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Residential and community rooftop rainwater harvesting in urban areas of Harare, Zimbabwe

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Introduction and country context

Zimbabwe is a landlocked country that lies in Southern Africa and is bordered by Mozambique, South Africa, Botswana, and Zambia. The climate can be described as tropical and temperate, with the rainy season starting around late November till March (CIA, n.d.). Winters are dry with cooler temperatures. Agriculture is the mainstay of the economy, followed closely by mining activities (CIA, n.d.).

The country has experienced the global effects of climate change, manifested locally through erratic rainfall patterns resulting in several crippling droughts over the past 30 years (Chaminuka & Nyatsanza, 2013). Closely linked to the phenomenon of drought is the associated shortage of treated water, coupled with rationing and non-supply in some areas (CIA, n.d.). This shortage of treated and piped water sources has resulted in citizens accessing water from rivers, streams, and other unprotected water sources. Mapepa and Adekoye (2019) and Chimbari (2012) list data that suggests that most households do not have alternative water sources as incomes remain extremely constrained following more than 20 years of social and economic hardship in Zimbabwe since the downturn of the economy in 1997. Unemployment is recorded at over 90% with most households living on less than a dollar a day (Mapepa & Adekoye, 2019; CIA, n.d.).

Waterborne diseases

These unsafe water sources have resulted in documented occurrences of disease, water-borne schistosomiasis and epidemics in Zimbabwe, affecting urban and rural communities alike (Chaminuka & Nyatsanza, 2013; Chimbari, 2012; Youde, 2010). These researchers reported that the most significant epidemic was the countrywide year-long cholera outbreak of 2008 which infected more than 100,000 Zimbabweans, killing over 4,000 people. A similar major outbreak of Typhoid was also recorded in 2012, concentrated in suburban areas where there have been erratic water supplies for years (Chaminuka & Nyatsanza, 2013; Chimbari, 2012). These two outbreaks are indicative of poor-quality water sources and the risk of untreated water.

Having lived in Harare, families and organizations that have additional financial resources can purchase what is arguably "treated" water for primary use that is delivered by trucks, for upwards of US$50 per 5000 liters, enough for about two weeks of careful use for a family of four. This has been compounded by the significant lowering of the water-table due to pressure on dwindling surface and subterranean water sources (Atwood, 2013). Many households and schools that previously enjoyed uninterrupted underground water sources have now found that prolific boreholes sometimes run dry, especially during the dry winter months. Unfortunately, boreholes remain a very expensive option, averaging US$5,000 upwards and requiring regular maintenance, electricity, and replacement of pumps, which are all costly and beyond the reach of the typical Zimbabwean family or community locations such as schools (Atwood, 2013).

Paper objectives

To this end, this paper seeks to highlight a viable option of urban rooftop rainwater harvesting for households, institutions, or schools in Harare, through: (i) collection and storage of available rainwater for general use and other uses like gardening; (ii) reduction of the incidence of disease by preserving limited treated water for hygienic use and using rainwater for secondary uses, and (iii) minimization of the incidence of illness and unnecessary loss of life due to schistosomiasis-related conditions by planning better water access.

This paper proposes an alternate approach to alleviate current water supply and quality issues experienced in most urban locations in Harare (Chimbari, 2012). The target population are houses, businesses, and schools that have standard domed roofed features which range from tin/steel, polycarbonate, or concrete tiled roofs that can channel rainwater to the ground through gutters. Harare receives, on average, about 32 inches of rainfall each year in the wet summer months (CIA, n.d.). With very few and low-cost modifications, rainwater can be harvested and used as-is for various secondary uses such as flushing toilets, cleaning, and watering gardens. This would ease pressure on the Harare City Council to prioritize the provision of scarce treated water for primary use such as drinking, cooking, and hygienic use (Youde, 2010).

Improving nutrition and livelihoods

This in turn may positively influence nutrition aspects for families as the food sources may significantly reduce susceptibility to diseases through the growing and consumption of home-grown fresh vegetables (Chaminuka & Nyatsanza, 2013). Securing diversified food options lessens the risk of purchasing contaminated vegetables from unsafe sources, reducing the incidence of diarrheal conditions (Chaminuka & Nyatsanza, 2013). Enhanced food security can also have a knock-on effect of preserving the environment as small spaces are well managed for maximum profits, sustainable outputs, and an expansion to viable livelihoods despite limited water sources (Mutekwa, Kusangaya & Chikanda, 2005).

Implementing urban roof rainwater harvesting

Rainwater harvesting has long been a viable option for many countries as an additional source of potable water (Elder & Gerlak, 2019). Typically, rainwater can be collected using ground-water collection drains that typically lead to a central water storage facility or lake (Gumbo, 1998). For example, Harare utilizes stormwater drains to channel rainfall ground-runoff to Harare's main water source, Lake Chivero, where it is treated and is supposed to be piped back to households (Gumbo, 1998). Due to the infrastructural challenges of an aging water reticulation system, many areas endure years without receiving piped water, while most receive erratic supplies, at best (Gumbo, 1998). This approach for rainwater collection was piloted by the United States Agency for International Development (USAID) in a few Harare households, to alleviate water supply issues (Jimenez, 2011). Vulnerable groups to accessing safe and accessible water supplies include children under the age of five, the elderly, and those with disabilities (NASCOH, 2013).

Benefits of rainwater harvesting

The author asserts that rainwater harvesting has a practical application immediately, in the short-term as well as in the long-term as most gutters and downpipes have a lifespan of between 15 to 20 years (Gumbo, 1998). This means that an initial investment in year one may have a potential return on investment that far outweighs the initial outlay, even after just five years. According to (Chaminuka & Nyatsanza, 2013), the benefits of urban roof rainwater harvesting can be qualitatively and quantitatively measured in terms of the following outcomes:
(1) Reduced dependence on erratic piped city water, increasing water supply predictability. (2) Lower costs of purchasing water or money that can be directed towards other financial priorities.
(3) Improved awareness of alternative water options and building resilience in favor of water conservation.
(4) Reduced time spent by households trying to access safe water elsewhere.
(5) Increased environmental sustainability and the possibility of urban livelihoods projects in the creation of vegetable gardens for improved nutrition.
This paper focuses on the five outcomes indicated above, which are directly attributable to the implementation of rainwater harvesting in the short- to medium- term.

Community participation

By stimulating community involvement, beneficiaries can be empowered to take charge of the provision of sustainable and regular water sources. There is a unique opportunity for Public-Private Partnerships (PPP's) or Corporate Social Responsibility (CSR) programs to partner with schools and communities to counter the ongoing challenges of providing regular water. This can include grants and subsidies in support of roof gutters for collection and water tank storage for later use. This can be a viable positive initiative for establishing a culture of community projects that positively support regular and clean water supplies for more urban communities. These are the two primary costs, in addition to piping and optional water pumps (Gumbo, 1998; Jimenez, 2011). A water collection system can take advantage of high rainfall yield days to store the water for later use on dry days.

Support and stimulation of small local businesses

The aim of such a project could stimulate the local business community. It can as well promote the decent work agenda at the local level for plumbing artisans, and manufacturing companies to produce associated collection and storage equipment. The use of endogenous components needed for the successful conversion from regular gutters to water collection gutters can be subsidized where possible (Gumbo, 1998). Additionally, significant discounts and subsidies could be offered to households purchasing their water tanks from authorized sources as well as fitment and configuration by approved companies or contractors. This will also go a long way in ensuring consistency in how the collection systems are erected for maximum effect and disease minimization due to cross-contamination or loss of water through leakages or evaporation (Elder & Gerlak, 2019). A sense of community partnership of shared water sources is encouraged to ensure security from diseases not just for individual households but for the greater community good (Gumbo, 1998).

Achieving the United Nations Sustainable Development Goals (SDG's)

This paper has the potential to impact several of the U.N. Sustainable Development Goals that were adopted globally in 2015 three months before the Paris Climate Change Agreement (SDGs, n.d.) The SDGs are a call to action, and by ensuring water security directly and indirectly impact can be realized in the long term as indicated in the graphic below.

SWOT Analysis

The specific problem to solve is that of access to alternative water sources that can be used for secondary purposes that do not require treated water, such as toilet flushing, watering gardens, washing vehicles, and so on. In summary, such a project could influence the following strengths, weaknesses, threats and opportunities in the long run.

Figure 1. Sustainable Development Goals (SDGs, n.d.).

Strengths identified
(i) Simple and low-cost retrofitting of existing gutters can turn wasted rainwater into collected water for households to use for secondary purposes.
(ii) Most urban houses in the city have sloped roofs as well as existing gutters already, lowering costs even further.
(iii) Low implementation cost with the potential for high benefit in the short to medium term.

Weaknesses observed
(i) Since existing roofs and gutters are being used, the water quality cannot be assured, so the water is suitable for secondary purposes.
(ii) Simple collection of rainwater does not allow for filtering or treatment of the rainwater, as a potential to expand the rainwater's use.

Opportunities presented
(i) Community members can take charge of the way they manage their available water more effectively and in an involved way without wastage.
(ii) PPPs can provide grants or subsidize costs by partnering with the community as part of CSR programs.
(iii) The project can be further used as an opportunity to educate households on sustainable water use habits.
(iv) Households can utilize the secondary water in nutrition gardens for own consumption or create livelihoods by selling any excess vegetables

Threats to implementation

- Funding for such a project may not be available at the individual or community level, despite the merits of water harvesting due to the depressed socio-economic environment in Zimbabwe.
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The Logical Risk Framework

The Logframe is included below and is based on the SWOT analysis for the project after installation and the review of literature in the preceding pages (Aquatabs, 2020; Gumbo, 1998; Jimenez, 2011; Leafguard, 2020). It identifies the risk indicators based on the strategic objectives as a basis for the assumptions.

#	RISK	MITIGATION	LIKELIHOOD
1	Use of rainwater for primary purposes such as drinking, thereby exposing themselves to the risk of disease	Introduce water treatment tablets in storage sources to sanitize all stored water	HIGH
2	Lack of individual ownership for community installations may result in collection systems ending up in disrepair	Create maintenance clubs for communal installations or schools, encouraging the use of the shared additional water resource	MEDIUM
3	Contamination of water due to rust and plant matter buildup	Encourage the use of UV treated gutters that are sealed to collect rainwater and eliminate foreign matter	HIGH

Figure 2. Risk Matrix

Conclusion

An urban roof rainwater harvesting project is a potentially viable option in alleviating the pressure of the municipality in providing treated water to a growing city population due to rural-urban migration and water reticulation systems that have not been expanded since the 1960s (Chaminuka & Nyatsanza, 2013). This approach can improve water access and reduce the risk of communicable diseases and epidemics by creating empowered community members with a greater awareness of the importance of safe water sources. Household vegetable gardens would also be encouraged, as a means of positively influencing community nutrition aspects, preserving the environment, and creating small sources of income within the community.

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