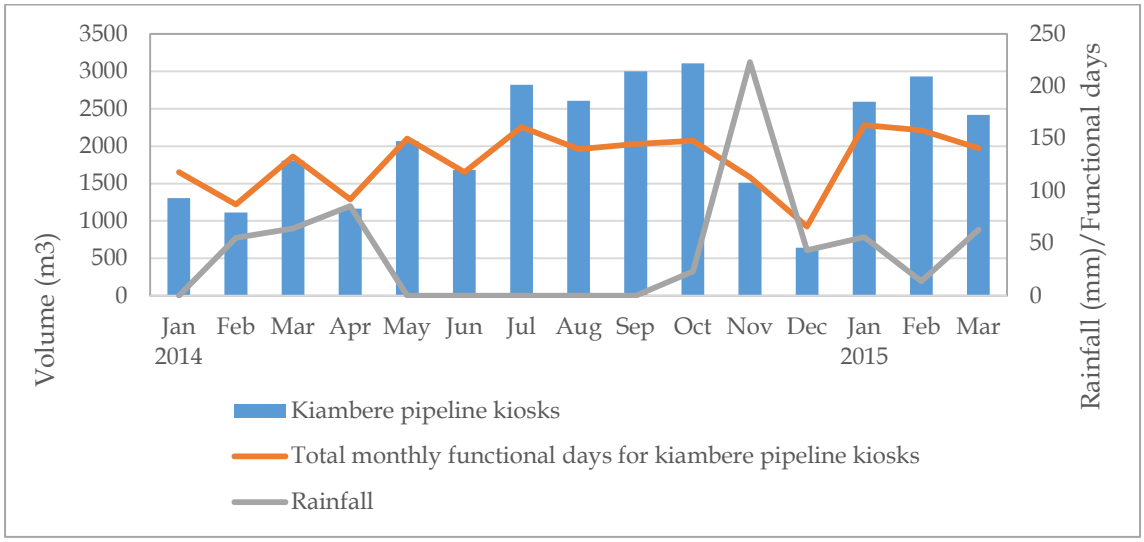
Figure 5. Rural water demand by infrastructure and rainfall in Kyuso (2013-15)



While rainfall is clearly linked to the seasonal volumetric usage pattern, the trends can be more fully explained if we consider the number of days per month that water was available. The graph below shows the available data from the Kiambere pipeline kiosks. While the general trend in supply is explained by rainfall and fall in demand due to the availability of other sources, the pattern corresponds more closely to the number of days the kiosks

were functional during that month. If a kiosk is only functioning for 15 days in a given month then less water will be sold, and correspondingly lower revenues will be generated and users will have to rely on alternative sources to meet their needs.

Figure 6. Kiambere pipeline water supply and kiosk functional days by rainfall (2014-15)



These trends are important when considering both financial sustainability and public health aspects. As demand drops, revenues also fall proportionally which should be factored into tariff calculations and maintenance costs, particularly as the survey has shown that kiosks may close for 2-3 months a year. Low demand is also an issue for kiosk attendants and other employees who are paid on commission or may be laid off.

5.4 Unit water costs

Data across periods were compiled to allow a provisional and incomplete understanding of relative unit costs of water by infrastructure provision. There are major caveats to the results which restrict the implications as revenue and expenditure data are not fully known with unit costs based on estimated consumption data and then compared using available revenue (assuming break-even outcomes) or cost data where known (handpumps). A reported subsidy (tax) for pumping Kiambere water to Kyuso is also discussed.

The analysis indicates:

- Handpump water supply cost is two to four times lower than alternative kiosk supplies;
- Including a government subsidy (tax in 3T terms) for Kiambere pumping costs increases the unit cost to USD 2.3 per m^3;
- Higher costs of Kiambere are tempered by high levels of satisfaction, water treatment and public regulation by WASREB;
- Water availability is highest for handpumps (98%) but seasonal demand and kiosk opening hours makes direct comparison difficult (see 5.3).

If these data reflect the true cost of reliable and safe rural water services it is greater than the tariff currently paid by local water users. Equally it is higher than the proposed USD 1 per m^3 suggested by the World Bank (2011) for African urban water supplies. The implication is rural water services are more expensive and user tariffs alone will not be sufficient to maintain services. The exception is for handpumps but uncertain water quality and the need for monitoring and regulation of infrastructure will inevitably raise the unit cost of provision. However, these cost estimates represent an uncoordinated and competing water infrastructure portfolio where significant cost savings are likely to be made if infrastructure and institutions are coordinated and regulated effectively at scale. With a local revenue base of over USD 25,000 per year there are significant local resources which could be harnessed with more effective coordination of investments by donors (transfers) or government (taxes). This is a non-trivial task in building institutional capacity and performance as discussed below.

Table 3. Unit cost comparison of handpump and kiosk water supplies, assuming break-even performance

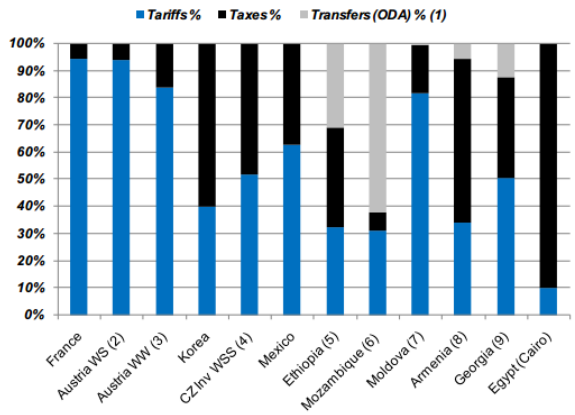
	Handpumps*	Kiambere kiosks	Groundwater kiosks
1. Estimated annual volume (m^3)	19,415	18,932	4,680
2. Availability (% days)**	98%	50%	41%
3. Local O&M costs (USD)	$8,368	?	?
4. Local revenues received (USD)	n/a	$17,880	$7,568
Crude cost per m^3 (USD)	**$0.43**	**$0.94**	**$1.62**

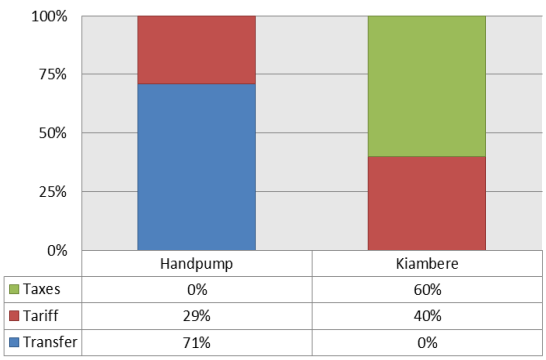
*Data from 2013 to be consistent on volume and cost data; ** reliability is the preferred metric but given some kiosks are functional but non open we choose availability here

5.5 3T analysis

We conclude by reporting a 3T figure that reports the relative share of tariffs, taxes and transfers with the available data for Kiambere kiosks and handpumps.

Figure 7. Apply the OECD 3T (2009) approach to finance of handpumps and Kiambere kiosks in Kyuso





We report Kiambere pipeline kiosks and handpump data as they are the only records available. Handpump data drawn from the first six months of the FundiFix model are multiplied by two to give annual estimates for user tariffs (USD 1,548) and the effective transfer (research donor) of USD 3,772 to cover the local O&M costs of USD 5,320. Kiambere data include actual annual revenue of USD 17,782 and a stated tax (here subsidy) for the energy costs of pumping per year of USD 26,820 for a total O&M cost of USD 44,720. These figures do not account for

salaries and other expenses in KIMWASCO or RFL Ltd. As such, the figures are imperfect but reflect the best available data on relative shares of the 3Ts. Three insights emerge:

- KIMWASCO has nearly an order of magnitude higher revenue despite less water supplied than handpumps;
- Handpump subsidy (transfers) is 14 per cent of the KIMWASCO subsidy (taxes);
- User tariffs are around one third of actual costs of service delivery.

5.6 Financial Sustainability

A common theme among survey participants who were asked about the challenge of sustainability came down to financial mismanagement. *"[The main challenge to sustainability is] mismanagement of funds – committees can misuse the funds, despite training."* Unlike official WSPs who are monitored by both the County Government and WASREB, it is unclear what arrangements are in place for monitoring small water systems, in particular auditing and ensuring financial accountability. Several committees had overstayed their maximum terms and not all have bank accounts or have any official registration. None of the committees that we spoke to could present complete accounts showing income and expenditure. Only one of the committees interviewed set aside funds for capital maintenance or replacement (required by the external partner), others plan to apply to County Government when needed. In effect, there are few incentives and many barriers to committees performing their management role in a way that leads to financial sustainability.

The experience of KIMWASCO as a WSP shows that financial accountability was also a problem in their initial approach. *"Initially we tried community management but there was never any money to be collected at the end of the month. The President blames the treasurer, the treasurer blames the attendant etc. There has always been a new water committee always after the previous one runs the kiosk down, this has not been sustainable."* Their solution was to appoint attendants paid on commission who are supervised by KIMWASCO staff and held accountable using meter readings.

Financial data for groundwater kiosks was difficult to access, but some committees shared their records with us for analysis. Taking one small system (submersible pump, diesel generator, reservoir and one kiosk) as an example from the end of September 2014 to beginning of April 2015, we can examine income and expenditure for the records available. This system charged one of the highest tariffs for water at USD 2.5 per m^3 and has generated a gross profit of USD 904 over seven months. Five villages are supplied, and an estimated 250 households per day in the dry season. Notably, the Sub-County had played a significant role in providing technical support (servicing the generator and carrying out repairs), although the committee were unsure of how these services were paid for. The committee also benefitted from training by the Sub-County in record keeping and project management.

Table 4. Summary of financial data for one groundwater kiosk

Volume of water sold	805m^3 (at \$2.5 US/m^3)
Number of days water was sold	97 out of a potential 195 days (50%)
Average revenue per day	USD 28
Revenues	USD 2,716
Expenditure	USD 1,812
Gross profit	USD 904

Despite the positive financial outcome, expenditure analysis failed to account for 69 per cent of costs casting uncertainty in the transparency of financial management. This example was demand-driven, as the community had made a request for a water system, so that when a donor was looking for possible locations, they were identified. The water from the borehole is saline, and there are issues with water availability (they can only pump in the morning). However, demand is such that they are able to cover O&M costs with a 33 per cent surplus.

6. Pathways to Universal Rural Water Services

In Kyuso, despite major improvements in operational performance of community handpumps two thirds of communities have not joined the FundiFix model in the six months since launch. The legacy of poor installation, site locations with high levels of groundwater salinity and limited community dependence on some handpumps partly explains why recruitment is not higher. As predicted in the Rights to Results report (2014) handpump density, particularly 'clustered' handpumps, were less likely to join compared to single or twinned handpumps. Nevertheless, community commitments to pre-pay for a professional and supra-community maintenance service have failed to match the stated commitments to join of the majority of the communities. If it is accepted that the maintenance service is of high quality, this raises questions of the role of infrastructure surplus, competing alternatives and the dynamic nature of rural water demand. Examining FundiFix's relative performance through the Water Audit provides evidence of barriers and opportunities for universal service delivery:

- **Rural water demand** is revealed to be heavily influenced by rainfall events which shifts water use from improved water infrastructure (kiosks, handpumps) in the dry season to unimproved sources in the wet season. Demand for treated piped water from the Kiambere pipeline kiosks generates ten times more revenue than current revenues for FundiFix (n=22) but supplies less water than the total handpump portfolio (n=66);
- **Financial analysis** indicates the local unit cost of handpump operation and maintenance is two to four times less than water supplied from kiosks despite higher availability throughout the year. The 3T analysis suggests rural water tariffs are around one third of costs (handpumps, kiosks) with government support (here, 'taxes') significantly higher for kiosks than the donor 'transfers' to launch the FundiFix model. One groundwater kiosk demonstrates a healthy, gross profit one third of revenues, which underlines the potential for sustainable water services based on user tariffs to insulate against uncertain political futures (taxes) and donor priorities (transfers). However, this kiosk is an exceptional case.
- **Institutional analysis** reveals no coordinated management of water infrastructure though County water officers recognise the nature of the challenges and KIMWASCO reports annual data to the national water service regulator. Uncoordinated government, donor and NGO investments in infrastructure have failed to build local institutions at the right scale and with accountability to maintain services over time.

Based on the evidence we conclude that pathways to universal rural water services will depend on significant institutional strengthening at the right scale and improved monitoring systems.

6.1 Institutional Coordination and Investment

Water institutions need to be strengthened at the right scale to manage infrastructure and ensure sustainable service delivery. A legacy of well-meaning but failing infrastructure investments creates a significant challenge to future financial sustainability in Kyuso, and across Africa. FundiFix's community recruitment rate provides an estimate of the likely infrastructure surplus or cannibalisation from alternative water supplies. The Kitui County Water Ministry would have a key policy role in identifying 'water service areas' that did not prescriptively follow 'urban' or 'rural' typologies but consider the infrastructure portfolio and population density to promote effective and long-term planning and delivery. Delivery of services could be public (e.g. KIMWASCO), private (e.g. FundiFix) or hybrid based on the context. Performance-based licences or contracts would be designed for delivery for the entire water service area. Service providers, whether water, maintenance or financial, would be regulated within existing (e.g. WASREB in Kenya) or new regulatory systems that were independent of policy interference and with power to progressively improve performance, revoke contracts or impose fines where necessary. As the infrastructure portfolio is reconciled, partner organisations (NGOs, INGOs, donors) would be registered at the national level with approved plans before infrastructure investments are made. Failure to comply would result in fines or the withdrawal of permission to operate in the country. Financial sustainability would target recovering local operational and maintenance costs from tariffs with a Water Fund providing a transparent mechanism for tariffs, taxes and transfers to be managed collectively and transparently in the long-term.

6.2 Improved Monitoring Systems

Information flows are critical for institutional coordination and performance. Incomplete, absent or inaccurate records of basic water services' data are common in Kyuso and much of Africa. Water service regulation often relies on 'self-reporting' by water service providers which often questions the validity of the data, if not triangulated. Increasing use of low-cost, mobile-enabled devices offers one route to improve the quality, frequency and coordination of data at scale. Transparent data flows not only support monitoring service delivery but can ensure policy progress is open for public scrutiny. Equally performance data can unlock new financial flows such as results-based finance, where finance is contingent upon verifiable records. Kyuso has a unique, long-term record of daily handpump usage which has provide a clear evidential base to guide the design of the pre-payment system, which also exploits mobile innovations in payment systems (M-PESA, FrontlineSMS). Monitoring systems inevitably incur costs but these may be relatively modest, as illustrated here, and the absence of data often results in costs disproportionately born by rural water users with limited recourse for those unaccountable for mistakes or opportunities to improve performance in the future.

Kyuso offers a challenging context to test new Sustainable Development Goals against the local realities of rural Africa. Policy has long advanced safe water supplies through shared, rural water infrastructure (kiosks, handpumps). However, the findings here provide evidence rural people rapidly switch to 'unimproved' water supplies (dug wells, surface water) after prolonged rains. Whether cost, convenience or taste issues influence these decisions, they are clearly observed along with the significant role of productive uses of rural water supplies, particularly for livestock. What this means for universal service delivery is uncertain but with increasing climate variability and extremes rural water supply should be managed as a resource system providing water services through alternative infrastructure. Rural water sustainability has never been amenable to politically-neat but operationally-complex metrics such as 'litres per capita per day'. Wider evidence of the impacts and implications of uncertain rural water demand for universal services is necessary to guide effective policy responses to improve water security at home, at school or at work.

7. Appendices

7.1 Acknowledgements

We gratefully acknowledge the time, support and guidance from Government of Kenya Ministry of Water and Irrigation, Water Services Regulatory Board (WASREB), Kitui County Government, Kyuso Sub-Country Water Office and the handpump users in Kyuso and Ngomeni Districts.

UNICEF (East and Southern Africa Regional Office, ESARO) generously provided funds for the research as part of a wider regional initiative for Rural Water Sustainability. The work builds on an earlier project funded by the UK Department for International Development (R5737).

Usual caveats apply with the authors taking full responsibility for any errors.

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Suggested citation:
Oxford/RFL (2015) Financial Sustainability for Rural Water Services – Evidence from Kyuso, Kenya. Water Programme, Working Paper 2, Smith School of Enterprise and the Environment, Oxford University, UK.
Available at: http://www.smithschool.ox.ac.uk/research-programmes/water.php

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