Toward SDG 6: Exploring the Potential for Wastewater Reuse in Nairobi, Kenya

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Abstract

SDG 6, Targets 6.1 and 6.2 focus on delivering and ensuring drinking water and sanitation for all people. There is considerable possibility for achieving SDG 6 and these targets in particular through improved use and management of water currently available to people both as blue water (rainfall and accessible groundwater) and as grey water. Put differently, there is great potential to make more of the water that we already have. Wastewater reuse is proving to be an economically and environmentally sound demand management strategy, especially with climate change uncertainties. To establish the current use and possible uptake of greywater reuse in Kenya, 27 in-depth interviews were conducted with the main stakeholders of water recycling within Nairobi and its environs. They included government officials, technical experts of recycling systems and formal and informal greywater users. Results indicate that grey and wastewater recycling can not only reduce fresh water demands, but the systems are also important in reducing the amount of untreated wastewater being discharged into the environment. Public authorities and implementers need to engage with other stakeholders to provide regulation and standardization of the industry. Improving the level of knowledge of these systems among members of the public would also build trust and increase the uptake of these systems.

Keywords:

Greywater, wastewater, reuse, SDG 6, Nairobi, governance

1.0 Introduction

The conventional methods of water supply and wastewater management systems utilized centralized large infrastructure to capture, store and transport massive amounts of water over long distances. These methods have been shown to be unsustainable for economic, social and environmental reasons and have failed to guarantee water security[1]. They are expensive to construct, have negative environmental impacts and basic human water needs are still unmet (Gleick, 2000).

It is estimated that in the coming years, 60% of the world's population will be urban dwellers (Stavenhagen, Buurman, & Tortajada, 2018). This population growth brings about unprecedented challenges, with provision of water and sanitation being a pressing issue and the most painfully felt when lacking. Municipal water systems are facing immense pressure to meet the needs of the rapidly growing population and in some places, pressures to meet increasing industrial demands and/or rising luxury expectations of the relatively advantaged, fueling the need for sustainable water use. While this scenario presents several challenges, it also offers an

[1] The United Nations defines water security as 'The capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability'

opportunity to move away from past inadequate water management systems to more innovative ways that incorporate integrated urban water management solutions like demand management strategies which involve the use of treated wastewater to meet demands (WWAP, 2017).

In Kenya, ever since the construction of the Ruiru Dam in the 1930s, water managers in Nairobi have consistently focused on large-scale development of surface water to meet increasing demand (Blomkvist & Nilsson, 2017). Water is sourced from distant river basins in greater proportions and at a greater pace to meet the demands of the fast-growing metropolis (Nilsson & Nyanchaga, 2011). A strategy based on supply extension is both physically and economically unsustainable, calling for the need to diversify water sources (Ledant & Martin, 2013). Alternative water sources include rainwater, brackish water, municipal wastewater and greywater. Of these, grey and wastewater presents a potentially viable option for Nairobi because of its reliability, availability and raw water quality as illustrated by Kariuki et al. (2011).

Thus, the main question that this study sought to answer was, “can greywater and wastewater reuse be a viable practice to reduce potable water use and subsequently contribute to achieving water security in a rapidly developing city like Nairobi”? Additional questions that guided the study were: “What are the drivers for and benefits from recycling greywater and wastewater?” “What are the main barriers against the uptake of greywater reuse?” and “What is the role of greywater and wastewater reuse in planning for urban water security?”

2.0 Methodology

2.1 Data Collection

Data collection consisted of both primary and secondary data collection methods. Primary data collection involved fieldwork which included in-person and phone interviews with various stakeholders of grey and wastewater recycling within the city and observations. Secondary data included a review of government documentation, reports and other relevant literature.

Building on the foundation literature, primary data was collected using semi-structured interviews and an interview guide was used to ensure that all themes were covered. Interviews were conducted in person whenever possible. Participants were grouped into four different categories and a set number of similar open-ended questions were asked of participants in the same category. This ensured regularity within the different categories while also allowing for unexpected themes and considerations that may come up to be explored.

In total, 27 interviews were conducted, and they consisted of 6 government officials from different departments, 6 technical experts who are in grey and wastewater recycling business, 5 clients who use the formal systems and 11 residents of Katwekera village in Kibera who use the informal system. Of the 27 interviews, 22 were conducted in person by the researcher and audio recorded, 2 were carried out by an assistant and the responses written down, one respondent refused to be recorded while another interview was over the phone.

2.2 Data Analysis

Qualitative analysis was used to understand the participants’ perspectives within their different social contexts. It was loosely based on the six step thematic analysis as outlined by Braun & Clarke (2006). Firstly, the data was transcribed, and ideas noted down. Next, initial codes were generated from these ideas, followed by a search for themes. The themes were then reviewed and defined and finally, report writing. Thematic analysis is a method used to identify, analyze and reports patterns within data and interpret various aspects of the research topic (Boyatzis, 1998; Braun & Clarke, 2006). It is a useful method for examining the different perspectives of the research participants, exploring the similarities and differences and generating unanticipated

insights in the data (Nowell, Norris, White, & Moules, 2017). This method was suitable for this study given the different participant categories and thus, different perspectives of the same issue.

Interview questions were not necessarily pre-coded but followed a similar pattern which helped in developing initial codes throughout the interviews that facilitated coding and analysis. Additionally, NVIVO, a qualitative data analysis software was used. Upon identification of the major themes, the user can separate the information within them to suit different subcategories. Some of the considerations made in the creation of subcategories for this study included highlighting specific words or ideas that reoccurred during the interviews, classifying a range of answers and identifying conflicting responses within a theme. In essence, while coding is done by the researcher, the program facilitates the organization of large chunks of data and eases the process of finding connections and understanding patterns within the data.

To maintain confidentiality, participants were coded according to their representative group followed by a numerical digit. Government officials were coded as GO, technical experts as TE, formal users as User and Kibera residents as KR. Participants were referred to based on their codes, e.g. “according to GO2” or “TE1 said…”

3.0 Results

3.1 Drivers for grey-wastewater reuse

3.1.1 Lack of a sewer line

In Nairobi, one of the major drivers for wastewater recycling is the lack of a sewer line. The law requires that wastewater should be discharged after it has met certain standards for houses, industries and other establishments that are not connected to the main sewer lines, forcing house owners to invest in various sanitation solutions like septic tanks, biodigesters and recycling systems. “On most occasions, people who consider wastewater in this country or East African countries do it because they don’t have access to the sewer line and that’s where the concept of the septic tank came. But over the years, the septic tanks have caused problems with neighbours, filling up and overflowing and people started looking into other options like recycling water” (TE1).

Issues with lack of a sewer line also brought to light the reason why most users mix their grey and black water. “It’s difficult to sell the concept to someone with a sewer line unless someone actually wants to recycle the water. That’s why most people don’t differentiate their wastewater and want you to treat all of it” (TE1). With these wastewater recycling systems, one is able to take care of both their grey and black water, which would otherwise require a different sanitation solution to deal with it.

3.1.2 Practical Benefits

An overwhelming majority of participants agreed that reusing grey and wastewater reduces the reliance on freshwater. In turn, this reduces water bills and provides ‘more’ water for non-potable uses. Estimates on cost savings were given by three technical experts. TE4 and TE6 mentioned that reusing water cuts their clients’ costs by 60% and 70% respectively. One of TE5’s clients saved on the Kshs. 10,000 [CAD 131] that he was spending on watering his lawn every month.

In Kibera, 5 out of 6 of the participants interviewed stated that reusing greywater helps them reduce on the use of, and the cost of obtaining freshwater. In terms of cost saving for formal users, recycling water also reduces the costs that would otherwise have been incurred through sewerage services or paying for exhauster trucks to empty septic tanks (User2, User 3, User 4, User 5).

Besides user benefits, wastewater recycling has positive ecological impacts as it reduces the amount of untreated wastewater discharged into the environment. The rivers in Nairobi are fed

by effluent discharge and treating before disposal reduces the pollutant loads in the rivers, as TE5 explains. “Most people actually discharge into rivers. If we had a way of capturing this water and treating it to at least a certain standard, even if it is half the standard and releasing it back to the environment, you can imagine how clean Nairobi river and all of the rivers in Nairobi would be.” (TE5).

3.1.3 Legislation

Water quality regulations (2006) stipulate that wastewater should not be discharged into the environment or public sewers without some level of treatment. This opened up the market for wastewater solutions making them a necessity: “The reality is the local legislation drove our business to come about. You would have customers with waste challenges and you’d solve their problem but generally people don’t like to spend money on wastewater, unless someone from NEMA [National Environmental Management Authority] is harassing them” (TE2).

The Water Resources Management Authority [WARMA] also encourages reusing the wastewater: “We promote zero discharge. We provide the permit for abstractors and eventually they must commit how they are planning on managing the waste that comes from their water use. We compel them to invest in waste management, and if they can recycle and have zero discharge, that’s better” (GO5).

3.1.4 Financial Incentives

Grey-wastewater recycling systems are expensive and as such, can only be afforded by specific clientele, leaving out a big portion of the population unable to obtain these systems. One of the participants explained how their company increases their market reach to middle-income areas within Nairobi: “When we started, we used to do Karen, Kileleshwa, Lavington; the suburb areas but nowadays we’ve been able to penetrate Machakos, Kitengela and Syokimau [middle-income areas]. We’ve come up with special pocket-friendly packages for those people. Instead of asking for the whole contract amount, you do an arrangement with a client where they pay what they can, maybe monthly, quarterly, etc.” (TE6).

3.1.5 Appreciation for modern technology

There is an appreciation for new technology that some people have, which can be linked to education and exposure. ‘Learned’ people are more willing to and have the capacity to invest in these systems. They are interested in how they work and can appreciate the technology. “We’ve encountered different clients; there are those who buy because of the technology, the doctors and engineers, but we also have those who buy purely for the need” (TE6). According to TE5, a majority of his clients are not really concerned about their water costs, which requires him to use a different strategy to convince clients to invest in the systems. “At the entry point, we hardly use water-saving as a selling point. We use modern technology as a key selling point” (TE5).

3.1.6 Environmental altruism

This ‘green’ sentiment is associated with those who are concerned about the state of the environment and was mentioned by some participants: “The cost of water is not really the reason why people are using the systems. there is the issue of using modern systems, reliability of cost and environmental awareness. people want to be able to reuse at least some of the water in their gardens” (TE5).

3.2 Barriers to grey-wastewater reuse

3.2.1 Cost/financial barriers

The cost of acquiring and maintaining the systems was established to be one of the barriers hindering uptake. Most, or sometimes all parts of the system are imported, which increases the cost of obtaining them. Having a greywater system also requires having separate lines and increases the costs of having these systems and thus makes many people opt for having all-inclusive wastewater recycling systems. “Wastewater recycling is not widely practiced because it’s an expensive affair” (TE4).

These systems require regular maintenance for optimal functioning and have monetary costs. There are also energy requirements as they run on electricity which can be costly, depending on the size of the system and the house occupancy. That also means that one needs to be connected to a reliable power supply, with power cuts affecting regular functioning (TE1). In addition, one needs to factor in the cost of chemicals like chlorine, which is needed for disinfection before using the water.

TABLE 1: AVERAGE SYSTEM COST IN THE FIRST YEAR

System	300,000
Civil works	250,000
Electricity per annum	25,000
Chlorine per annum	20,000
Service contract per annum	20,000
Year 1 total	Kshs.615,000 [CAD 8082]

3.2.2 Lack of government support

Participants attested to a lack of government support, especially for technical experts who are in the industry. When asked what the government is currently doing to aid in wastewater recycling in Kenya, three technical experts answered ‘nothing’ (TE2, TE6, TE5). “Instead of making business easier by e.g. doing subsidies for people who choose to put in wastewater treatment system to conserve water and what not, they charge you additionally. There’s absolutely nothing to promote business” (TE2).

The lack of support can also be seen in the lack of proper guidance regarding wastewater reuse. TE5 explained this, comparing it to Japan where the government has regulations on what to use when not connected to the sewer system. “I’d say a lot of people want to do the right thing, but the government has only given a guideline to the standards you should meet. They haven’t told the people what they should be using, and how to do it. Like in Japan, they identified a system; like the *Jokaso*[2] system is a product across the country, anybody can actually start producing their own *Jokaso* as long as it meets and passes the required standards” (TE5).

One government official pointed out a lack of collaboration between people who practice wastewater recycling and the government: “Unless they come to us for technical advice, we really don’t interact with people who are recycling” (GO4).

3.2.3 Public perception and health risks

The perception on wastewater recycling can be demonstrated in two ways: attitude towards water and the yuck factor associated with recycled water. The amount of water required for household activities is far less than that required for industries, or for agriculture and as such, there is a reluctance to recycle water for conservation purposes.

[2] *Jokaso* is a Japanese word that translates to ‘purification tank onsite wastewater treatment system’

Reusing recycled water is still viewed negatively in Kenya, and fuels health concerns over the safety of the water. While most system users voiced no concerns over the quality of the recycled water, some participants attested to the perception surrounding wastewater recycling.

3.2.4 Lack of knowledge and awareness

Knowledge on recycling systems is limited in Kenya as findings suggest. The high costs of the system make it accessible to only a specific segment of the population, limiting knowledge from those who cannot afford them. Most of the participants interviewed in Kibera did not know about these 'complex' systems or how they worked. Technical experts also acknowledged the lack of awareness among the public and even those in close proximity with people who recycle water. "You'll find in a place like Karen where we've done a lot of projects, your neighbor will reuse this water, but you don't even have any information about it and you didn't have any idea that this can be done" (TE6).

3.2.5 Lack of standardized systems

Currently, suppliers of recycling systems source the whole unit as a complete package or import parts and assemble the system locally from different countries. Participants mentioned that local manufacturing would reduce the costs of the systems and would also help in standardization of the industry.

The different systems have different maintenance requirements as explained by technical experts. For some, maintenance is done every four months, for others, twice in a year and some saying they do it once a year with periodic checks in between, especially during the holiday seasons to avoid overload in the systems. While these differences may be ideal for the client, it would make it hard for government to regulate the young industry. However, the imported systems are said to be well developed due to their prevalence in the countries they have been sourced from, which include USA, Germany and Japan.

4.0 Discussion

4.1 Recycling as sanitation solution

The adoption of alternative wastewater management as opposed to centralized wastewater treatment schemes has been extensively discussed in literature. As a form of decentralized wastewater management, recycling systems offer significant benefits to the user, are less resource intensive and more ecologically sustainable. The results indicate that there is an opportunity for decentralized wastewater schemes in Nairobi whether for individual houses or for a cluster of homes. One of the technical experts discussed the possibility of having one recycling system for a cluster of 100 homes as a sanitation solution in middle income areas, giving the benefit of reusing water and distributing overall costs of the system among the system users.

In line with the literature, discussions with one of the technical experts gave good assessments on onsite wastewater treatment in Japan compared to that in Kenya. The use of *Jokaso* devices for onsite wastewater treatment in Japan is extensive and established. In areas where people can't connect to a centralized sewer line, all household wastewater goes directly into a *Jokaso* system. Initial *Jokaso* systems only treated blackwater with greywater being discharged directly into the environment. The greywater was however found to be a source of water pollution and as of 2001, only systems that treat both grey and black water were approved for new installations (Gaulke, 2006).

4.2 Water reuse benefits

As was established in both the interviews and the literature, grey-wastewater recycling and reuse has several economic and environmental benefits. At a household level, it reduces water and sewage bills and provides 'extra' water for non-potable use. On a larger scale, the reduction in domestic water consumption can reduce freshwater demand and lower the rate of groundwater extraction. The reduction in potable water demand through water reuse has been a contentious topic in literature with some authors claiming that recycling wastewater has no effect on potable water demand. Results from this study suggest that wastewater reuse has the capability to reduce demands over time. However, these findings are limited by the geographical scope and sample size and would need further research to be ascertained.

Use of reclaimed water for non-potable needs can free up the current water supply system capacity to cater for more people. With several parts of Nairobi experiencing water rationing several times a week, the freshwater saved through water reuse can be supplied to more people and at a lesser cost if more establishments practiced recycling and reuse, findings from this study established. The main direct environmental benefits from recycling was the reduction in pollutant discharge in streams and rivers. One participant mentioned the release of untreated wastewater in areas without sewer connection and another the use of untreated wastewater for farming. This was supported in literature studies reporting rampant cases of sewage use in Kenya for agricultural use, posing public health risks (Kaluli, Githuku, Home, & Mwangi, 2011).

Studies have shown that the viability of water reuse increases, and more benefits are experienced when done at a larger scale as opposed to individual houses. A study conducted by Friedler (2008) in Israel established that for a country experiencing water shortages, the benefits of reusing greywater were much more significant when the practice was rolled out nationally or regionally as opposed to individual consumers. The same would be applied for Nairobi. Currently, the benefits of reusing grey-wastewater can only be experienced by the users and cannot be applied at a larger scale, which would be a probable explanation for the reluctance by government officials on issues with residential water reuse.

4.3 Need for Better Governance

Establishment of firm, sound regulations can go a long way in improving uptake and increasing overall public acceptance for reclaimed water. Wastewater recycling has been mentioned severally in various government documents. However, specific guidelines on water reuse are missing as they have not been clearly set out in these documents. In addition, enforcement of the already present regulations are also inadequate. As the findings established, both government officials and technical experts attested to poor enforcement of the current regulations on effluent discharge. Some participants also attested to a lack of knowledge on the legislative frameworks in place to support recycling and reuse.

There has been significant progress over the past years with regards to the water reuse policy environment in Kenya. There is a noticeable aspiration to reuse water in Kenya for pollution control, climate change adaptation, as a new source of water supply and for green economic growth as discussed in the literature. Current provisions are limited to irrigation and environment sectors; there are guidelines that address the quality of water for reuse in irrigation and for discharge into the environment. Findings from this study showed that formal users followed guidelines on effluent discharge into the environment carried under the [Environmental Management and Co-ordination Act] EMCA, 1999 (Government of Kenya, 1999).

4.4 Grey-wastewater reuse feasibility

4.4.1 Economic feasibility

Price is an important variable that can significantly affect the uptake of reuse practices. Price can be viewed in two ways, the first is the price of the grey-wastewater systems while the second is the price of potable water. Some participants attested to water being priced cheaply in Kenya, but as literature suggests, this is dependent on economic levels. Lower income levels have been found to pay higher costs for water compared to those in higher and middle-income areas, yet this is the segment of the population that has been established to be able to afford the systems. Technical experts alluded to the fact that saving on water costs was not a driver for business based on Return on Investment (ROI) point. However, users attested to that being one of the benefits they have received from having the systems, but not a motivation to install the systems. Sufficient demand for the systems would reduce their costs through economies of scale or through increased marketplace competition.

4.4.2 Social feasibility

Technical experts gave a low score on knowledge of water reuse among the public but were quick to acknowledge that there has been a significant increase in the number of people adopting the practice and seeking out their services. Educational levels were found to influence the awareness of water reuse as more educated people appreciate the technology and the benefits of having the system. Income levels determine who would be able to afford the systems as purchase and maintenance costs are a big factor.

The public's attitude towards water affects conservation efforts. Viewing water as a social good and not an economic good limits the number of people willing to use water conservatively, especially at the residential level, where domestic water consumption is far less compared to industrial and agricultural use. The 'yuck' factor associated with recycled water makes people shy away from adopting the practice. This was evident in Kibera where some participants were opposed to paying for a decentralized system, wondering how the water would be 'clean'. For both instances, educational efforts tailored towards different population segments would help change the attitudes and would improve the appreciation of both freshwater and reclaimed water.

4.4.3 Technical feasibility

Wastewater recycling systems require both availability of land and secure tenancy for construction, which would be a hurdle for those who have neither. While the systems are automated for day to day operations, they have been established to be maintenance intensive. They need to be monitored on a regular basis to ensure that the pumps are working, and chlorine levels are sufficient to avoid contamination. Technical services have to be done every few months depending on the type of system. Participants reported that the water quality was good for their (non-potable) uses but needed appropriate maintenance for it to be sustained. Proper disinfection of the effluent before reuse is also an important step to avoid bacterial transfer, especially if the water is used for toilet flushing. As discussed above, it was also both economically viable and practical to install systems that can treat all domestic wastewater and thus, were the most prevalent in Nairobi. For Kibera residents, the bucket method was sufficient with no treatment prior to water reuse.

4.5 Water reuse and urban water planning

The third objective of this study was to find out the role of greywater and wastewater reuse in planning for urban water security. The analysis shows that reclaimed water can play a major role in urban water security as it is both a water conservation strategy and a sanitation solution. In discussions with participants, it emerged that government officials leaned towards conventional

pipe solutions with little consideration for other measures in planning for future water supply. The focus of the government is on increasing distribution and minimizing losses. However, with distribution losses estimated to be 38% as of 2018 (WASREB, 2018), an increase in production would only result in more water lost. Complementary systems of water supply need to be thoroughly considered for Nairobi.

In cities like Windoek, Namibia, reclaimed water is quantified as part of the city's main water supply sources. Furthermore, municipal by-laws have incorporated maximum wastewater reuse and water saving measures that are highly enforced during times of drought (Lahnsteiner & Lempert, 2000). Globally, several cities rely on reclaimed water as an integral part of their water supply system. With looming climate change uncertainties, urban water managers have no option but to incorporate conservation measures and water efficiency mechanisms as part of their future water planning. For climate change adaptation to be successful, alternative considerations have to be made and acted upon. Grey and wastewater reuse presents a climate independent water supply strategy that increases with increase in water use.

Following the success of Millennium Development Goals (MDGs), 17 Sustainable Development Goals (SDGs) were adopted by world leaders to go further in the eradication of poverty, protection of the planet and ensuring prosperity for all (United Nations, 2015). The sixth goal, 'ensure access to water and sanitation for all' is directly related to water security and provides an agenda for sustainable urban water and wastewater management for more resilient cities (Varady, Zuniga-Teran, Garfin, Martín, & Vicuña, 2016).

Conventional strategies for water supply that maximize resource exploitation have failed to guarantee water security, especially in this era of climate change influences. Water has not been managed equitably nor sustainably (Varady et al., 2016). To support the shift towards a circular economy and for SDGs to be successful, the potential of wastewater reuse cannot be ignored in urban water management. For Nairobi, this would mean taking concrete measures to increase the uptake of water reuse and to quantify it as part of its water resources.

5.0 Conclusion

Emphasis on water supply and sanitation has always been on centralized big infrastructure that are both expensive to construct with great social and environmental consequences and are yet to guarantee water security so far. There are other ways to augment supply that are not only flexible but are also readily available and scalable. In an era of climate change uncertainties and for sustainability to be achieved, complementary systems of delivery have to be incorporated in urban water planning. Grey-wastewater recycling is a promising option for Nairobi where water and sewerage services are inadequate. Apart from individual houses, decentralized cluster systems that serve a community can also be adopted.

The barriers that hinder wider adoption of the practice are possible to overcome. The growing number of urban wastewater recycling systems globally indicate that water reuse is an important strategy for sustainability efforts. Water reuse practices have been found to be a water conservation measure and sanitation solution for Nairobi. Financial incentives for homeowners are a good means to overcome the barriers identified. Additionally, education efforts towards different audiences on the technical systems and safe reuse practices are also important strategies for uptake. The government should also formulate proper water reuse regulations that address water quality needs for all sectors (including domestic non-potable uses) and carry out implementation plans that match policy statements.

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