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Business Case Study: GDM Water Kiosks in Eastern Uganda

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Summary

Introduction

Small water enterprises, consisting of community-scale water treatment systems in combination with water kiosks, such as GDM water kiosks, play an important role in increasing access to safely managed drinking water, especially in rural areas. To run a small water enterprise sustainably, a well conceptualised business model is required. This case study presents insights on the impact of different community management and business models on the business performance and operation of GDM water kiosks.

Methods

Eawag started the installation and evaluation of GDM water kiosks at the shore of Lake Victoria in 2015. In the initial operation period, it was observed that the business model of the GDM kiosks was financially not entirely sustainable. Therefore, a survey to identify the factors that would support a successful business operation of the GDM water kiosks was conducted in autumn 2018. Based on insights gained during the survey and the experiences made during the first years of operation, an improved business model was developed and tested.

The organisational structures of the initial and improved business models were compared and their performances analysed using water meter readings, manual log book entries about the number of jerry cans sold to households and provided to schools, and data on the income and expenses. The improved business model also included automatic dashboard recordings on water volume consumed and financial transactions.

Results & Discussion

From 2016 – 2019, during the operation of the initial business model, the average daily water consumption at the kiosks was 1’000 – 2’000 L with the pay as you fetch (PAYF) model, and 3’000 – 5’000 L with a monthly subscription model. Monthly average revenues ranged from 20’000 to more than 100’000 UGX and monthly expenses from ~ 10’000 - 25’000 UGX, and from 200’000 – 270’000 UGX when instalments for paying back a new pump had to be made. Data analysis revealed that almost half of the water consumed was not reported and/or billed. Poor and unreliable management, untrustworthiness, the lack of technical skills, limited institutional and local ownership, inconvenient opening hours and a cheaper, but contaminated alternative water source were found to be the main challenges.

In the improved business model, the local government was better integrated into the organisational structure, the kiosk committee members were direct beneficiaries of the kiosk and local mechanics were more comprehensively trained. Additionally, an automatic pre-paid system (water ATM) was installed and the storage tanks elevated to increase the water pressure at the tap and reduce waiting times. With the improved business model, the monthly revenues increased by a factor of 3.5 to a monthly average of over 300’000 UGX. However, the water consumption in the studied kiosk dropped from 3’000 – 5’000 L to 2’200 L/day on average. Financial transparency increased tremendously, as water could only be accessed by swiping a pre-paid token.

Conclusion

During the operation of the initial business model, inadequate management and control mechanisms led to financial handlings that were not transparent, misappropriation of funds and underreporting of water distributed. The income initially generated was sufficient to cover the daily operations of the kiosks, minor repairs and to partially purchase new pumps. However, the income generated was not sufficient to cover the costs of major repairs or eventual replacement of the infrastructure (such as the replacement membranes, which have an expected lifetime of more than 10 years).

Our analysis provided evidence, that a water ATM can be a key feature in a sustainable business model for a rural water supply system because it can increase revenues and transparency. Even though the revenues increased in the improved business model, a GDM water kiosk will probably not generate sufficient income to finance the replacement of infrastructure. However, it was observed that overall water consumption dropped after the installation of a water ATM; therefore, specific measures need to also be introduced to ensure access to safe water for the poorest members of the community, who might not be in position to pay the standard water price. A strong local leadership that takes responsibility and ownership for the management and operation of the water business, localised and affordable operation and maintenance, and support from the local government are very important for a successfully operated rural business model for water supplies.

1. Introduction

In 2017, 65 percent of the population in least developed countries, particularly those living in remote rural settings or informal urban settlements, did not have access to a safely managed drinking water supply (WHO 2019). Small water enterprises, consisting of community-scale water treatment systems in combination with water kiosks, therefore, play an important role in decentralised water supply (Nijru 2005). Various business concepts and ownership and management models have been implemented by different small water enterprises and are becoming more and more important: community managed systems, models operated by private or social entrepreneurs, public private partnership models, as well as community systems operated by public utilities.

Management and ownership models, expenses, pricing and location were identified to have a significant influence on sustainability (SWN 2014; Otter *et al.* 2020). In addition, the sense of ownership is a very important factor with a significant impact on the economic performance and sustainability of a water kiosk (Madrigal *et al.* 2011; Contzen & Marks 2018). Links to existing community structures, such as for example schools, can support the long-term operation of a kiosk (Butler & Weyrich 2013). Generally, a good operation is reported in relation with strong collaboration structures between key partners (Ampadu-Boakye & Hebert 2014).

Gravity-driven Membrane Filtration in Water Kiosks

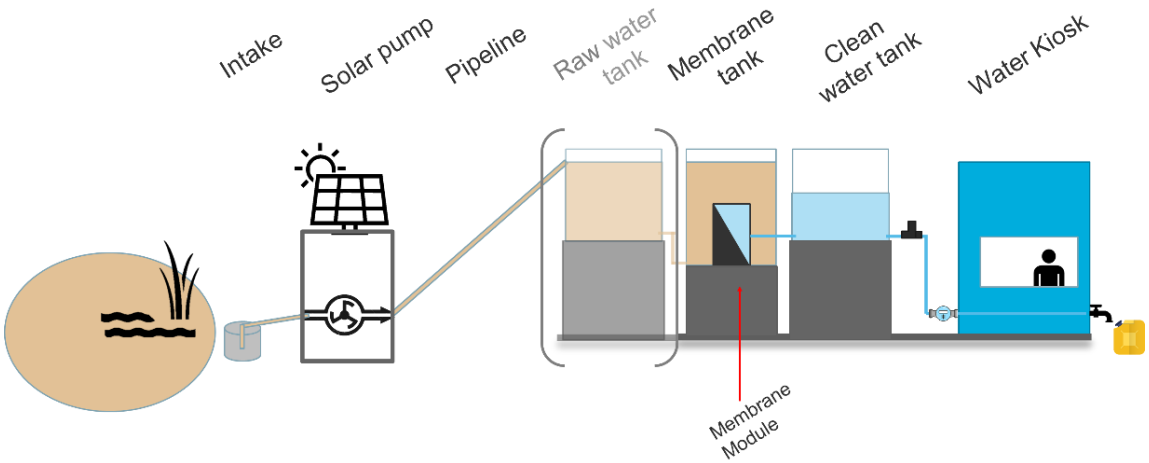

Figure 1: Overview of a GDM water kiosk

In Eastern Uganda, communities living at the shore of Lake Victoria use the untreated water from the Lake for a wide variety of purposes, including for drinking. The consumption of this highly contaminated water is associated with health risks. Therefore, water kiosks using gravity-driven membrane (GDM) filtration as a water treatment technology were constructed at five locations in Busia and Namayingo Districts.

GDM uses the gravity pressure of water and ultrafiltration membranes with a pore size of 20-40 nm to treat drinking water. When biofilm is allowed to form on the membrane over time, water flux stabilises at 4-10 litres per hour per square meter of membrane (LMH) and filters do not clog (Peter-Varbanets *et al.* 2010; Pronk *et al.* 2019). Very little maintenance is required to operate GDM systems (Peter-Varbanets *et al.* 2011). Project evaluations revealed that the systems are very durable and can be operated over years requiring only a monthly backflush. Filters remove sediments and all classes of pathogenic microorganisms, including viruses, bacteria and protozoa (Peter-Varbanets *et al.* 2017).

GDM filtration can be applied to drinking water treatment at household level, as well as at community level. Due to the ease of operation and low requirements for external inputs, such as replacement parts, chemicals or electricity, GDM is very suitable for installation in locally managed community-scale systems in remote areas (Peter-Varbanets *et al.* 2017).

An overview of the system is presented in Figure 1. In all sites, water from Lake Victoria is pumped up to the treatments systems at the schools using a solar pump. Depending on the set-up, the raw water is either pumped into a raw water tank (three tank set-up) or directly into the membrane tank (two tank set-up). Water is filtered with ultrafiltration membrane modules and the flows are driven by gravity to the clean water tank. The treated water is available for the community at the taps of a water kiosk. Project evaluation on the technical performance of the systems revealed that the GDM systems are very robust, can be operated with little maintenance over years also in very remote rural contexts and provide reliable water quality at the tap (Peter-Varbanets *et al.* 2017).

All the five water kiosks are owned and operated by the local communities. The management strategies and business models implemented have evolved since the inception of the water kiosks.

This case study presents insights on the impact of different community management and business models on the business performance and operation of the GDM water kiosks. The goal of this study was to assess the impact of the community management model and the effects of adaptions of the model on the business performance and operation of the GDM water kiosks.

2. Methods

Process of project implementation

Eawag started with the installation and evaluation of GDM water kiosks at the shore of Lake Victoria in 2015. The selection of sites for the constructions of the kiosks was done in collaboration with a local partner organisation on the basis of the following criteria:

- demand in the community for safe drinking water
- the only water source is surface water (pond, river or Lake Victoria) or saline ground water
- no source of industrial water pollution nearby
- presence of a local school with more than 500 pupils
- interest of the school management and the surrounding community in engaging in operation and maintenance of the water treatment facility
- village leader's support for the project
- willingness of the community to physically contribute to the construction of the facility
- near distance to a sufficient number of households in the catchment area
- no competing project is distributing water or constructing boreholes or wells

Five water kiosks were established at communities in Busime, Bulwande, Lugala, Bumeru and Bulundira in Busia and Namayingo Districts in Eastern Uganda.

Eawag collaborated with a local NGO and people from the selected communities on the installation and construction of the infrastructure of the water kiosks. Kiosk management committees were selected by the local community and trained in operation and maintenance of the systems and in business management and bookkeeping. The kiosks in Busime, Bulwand and Lugala started their operation in the first half of 2016, while the kiosks in Bumeru and Bulundira began in the middle of 2018.

A WASH training curriculum was developed and implemented in the local schools adjacent to each of the water kiosks. During the first year of kiosk operation, the local NGO conducted household visits and community meetings to highlight the importance of WASH and promote the sale of treated water at the kiosks. Water Experts of the local NGO and Engineers of the local Nalwire Technical School were trained on major servicing and maintenance of the GDM water treatment system and the solar pump.

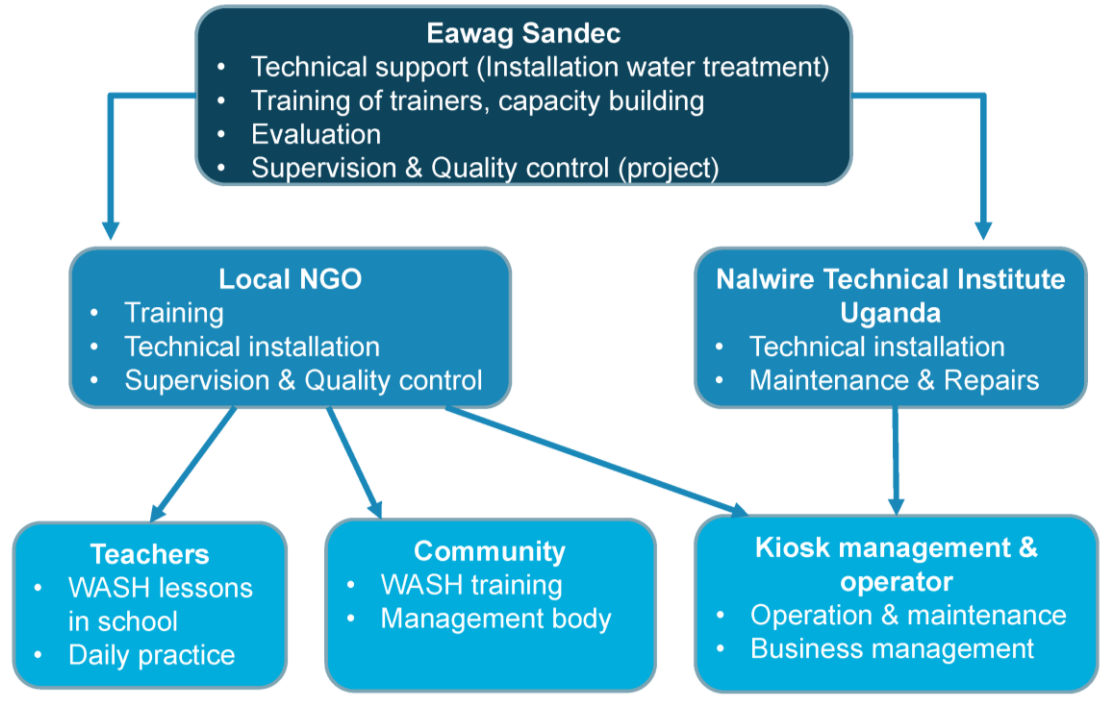

Figure 2: Responsibilities of stakeholders involved in project implementation

During the first three years of operation, water consumption at the kiosks was stable or continuously increasing. The revenues generated covered the local costs of daily operation and small repairs. The revenues, however, were not sufficient to cover the expenses for repairs that involved larger investment (such as the replacement of a pump), salaries of technical experts and their travel costs. Consequently, the business model of the GDM kiosks was not financially sustainable. Therefore, a survey to identify factors that would support a successful business operation of the GDM water kiosks was conducted in autumn 2018. It included a series of interviews and group discussions with stakeholders involved in the management, operation and use of the water kiosk.

On the basis of insights gained from the survey, experiences made during the operation of these facilities and continuous exchange on the performance of the GDM kiosks with the implementing organisation, the management committee of the kiosks, village leadership and individual users, an improved business model was developed to improve the sustainable operation of the GDM kiosks.

In November 2020, the improved version of the business model was tested at the GDM kiosk in Lugala. It included changes in the organisational structure of the kiosk committee, an automatic water vending machine (water ATM), opening of a bank account, the training of local mechanics and stronger involvement of the local government.

The water ATM enabled digitalised financial transactions, whereby users pay for a prepaid water credit, which is uploaded onto a token. Using the token, users then can withdraw water from the water ATM without the operator having to be present. Data of financial transactions and water volumes dispensed are recorded by the ATM and transferred via mobile internet (SIM card in the ATM) to a central server. Current information updates are monitored online on a dashboard.

The structure of the original and improved business models were analysed using the business model canvas from Osterwalder and Pigneur (2010) and organigrams.

Data collection and analysis

Between 2016 to 2019, the following operational parameters were monitored:

- water consumption via water meter readings
- number of jerry cans distributed per day (number of jerry cans sold to the customers and number of jerry cans given away for free to the schools)
- revenues generated from water sales
- expenses initially were only irregularly recorded by the local management teams

These parameters were recorded by the kiosk operators in log books. Data was then manually transferred by staff of the local NGO into a digital Google sheet. Mainly due to technical issues with the solar pump delivering water from Lake Victoria to the water kiosks, the water kiosks experienced non-operational periods of weeks to months. The absence of the kiosk operator or not sufficient sunlight were responsible for shorter interruptions (days to weeks). The treatment site with the ultrafiltration membranes did not face any technical issues and never was the cause of service interruptions.

For the analysis, only data from months with a water consumption of more than 5 m^3 was considered, as it was assumed that a system breakdown was responsible for lower volumes of consumption. Between January 2016 and July 2019 (40 months), the system was not operating for ten months in Bulwande, six months in Lugala and three months in Busime.

The systematic assessment conducted in autumn 2018 included structured, quantitative household interviews with 60 randomly selected households in Bulwande and Busime. In addition, household interviews were conducted with 15 purposively selected households that previously used to buy water from the kiosks in Bulwande or Busime, but stopped doing so. The questionnaire contained closed and open questions on the use of and preference for different water sources, including the water kiosk, volumes purchased, payment schemes and reasons for the use or non-use of the water kiosk. Interviewees were also requested to provide suggestions for improvements.

Semi-structured qualitative interviews were conducted during focus group discussions with the kiosk management committee, the school management and teachers and with the parents association. Individual semi-structured qualitative interviews were conducted with the kiosk operators, the chairperson of the kiosk

committee and the head teacher, using a structured interview guide with questions on the type and numbers of customers of the kiosk, purpose of the water purchases, reasons for the use and non-use of the water kiosk, challenges faced so far in operation and maintenance of the kiosk. In addition, the interviewees were requested to provide suggestions for improvements to the management procedures of the kiosk, the community outreach activities, and the relation between operators and the customers, and to assess the location of the kiosk.

Interviews were conducted in the local languages, Samia and Luganda. The answers of quantitative interviews were recorded on tablets via the application Open Data Kit. Notes of the qualitative interviews were taken on-site.
Interviewees were informed about the purpose of the interviews, that participation is voluntary and that the information provided would be anonymised. Interviews were only conducted with persons or groups that had provided informed consent.
The study protocol was reviewed and approved prior to the survey by the Ethics Committee of Makerere University, the Uganda Nation Council for Science and Technology, and the Ethical Committee of Eawag, the Swiss Federal Institute of Aquatic Science and Technology.

After installation in November 2020, the water ATM automatically monitored the water consumption and the revenues generated from water sales in Lugala. Water consumed was measured via a water meter installed in the water ATM. The revenues were logged automatically from the system’s transactions. The data was sent to an internet online dashboard. To compare the data on water consumption from the dashboard of Lugala with the water consumption of the other kiosks, the local NGO collected the data that was recorded in the log books of the kiosks.

A limitation of the analysis was the quality of data in the log books. The data were recorded in log books by the kiosk operators and transferred to an Excel sheet by the local NGO staff. There were several sources of errors in this process. For example, the number of jerry cans were recorded with tally marks by the kiosk operator. It is likely that the number of jerry cans recorded was not always correct, either due to intended or unintended errors. The values of the water meter readings, however, were probably accurate. An in-depth comparison of data recorded in the log book and values reported in the Google sheet was conducted in Busime. Between January 2016 and July 2019, the total amount of revenues collected differed by 6% (log book: total = 2.10 mio UGX, monthly average 52’600 UGX; Google sheet: total = 2.23 mio UGX, monthly average: 55’700 UGX). On average, the monthly incomes were 6% higher in the google sheet (mean difference = 2’725 UGX/month, standard deviation = 20’212 UGX/month, max difference = 67’000 UGX/month). In 20 out of 38 months, the difference was smaller than 5%. These findings suggests that the process of transferring the data from the log book to the Google sheet was subject to errors.

3. Results and Discussion

Initial management structure and business model

The organisational structure of the original management model is shown in Figure 3. The kiosk committee consisted of nine members from the local community. The local councillor 1 (LC1), a lower level government representative, attended the meetings of the kiosk committee upon invitation. The kiosk committee also reported to the LC1. The local NGO that implemented the project was in regular contact with the chairperson of the committee and the kiosk operator, but did not frequently meet with the local government representative.

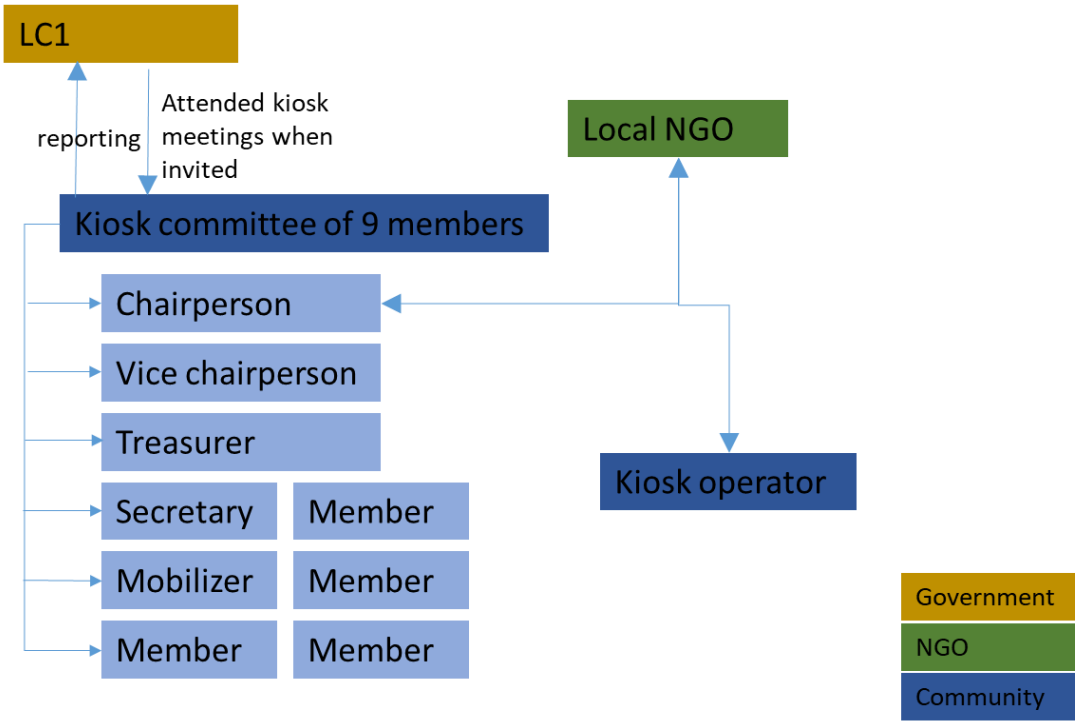

Figure 3: Organigram of the initial kiosk management (LC = local councillor)

The canvas of the initial business model is presented in Figure 4 and the following explains the terms in that figure. One **key partner** was the Nalwire Technical Institute, a University of Applied Science in Eastern Uganda, that trains water engineers. An engineer from the Nalwire Institute, together with water experts from the local NGO, were responsible for the installation and maintenance of the kiosks. The local NGO was responsible for the communication with the local community, trained the management committee and the operator in business management and operation of the water kiosks, was responsible for monitoring and communicated with Eawag.

The **key activity** of the kiosk was the treatment and sale of drinking water. A secondary activity was the management of the shop in the kiosk buildings that offered hygiene products and other products of daily use. The **key resources** included the infrastructure to treat the water, the contributions of the communities in the form of construction materials or manpower, the expertise of the kiosk operators and some voluntary engagements of people involved in management and operation of the kiosks. The key **value proposition** was to provide better access to safe drinking water and hygiene products.

The **relationship with the customers** was through initial household visits and community training and later via personal contacts during water sales. The schools had hygiene education included in their curriculums and the kiosk committees were informed during community meetings about the activities at the kiosks. The **customer segments** were the school children of the schools, where the kiosks had been constructed, and households living in the catchment area of the schools. The schools received the water for free. The largest share of water was sold to private households living near the kiosks. A small group of very poor families obtained the water for free. The decision of whether a family can get water for free was taken by the kiosk committees and the communities.

Regarding the **cost structure**, the revenues generated by the water sales were used to cover the expenses for the operation of the kiosk and small repairs. The capital expenditure for the installation of the infrastructure, major repairs, training and capacity development and initial promotion activities were covered by external funds. The kiosk committee paid for minor repairs, meeting allowances and, after some time, salaries of the kiosk operators. Two different payment models were implemented as **revenue streams**. In the pay per usage model, customers paid per 20L jerry can. The starting price of 50 UGX per jerry can was later raised to 100 UGX. In Lugala, the customers paid for their water via monthly subscriptions of 3'000 UGX that permitted them to initially collect five and later three jerry cans per day.

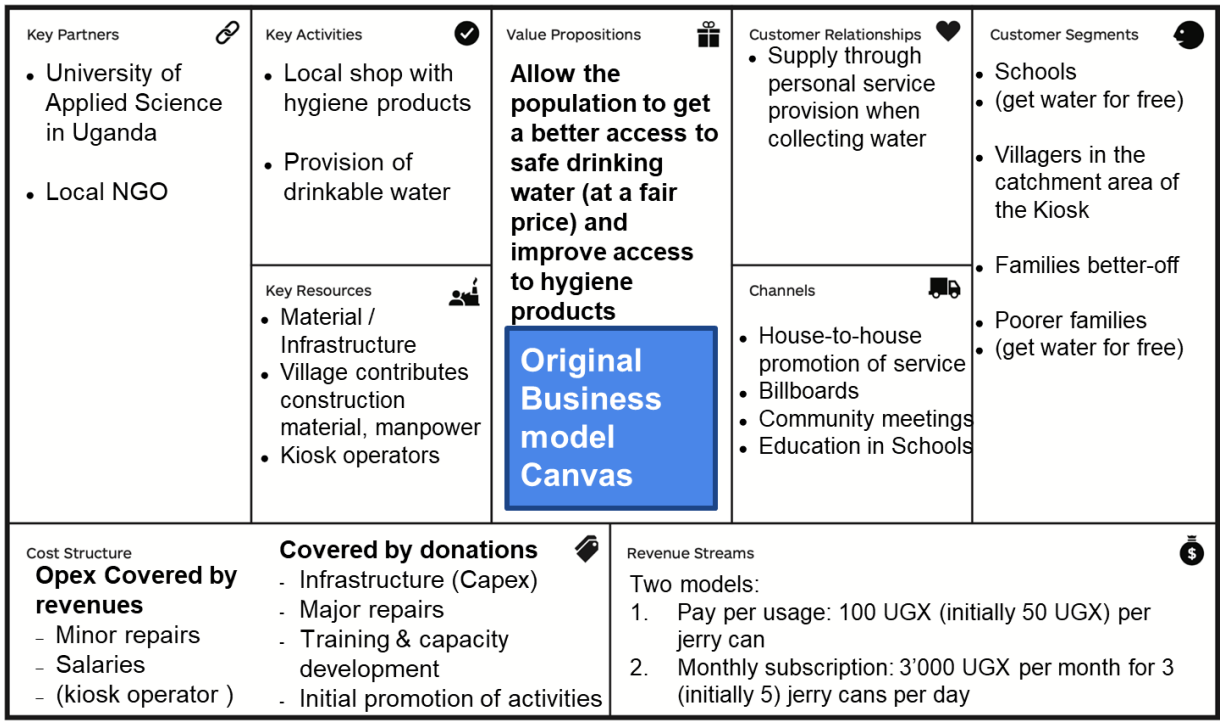

Figure 4: Business model canvas of original business model

Water sale in the initial business model

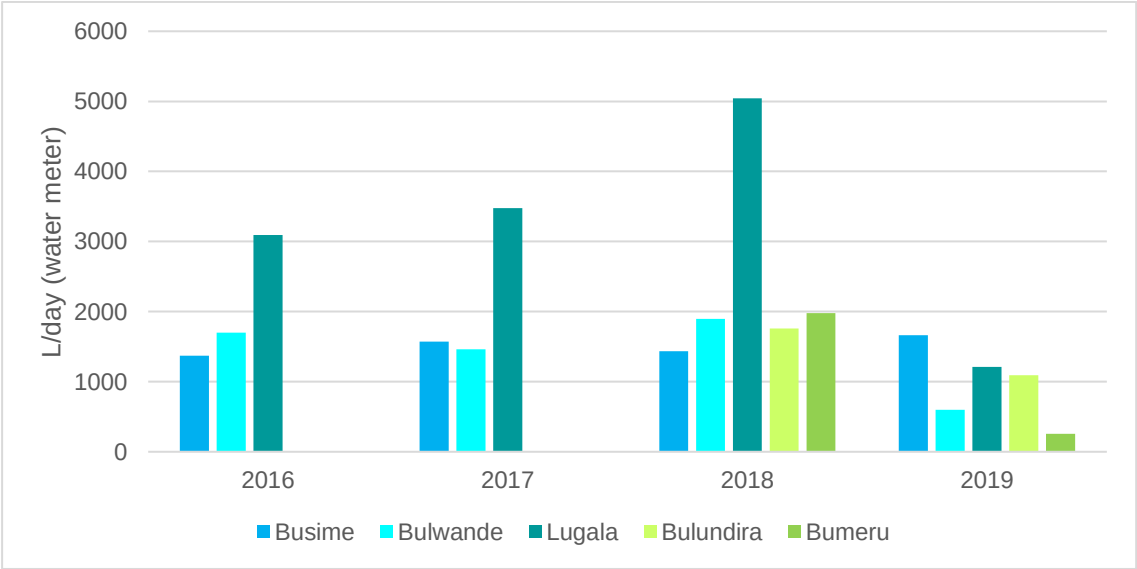

Figure 5: Daily water consumption from 2016-2019 in the GDM kiosks based on the water meter reading

Figure 5 presents the daily water consumption in the different GDM water kiosks. From 2016-2018, the amount of water consumed was quite stable. Lugala, where people paid for their water in monthly subscriptions, had the highest water consumption. A plausible explanation for this is that the lower water price per jerry can than at the other water kiosks motivated customers to collect more water. With the monthly

subscription, a jerry can cost 33 UGX (initially 20 UGX). Compared to the pay as you fetch (PAYF) prices (100 UGX, initially 50 UGX) this is only a third of the cost. In addition, households paid a flat rate that enabled them to collect initially five, then later three jerry cans per day. In the PAYF model, customers were more likely to keep their costs low by collecting the lowest volumes of water required.

In 2019, data from the water meters indicated that the water volumes consumed decreased significantly with the exception of Busime. All the systems struggled with the functionality of the pump in that year. In addition to problems with the pump, serious management issues were reported in Bulwande. In Lugala, a highly motivated operator left the kiosk, which led to irregular opening times and the decrease in water sales.

Another reason for the lower water consumption at the kiosks could be that the operators reduced the distribution of water that was unaccounted and not paid for after they were informed that monitoring revealed a high discrepancy between the water meter readings and the reported volumes sold (also compare with Figure 7).

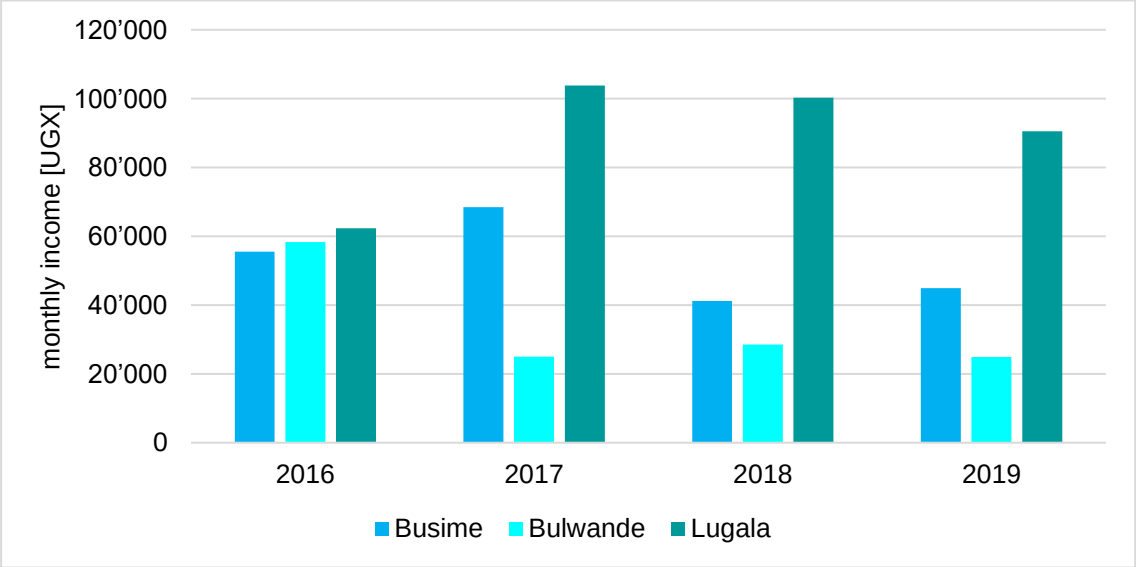

Figure 6: Monthly income from water sales of the GDM kiosks from 2016-2019

Figure 6 presents the monthly incomes of the different GDM kiosk from 2016-2019 when the pump was operating. Large differences between the kiosks can be observed. While the water consumption in Busime was more or less stable from 2016 - 2019 (Figure 5), the average monthly income decreased in 2018 and 2019 (Figure 6). We hypothesise that the reported income decreased due to increased untrustworthiness in the management of revenues generated at Busime in 2018 and 2019. Similar discrepancies between water consumption and revenues generated were observed in Bulwande. In Bulwande, reported revenues disproportionally dropped already in 2017 to a level of around 20'000 UGX per month. One possible explanation for this could be that the sense of community ownership was particularly low in Bulwande, according to the local NGO, and that the kiosk operator frequently changed.
In Lugala, the monthly income increased to over 100'000 UGX per month in 2017, but decreased to 90'000 UGX per month from January to July 2019. Surprisingly, the revenues did not drop as much as the water consumption. A possible explanation is that the customers were loyal to the kiosk and paid their monthly subscription during the four months when the kiosk was not fully operational. The flat fee revenue collection in (Lugala) with a lower water price per jerry can lead to higher revenue collections than the pay as you fetch (PAYF) revenue collections in Bulwande and Busime. These findings contradict the results of a study by Foster & Hope (2017) that analysed the management and business performance of 200 water points over 27 years in Kenya. Foster et al. found that PAYF models generated double the revenue compared to the flat fee approach. A possible explanation for this is that the leadership of the management committee was particularly strong and the operator in Lugala highly dedicated. These could account for the high revenue at that site, while

weak monitoring and controlling systems at the other kiosks facilitated the misappropriation of revenue from the kiosks.

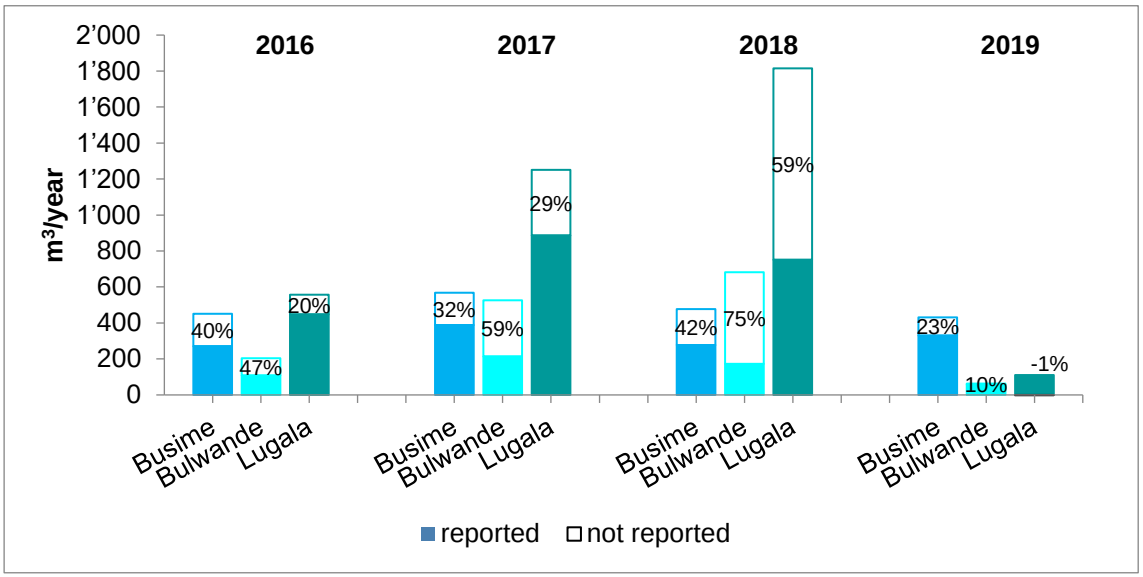

Figure 7: Comparison between the water consumption reported and the water meter

Figure 7 presents a comparison between the water consumption reported by the kiosk operator and the water meter. The number of jerry cans reported by the operator in his log book was multiplied by a water volume of 22L. The comparison of water sales reported in the log book and water consumption recorded by the water meter revealed that up to ¾ of the water consumed was not registered in the log book. In Busime, the proportion of water consumption not reported was constantly at around 30-40% until 2019, while the proportion of water not reported increased over the years at Bulwande to 75% and in Lugala to 59%.

In 2019, the proportion of unreported water sales decreased at all kiosks. A possible explanation for this could be the implementation of the survey in autumn 2018. The local partner was confronted with the high discrepancy between water metered and water sales reported by the kiosk operators. During the four years from 2016 – 2019, 44% of the water distributed had not been recorded in the log books.

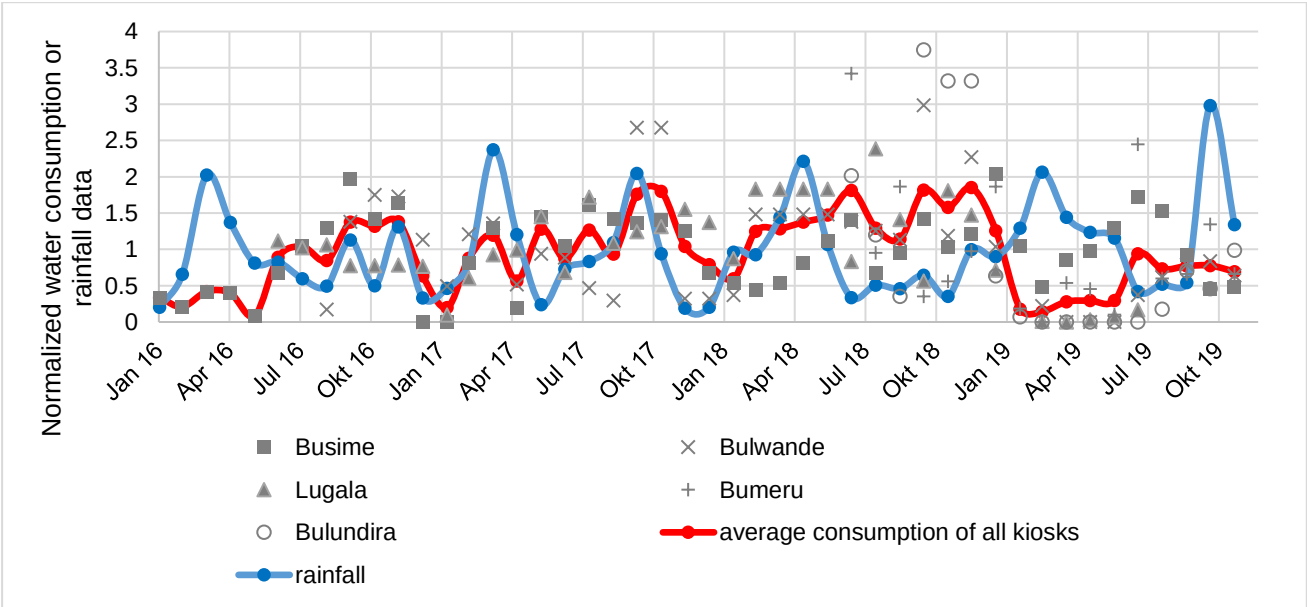

Figure 8: Water consumption compared to rainfall data of the World Bank

Figure 8 presents a comparison between normalised water consumption and rainfall data to investigate the potential association with the seasonality of water consumption. Monthly precipitation data of Bugiri district, a neighbouring district to Namayingo, from 2016 – 2019 was used (World Bank, 2022). The data was normalised over the period from 2016-2019. The water consumption did not clearly correlate with average rainfall data. Increased water consumption during dry seasons and lower water consumption in rainy periods could not be observed until June 2018. From July 2018 onwards, a tendency of anti-correlation can be observed. However, in the rainy season 2019 (March – June) the pumps were partly not working in Lugala, Bulwande and Bulundira. Foster and Hope (2017) found significantly lower revenues from water sales during the rainy season. Also at our study site, the local partner organisation reported that in the rainy season, significantly less people fetch water at the GDM kiosks because they harvest rainwater.

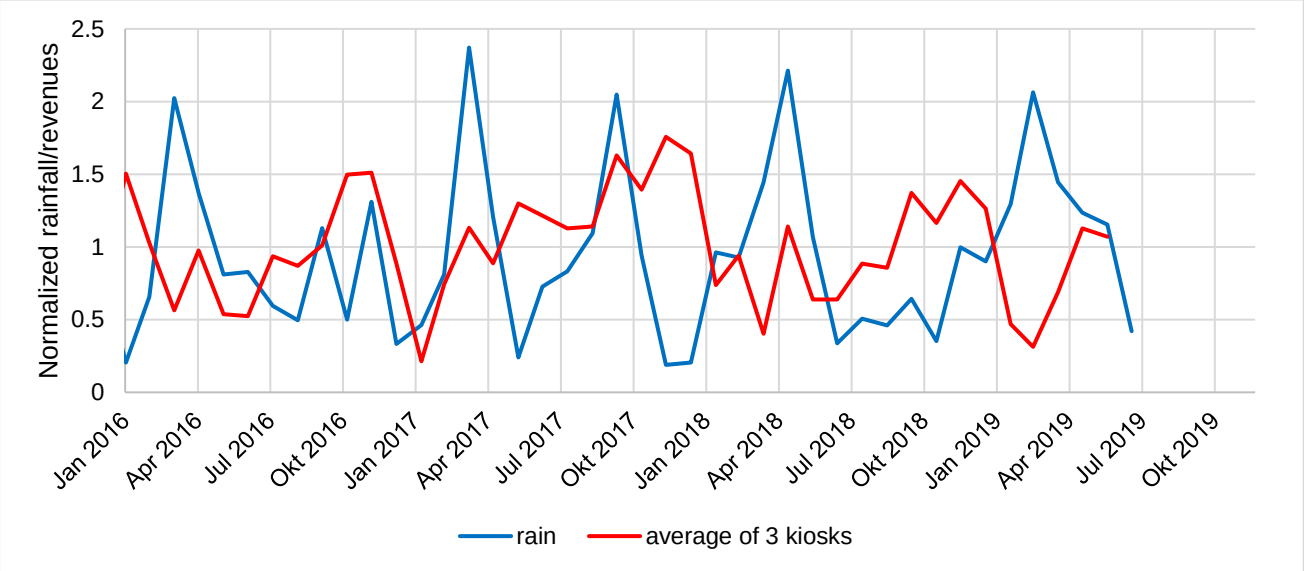

Figure 9: Revenues compared to rainfall data of the World Bank

Comparison of the financial revenues of the GDM kiosks and rain from 2016-2019 is shown in Figure 9. Revenues generated dropped during the rainy periods in April 2018 and April 2019, and increased during the dry periods in late 2017 and late 2018. However, consumption and rainfall did not anti-correlate before 2016 and data from the rainy season in April 2019 is misleading since some pumps did not function during this period in Lugala, Bulwande and Bulundira.

Anti-correlation is slightly more evident for water revenues than for water consumption. Possibly the kiosk operators used the water in the rainy season for other purposes than water sales, e.g. for cleaning the kiosk or irrigation, as it was available anyway. But, in this way, no revenues were collected. Overall, we suspect that other aspects, such as pump break downs, weak ownership or poor leadership might have had a larger impact on water consumption than the rainy season (see “Qualitative assessment of the initial business model”).

Expenses and savings in the initial business model

Table 1 provides findings on monthly revenues and expenses for operation and maintenance under the initial business model structure of the water kiosks. In Busime and Lugala, the kiosk committees had to purchase new pumps as the old ones stopped functioning and they were paid in instalments. If, in the considered period instalments had to be paid for the pump, it is noted in the table.

Table 1: Overview of profits with the initial management structure

location	*Busime*	*Bulwande*	*Lugala*	*Busime*
monthly revenues (UGX)	53'575	27'155	59'555	42'517
monthly expenses (UGX)	24'400	11'695	267'036	200'571
% expenses from revenues	46%	43%	448%	472%
instalments for pump	no	no	yes	yes
# months	22	11	11	12
Year	2017-2018	2019	2019	2019

The data revealed that average monthly revenues generated by the kiosks were sufficient to cover the cost of regular operation and minor repairs. Savings generated over a period of 1-2 years, however, were not sufficient to cover the major investments, such as the replacement of a pump that costs ~ 3'800'000 UGX. Not considering the cost for the replacement of pumps, more than 50% of the revenues could be saved, which is about 10 – 25'000 UGX per month. Expenses for the replacements of the pumps were about 4.5 times higher than the revenues generated. Considering these higher cost for amortisation, the operation of the water kiosks was not sustainable at all. With the initial management structure, the kiosks only generated sufficient revenues to cover operation and minor repairs, but not major investments, such as a new pump, new membranes, fundaments or buildings.

Qualitative assessment of the initial business model

The systematic assessment conducted in autumn 2018 identified the following challenges relating to the business model and management procedures of the kiosks at Bulwande and Busime, which generated lower revenues than the model implemented in Lugala:

- In Bulwande, customers also used a **nearby borehole** even though the groundwater was salty, as reported by our local partner organisation. The borehole was drilled after the construction of the GDM kiosk. For a monthly subscription of 1'000 UGX, an unlimited number of jerry cans could be fetched. Therewith, the borehole provided water at lower cost than the GDM kiosk if more than 20 jerry cans per month were collected.
- In Bulwande and Busime, **poor and unreliable leadership** was observed. The kiosk committees did not meet regularly and did not take responsibility for the kiosks' operations in case of breakdowns. Also, they did not control the presence of the operators at the water kiosks and their working hours. In Bulwande, representatives from the school that hosts the kiosk on its property, mainly selected the kiosk committee. The community was not involved in the selection. Therefore, the community members believed that the school owned the kiosk and, consequently, the ownership and involvement of community members was low.
- There was a **lack of transparency** and mismanagement of kiosk funds. There was no or inaccurate accountability of revenues and expenses and no control mechanisms were installed. Cases of misappropriation of kiosk funds were detected. Customers also criticised this lack of transparency in the kiosk management.
- In Bulwande and Busime, **inconvenient and/or unreliable opening hours** were criticised by the water users. Even though not directly mentioned by the kiosk operators or anyone else in the survey, we suspect that the voluntary or partially voluntary engagement of the kiosk operators were part of the reason why the opening hours became irregular over time. Voluntary engagement can decrease over time in community-based water supply systems (Harvey & Reed 2007; Quin *et al.* 2011; Leclert *et al.* 2016).
- In cases of breakdowns of the pumps, the kiosk committees did not notify the local NGO in time or the NGO did not immediately react to requests from the community. The **communication lagged** some days to weeks and led to interruptions of the water supply at the water kiosks for extended periods of

time. During the interruptions, customers had to collect water from alternative sources and in some cases they did not return to the kiosk after the repair of the pumps.

In addition to the challenges presented above that were identified during qualitative interviews and group discussions, the local NGO, which supports and services the kiosks and which was responsible for the capacity development of the local stakeholders on the operation and management of the kiosks, identified the following weaknesses:

- **Limited knowledge of the system:** Despite having originally planned capacity building activities, the local team (kiosk committee and operator) was not capable of conducting the required repairs when the system broke down due to lack of sufficient technical skills. Calling in the engineer from the local Nalwire Technical institute to also conduct minor repairs led to high maintenance costs.
- **Limited local and institutional ownership:** Due to the focus of involving the school management in the management of the water kiosks, the sense of community ownership of the kiosks was not sufficient. The kiosks were operated and managed by only a few individuals. The involvement of local leaders and district leadership needed to be improved.
- **Inadequate / inconsistent monitoring and data:** The monitoring of kiosk operation, control mechanisms and the data collected from the kiosks needed improvement.

Figure 10 presents a summary of the challenges identified in the original GDM kiosk business model and the proposed solutions.

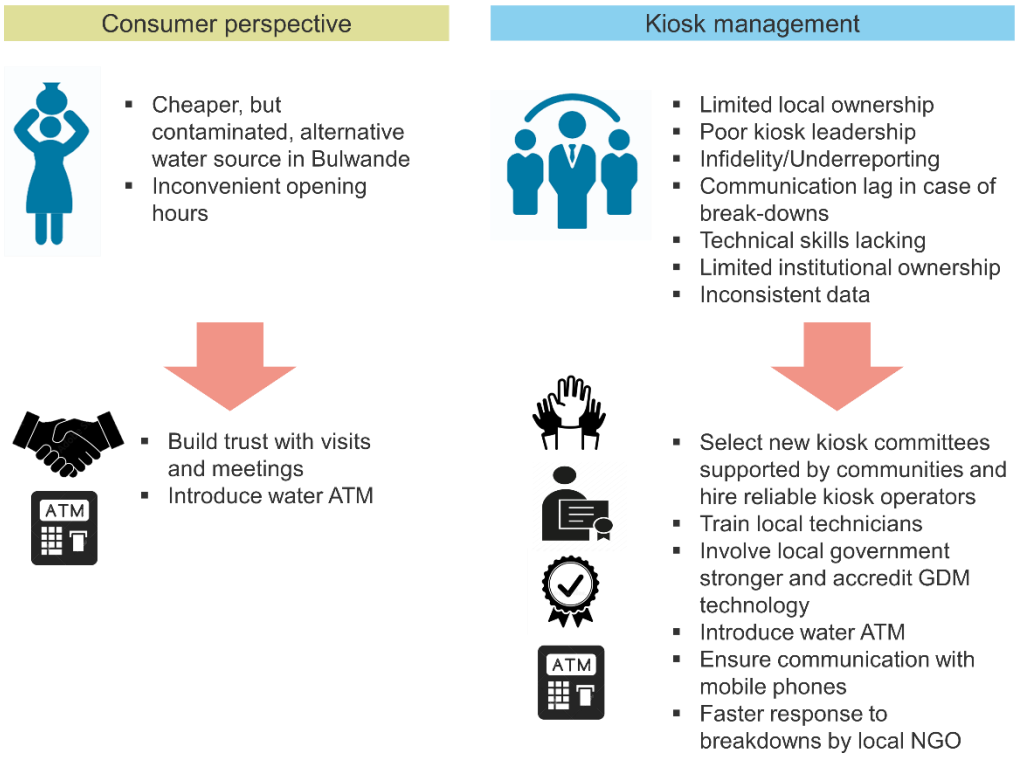

Figure 10: Weaknesses and solutions identified in the original GDM kiosk business model

Community meetings were organised to address issues of misappropriation of funds and underreporting of jerry cans and to reorganise the management structure, which involved new committees of the kiosks. Furthermore, it was identified that the operator's mobile phone costs had been a reason for not informing the local NGO about system breakdowns. Therefore, the operators were informed that their mobile phone expenses for calling the local NGO would be covered by the kiosk revenues. In addition, the local NGO committed to a faster response (within 2 – 3 days) to breakdowns. A key recommendation of the assessment was to have a cashless payment system in the form of a water ATM. Such an installation would solve the challenge with opening hours, as water can be accessed 24h a day. In addition, the automatic tracking of financial transactions and water volumes dispensed would enhance accountability, as water is only released if sufficient credit is on the tag (similar to a bank card). Another recommendation was to improve the training of

local mechanics to enhance the local capacity for minor maintenance work in the neighbourhoods of the kiosks.

Furthermore, the GDM technology should be accredited by the Accreditation Technology Center (ATC) of Uganda. With the official recognition, the GDM kiosks could be listed as official governmental water points. Therewith, the district governments would assume more responsibility for supporting the local communities in maintenance, including the allocation of financial resources.

Lessons learnt from the original business model

From the experience of the GDM water kiosks running the “initial business model”, we learnt that:

1. The experience in Lugala revealed that strong leadership and community commitment in management and operation combined with a monthly subscription fee can boost the water consumption.
2. In a cash-based payment system where the operator reported the jerry cans consumed with tally marks, it was challenging to establish a transparent accounting system. Almost half of the water that was consumed was not reported by the kiosk operators! As a result, it was unclear how the revenues were used to cover expenses (including the kiosk operator’s salary).
3. In our cases, a correlation between rainfall and water sales was not clearly evident. Other factors, such as kiosk management, opening hours or functionality of the system, seemed to be more important.
4. From the customers' perspective, convenient opening hours and a competitive water price were important factors that motivated purchases.
5. A reliable kiosk management that takes responsibility and leadership, as well as a transparent payment system, seem crucial for the sustainable operation of a GDM water kiosk.
6. Local technical know-how on how to maintain the system could improve the timely repair and maintenance of the water treatment system and reduce maintenance costs, instead of involving external experts from nearby urban centres.

Improved management structure and business model

Based on the insights gained during the initial business operations, several modifications of the initial model were implemented.

To enhance monitoring and accountability of financial transactions related to the sale of water, a Susteq water ATM was installed in Lugala on the 24. November 2020. In addition to the installation of the water ATM, a bank account was opened for the kiosk, to reduce the amount of cash in circulation that could potentially be misappropriated. Fundaments of the tanks at the water kiosk had to be raised as the water ATM requires a higher flow rate of the water for smooth operation. The increased flow rate at the tap also lead to shorter waiting times at the kiosk – an additional benefit to customers.

The existing kiosk committee was restructured to include current customers of the kiosk in the management and also include local government representatives. The new kiosk committee consisted of ten members, one being the LC1, a government representative. The remaining nine were direct beneficiaries of the kiosk and live in the area. The kiosk operator and two local mechanics were now also part of the kiosk committee.

The local NGO provided additional in-depth technical trainings on major kiosk maintenance and repairs to the local mechanics, the kiosk operator and the extension workers and technicians from the district government. The local mechanics were integrated into the management system as members of the kiosk committee. Enhancing the capacity of the local mechanics could reduce dependence on the engineer from Busia for maintenance to a more local level and therewith significantly reduce the expenses for transport and allowances to maintain and repair the GDM system. In the case of a system breakdown, the first ones to be contacted were the local mechanics. If they were unable to solve the issue, they contacted the district government. If the problem could not be solved by the district water office, the engineer from Nalwire Technical Institute or the water experts from the local NGO were contacted.

The LC1 government representative who is part of the kiosk committee regularly reported to the LC3, a higher-level government representative, who then reports to the district government (LC5). The chairperson of the

committee also reported to the local NGO and the committee reported to the community in quarterly meetings. The organisational structure of the improved management model is shown in Figure 11.

The process of establishing the GDM kiosk at Lugala as an official district water point in Namayingo was concluded in April 2022. To be affiliated as a government water point, the GDM technology needed to be officially accredited as an appropriate method to treat drinking water by the Appropriate Technology Center for Water and Sanitation (ATC) in Uganda of the Ministry of Water and Environment. With a Memorandum of Understanding, the local government committed to support the operation and maintenance of the GDM kiosk and is officially mandated to service the kiosk. Additional expertise for major maintenance and repair services is available at the Nalwire Technical Institute and the local NGO that had managed the construction of the systems.

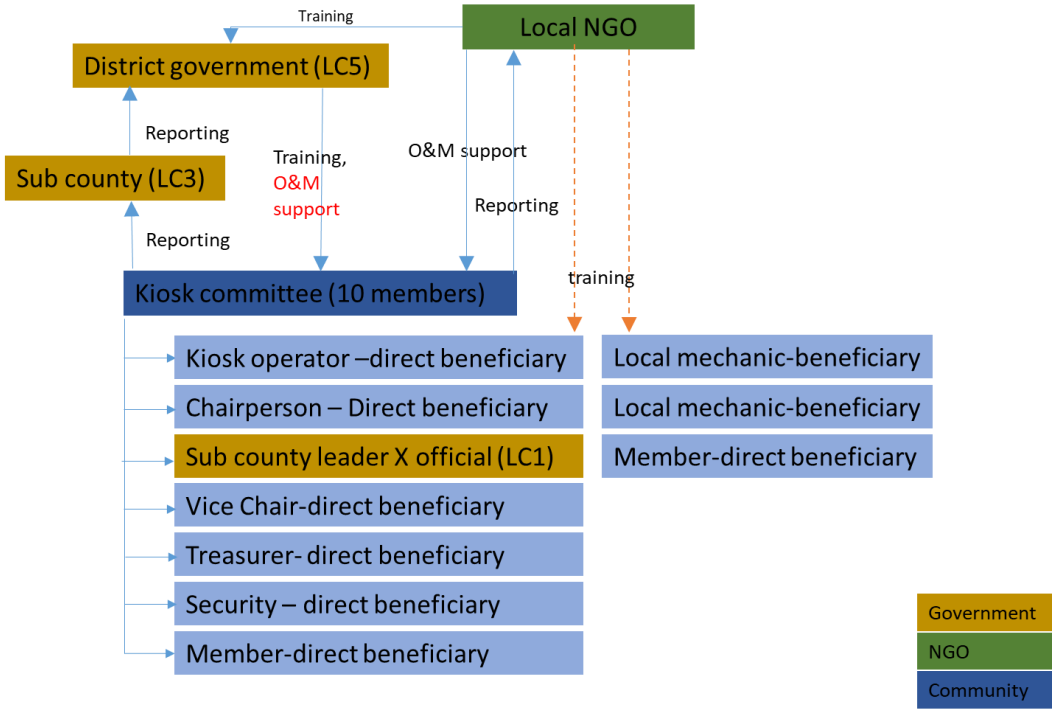

Figure 11: Management structure of the improved business model

The improved business model canvas is shown in Figure 12. The changes are highlighted in blue. The local government with local (LC1), county (LC3) and district level (LC5) were included as new key partners. As highlighted in key resources, the local mechanics played an important role in providing local technical know-how and responsibility. As they are being paid for repair work, they also appear in the cost structure. In comparison to the initial business model, the kiosk operators receive a regular salary. The installation of the water ATM led to a new form of customer relations: The customers now topped up their credit token instead of paying for the water in cash. In addition, they had 24h access to the water - also when the operator was not present at the kiosk. Water could only be accessed if it had been prepaid.

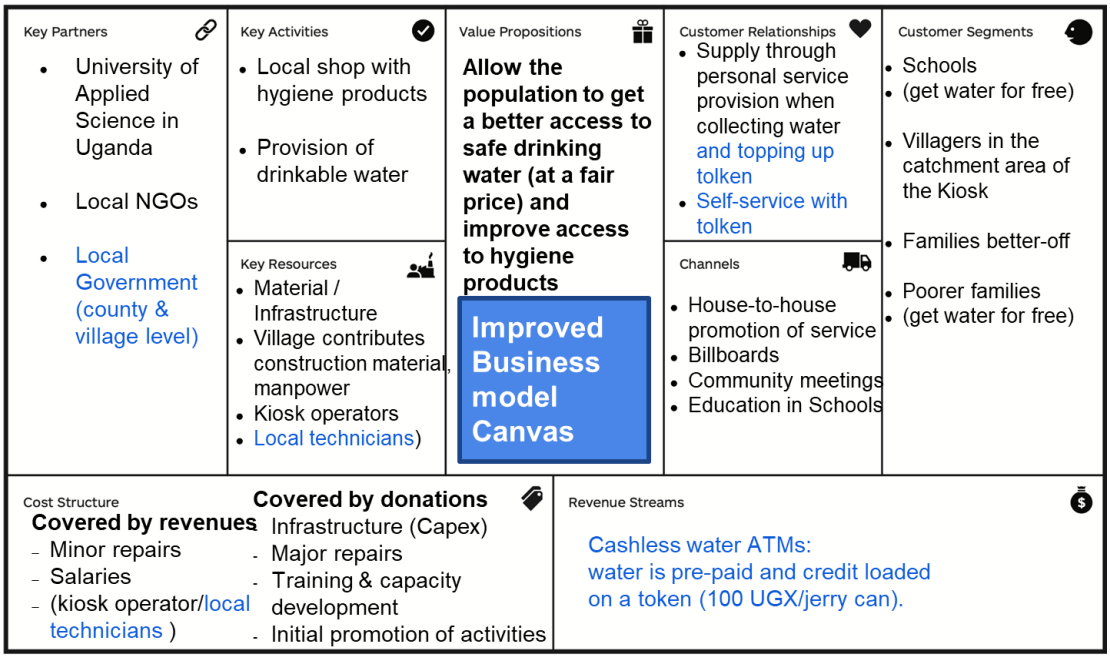

Figure 12: Business model canvas of the improved business model

Water sales in the improved business model

The improved business model was implemented at the Lugala GDM kiosk. Figure 13 presents daily average water consumption and monthly revenue from water sales after the installation of the water ATM since February 2021. On 20. May 2021, the pump broke down and kiosk operation stopped until July 2021 when the pump was repaired.

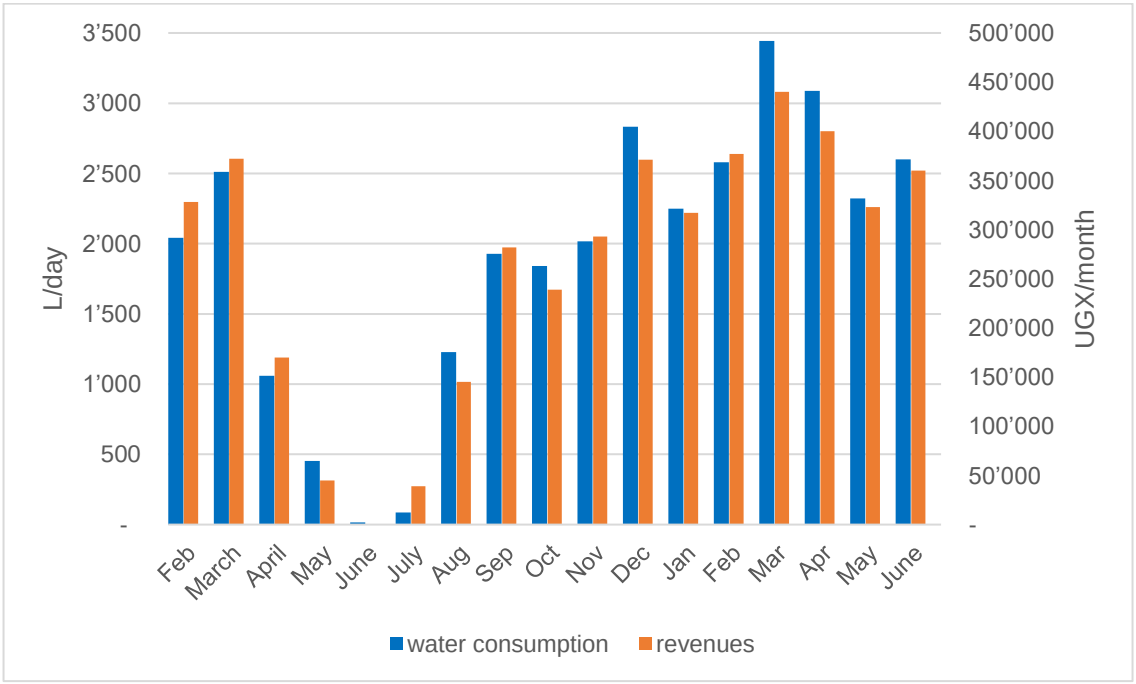

Figure 13: Lugala GDM kiosk daily water consumption and monthly income since installation of the water ATM (2021-2022)

In Table 2, key figures of the initial and the improved business model are compared for the periods when the system was operating (> 5 m^3/month).

Table 2: Comparison between initial and improved business model at Lugala GDM kiosk

	Lugala initial	*Lugala improved*
Average daily consumption	4'386 L/d	2'235 L/d
Proportion reported	64%	100%
monthly revenues (UGX)	81'386	310'286
monthly expenses (UGX)	n.a.	114'856*
% expenses from revenues	n.a.	37%
instalments for pump	no	no
# months	28	12.67
Year	2016-2018	2021-2022

* only for 8.67 months

Since the installation of a water ATM at Lugala, the overall water consumption dropped by about ½ compared to the 2016 - 2018 period, whereas the revenues increased by a factor of more than 3.5. During the period from March 2021 until June 2022, the average daily water consumption was 2'235 litres/day (not taking into account the time when the pump was not operational from mid-May until the end of July 2021). At the same time, the water revenues increased to an average of 310'286 UGX per month. From 2016-2018, the average daily consumption when the pump was operating was 4'386 litres/day, while the average monthly income was 81'386 UGX. Similar results were found by a different study that compared the income at two water kiosks where pre-paid systems were installed and found that the income doubled compared to the post-paid system (Tonya & Mpangala 2018).

In comparison, at the Bulwande GDM kiosk, where operations followed the set-up of the initial business model until autumn 2021, the revenue increased from an average monthly income of 32'500 UGX in 2016-2018 to 47'000 UGX in 2021. Thus, the income at Bulwande increased by a factor of 1.4 as compared to Lugala, where the income generated through the improved business model increased by a factor of over 3.5. The data also shows that, similar to Lugala, more water was consumed at Bulwande in the years 2016-2018 (1'685 L/day) than in 2021 (1'398 L/day). However, the decrease in water consumption was lower at Bulwande than Lugala where the water ATM was installed. In Bulwande, about 20% less water was consumed, whereas in Lugala the decrease was about 50%. However, while 100% of the water was reported in Lugala due to the installation of the ATM, only 42% of the water consumed in 2021 was reported at Bulwande.

The increase of revenues from water sales indicates a positive effect of the water ATM on business performance. However, water ATMs should not necessarily be considered as "a panacea for inclusive and sustainable rural water services" (Komakech *et al.* 2020). The study on the benefits and constraints of water ATMs concluded that: (i) the investment costs for a water ATM are high and unlikely to be covered by a rural community, (ii) prepaid technologies are likely to breakdown frequently, (iii) the prepaid technology is also not entirely transparent, (iv) the prepaid technology does not solve all socio-political struggles over water provision, and (v) improved revenue collection is not necessarily translated into better planning (Komakech *et al.* 2020). In our case in Lugala, the water ATM had been running for over one year. Until now, no breakdowns have been reported. This may be due to the high water quality provided at the water kiosk in Lugala, where water is treated by ultrafiltration prior to distribution, while the turbid water in the study of Komatech et al. increased the risks of clogging and failure of the control valve. The data collected via the water ATM at Lugala is provided to the management committee of the kiosk and the local NGO. However, the initial investment was covered by donors as the kiosk committee would not have been able to afford it.

The fact that less water is consumed, although a higher income is generated (Table 2), could potentially be problematic and needs further investigation. This also addresses socio-political aspects and the question of inclusiveness. Is it possible that some customers, especially from lower income segments, switched to unsafe sources because the price for water increased? How does the strategy impact efforts to provide universal access to safe water? If certain groups currently are excluded, how can or should the model be adapted to be more inclusive?

Longer term evaluations are required to assess if the improved revenue collection, monitoring and accounting will lead to the sustainable long-term operation of the kiosk. Additional factors, such as the impact of locally trained mechanics on reducing maintenance cost and government support for the established kiosks and potential scaling-up activities, will also have to be investigated.

Expenses and savings in the improved business model

Total expenses in the period from March 2021 until February 2022 were 995'800 UGX, which is an average of 114'856 UGX/month (considering the period of 8.67 months when the pump was operating). The expenses include the salary of the operator and minor operation and maintenance costs, such as transport costs, cleaning, small repairs, meeting allowances and mobile phone credit, etc. No major investments were made (repairs of pump, membranes or buildings).

Table 3: Comparison of expenses and savings from the initial and improved business models

location	*Bulwande*	*Busime*	*Lugala*	*Lugala*
Business model	Initial	Initial	Initial	Improved
monthly revenues	27'155	53'575	59'555	310'286
monthly savings	11'695	24'400	- 207'481	195'469*
% expenses from revenues	43%	46%	448%	37%
instalments for pump	no	no	yes	no
# months	11	22	11	12.67
Year	2019	2017-2018	2019	2021-2022

* only for 8.67 months

In the initial business model, not considering repayments for the pump, monthly savings of around 10-25'000 UGX per month were reported in Bulwande and Busime, which is 4 - 10 less than the savings generated in the improved business model in Lugala. The proportion of expenses from revenues was consistently around 40% in both the initial and improved business models. During the periods of the highest income generation of the initial business model in Lugala, the monthly income was around 100'000 UGX. That is three times less than the income generated with the improved business model. The monthly expenses for O&M, however, during the improved business model increased to 114'856 UGX from 10 – 25'000 UGX in the initial model. The higher costs in the improved model were generated by the employment of the kiosk operator who received a fixed salary and compensation to the local mechanics for maintenance work.

A breakdown of the revenues is presented in Figure 14. Almost 90% of the total revenues were used for O&M (~44%) or saved on the bank account (~44%). A bit more than 10% was accounted as "free water". This water was given away for free to school children and the most vulnerable households in the community. A breakdown of the type of expenses for O&M is presented in Figure 15. Most of the money was used for the salary of the operator, airtime (incl. mobile internet for sending data) and maintenance work. The data suggests that on the basis of income generated during the implementation of the improved business model, savings could be generated that potentially could contribute to major renewal investments (pump, membranes or buildings).

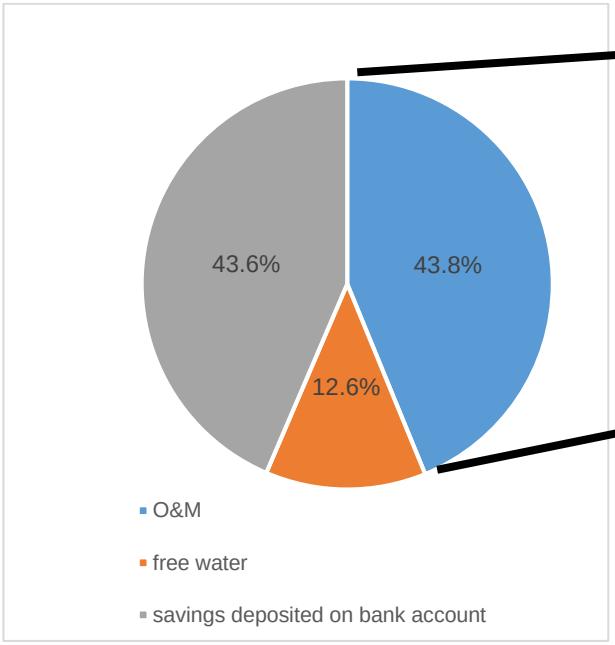

Figure 14: Breakdown of revenues from water sales

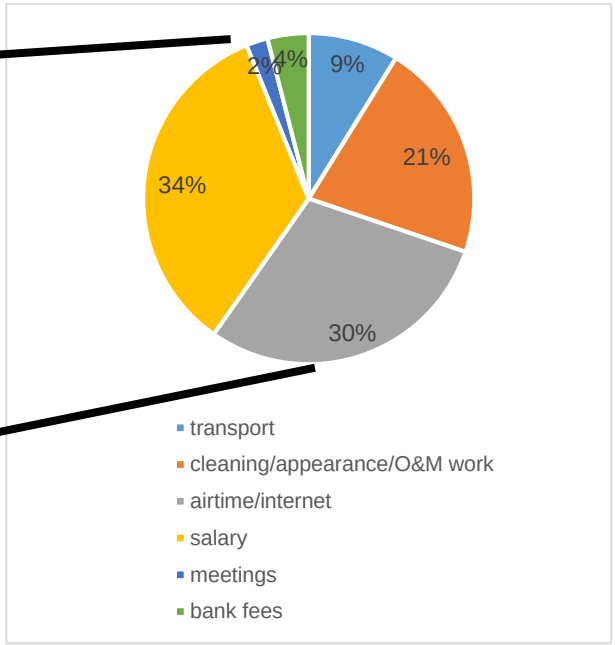

Figure 15: Breakdown of O&M expenses

Lessons learnt so far from the improved business model

1. The installation and use of a water ATM led to significantly higher revenues from water sales as all the water consumed was accounted for.
2. Water consumption decreased after the installation of the ATM. It needs to be carefully assessed why less water is distributed and if lower-income segments of the population are excluded due to the higher water price. Specific measures should be taken to assure inclusiveness (“leave no one behind”).
3. The water ATM offered transparency and reduced the risks of untrustworthiness by the kiosk operator. Every transaction was traceable.
4. A bank account improved transparency and could further reduce the risk of misappropriation of funds. However, it was quite challenging to register a bank account with multiple signatories as the next bank branch was far away and various documents were required to open an account.
5. The water ATM was a high investment and we believe that it usually would have to be financed by external funds (donors, government, etc.).
6. Due to the installation of the water ATM, it seems realistic that the revenue of a GDM kiosk could contribute towards major renewal investments (pump, membranes or buildings) in addition to the minor repairs.

4. Conclusion

This study assessed a community managed business model in GDM kiosks in Eastern Uganda and interventions to improve it. Insight gained during the operation of the initial business model of the GDM kiosks confirmed the importance of adequate management and business planning, transparent and traceable accountability and a strong leadership. During the operation of the initial model, inadequate management and control mechanisms supported financial handlings that were not transparent and that led to the misappropriation of funds and underreporting of jerry cans filled with water. This loss of valuable income poses a considerable threat to operating sustainable water treatment enterprises in remote rural locations where income levels of the population of the rural community are mostly low. Locally available, low-cost O&M services are, therefore, particularly important to keep the running costs low – even calling a local engineer from the closest small town caused a considerable cost burden i.e., covering his wage and transport - and to provide quick repairs upon demand.

A well-functioning maintenance service and regular opening hours are key for the water kiosk to be a reliable water source for customers. During each system breakdown, customers had to find an alternative source of drinking water and it took time after each repair for water sales to recover. Although not directly mentioned in the interviews conducted with the kiosk operators, we suspect that the irregular payments of salary under the initial business model over time led to unreliable opening hours. Other studies confirmed that voluntary or partially voluntary engagement decreases over time (Harvey & Reed 2007; Quin *et al.* 2011; Leclert *et al.* 2016).

The income generated during the initial business model was sufficient to cover the daily operation of the kiosks and minor repairs, and the kiosks were able to generate savings on their accounts that were used by two kiosks to partially purchase new pumps. However, the income generated was not sufficient to cover the cost of major repairs of essential equipment, such as a new pump, new membranes, new fundaments or new buildings. Therefore, additional stakeholders who could support larger maintenance and renewal of infrastructure are required, for example, the local government or external donors.

Measures to improve the initial business model included the installation of a water ATM to digitise and monitor financial transactions related to the sale of water, restructuring of the management committee to include current customers of the kiosk and local government representatives, and capacity development of mechanics residing in the community and technicians of the government on repairing the water system. In addition, the GDM technology was accredited in Uganda as an appropriate technology to treat drinking water by the ATC. This was a precondition that the district government of Namayingo committed to in order to support the O&M of the GDM kiosk in Lugala.

The installation of the water ATM increased the revenue by a factor of 3.5 and documented 100% of the water sales. These findings are comparable to insights gained from other studies where the revenues doubled after the introduction of a pre-paid water system (Tonya & Mpangala 2018). That is a significant improvement of business operations, as during the year before the ATM installation, almost half the water distributed was not accounted for. Our study provided strong evidence that a water ATM can reduce the risks of untrustworthiness of the kiosk operator or the kiosk committee. Even though a water ATM offers an attractive solution for revenue collection in rural water supplies, there are also potential drawbacks to consider. While the installation of the water ATM increased the revenues, concurrently, the overall water consumption dropped. The reasons for this need further investigation. It is possible that customers from lower income segments switched to alternative water sources. Specific measures need to be introduced to counteract and provide universal access to safe water for all. In Lugala, the kiosk management decided to provide a token with preloaded water credits to ultra-poor households and the households eligible for free access to kiosk water were selected during a community meeting. Furthermore, a water ATM is a major infrastructure investment, adds complexity to the water distribution system and consequently increases the risk of failure.

Although the installation of the water ATM increased revenues in Lugala, the income generated will probably not be sufficient to cover all maintenance costs, infrastructure renewal and amortisation. However, compared to the initial business model, contributions to larger renewal investments seem possible and could potentially be matched by local governments. Longer-term monitoring and further investigation is required to assess the impact of training mechanics residing in the community and the support of the local government, where the

GDM kiosks are considered as official district water points. Also, more time is required to understand the government’s needs so that it can provide maintenance and servicing support to the GDM water kiosks.

Our analysis underlines that a water ATM can be a key feature in a sustainable business model for a rural water supply system. It can increase revenue and transparency. Nevertheless, a strong local leadership that takes responsibility and ownership for the management and operation of the water business, localised and affordable operation and maintenance and support from the local government are very important for a successful rural business model for water supplies.

5. References

Ampadu-Boakye J. and Hebert R. (2014). Field insights: Cluster Management in Ghana. The Promise and pitfalls for managing water service for multiple communities., Networks SW.

Butler R. and Weyrich C. (2013). Experiences and Analysis of Safe Water Kiosk Models in Kenya.

Contzen N. and Marks S. J. (2018). Increasing the regular use of safe water kiosk through collective psychological ownership: A mediation analysis. Journal of Environmental Psychology 57, 45-52.

Foster T. and Hope R. (2017). Evaluating waterpoint sustainability and access implications of revenue collection approaches in rural K enya. Water Resources Research 53(2), 1473-90.

Harvey P. A. and Reed R. A. (2007). Community-managed water supplies in Africa: sustainable or dispensable? Community development journal 42(3), 365-78.

Komakech H. C., Kwezi L. and Ali M. (2020). Why prepaid technologies are not a panacea for inclusive and sustainable rural water services in Tanzania? Water Policy 22(5), 925-42.

Leclert L., Nzioki R. M. and Feuerstein L. (2016). Addressing governance and management challenges in small water supply systems–the integrity management approach in Kenya. Aquatic Procedia 6, 39-50.

Madrigal R., Alpízar F. and Schlüter A. (2011). Determinants of Performance of Community-Based Drinking Water Organizations. World Development 39(9), 1663-75.

Nijru C. (2005). How Small Water Enterprises can contribute to MDGs for water. , Loughborough University, London.

Osterwalder A. and Pigneur Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers. John Wiley & Sons.

Otter P., Sattler W., Grischek T., Jaskolski M., Mey E., Ulmer N., Grossmann P., Matthias F., Malakar P., Goldmaier A., Benz F. and Ndumwa C. (2020). Economic evaluation of water supply systems operated with solar-driven electro-chlorination in rural regions in Nepal, Egypt and Tanzania. Water Research 187, 116384.

Peter-Varbanets M., Dreyer K., McFadden N., Ouma H., Wanyama K., Etenu C. and Meierhofer R. (2017). Evaluating novel gravity-driven membrane (GDM) water kiosks in schools. In WEDC conference papers. (p. 2735 (7 pp.). In: 40th WEDC international conference. Local action with international cooperation to improve and sustain water, sanitation and hygiene (WASH) services, Loughborough, UK, p. 2735.

Peter-Varbanets M., Hammes F., Vital M. and Pronk W. (2010). Stabilization of flux during dead-end ultra-low pressure ultrafiltration. Water Research 44(12), 3607-16.

Peter-Varbanets M., Johnston R., Meierhofer R., Kage F. and Pronk W. (2011). Gravity-driven membrane disinfection for household drinking water treatment. . In: The Future of Water, Sanitation and Hygiene in Low-Income Countries: Innovation, Adaptation and Engagement in a Changing World. Proceedings of the 35th WEDC International Conference.

Pronk W., Ding A., Morgenroth E., Derlon N., Desmond P., Burkhardt M., Wu B. and Fane A. G. (2019). Gravity-driven membrane filtration for water and wastewater treatment: A review. Water Research 149, 553-65.

Quin A., Balfors B. and Kjellén M. (2011). How to “walk the talk”: The perspectives of sector staff on implementation of the rural water supply programme in Uganda. Natural Resources Forum 35(4), 269-82.

SWN (2014). Community Safe Water Solutions: India Sector Review. , Safe Water Network., New Delhi, India.

Tonya E. and Mpangala G. (2018). Improving revenue management for sustainable rural water services: innovative prepaid water system. In: 41st WEDC International Conference, Egerton UNiversity, Nakuru, Kenya.

WHO (2019). JMP. Progress on household drinking water, sanitation and hygiene 2000-2017. Special focus on inequalities. , United Nations Children’s Fund (UNICEF) and World Health Organization, New York.

World Bank (2022). The Climate Change Knowledge Product. Available at: https://climateknowledgeportal.worldbank.org/ [Accessed: 09.08.2022]