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Journal of
Water, Sanitation & Hygiene for Development

 Journal of Water, Sanitation and Hygiene for Development Vol 00 No 0, 1 doi: 10.2166/washdev.2024.038

Practical Paper

Maintaining groundwater collection over the rainy season with water ATM price reductions: a study in Kitui County, Kenya

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ABSTRACT

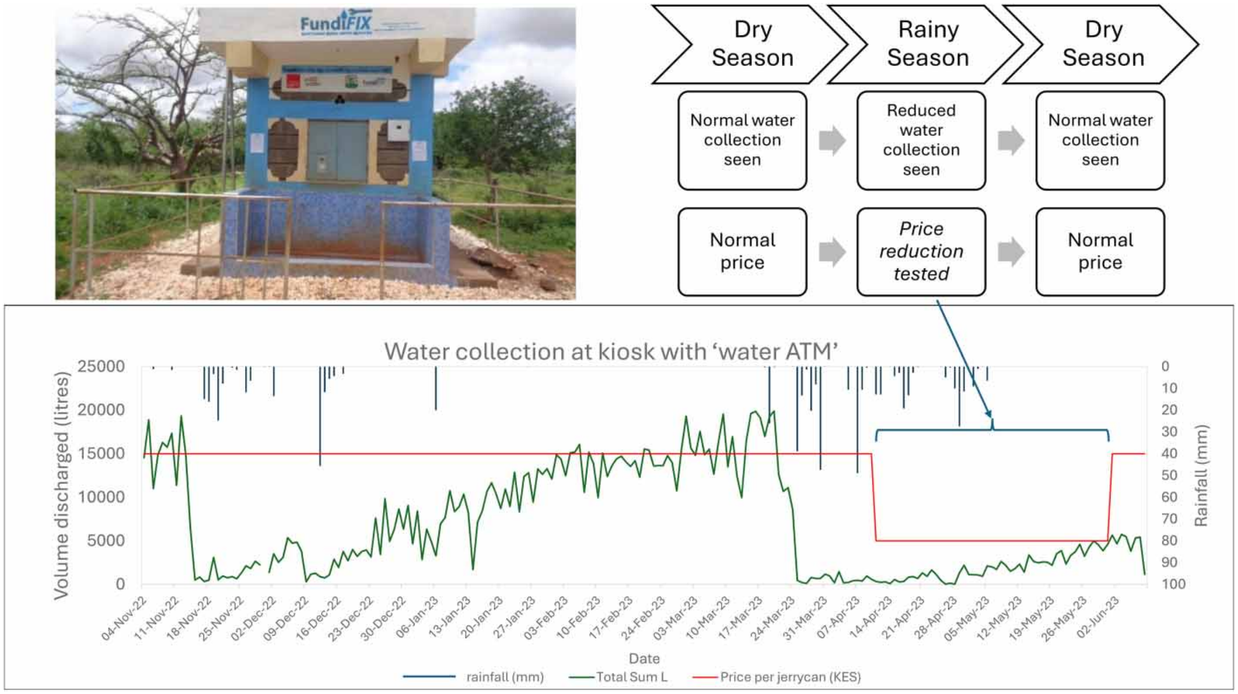
Rainy seasons across rural sub-Saharan Africa see a dramatic reduction in the collection of groundwater from water points, exposing communities to health risks and reducing sustainability of service providers. Kenyan water service provider FundiFix operates water points in dispersed rural communities in semi-arid Kitui County and sees five to ten times less water collected, and revenues close to zero, during rainy seasons. Water ATMs record precise volumes of water dispensed and allow for timely price changes. It was hypothesised that reducing price from 3 KES to 1 KES per jerrycan would cheaply maintain clean water collection and possibly increase revenue. FundiFix tested this intervention over the March-April-May 2023 rainy season at three water ATM piped schemes and communicated the price reduction to users, with a fourth control unchanged. This did little to nothing to maintain the collection of water at dry season levels. This shows other practitioners that to address the seasonality challenge price reductions need to be combined with deeper understanding of user behaviour, which requires further study. This study only cost 100 USD in lost revenue from reduced price. Implications for practitioners are outlined. Conditional transfers of water credit to users, rather than price reductions, are discussed.

Key words: health, Kenya, seasonality, water ATM, water pricing

HIGHLIGHTS

- The price of clean water at rural kiosks with water ATMs was reduced over a rainy season.
- These reductions did not have desired effect of increasing demand for clean water in this study.
- This suggests the relative influence of price is outweighed by other community behavioural factors.
- Pricing alone was not sufficient to overcome the seasonality challenge on health and sustainability and analysis of behavioural determinants and supplementary interventions are needed.

GRAPHICAL ABSTRACT



INTRODUCTION

During rainy periods across rural sub-Saharan Africa, collection from improved water points tends to reduce, often dramatically, predominantly due to the availability of free alternative sources of water (Kelly *et al.* 2018; Thomson *et al.* 2019; Ingram & Memon 2021; Cronk *et al.* 2024). This reduction can have adverse impacts on public health and the financial sustainability of water services. Water-related illnesses often increase during rainy seasons, in particular diarrhoeal disease, with health risks introduced from lower quality water collected from roofs or surface sources that improved water service provisioning is meant to mitigate (Thiam *et al.* 2017; Kraay *et al.* 2020; Daly & Harris 2022). Groundwater is generally considered to be of better quality, particularly compared to surface water that is vulnerable to contamination especially after heavy rain flushes pathogens following dry spells (Parker *et al.* 2010; Katuva *et al.* 2020; Kraay *et al.* 2020). Rainwater from rooftops also tends to be significantly more likely to be contaminated than groundwater (Baguma *et al.* 2010; Bain *et al.* 2014a, 2014b; Hamilton *et al.* 2019).

These challenges characterise the situation in semi-arid Kitui County in eastern Kenya, where the social enterprise FundiFix is providing water services to low-population-density rural communities through approximately 26 improved water points. FundiFix is innovating a payment-by-results service model that combines external finance and revenue collection. It operates and provides maintenance, ensuring the sustainability for groundwater-based systems in communities that lack other public or private provisioning. Communities are relatively dispersed with distances from homes to FundiFix-managed communal kiosks ranging from a few hundred metres to up to 5 km. During rainy seasons, users collect much less water from these kiosks and instead collect from a range of alternative sources. Across the population, these typically include surface water, including streams or ponds, of varying distances from households and harvesting of rainwater from roofs. The latter is typically done at the household level, but water is often directly collected from unclean roofs into open containers rather than through improved rainwater harvesting infrastructure. This varied selection of sources reflects the complex household water needs arising from diverse preferences, pressures, and norms (Hoque & Hope 2018) but introduces health risks (Bain *et al.* 2014a; Thiam *et al.* 2017; Kraay *et al.* 2020; Daly & Harris 2022; Nowicki *et al.* 2022).

Reducing the price of water over rainy seasons in this context is hypothesised to lower barriers to households' continued collection of cleaner groundwater (Ingram & Thomson 2022), thus partly mitigating health risks from switching to poorer quality water (Brown & Clasen 2012; Thomson *et al.* 2024), while also helping to maintain revenue for service providers and support service sustainability (Hope *et al.* 2020; Armstrong *et al.* 2022). New 'water ATM' systems, which are automated water points operated with pre-payment tags, provide service providers with accurate, time-stamped, remotely collected data on water volumes dispensed. These systems remove reliance on self-reported water use or check water meters, which allow for the price charged for water to be changed with ease. FundiFix operated eight groundwater-supplied water ATMs at kiosks in Kitui at the time of the research. Four of these provided the required monitoring here to test this hypothesis.

The objective of this research was to test if this proposed price reduction improved collection from FundiFix kiosks during the 2023 March–April–May rainy season and to pilot this as a new intervention to enhance community health and service sustainability. It was hypothesised that a reduced price would increase collection from these public kiosks. Price elasticities reviewed from communal water points elsewhere across developing countries averaged about −0.4 (Ingram & Thomson 2022). This suggested that price change would have reasonable influence on demand in such contexts.

THE SEASONALITY CHALLENGE FOR FUNDIFIX

The suppressed collection from rural water kiosks operated by FundiFix in Kitui County in Kenya during rainy seasons results in large reductions in revenue compared to levels of collection in the dry season. Figure 1 shows that a sample of four water ATMs (see Methods) recorded between 5 and 10 times less volume collected during the rainy season compared to the dry season, which dramatically exemplifies this seasonality challenge outlined above. At times, FundiFix has had to close certain water points over rainy seasons because of a lack of demand, thus blocking access to those who have wanted to access these sources of clean water. This undermines their goal to provide quality water services and improve community health. There are, therefore, potentially high dividends from overcoming this seasonal reduction in water collection. FundiFix's need for solutions to this major challenge is shared with other rural water service providers.

Ingram & Thomson (2022) suggest that price reductions could reduce water-related diseases at a low cost per DALY averted, and, in cases where the elasticity of demand for groundwater is high, that a price reduction could lead to increased revenue with higher volumes vented outweighing the price reduction. As FundiFix's costs are predominantly fixed (e.g. staff salaries) rather than directly linked to the volume of water (e.g. pump costs), price reductions in the rainy season that increase volumes sold could be made as a purely business decision, irrespective of possible health benefits.

METHODS

FundiFix tested a price reduction in Kitui County over the March–April–May rainy season of 2023. The price reduction selected was from 3 KES (~0.02 USD) to 1 KES (<0.01 USD) per jerrycan. A drop from 3 to 2 KES was thought to not

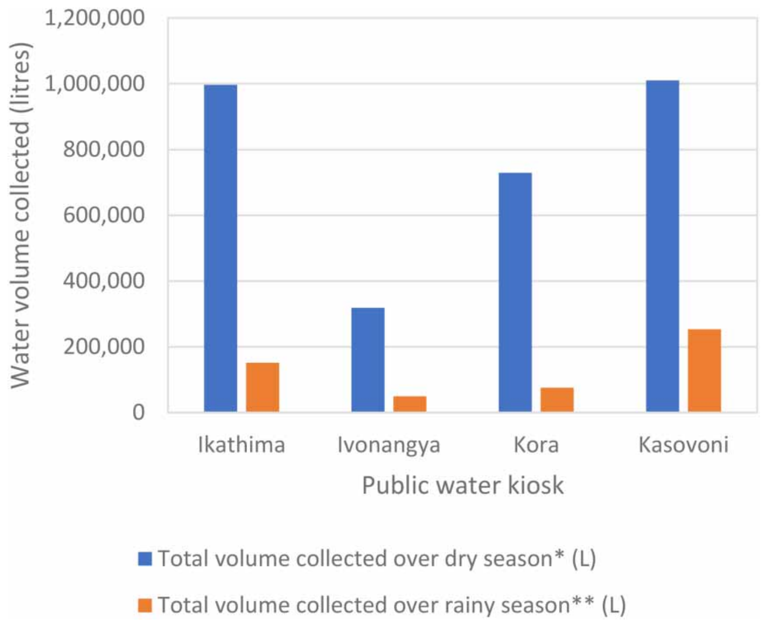


Figure 1 | Comparison of water collected over dry and rainy seasons. *Taken as 1st Jan to 20th March 2023; **21st March to 31st May 2023.

signal a strong enough price drop, and a drop to 0 KES risked profligate collection and would produce no revenue. An integer value was needed for ease of communication with the community.

Four rural communities were selected. Each community has one water ATM kiosk and no other improved water points. Selection was based on (1) long-standing and good quality relationships with FundiFix to ensure benefit to communities and mitigate social risks, (2) proximity to the local FundiFix office to facilitate implementation, and (3) the uniformity of water ATM technology (systems manufactured by Susteq). These kiosks have different primary uses (see Table 1).

The price drop was designed to be in place for the length of the rainy season. The exact onset and end are unpredictable, particularly in the context of climate change variability and limited hydrometeorological monitoring information. On-the-ground rainfall information from FundiFix staff based in the nearby town had to be relied upon and was solicited daily. Starting too early risked significant lost revenue. Starting too late risked users habituating collection from alternative sources.

The price was dropped on 11th April 2023. The rains were expected earlier; however, onset at the exact communities was hard to judge as this rainy season was characterised by the uneven distribution of rain in time and space (Kenya Food Security Steering Group 2023). The end date was set to 31st May as it was assumed that the rains would continue until then and to have a memorable timeframe for users.

The price reduction was communicated in advance to users with posters in the local Kamba language on three of the water ATM kiosks informing users of the price drop (Figure 2). Bulk SMS messages were also sent to the community members in English. Both posters and SMSs included a short 'nudge'-type message to use clean water for better health: *Attention! Price per 20 L jerrycan at Ikathima water kiosk is reduced from 3 kes to 1 kes to encourage use of clean water this rainy reason. This promotion starts TODAY (11/04/2023) and will last until 30/4/2023 ONLY. Any questions please contact FundiFix on 071#######*. FundiFix also communicated with key community committee members in advance to 'prime' behaviour change. Price at Kasovoni was maintained at 3 KES (~0.02 USD) as a control for the study, and there was no communication with this community.

Table 1 | Communities selected for study

Community	Water use	Taps per kiosk	Price before intervention
Ikathima	Water for household use	Two taps	3 KES (~0.02 USD) per jerrycan[a]
Ivonangya	Water for household use	Two taps	3 KES (~0.02 USD) per jerrycan
Kora	Water for livestock due to high salt levels	Three taps	3 KES (~0.02 USD) per jerrycan
Kasovoni	Water for household use	Three taps	3 KES (~0.02 USD) per jerrycan Control community, price drop not implemented

[a]23 litres dispensed to ensure a '20 litre' jerrycan is completely full.

Figure 2 | Kiosk with water ATM and poster communicating price reduction to the community.

Rainfall data were collected from the Global Precipitation Measurement (GPM) satellite product (Skofronick-Jackson *et al.* 2018) for the specific coordinates of each kiosk during the study period and afterwards. Water ATM volume and revenue data were available from the online dashboard provided by the technology manufacturer, Susteq.

All data were analysed on a daily timescale. Sub-daily collection dynamics can show valuable insights (Ingram & Memon 2021) but are not directly relevant to this seasonal study. Likewise, water ATM data for individual taps per kiosk followed the same trends as the kiosk as a whole and this analysis is not included.

RESULTS

Overall, the price reduction had no measurable impact on groundwater collection over the rainy season at these FundiFix public kiosks. This suggests that the hypothesis that reduced prices would increase collection was wrong. This period instead saw the same dramatic suppression of the collection of groundwater, as shown in Figures 3–6, as experienced by FundiFix in previous rainy seasons.

The volume collected during the price drop period compared to the rest of the study period (Ikathima = 7.3%, Ivonangya = 7.8%, Kora = 4.8%; mean = 6.6%) is even less than between the same periods in the control site (Kasovoni = 12.6%). This suggests that price drop did nothing to increase demand and price elasticity here is zero, i.e. perfectly inelastic, where a change in price yields no change in demand. No change in water collection is seen at the start of the price drop. Demand does show a gradual increase during the price drop period at all sites, which could suggest that once the pricing incentive takes hold, it slowly rises. However, this trend follows the departure of the rainy season and subsequently reduces the availability of alternative water sources. It is also observed both at the end of previous rainy seasons and at the control study site, and therefore cannot be linked to the lower price. The greater total volume collected at the control site of Kasovoni reflects more users than the other sites. There was potential for water collection to drop again on the restoration of the normal price because of the price shock of returning to 3 KES (~0.02 USD), but this is not seen in these data either. Figures 3–6 show that the start of the price reduction was after when the rainy season onset began to influence collection between 20 and 22 days. This is because of the difficulty in predicting onset (see Discussion).

Analysis of the number of collection events per day or average litres per collection event showed no further insights. The revenue collected over the period followed the reduced water collection and was very low, as was the case with previous rainy seasons.

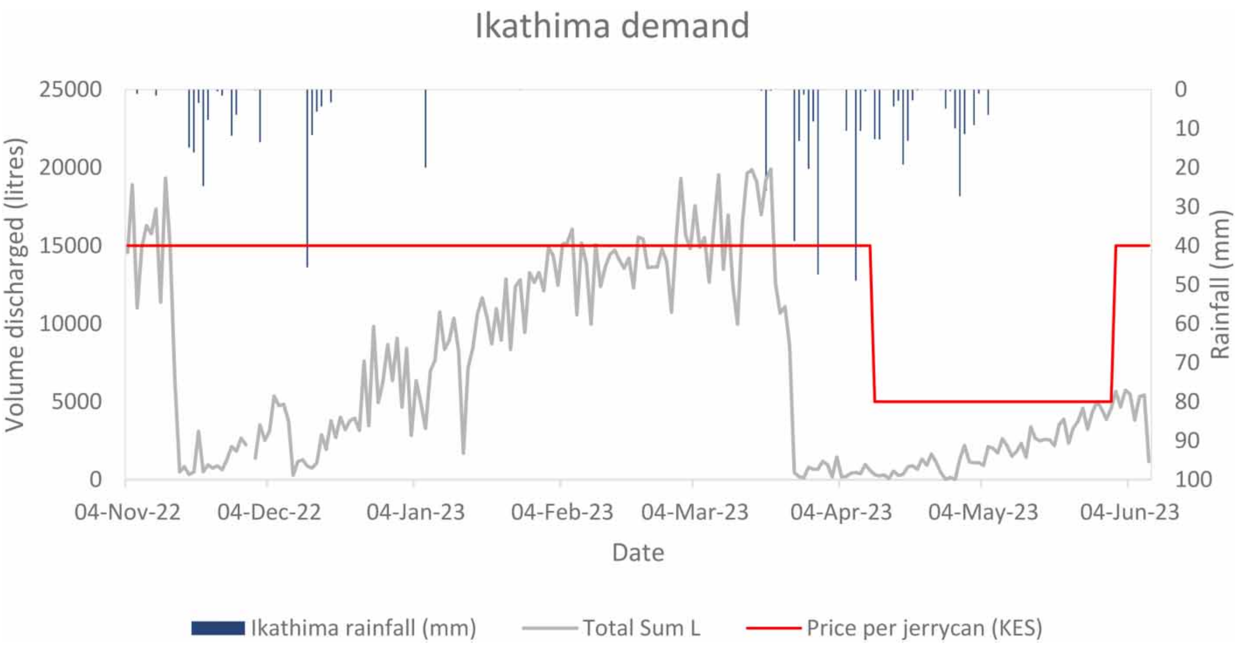


Figure 3 | Collection of groundwater at Ikathima kiosk.

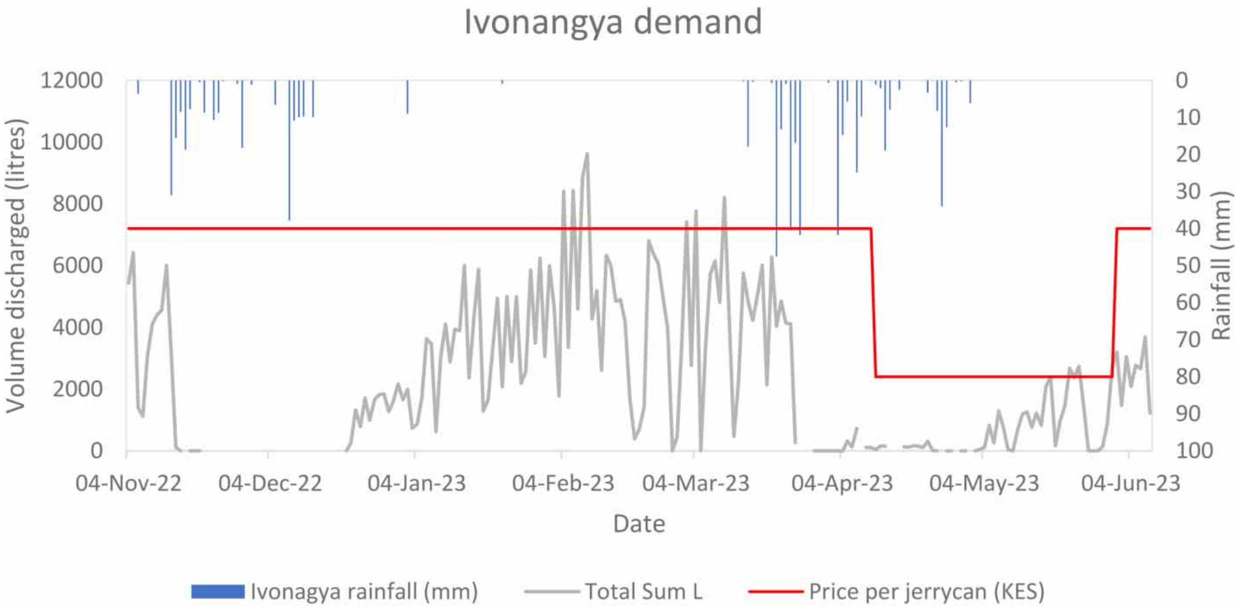


Figure 4 | Collection of groundwater at Ivonangya kiosk.

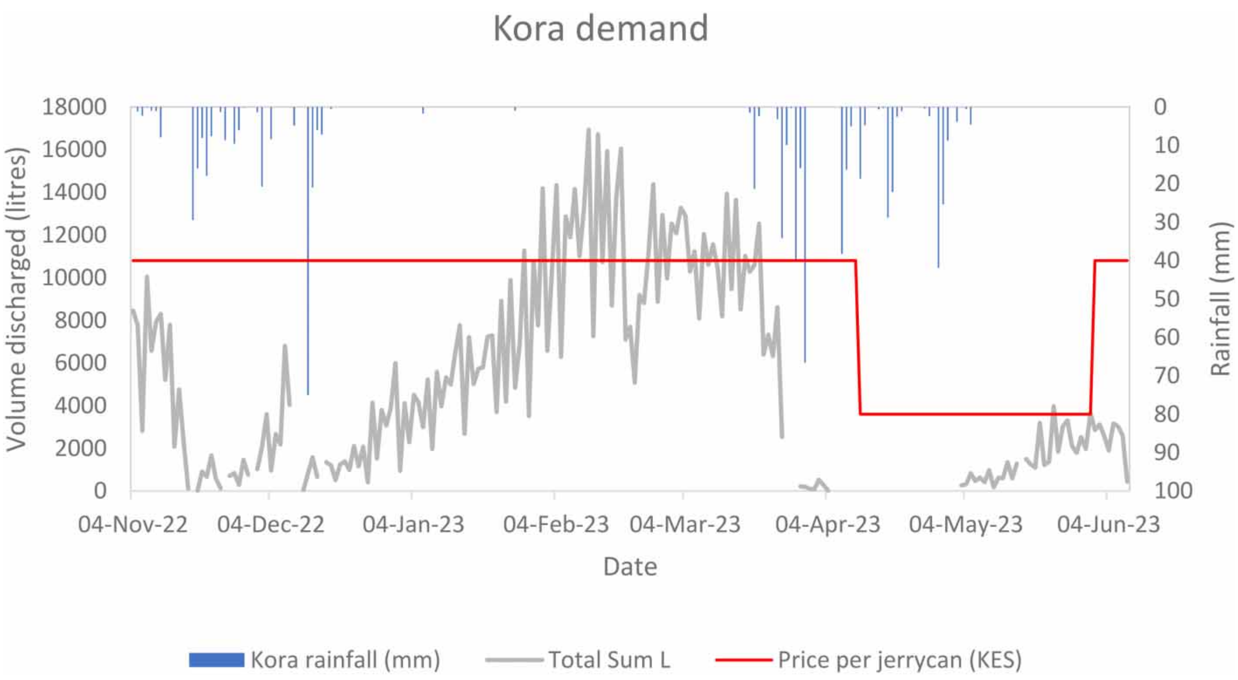


Figure 5 | Collection of groundwater at Kora kiosk.

The price reduction tested here did not result in significant lost revenue compared to the revenue that would have been collected at the normal 3 KES (~0.02 USD) per jerrycan, assuming no price influence, as shown in Table 2. Based on the assumption that the volume of water sold would have been the same if the price were not reduced, the total revenue lost due to the price reduction in this study was 14,586 KES, or about 100 USD, not including administrative costs.

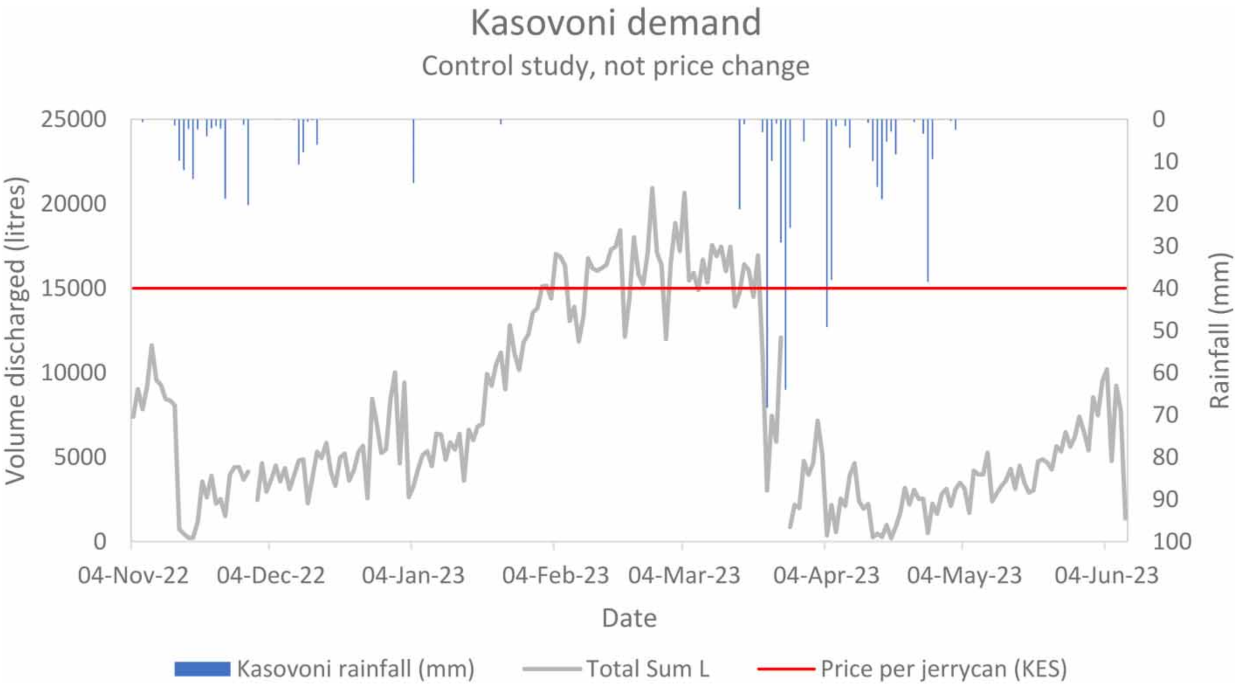


Figure 6 | Collection of groundwater at Kasovoni kiosk (control).

Table 2 | Lost revenues from the study

Community	Ikathima	Ivonangya	Kora	Kasovoni (control)
Total volume collected over study (L)	98,379	30,644	42,840	166,571
Expected revenue over study period at 3 KES per jerrycan (KES) [(vol/23) * 3]	12,832	3,997	5,588	21,727
Actual revenue over study at 1 KES per jerrycan (KES)	4,482	1,361	1,988	As above
Lost revenue over intervention	8,350	2,636	3,600	Nil
	Total lost revenue = 14,586 KES (~100 USD)			

DISCUSSION

In this study, it appears that a price reduction of 3 KES (~0.02 USD) to 1 KES (<0.01 USD) per jerrycan had no influence on the collection of groundwater from kiosks in these communities. The communities remained exposed to health risks associated with drinking lower-quality water collected from surface sources and roofs. This lack of influence of price reduction was seen for kiosks used for both household water and livestock.

It was hypothesised that there would be some increase in water collection with the price incentive and associated messaging, particularly for the kiosks that primarily provide water for household use, counteracting the decrease in willingness to pay observed during rainy seasons. A review of the price elasticity of communal water points across developing countries averaging at about −0.4 (Ingram & Thomson 2022) suggested that there would be at least some impact on demand from a lowering of price. Water source substitutes, the low-income context, lack of water scarcity, and a lowering of an affordability hurdle should all act to increase demand as shown elsewhere (Jansen & Schulz 2006; Cheesman *et al.* 2008; Nauges & van den Berg 2008; Nauges & Whittington 2010; Garrone *et al.* 2019). The lack of change in demand seen here is unexpected and suggests that a price reduction on its own is not an effective intervention to increase water collection from public kiosks.

This finding emphasises the importance of other behavioural determinants behind water source choices in the community. Several price and non-price factors could influence these choices. Contextual knowledge of FundiFix suggests that the convenience of free alternative sources closer to the household such as rooftop collection compared to a public water point away from the household is possibly a major factor. Another might be the prioritisation of water quantity over quality. These would need further investigation with users. Previous socio-economic assessments here indicate that pastoralism and remittances are the main sources of income, with some additional income from farming rain-fed drought-resistant crops such as green grams (Hoque & Hope 2018). While there is some limited, anecdotal evidence of reduced cash reserves prior to harvest that might affect the ability to pay for water, seasonality has not featured prominently as a key influence on household incomes and payment for water. This suggests that liquidity is not an issue. Households spent an average of 2.1% of monthly expenditures on water across diverse water points (Hoque & Hope 2018), suggesting that this price drop is not substantial relative to other expenditures. How users conceive of payment and value may also help explain why users were not influenced by lower prices. The pre-payment of credit with water ATMs can mean that users often top up in bulk and then use the credit until it runs out. Only half of the respondents in a study of water ATMs in a similar setting in Tanzania had any precise understanding of price per volume (Ingram & Memon 2020).

The combination of economic factors with perceptions of relative health risks of different water sources does not influence behaviours as much as we might have expected. This further emphasises the importance of motivations, barriers, and decision-making processes of users, alongside contextual factors, that shape household behaviour for accessing clean water points. This is an area of increasing research. For example, new evidence from Kenya shows that stronger feelings of collective ownership towards (non-ATM) safe water kiosks are associated with greater use during rainy seasons (Contzen & Marks 2018; Contzen *et al.* 2023).

To understand if seasonal price reductions might influence collection from communal water points in other contexts, we suggest that qualitative investigations into the role of psychological, social, institutional, and economic determinants behind the choice of water source are crucial. The relatively small amount of revenue (about 100 USD) lost from the reduced price over three communities during this study is a low enough cost to propose that similar price drops be tested, based on such qualitative understanding, under different and potentially more favourable circumstances by other service providers. For example, this can be implemented easily where water ATMs are already operating, following the above method, especially in cases where public water points are closer to households.

The timing of the price drop was misaligned with the onset and end of the rainy season in this study. Accurate on-the-ground information was challenging, coming second- or third-hand and geographically non-generalisable. Satellite rainfall data were not readily available in real time and had inaccuracies on the daily timescale and poor resolution for village-level decision-making. We were able to infer limitations of the rainfall information from the drop in groundwater volumes seen in the water collection data (Thomson *et al.* 2019; Ingram & Memon 2021). If the price drop had started before the rains arrived the behavioural incentive in users might have been instilled more effectively; however, this would have risked significant lost revenue from the period when demand was still high. While this further underlines the utility of accurate forecasting and weather products, especially as weather patterns become less predictable under climate change, it also demonstrates the limitations of hydrometeorological forecasting for weather-based interventions.

IMPLICATIONS FOR PRACTITIONERS

The study highlighted factors relevant to other service providers. The first is that water ATMs provide an opportunity for more nuanced operations beyond monitoring and reporting. It is possible to make price changes and analyse the results with a new degree of precision, accuracy, and speed. This is not prohibitively onerous for staff but does require a different set of skills than those required to repair and maintain water supply systems (Nyaga *et al.* 2024).

The second is that price changes alone, even with the messaging FundiFix provided, did not increase demand. Offering or changing a service does not necessarily stimulate demand or behaviour change. Further engagement with communities to consider factors such as beliefs, norms, awareness of health benefits, trust in water quality, and economic pressures was implicitly needed.

Finally, it was clear that the rainfall information available was not accurate enough to time the price drop for the onset of the rains. Rainfall information directly from the community would have been more useful in this case, as the timing of the onset of rain was likely more important than an accurate measurement of the amount of rain.

FUTURE RESEARCH

This study was conducted at a small scale by one service provider in anticipation of a possible slight increase in clean water consumption and revenue and at worst a minimal reduction in revenue. This study shows that possible revenue losses are probably low enough to test this type of intervention further without it having a significant negative impact on service providers' finances. A deeper qualitative understanding of users' responses to price reductions will be an important precondition to further testing, and interviews with users can provide this data.

A more comprehensive study should include investigating effective messaging for community awareness of the price drop and its implications. This could incorporate health messaging drawn from the behavioural sciences and a better understanding of the basis of household water collection decisions. A more formal study could also include longitudinal interviews or surveys to understand how and why different households and water users responded, or did not respond, to the change in price, and an investigation of water credit on users' tags. Considering intersectional identities and varied water needs could identify more equitable and inclusive strategies.

A future study could also consider different ways of incentivising increased water collection. In this study, FundiFix reduced the volumetric price of water. An alternative could be to send credit directly to users' tags for use only during the rainy season, using the principles behind conditional cash transfers, which are widely used in other development programmes. This could have several advantages. It might instil the idea of having gained something that needs to be used during a limited period, which could be more effective than reducing the price. It allows targeted support, for example with all households receiving the same extra credit so that the benefit of the scheme would not go disproportionately to larger users (e.g., those watering cattle). It would also provide a mechanism for the service provider's lost revenue to be replenished directly by external subsidy, and the value of this subsidy only be reclaimed if the credit is used. This could appeal to funders as a simple, measurable, and output-based way to directly increase clean water use and support service provider operations. Identifying such pathways to de-risk and innovate can help unlock private sector involvement in equitable development action (Gannon *et al.* 2021).

CONCLUSIONS

The seasonality challenge of the reduced collection of clean water impacts community health and service sustainability. In this study, the Kenyan service provider FundiFix tested the hypothesis that reducing the price of water at public kiosks during the rainy season would stimulate demand for groundwater, typically a safer source of water than the alternatives accessed during the rainy season. This price drop had little to no effect on demand, suggesting that the relationship between source and water quality and health that underpinned the rationale for this intervention is either not perceived or not valued by users, or that water source choice is more strongly influenced by other behavioural determinants.

While this study may have produced a null result, the revenue lost was very low and this intervention could likely be further investigated without adverse impact on the service provider. Such testing could be undertaken in a potentially more favourable setting and should include a more formal focus on behavioural incentives, water collection choices, and other ways of stimulating demand for groundwater other than a drop in volumetric price.

FUNDING

This project was supported by the University of Oxford's EPSRC and ESRC Impact Acceleration Accounts (reference number: 0012301; Grant number: EP/X525777/1), along with financial support (W.I. and K.G.) from the Grantham Foundation for the Protection of the Environment. It also received funding from UK aid, provided by the UK government, and from the International Development Research Centre in Ottawa, Canada as part of the Climate Adaptation and Resilience (CLARE) research programme.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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First received 23 January 2024; accepted in revised form 12 August 2024. Available online 22 August 2024