Seasonality, Water Use and Management of Community-Based Water Projects in Urban Slums: Findings from Nairobi's Kayole Slums, Kenya

Jacktone Akelo
PhD Student, Department of Development Studies
Africa International University
Nairobi, Kenya
Email: joakelo1971@gmail.com

Daniel Nzengya, PhD
Director - Research and Innovation, Development Studies,
St Paul's University
Limuru, Kenya
Email: dmuasya@spu.ac.ke

Abstract

Although progress has been made to accelerate access to safe drinking water globally, it is estimated that over 800 million people still lack access to safe water, and have to rely on unsafe and often contaminated water sources. With a population of 50 million, 40% of Kenyans rely on unimproved water sources, including ponds, shallow wells and rivers. Consumption of unsafe water is responsible for over 500,000 deaths annually due to diarrheal disease. Approximately one-third of boreholes with hand pumps fail within five years of construction, interrupting water service that force users to revert to alternative, potentially unprotected, sources. Modelled data suggest that this may undermine any health benefits provided by the water system. The goal for this study was to analyse the seasonality of water use and management of community-based water projects in urban slum settlements. A case of Spring Valley Centre Water Project of Kayole Slums in Nairobi County, Kenya, was studied. A simple linear regression was used, with relationships fitted between the data and time series steps. The observed data over time (time series data) was used to construct three components of a time series - trend, seasonality and the random component. The analysis of the monthly revenue from water sales at the kiosk, over a study period of 2013 to 2020, indicated that the activities peak once a year and drop to a low once in the year. The earlier years (2013 to 2015) could, however, be seen to have annual revenue from water sales at the kiosk varying at a lower rate compared to the latter years of 2015 to 2019. These findings of seasonality in revenues require water management committees to consider planning for continuous functionality and sustainability, while creating awareness against relapse to consumption of water from contaminated sources.

Keywords: *Urban slums, community-based water projects, seasonal availability, revenue seasonality trends, water sustainability*

1. INTRODUCTION AND BACKGROUND

1.1 Background Statement and Study Objectives

Access to safe drinking water is still a huge problem facing a majority of Kenya's citizens. Based on current water demand and future national development plans, it is estimated that Kenya could face a 31 percent gap between water demand and a practically available water supply by 2030 (Muok, 2020). The problem of lack of accessibility to safe, reliable and affordable water is particularly severe in the rural areas and urban slums. Water supply is infrastructure intensive and providing water in rural areas, especially where households are sparsely distributed, poses a challenge to most service providers. This problem is worsened by the costs of putting up water infrastructure vis-à-vis the ability of rural households to pay for piped water services. In crowded urban slums, lack of space affects development and maintenance of piped water infrastructure. Furthermore, the rate of proliferation of urban slums and informal urban settlements overwhelms efforts by governments and donor agencies to keep pace with population growth in these areas. Other estimations suggest that one-third of boreholes with hand pumps fail within five years of construction. These failures result in interruptions in water service that force users to revert to alternative, potentially unprotected sources. Reverting to water from an unprotected source may undermine any health benefits provided by the water system.

In Kenya, whose population is approaching 50 million, 40% of the population rely on unimproved water sources, like ponds, shallow wells and rivers. Kenya is classified as a water scarce country with per capita water availability being below the global benchmark of 1000 m^3 (Kanda et al., 2013), with very unevenly distributed surface water resources. The present situation of 647 m^3 per capita is far below similar countries in the region. This is expected to get worse by the year 2025 when water per capita is projected to be about 235 m^3 (WRMA, 2009). The western part of the country has relatively abundant water resources, while the rest of the country has very scarce water resources with the northern and eastern parts of the country being largely a desert. Moreover, Kenya's population has grown remarkably since the country's independence in 1963 to about 47,564,300 in 2019 (KNBS, 2019), affecting the per capita water availability. The problem of declining water per capita in Kenya has been worsened by degradation of the country's surface water resources, rivers, and lakes, degradation of the country's water towers, water catchments, deforestation, pollution and climate change, characterized by extreme and more prevalent droughts. For the economy, local water stress is already a factor, not only in the arid areas but also in more water-rich regions where water-intensive economic activity has grown rapidly, such as Naivasha, greater Nairobi, and northern Mt. Kenya (Muok, 2020). Rapid urbanization has further compounded Kenya's water supply challenges. The rise in the volumes of urban run-off and wastewater generation can be seen against the backdrop of a lack of wastewater treatment systems. Aging and dilapidated sewerage treatment infrastructure results in many small towns, and also cities, discharging wastewater untreated or only partially treated, further contaminating the limited surface water resources.

Community-managed water services have been promoted as an alternative to accelerate water service provision, particularly in urban slums and rural areas. One challenge that continues to face community-managed water services is the continued reliance on multiple sources of water by households, undermining revenue to the community-water committees managing water delivery points such as water kiosks. A researcher, using a cross-sectional survey, reported that a majority of households relying on community-managed water points tended to switch over to cheaper and more abundant water sources during rainy seasons, and only reverted to improved community-managed services during the dry season (Kelly et al., 2018a). However, there are limited research projects, particularly in Kenya, that have utilized long-term data to explore the severity of this phenomenon.

This paper uses data collected from a slum community-managed water point on water sales recorded for a period of eight years. The aim was to investigate trends in monthly seasonality and annual trends. Time series data were complemented by interviews with individuals managing water kiosks to complement quantitative analysis of trends and shed more light on the trends observed. The overall question was; how does the management of a community-based water point affect the seasonality of water use? We hypothesized that there were not significant differences in the seasonal use of water from community-based water points, especially within the slum areas.

1.2 Community-managed Water Service Provision

The UN Sustainable Development Goals has categorized SDG6 to ensure availability and sustainable management of water and sanitation for all; and this has been shown to be related to seven other SDGs (Blanc, 2015). Safe drinking water, while abundantly available in some countries, remains a scarcely available communal resource in some regions worldwide (Contzen & Marks, 2018). About 880 million people do not have access to safe drinking water and almost 2.6 billion have limited access to adequate sanitation (UNICEF, 2008). It is estimated that over a quarter of the global population still depends on unsafe drinking water supplies impacted by faecal contamination (WHO & UNICEF, 2015; Onda et al., 2012). Countries in sub-Saharan Africa have particularly low levels of access to safe drinking water. To a large extent, these are socially and politically induced challenges, defined by the established water governance. The concept of water governance refers to the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and to deliver water services to different levels of society (Rogers & Hall, 2003). In other words, water governance has been defined as the system of actors, resources, mechanisms and processes, which mediate society's access to water (Franks & Cleaver, 2007).

Kenya is a representative of regional trends, with 74% of the population residing in rural areas and only about half of rural households identifying an improved water point as their main drinking source (Supply et al., 2015). In Kenya in 2002, the Water Act was enacted to provide for the management, conservation, use and control of water resources and for the acquisition and regulation of the rights to use water (Kanda et al., 2013). The 2002 Water Act introduced comprehensive and radical changes to the legal framework of the water sector in Kenya. These reforms revolved around four themes of management and provision of water services; policy-making, administration and regulation; decentralization of functions; and involvement of non-governmental entities (Mumma, 2007). The Act provided a role for community groups, organized as water resources user associations (WRUAs), in the management of water resources (Aarts, 2012). In the Water Act itself, however, not much could be found about how WRUAs should be structured. In the water resource management rules, a WRUA was defined as an association of water users, riparian landowners, or other stakeholders who have formally and voluntarily associated for the purposes of cooperatively sharing, managing and conserving a common water resource. The Kenya Water Act 2002 was amended in 2012 and has been revised in 2016.

The passage and promulgation of Kenya's 2010 Constitution had several implications for the water, agriculture and other devolved sectors in the country. For example, the constitution acknowledged access to clean and safe water as a basic human right and assigns the responsibility for water supply and sanitation service provision to the 47 established counties (Nyika, 2020). The primary purpose and goal of the 2016 Water Act was to align the water sector with the Constitution's devolution primary objective. The Act recognized water-related functions as shared responsibility between the national government and the county governments. Further, it gave priority to use of abstracted water for domestic purposes over irrigation and other uses. The 2016 Act also established institutions, such as Basin Water Resource Committees (BWRCs) and Water Resources Users Associations (WRUAs), providing different platforms for private sector participation on water resource management issues.

The 2002 Water Act reforms in the sector in Kenya were meant to enhance community and private sector participatory approaches in decision-making as per the Dublin principles, where the stakeholders in the water sector participate and have control of the process and the decisions being made. The Constitution of Kenya also provided for public participation in the management of resources. In Section 69 (1d) of the Constitution, it stated "the state shall encourage public participation in the management, protection and conservation of the environment", including water. However, participation by the poor and the marginalized have been noted to be limited due to various reasons (Kanda et al., 2013). Participation actually imposes significant transactions costs for the poor, and might not be worthwhile for participants, due to problems in organizing collective action and the risks of unreasonable and meaningless participation, and policies that transfer responsibility without authority.

1.3 Seasonality of Water Use

Access to safe water, considered a basic need and human right by many, is far from reality for many people (Bisung & Elliott, 2014). They reported that globally, almost 10% of the burden of disease was attributed to unsafe water, inadequate sanitation, and poor hygiene. It is estimated that consumption of unsafe water is responsible for over 500,000 deaths annually due to diarrheal disease globally (Prüss-Ustün et al., 2014). For example, Bisung and Elliot (2014) reported that 1.4 million children's deaths each year were caused by diarrheal diseases and 88% were attributable to unsafe water, inadequate sanitation and insufficient hygiene. In addition, one in five children born in low and middle income (LMI) countries died from child malnutrition associated with repeated diarrhoea or intestinal nematode infections induced by unsafe water, inadequate sanitation and poor hygiene before they reach age five. Further, there were numerous adverse effects of lack of water, sanitation and poor hygiene on maternal and new-born health. Specifically, there were adverse impacts resulting from water carrying by pregnant women and hygiene-related infections during and after delivery. Additionally, health-care facilities including hospitals, health centres and residential care settings required access to safe water and adequate sanitation to provide clean tools. They further assessed the need for adequate hygiene practices among caregivers to reduce the risk of hospital-based infections. The disease burden and economic impacts resulting from lack of access to water, inadequate sanitation and poor hygiene are central to poverty reduction efforts and development concerns in many LMI countries. The cost of treating waterborne and water-related diseases, low productivity resulting from sickness due to unsafe water, productive cost of time spent collecting water, and lack of water for household livelihood activities such as gardening and animal rearing have significant impacts on poverty reduction and community development.

The universalization of drinking water in communities, including rural and slum communities, poses a great challenge to developing countries, where rural areas often receive poor water service coverage and limited attention from authorities (Machado et al., 2019). An estimated 20% of community hand pumps in sub-Saharan Africa were non-functional at any given time (Banks & Furey, 2016) and most system breakdowns occur three to five years after construction. There has been growing concern about the high failure rates of newly installed water points, often within the first few years of construction (Adank et al., 2014; Smits et al., 2012). Because all water systems eventually break down, it is important to ensure that water systems are managed effectively and rehabilitations can be carried out quickly (Kelly et al., 2018a). An important management model established in remote communities worldwide to facilitate access to drinking water is the community management model of water supply systems (Machado et al., 2019). The sustainability of community-managed water systems is dependent on both technical characteristics of the system and the management characteristics of the water committee. That is, the sustainability depends in part on the ability of local water committees to repair breakdowns and carry out the operation and maintenance (O&M) of the system (Kelly et al., 2018b). Klug et al. (2017) examined the pathways through which a water committee could successfully rehabilitate a broken-down system, as well as the obstacles, which hinder system repairs. Though their study found that committees could rehabilitate systems through several pathways, but all of these required the mobilization of financial resources and most included support from external support actors. In their research, Machado et al. (2019) observed that a significant number of publications had confirmed the need for constant post-construction support from external agencies regarding technical, managerial and financial aspects to ensure the long-term sustainability and functionality.

The concept of 'functionality' has emerged as a central motif within current development efforts to provide people with a safe and affordable water supply. Functionality has notably achieved currency in sub-Saharan Africa in relation to securing the sustainability of hand-pumped water supply (Lockwood & Smits, 2011). The need for improved functionality in this region was great due to a perceived deficit in government capacity to deliver and maintain services, and disappointing results of the MDG initiatives (Whaley & Cleaver, 2017). A core feature of the post-construction phase concerns the day-to-day operation of the community governance arrangement. In the critical academic literature there have been several critiques levelled at the requirement for water point committees (WPCs) to fulfil many of these expectations, oftentimes drawing on feminist analysis of the everyday politics of water. Seasonal availability of surface and rainwater affects use of water systems; some types of breakdowns are more common in the rainy or the dry season; seasonality affects committee activity, resource mobilization and external support; operations and maintenance (O&M) may be more achievable in the dry season; extended, iterative community engagement leads to more effective water committees. Even if appropriate structures and rules were handed down during community engagement, institutional building was also a transformative process that must change ideas, resources and relationships around those ideas (Abers & Keck, 2013). The institutional building was often a slow, iterative process (Kelly et al., 2018b), sometimes with results that move in the direction and or speed that is not acceptable to the builder. In the case of community-managed water systems, new financial and human resources must be mobilized to carry out O&M (Klug et al., 2017).

It observed that seasonality could affect the functionality of community-managed water systems as experienced during long dry season with less than 25 mm of rainfall per month (MacDonald et al., 2012). Groundwater availability (Eilers et al., 2007) and surface water area (Kaptué et al., 2013) both rapidly decrease in the dry season and rainwater harvesting becomes difficult. Seasonality has been shown to influence water demand in rural households (Calow et al., 2010), choice of primary water source, and willingness to pay for water. There is little evidence exploring how seasonality affects water system management, especially in the rural community-management context (Kelly et al., 2018b).

2. MATERIALS AND METHODS

2.1 Research Design

The study used time series analysis to examine monthly seasonality and annual trends in water sales from Spring Valley Centre (SVC) water point (WP). The records of water sales from January 2013 to August 2020 were collected from the SVC water point. Records of water sales for SVC WP were obtained from the management committee. With the sales data, a simple linear regression was used, where relationships were fitted between the data and time series steps. First the observed data over time was used to construct three components of a time series—trend, seasonality and the random component. The three components estimated the data when summed up. The trend was reconstructed from the series by de-seasoning the series, a step that was achieved by aggregating the monthly data to annual data by summation. Seasons were estimated by averaging 12 months over the study period, giving a climatology of a certain period. Summation of the two components, estimated the series although with a small difference, which was considered the random components in the data. The random component was not modelled further but rather, it represented the error in our analysis. However, the other two components were used. A linear regression model was fitted on the trend. Analyses of time series were complemented with interviews with individuals managing the water point to further explain plausible reasons for the underlying trends from the time series data.

Apart from the time series sales data, key interviews were also conducted with the SVC manager and the founder. Further, a transect walk was taken within the centre to observe the functionality of the water, which was done through establishing that members of the community were actually drawing water, and that the water kiosk displayed a schedule for their opening times. These were done in September 2020.

2.2 Brief of Spring Valley Centre Water Point

Spring Valley Centre (SVC) water project is located within the Kayole Slums of the Spring Matopeni Sub-location, Nairobi County (GPS: 01^0 15'41" S, 36^0 55'71"E). The centre was started in July 1999 with a response program to families that had been forcefully removed from the Spring Valley in Nairobi's Westland. The centre started with a feeding program for the families, a school, and children's home. The centre is currently running a primary school with over 450 pupils, and children's home for over 100 children. For the female youths who are not in basic education, they undergo technical training in tailoring and dress-making.

Four Christian organizations, including the FUD-Linda Lively Canion, First United Methodist Church (Durango, USA), Spring Valley Centre and Living Water International (LWI) partnered to establish the water project for SVC in 2012. After initial project assessments, the parties agreed to drill a borehole at the centre. The reason for a water point at the centre was that the Nairobi City water supply was either rationed or entirely disconnected, most of the times, in slum areas such as Kayole. The project was completed in December 2012, and handed over to the SVC in January 2013. The water point was a submersible electric pump, automatic and manually operated, drilled to a depth of 210 metres, with static water level at 58.6 metres and a casing diameter of 152 meters with a water yield of 5 m^3 per hour. The project was undertaken at costs of US$ 40,392. with a target population of 3,000 people of Spring Valley, Kianguio and Matopeni villages.

The SVC water project was managed through a board that was composed of two representatives from the community. The board also oversees the operations of other projects. The board was reported to be meeting quarterly, and had functions beyond the water point, including other projects like the school and children's home. The board levied a user fee of

KES 5 for every 20-litre container collected from the water kiosk by the community members. However, the SVC water project also gave waivers for the disabled members of the communities. The water was also used for other activities within the centre without additional charges. From the user fees collected, 80% was designated to be used for running the water point, including paying electricity, kiosk attendants, servicing, operations and maintenance. The remaining 20% was saved in the Water Project Account for repairs in case of breakdown.

3. FINDINGS OF WATER USE SEASONALITY STUDY

2.1 Monthly Seasonality Trends

Results of the time series analysis showed monthly seasonality in water sales, with distinct peaks and troughs, repeated throughout the study period (Figure 1). Revenues from water sales peaked highly in January and then again later on in the year. Averaged at about KES 70,000 (clearly seen in 2014 to 2017), the late year months October to December and through January to February of the following year. This peak season effectively exhibited maximum sale activities in the month of December of the year. On the other hand, the low activity season was exhibited in remaining months of the year at this water kiosk; that is, from March until September. The low season was averaged at about KES 40,000 in the period 2013 to 2017 while the average deepens to lower values in 2018 to 2020 observed months (about KES 40,000). The sharpest decline was observed in the month of April in each of the years observed.

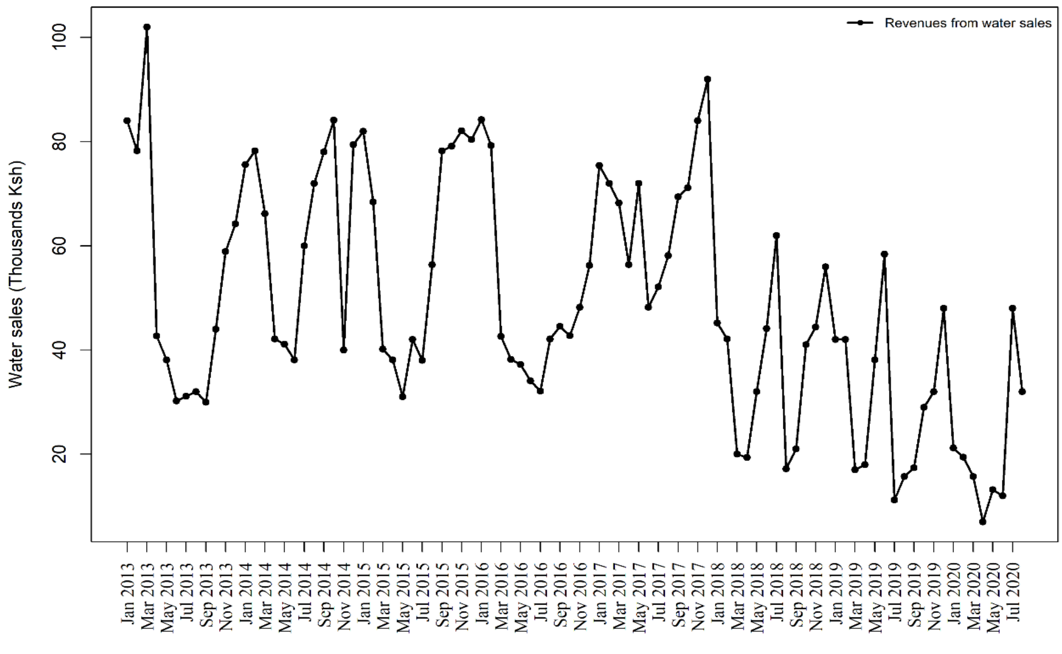

Figure 1: Time Series of Revenue from Water Sales at the Kiosk

In Figure 2, analysis of the monthly revenue from water sales at the kiosk indicated that the activities peak once in a year and drop to a low, also once in the year. With these findings, a few questions were asked. The authors sought to understand why the water kiosk seems to record high sales during the months of January/February and October through December. As well, they sought to know why the water kiosk seemed to record a reduction in sales during the months of March through September. The record of high sales was given that these months were periodically dry months; meaning that they have low rainfall, and so many people buy water from the SVC kiosk. The second reason for high sales was that these months, especially November and December, were long school holiday months, so many children were at home, resulting in high water usage.

Further, key informant interviews presented two reasons concerning the findings on the reduction of water sales in other months. First, these months were the long rainy season, especially March and April. Many people harvested rainwater from their roofs, leading to fewer water purchases in SVC kiosk. Second, the months of June and July were considered cold months; so usage of water for bathing was low, leading to low water purchases. Finally, in August and September, Nairobi Country office usually supplied water to the populations in Spring Valley, resulting in lower sales.

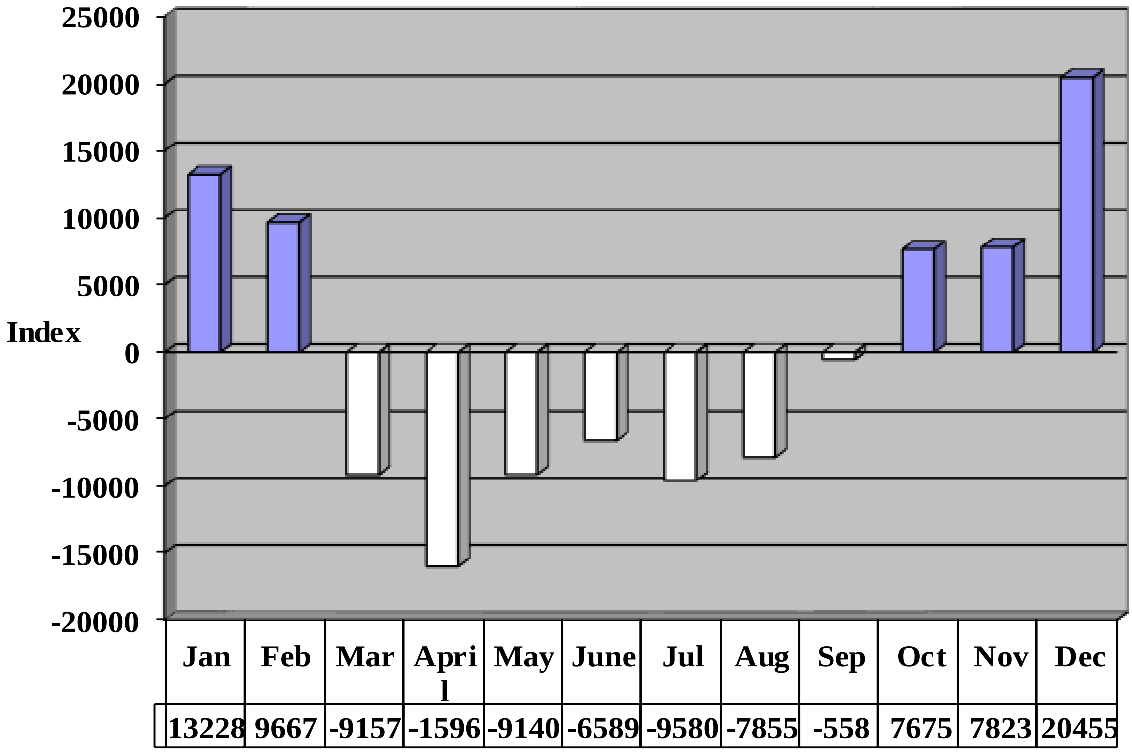

Figure 2: Bar Plots of Seasonality Indices of Revenue from Kiosk Water Sales

The hypothesis that there were not significant differences in the seasonal use of water from community-based water points, especially within the slum areas, has been rejected. We conclude that there are significant differences in the seasonal use of water, as depicted from the sales records, with peaks and troughs.

3.2 Annual Seasonality Trends

This section poses the question: Does revenue data from water kiosk sales reveal increases or declines in the annual trends? If yes, which years show characteristic peaks and troughs or lows? What is the annual average increase or decline? From the analysis, the earlier years (2013 to 2015) can be seen to have annual revenue from water sales at the kiosk at a lower rate compared to latter years of 2015 to 2019. The year 2020 was overlooked in this discussion since it had only 8 months of complete data, while other years had 12-month data, hence the annual revenue being lower than all the other years might have not been true.

In this regard, both the maximum and the minimum values were observed in the latter years of study, specifically, in 2017 and 2019 respectively. This shed light on how unstable values were in those latter years. Generally, there was a declining linear slope of averagely KES 4,692 per year.

From the graphical presentation shown in Figure 3, it was noted that there was increased sale of water from the SVC water project, especially in 2017. Key informant interviews with the programme manager provided two explanations. First, it was noted that 2017 was a dry year, and neither the Nairobi Water and Sewerage Company (NWSC) nor any other Nairobi County water service providers supplied water at Spring Valley Village. Second, there was an influx of new residents in Spring Valley from neighbouring villages in Kayole area. This influx of new residents led to lots of water dispensation due to fear of violence as 2017 was an election year.

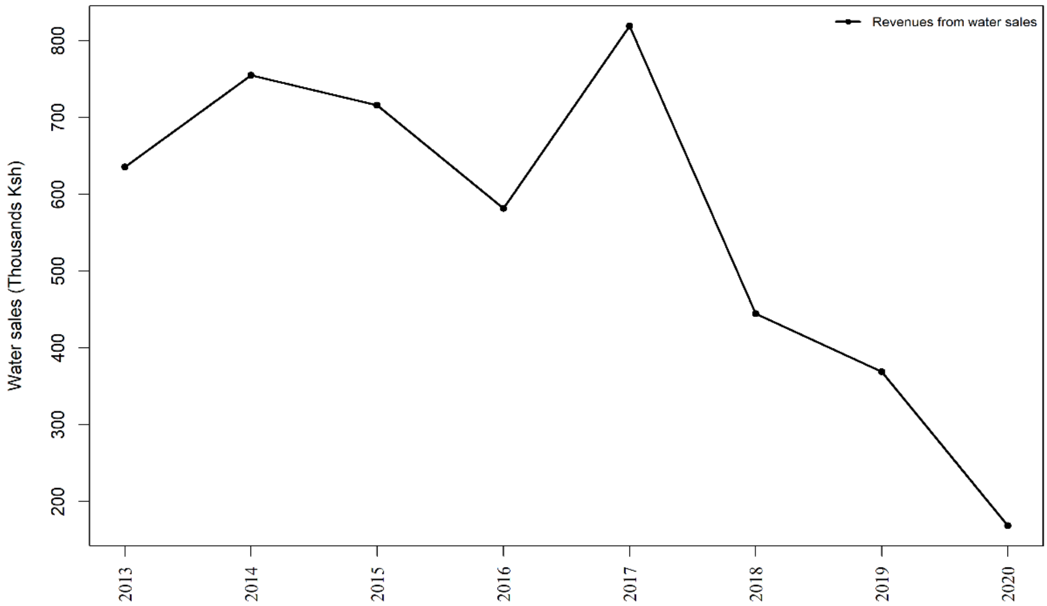

Figure 3: Time Series Plot of Annual Revenue from Kiosk Water Sales

The years succeeding 2017 saw a decline in the records of water kiosk sales. The key informant interviews revealed two important reasons. First, one new borehole was drilled by the Spring Valley Matopeni Ward MCA, which is about 1 km from the SVC borehole water point. This resulted in a loss of about 30% of SVC clients to the new borehole. The second reason for the decline was that the *Sonko Rescue Team* gave free water to the Spring Valley people, at least twice a week. A similar effort was concurrently being undertaken by the Nairobi Metropolitan Services (NMS).

4. STUDY DISCUSSIONS ON SEASONALITY TRENDS

The aim of the study was to investigate trends in seasonality with a time series sales data of 8-years complemented by key informant interviews and observations. The study found out that the Board of SVC used 80% of water sales incomes for recurrent costs of the water system and 20% was saved for major breakdowns. The records showed that within the 8 years, the SVC had collected about KES 4,488,387. From this revenue, KES 897,677 was saved for the breakdown. During the period, there had been one major breakdown that occurred in 2016, which resulted from an electrical power surge which destroyed the motor and pump. From the savings, about KES 280,000 was spent to undertake the repairs, within a period of 2 weeks.

This finding to undertake repairs for such a major breakdown seemed to confirm suggestions that the seasonality affects committee activity, resource mobilization and external support. Operations and maintenance might be more achievable in the dry season; extended, iterative community engagement leads to more effective water committees (Whaley & Cleaver, 2017). The breakdown caused a closure of the water point for about 2 weeks. Before the breakdown, when the early warning signs were observed, the SVC stopped sales to the community members outside the centre and only used the water in the reservoir for the centre residents.

Resource mobilization was usually a component of community management, which was commonly misunderstood due to short community engagement periods (Kelly et al., 2018b). In the case of SVC water project, someone could only look at the water project execution period of four months (October 2012 - January 2013); and practically that was such a short time. However, the LWI spent some time before and after the water project execution in walking along to build on the aspects of community engagement and water committee trainings. Current resource mobilization practices for community-managed water systems were considered to be insufficient for capital costs (Fonseca et al., 2013) or major repairs (Foster & Hope, 2016).

However, the findings disproved the study findings that committees could only rehabilitate systems through several pathways, all of which required the mobilization of financial resources and most included support from external support actors (Klug et al., 2017). The findings further disproved the observation that the need for constant post-construction support from external agencies regarding technical, managerial and financial aspects to ensure the long-term sustainability and functionality (Machado et al., 2019). This community-managed water project undertook such a major repair from their own generated revenues and were resilient to continue operations even during the COVID-19 pandemic. However, the reduced sales and mushrooming of other water kiosks and providers might affect the centre. Nevertheless, while the reported and observed new development of other water kiosks and providers was good for the safe water access of the increasing population of Spring Valley slums, the reduced use will also result in reduced minor breakdowns, if any.

Furthermore, a portion of the revenues was also used to pay for the electricity bills for the whole centre, and not necessarily the part consumed by water abstraction. During the COVID-19 pandemic (March 2020 to date), the SVC board approved for free water collections for half-days (from 6-11am) on Mondays and Wednesdays as part of the response to support the communities around the centre. Furthermore, the water used by the other projects of the centre were not charged to these projects.

Some authors have observed that seasonality poses threats to the functionality of community-managed water systems due to experiences of a long dry season (MacDonald et al., 2012). Others have pointed out that groundwater availability and surface water area (Eilers et al., 2007; Kaptué et al., 2013) were rapidly decreased in the dry season and rainwater harvesting became difficult. As well, the seasonality had been shown to influence water demand in households (Calow et al., 2010; Griffin & Chang, 1991), choice of primary water source and willingness to pay for water (Schweitzer et al., 2013). These findings have been confirmed by this study as the key informant interviews reported that during dry periods of October through January, they recorded the highest sales across the years reviewed.

5. CONCLUSIONS AND RECOMMENDATIONS

Though a safe water source may be available and accessible, people still have a right to choose other sources, not necessarily safe ones. The study has shown the seasonality of the use of safe water as shown by the analysed sale records for a period of time. The community-based management committee plays such a critical role of governance that ensures the continued functionality of the water points. The recommendations by Kelly et al. are that the focus of external support actors must shift from water system-based implementations to water service-based ones. More resources should be used to engage with communities in the long term, as opposed to building new systems which communities are unable to maintain (Kelly et al., 2018a), a conclusion which also holds for this study.

This study only looked at the seasonality pattern of a single case water point within Kayole slum within Nairobi city. Future research studies could look at the seasonality and trends in multiple water points within other cities. Further research could also look at the seasonality and trend comparisons within urban slums and rural community-managed water points.

REFERENCES

Aarts, J. (2012). Will Community-based Water Management Solve Africa's Water Problems? The performance of Water Resource User Associations in the Upper Ewaso Ng'iro river basin, Kenya.

Abers, R., & Keck, M. E. (2013). Practical authority: Agency and institutional change in Brazilian water politics. Oxford University Press

Adank, M., Kumasi, T. C., Chimbar, T. L., Atengdem, J., Agbemor, B. D., & Dickinson, N. (2014). The state of handpump water services in Ghana: Findings from three districts. Sustainable Water and Sanitation Services for All in a Fast Changing World: Proceedings of the 37th WEDC International Conference, Hanoi, Vietnam, 15–19.

Banks, B., & Furey, S. G. (2016). What's working, where, and for how long. A 2016 water point update to the RWSN (2009) statistics. Proceedings of the 7th RWSN Forum, 29.

Bisung, E., & Elliott, S. J. (2014). Toward a social capital based framework for understanding the water-health nexus. Social Science & Medicine, 108, 194–200.

Blanc, D. L. (2015). Towards Integration at Last? The Sustainable Development Goals as a Network of Targets. Sustainable Development, 23(3), 176–187. https://doi.org/10.1002/sd.1582

Calow, R. C., MacDonald, A. M., Nicol, A. L. & Robins, N. S. (2010). Ground water security and drought in Africa: Linking availability, access, and demand. Groundwater, 48(2), 246–256.

Contzen, N. & 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.

Eilers, V. H., Carter, R. C. & Rushton, K. R. (2007). A single layer soil water balance model for estimating deep drainage (potential recharge): An application to cropped land in semi-arid North-east Nigeria. Geoderma, 140(1–2), 119–131.

Fonseca, A., McAllister, M. L. & Fitzpatrick, P. (2013). Measuring what? A comparative anatomy of five mining sustainability frameworks. Minerals Engineering, 46, 180–186.

Foster, T. & Hope, R. (2016). A multi-decadal and social-ecological systems analysis of community waterpoint payment behaviours in rural Kenya. Journal of Rural Studies, 47, 85–96.

Franks, T. & Cleaver, F. (2007). Water governance and poverty: A framework for analysis. Progress in Development Studies, 7(4), 291–306.

Griffin, R. C. & Chang, C. (1991). Seasonality in community water demand. Western Journal of Agricultural Economics, 207–217.

Kanda, E., Taragon, J., Waweru, S. & Kimokoti, S. (2013). The Water Act 2002 and The Constitution of Kenya 2010: Coherence and Conflicts Towards Implementation.

Kaptué, A. T., Hanan, N. P., & Prihodko, L. (2013). Characterization of the spatial and temporal variability of surface water in the Soudan-Sahel region of Africa. Journal of Geophysical Research: Biogeosciences, 118(4), 1472–1483.

Kelly, E., Shields, K. F., Cronk, R., Lee, K., Behnke, N., Klug, T., & Bartram, J. (2018a). Seasonality, water use and community management of water systems in rural settings: Qualitative evidence from Ghana, Kenya, and Zambia. Science of The Total Environment, 628–629, 715–721. https://doi.org/10.1016/j.scitotenv.2018.02.045

Klug, T., Shields, K. F., Cronk, R., Kelly, E., Behnke, N., Lee, K., & Bartram, J. (2017). Water system hardware and management rehabilitation: Qualitative evidence from Ghana, Kenya, and Zambia. International Journal of Hygiene and Environmental Health, 220(3), 531–538. https://doi.org/10.1016/j.ijheh.2017.02.009

KNBS. (2019). 2019 Kenya Population and Housing Census Volume I: Population by County and Sub-County.

Lockwood, H. & Smits, S. (2011). Supporting rural water supply: Moving towards a service delivery approach. Practical Action Publishing.

MacDonald, A. M., Bonsor, H. C., Dochartaigh, B. É. Ó., & Taylor, R. G. (2012). Quantitative maps of groundwater resources in Africa. Environmental Research Letters, 7(2), 024009.

Machado, A. V. M., dos Santos, J. A. N., Quindeler, N. da S., & Alves, L. M. C. (2019). Critical Factors for the Success of Rural Water Supply Services in Brazil. Water, 11(10), 2180. https://doi.org/10.3390/w11102180

Mumma, A. (2007). 10 Kenya's New Water Law: An Analysis of the Implications of Kenya's Water Act, 2002, for the Rural Poor. Community-Based Water Law and Water Resource Management Reform in Developing Countries, 158.

Muok, B. O. (2020). Impacts of Conflicting, Institutional Mandates on Water Security: Pathways for Water Sector Development in Turkana County, Kenya. Science, Technology & Public Policy, 4(2), 44.

Nyika, J. M. (2020). Climate Change Situation in Kenya and Measures Towards Adaptive Management in the Water Sector. International Journal of Environmental Sustainability and Green Technologies (IJESGT), 11(2), 34–47.

Onda, K., LoBuglio, J., & Bartram, J. (2012). Global access to safe water: Accounting for water quality and the resulting impact on MDG progress. International Journal of Environmental Research and Public Health, 9(3), 880–894.

Prüss-Ustün, A., Bartram, J., Clasen, T., Colford Jr, J. M., Cumming, O., Curtis, V., Bonjour, S., Dangour, A. D., De France, J., & Fewtrell, L. (2014). Burden of disease from inadequate water, sanitation and hygiene in low-and middle-income settings: A retrospective analysis of data from 145 countries. Tropical Medicine & International Health, 19(8), 894–905.

Rogers, P., & Hall, A. W. (2003). Effective water governance (Vol. 7). Global water partnership Stockholm.

Smits, S., Lockwood, H., Le Gouais, A., Schouten, T., Duti, V., & Nabunnya, J. (2012). A principle-based approach to sustainable rural water services at scale: Moving from vision to action. Triple-s Working Paper, 1.

WHO & UNICEF. (2008). Progress on drinking water and sanitation: Special focus on sanitation. In Progress on drinking water and sanitation: Special focus on sanitation (pp. 58–58).

JMP WHO/UNICEF (2015). Progress on sanitation and drinking water: 2015 update and MDG assessment. World Health Organization.

Whaley, L., & Cleaver, F. (2017). Can 'functionality' save the community management model of rural water supply? Water Resources and Rural Development, 9, 56–66. https://doi.org/10.1016/j.wrr.2017.04.001