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A Cost Benefit Analysis Approach to Household Bottled Water Consumption in Nairobi County

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Abstract

The benefits accrued from bottled water consumption have been growing globally, playing an important role in provision of clean drinking water to populations experiencing challenges in clean drinking water access. While bottled water is promoted as a solution to access to clean drinking water, it presents a socioeconomic challenge given its economic costs, safety concerns and socioeconomic inequalities in clean water access. The study adopted a descriptive research design to examine the socioeconomic costs and benefits of bottled water consumption, extents of bottled water consumption and aspects that explain continued bottled water consumption. The qualitative methods focused on extents and health cost benefits of bottled drinking water consumption. Quantitative methods focused on the monetary aspects of bottled water. The contingent valuation method was utilized to determine households' willingness to pay for better drinking water services and an economic Cost Benefit Analysis of bottled water was done. Data was collected from 263 households using questionnaires and from 17 supermarket outlets using observation checklists. The study found that 38% of households consume bottled water regularly. 73% of households preferred to consume bottled water for other sources of water. Households were willing to pay 1.8% to 7.5% of their income for better drinking water quality services. Bottled water consumption was not viable, with a Benefit Cost Ratio of 0.36. Regression analysis showed that availability, water quality, taste, safety, and convenience of bottled water were aspects that explain bottled water consumption in Umoja with values of −0.446, −0.083, 0.350, −0.194, and −0.046 respectively. The study therefore proposes a multifaceted approach towards sustainable bottled water consumption extending beyond infrastructural improvements including interventions for behavioral changes, quality control enforcement, strengthening standards of bottled water supply and encouraging use of sustainable packaging.

Keywords

Household Bottled Water, Cost Benefit Analysis

1. Introduction

The benefits accrued from bottled water consumption have been growing globally, with the industry contributing significantly to the global economy, while playing an important role in provision of clean drinking water to populations experiencing challenges in clean drinking water quality and availability (Parag, Elimelech and Opher, 2023). This indicates the consistent rise in global bottled water consumption. The global annual consumption of bottled water was estimated at 350 billion liters and about 270 billion US dollars in 2021 with an increase of about 73% in the past decade and the global market is predicted to increase at a rate of approximately 7% to 500 billion US dollars in the years 2025 to 2030 (Bouhlel, Köpke, Mina, & Smakhtin, 2023). This global growth is attributed to consumer demand driven by the perception of consumers towards bottled water consumption (Cohen et al., 2021). Consumption of bottled water is currently highest in the Asia Pacific region, accounting for about half of global consumption. This can be attributed to the region's population, poor public infrastructure, high levels of water pollution and limited access to clean drinking water (Prüss-Ustün et al., 2019). Bottled water use is also rising among the urban poor in low-income countries. Walter, Kooy, and Prabaharyaka (2017) found that affordability, convenience, and perceived reliability are major factors influencing bottled water consumption in these communities. Despite its higher per-unit cost, refillable bottled water is often viewed as the most accessible safe drinking option. Consumer preferences in Nairobi, Kenya, are shaped by factors such as taste, odor, and perceived quality. According to Njeru (2016), bottled water is often chosen over tap water for its convenience, especially when public water is unavailable or difficult to transport. Despite its higher cost compared to tap water, bottled water is increasingly seen as an affordable and reliable option in urban settings. A study by Katonge and Namangaya (2024) in Dodoma, indicated a positive perception towards bottled water quality and safety with significant differences across different age groups and occupations. Favorable perception was observed among younger respondents, while older respondents indicated concerns about safety. A study by Fuente, Mulwa and Cook (2023) found that provision of verbal and visual information to households about the water infrastructure and service delivery in Nairobi increased their perceptions of "fair" water bills by 15% - 24%. A study by Maselela et al. (2024) reported that households may perceive bottled water as an alternative to available sources due to a lack of confidence in clean potable water, observing a lack of trust between citizens and government on the provision of potable water and an absence of oversight and enforcement of existing bottled water regulations, resulting in health risks due to consumption of contaminated bottled water.

Ochungo, Ouma, Obiero and Odero (2019) indicate that little has been done to assess the cost implication of the practice of bottled water consumption to augment inadequate municipal water supply in Kenya. Further, the study found that households in Langata Sub County pay more than two and a half times above their water utility bill per month to augment their drinking water needs. Despite the underlying issues with both traditional drinking water services and bottled drinking water, bottled water provides an avenue for the provision of clean drinking water and a lot needs to be done to make it equitable, available, affordable and reliable.

2. Health and Economic Dimensions of Bottled Water Consumption

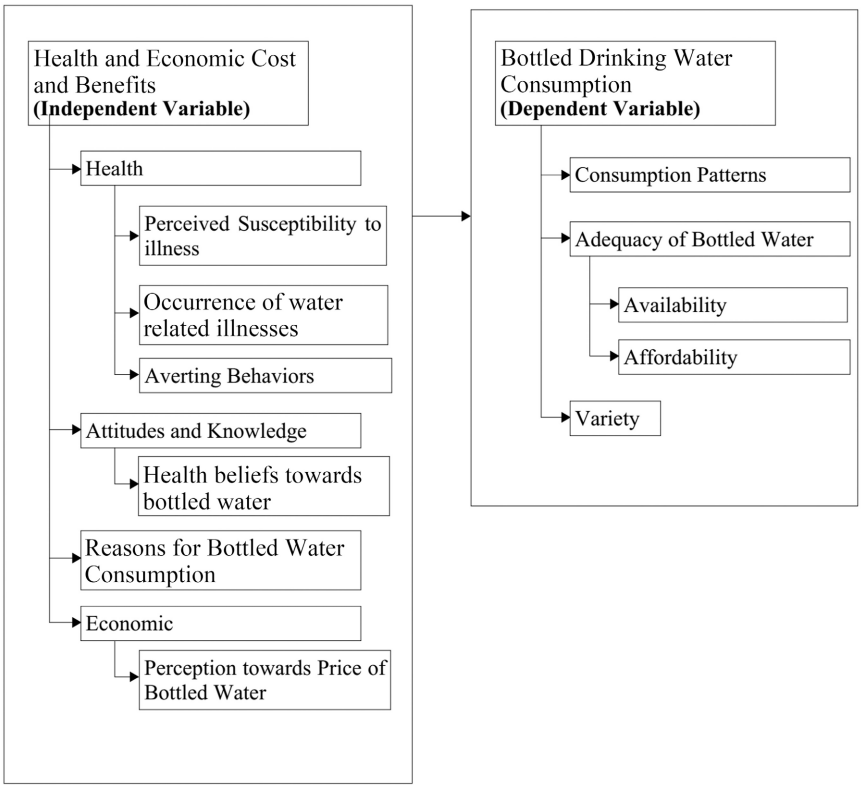

Figure 1. Conceptual framework.

There has been a surge in the demand for bottled water due to a rise in awareness about waterborne diseases, including malaria, typhoid, diarrhea and food poisoning. Availability of varieties of bottled water such as flavored bottled water and functional bottled water to consumers also contribute to the surge in bottled water consumption. The rise in urban population, increase in disposable income, improvement in standard of living, and emergence of eco-friendly materials for bottles are crucial factors responsible for the growth of the bottled water market (Mittal and Prasad, 2022). Bottled water appeals to many as being far more convenient than tap water (Miller, 2006). Bottled water is portable. Plastic bottles are re-usa-

ble due to their re-sealability. Bottled water has been marketed as a beverage for healthy lifestyle and has been associated with personal success, a symbol of status, other than it being convenient. Even though most bottled water sold globally is purified tap water, the public seems to be convinced that that bottled water is superior to other forms of drinking water (Parag, Elimelech and Opher, 2023). An analysis conducted in 92 countries in September 2022 indicated that globally, a 1.5-liter bottle of water costs an average of $0.70 indicating its high monetary cost while in countries where bottled water was most expensive, a 1.5-liter bottle retailed at $1.74 while and in countries where the price was lowest, a 1.5-liter bottle retailed at $0.14 (Fleck, 2023). Studies show that bottled water is typically less well-monitored than public service water (Cohen et al., 2021). In low- and middle-income countries, mostly in Africa, despite reported growth in packaged-water consumption, basic data quantifying the magnitude and volumes of packaged water consumed and resulting environmental consequences at local or national scales continue to be limited (Wardrop et al., 2017). Water stressed areas and areas experiencing water quality issues, such as concerns about the safety of tap water can experience increased bottled water consumption. Water borne disease outbreaks, and perceptions of taste and odor problems can also influence consumer choices of bottled water (Cohen et al., 2021). The production and distribution of a unit bottled water consumption requires between 5.6 to 10.2 MJ per liter in terms of energy (Qian, 2018). Plastic containers used in distribution are damaging to the user and to the environment including the leaching of carcinogenic materials such as antimony into the water. Elevated temperatures are responsible for the release of antimony from polyethylene terephthalate plastics used for water bottles due to improper storage of bottled water. Life cycle assessments of bottled water production transport and associated wastes such as greenhouse gas emissions indicate adverse impacts on the environment due to bottled water production (Cohen et al., 2021). A study conducted by Mohamed et al. (2021) indicates that the demand for drinking water in Kenya has necessitated proliferation of bottled drinking water companies in Kenya. A number of bottled water were contaminated with multi-drug-resistant heterotrophic bacteria, with bottling processes contributing to contamination. In 2016, more than 300 water brands were banned by the Kenya Bureau of Standards. Understanding of water use at the micro level such as household level is integral in rational and effective management and use of water resources. A major impediment to implementation of public provision of safe and reliable drinking water is the lack of information on household preferences with regards to potential improvements in water services. It is important to understand household preferences to determine preferred levels of services and design appropriate policies for sustainability (Van, 2013). Spatial dimensions of bottled drinking water consumption are related to its production, distribution, and consumption patterns. This includes the sources of water, the spatial distribution of bottling plants, transportation networks, market demand and the environmental impacts of bottled water consumption. Water origin adversely affects bottled water quality as well as its profitability (Bouhlel et al., 2023). According to a United Na-

tions University report on global Bottled water Industry trends and impacts, the main source of bottled water is ground water. Bottled water quality is also affected by the type of treatment process such as chlorination, ultraviolet disinfection, ozonation and reverse osmosis, storage conditions such as duration, light exposure and temperature, and the packaging materials used in production (Bouhlel et al., 2023). Production of bottled water involves a network of distribution, including transportation and delivery to consumer households. In urban areas, spatial organization of distribution networks affect availability and convenience of bottled water (Kaiser & Spuhler, 2019). The spatial distribution of retail outlets and consumption patterns play a role in the availability and demand for bottled water. Informed by the literature review and theoretical in the field of bottled water consumption, a conceptual framework was derived. Figure 1 above shows the conceptual framework derived, framing the relationship between bottled drinking water consumption and the health and economic costs and benefits of bottled drinking water consumption in the study.

3. Methodology

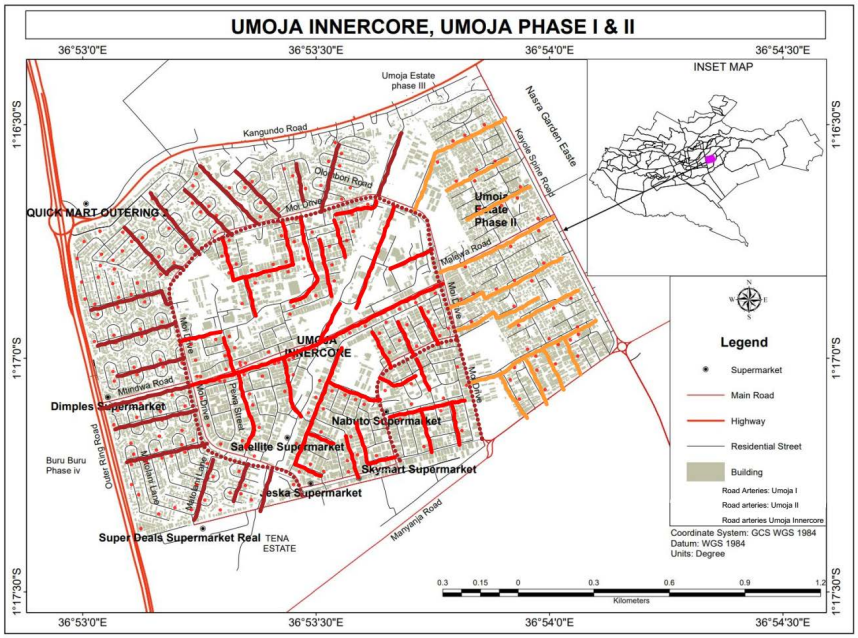

Figure 2. Map showing distribution of sampled households (Source: Adapted from Google Earth).

This research was designed as a descriptive research design focusing on selected households in Umoja neighborhoods. The study used both qualitative and quantitative approaches including administration of 263 questionnaires to households and the use of observation checklists in all supermarket outlets in Umoja. The study targeted bottled water users in households in Umoja, located within Embakasi sub county and Eastlands area in Nairobi, with three neighborhoods: Umoja I, Umoja II and Umoja Innercore. Umoja has a population of 140,216

with a population density of 44.547 people per square kilometer, currently a high density, low-income to lower middle-income neighborhood (KNBS, 2019). The complexity of the study required the use of both probability and non-probability sampling procedures to collect data from the field. The questionnaires were distributed based on the population of the three areas, thus 40% of the questionnaires were administered in Umoja Phase I, 35% in Umoja Innercore and 24% in Umoja Phase II. The two-stage cluster sampling process was applied, where random sampling was applied to the mutually exclusive identified clusters to ensure representation of the entire population. Simple random sampling was adopted in each of the three areas within the study area based on the road network as shown below, with households being identified from the road arteries arising from Moi Drive and the main artery passing through Moi Drive. The roads were identified in Phase I, 14 in Umoja Innercore and 11 in Phase II as shown in **Figure 2** above.

Benefit-cost analysis method was used to compare the costs and benefits of consumption of bottled water in Umoja, allowing for independent analysis of various aspects that are not directly related, including economic and health impacts of bottled water consumption. This comprised determination of costs and benefits, conversion of market prices to accounting prices, monetization or quantifying non-market impacts, inclusion of any indirect effects, social discounting (costs and benefits were discounted) and calculation of economic performance indicators such using the benefit-cost ratio.

$$\mathrm{BCR} = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+r)^t}}$$

where B_t is the benefit at time t;

C_t is the measure of costs at time t;

BCR is the Benefit Cost Ratio;

R is the discounting rate;

t is the number of years over which the costs and benefits were discounted.

When the benefit-cost ratio exceeds one, then the benefits are considered to be more than the costs, while if the BCR ratio is less than one, the benefits are considered to be less than the costs (Shively, 2012). A discounting rate of 13% was used, which is the current lending rate of the Central Bank of Kenya as at June 5th 2024. T was chosen to be 40 years, an assumption used in estimating annualized and recurrent costs in household water interventions (Hutton and Haller, 2004).

This study utilized the direct approach to establish estimates for households Willingness To Pay for better water quality. The Contingent Valuation Method (CVM) approach was used, by simply asking individuals how much they are willing to pay for what they consider better water services.

4. Study Area

The study was carried out in Umoja area in Nairobi County, located 01˚16'56" South of the Equator and 36˚53'32" East of the prime meridian as shown in Figure 2 above. It comprises of three smaller neighborhoods: Umoja I, Umoja II and Umoja Innercore. The area consists of high-density neighborhoods with buildings consisting of apartments four and five stories high.

5. Results

The study found that 38% of households in Umoja consume bottled water regularly. 73% of all respondents reported that bottled water is their preferred source of drinking water as shown in Figure 3 below. It was observed that the three neighborhoods in Umoja had fairly similar patterns of bottled drinking water consumption. All households in Umoja were considered to have basic bottled drinking water services given that households were within a kilometer of places where bottled drinking water is sold. Bottled drinking water is available in all supermarket outlets and water vending kiosks in various types, brands and sizes. each additional affiliation.

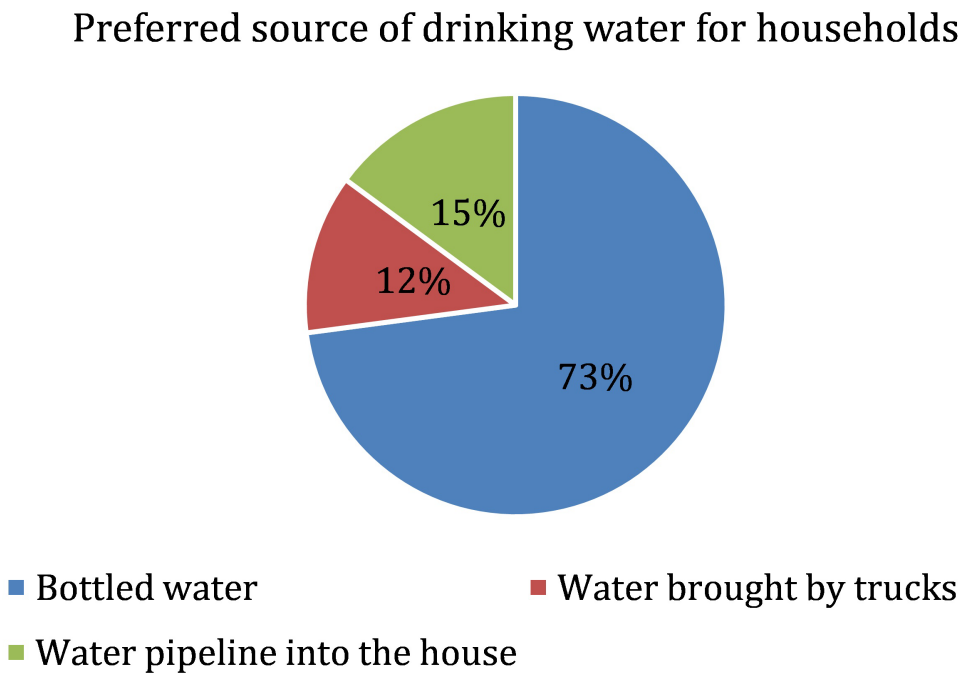

Figure 3. Preferred source of drinking water for households.

The study found that 93.3% of households whose household head had a post graduate education level consumed bottled water regularly as shown in Table 1 below. Among households where the household head had a primary school education level, 66.7% of them consumed water from a pipeline int their house while 33.3% sourced their drinking water from a water pipeline outside their household.

Table 1. Source of drinking water by education level of the household head.

Education level of head of household	Source of drinking water				
	Borehole	Bottled water	Water brought by trucks	Water pipeline into the house	Water pipeline outside house
	Row N %	Row N %	Row N %	Row N %	Row N %
Post Graduate	0.0%	93.3%	0.0%	6.7%	0.0%
Graduate	4.7%	30.2%	30.2%	26.4%	8.5%
Vocational	13.8%	20.7%	5.2%	31.0%	29.3%
Secondary	26.7%	33.3%	0.0%	30.0%	10.0%
Primary	0.0%	0.0%	0.0%	66.7%	33.3%

In terms of the variety of bottled drinking water consumed, 45% of households bought branded water, 36.2% of households bought refill bottled drinking water while 18.3% of households consumed both. A total of 22 bottled drinking water brands were observed in the various supermarket outlets indicating a variety of brands being sold and retailing at various prices. Still water was observed in all outlets while sparkling and flavored water was observed in some supermarket outlets.

The study found that 92% of households reported that they trusted the safety of bottled water. It was noted that 87.5% of respondents that trusted the safety of bottled water consumed bottled water regularly. 82.2% of respondents thought that bottled water is more hygienic than tap water. 79.1 per cent of Umoja residents did not experience water related illnesses and 54.2% of respondents were neutral about their susceptibility to water related illnesses. Different measures were practiced by households to prevent water related illnesses. 57.7% of households treated drinking water with 64% of households treating their drinking water using Chlorine/Bleach, 26% of households boiled their drinking water to make it safe, while 11% of households used water filters among other methods. Households were willing to pay 1.8% - 7.55% of the household income to get better drinking water services.

The study also found that 43% of households spend between 500 and 1000 Kenya shillings monthly on bottled water as shown in Figure 4 below.

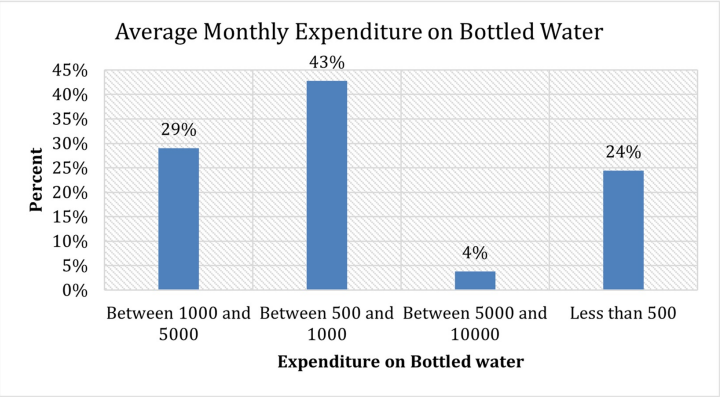

Figure 4. Average monthly expenditure on bottled water.

The study also found that 80% of households that earned more than Ksh. 50,000 per month consumed bottled water regularly as shown in Table 2 below.

Table 2. Monthly income and source of drinking water for households.

Average monthly income	Source of drinking water				
	Borehole	Bottled water	Water brought by trucks	Water pipeline into the house	Water pipeline outside house
10,000 to 25,000	12.1%	37.9%	4.5%	27.3%	18.2%
25,000 to 50,000	4.9%	17.6%	19.6%	41.2%	16.7%
Less than 10,000	22.9%	14.3%	0.0%	40.0%	22.9%
More than 50,000	0.0%	80.0%	20.0%	0.0%	0.0%

It was noted that 51.3% of households in the study stated that unavailability of tap water as a major reason for bottled drinking water while 26.2% attributed their bottled drinking water consumption to convenience and availability of bottled drinking water as shown in Figure 5 below.

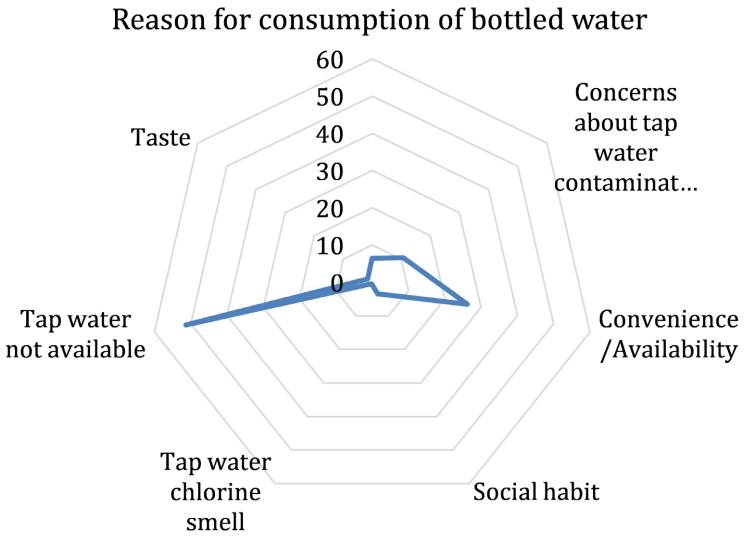

Figure 5. Reasons for consumption of bottled water Source: Author, 2025.

The regression analysis indicated that that several aspects were likely to relate to the prevalence of bottled drinking water consumption including availability of bottled water, convenience of bottled water, trust in bottled water safety and taste of bottled water. The aspects likely to relate to bottled water consumption include household availability of bottled water, convenience, trust in bottled water quality, safety of bottled water, taste of bottled water. As per the SPSS generated, the multiple regression equation was obtained as follows:

$$Y = 0.935 + 1.051x_1 - 0.446x_2 - 0.083x_3 + 0.350x_4 - 0.194x_5 - 0.046x_6$$

The variable on bottled water price change was not significant as its P value was

more than 0.05 as shown in Table 3 below. The regression equation established that taking all factors into account (independent variables) constant at zero, bottled water consumption level would be 0.935. The findings also show that bottled water convenience and safety positively affect bottled water consumption.

Table 3. Regression coefficients.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.935	0.257		3.638	0.000
	Bottled water is convenient for use	1.051	0.037	0.978	28.062	0.000
	bottled water is readily available for use	−0.446	0.056	−0.258	−7.996	0.000
	Bottled water has better taste than other sources	−0.083	0.026	−0.088	−3.245	0.001
	Bottled water is a safe source of drinking water	0.350	0.047	0.222	7.393	0.000
	Bottled water has quality concerns due to contamination	−0.194	0.045	−0.116	−4.347	0.000
	Bottled water price change affects my consumption of bottled water	−0.046	0.025	−0.047	−1.809	0.072

Note: a. Dependent Variable: Bottled water is regularly consumed in my household.

The study shows that households find the convenience, availability, taste of bottled water and the perceived safety of bottled water worth an expense. Bottled water is more affordable to households with higher incomes as they likely to spend a smaller percentage of their income on bottled water.

The study found that bottled water consumption in Umoja I is not economically viable indicated by a BCR of 0.31, while that of Umoja Innercore was 0.39 and that of Umoja II was 0.36 as indicated in Table 4 below.

Table 4. Cost benefit analysis.

Area	Benefits	Costs			BCR
	Average Monthly amount spent on BW + Monthly Benefit	Cost of the dispenser	Average Initial cost of the container	Total Costs	
Umoja I	1338.7	3944.46	409.798	4354.258	0.31
Innercore	1550.00	3591.79	396.406	3988.196	0.39
Umoja II	1808.59	4353.41	336.740	4690.15	0.39
Umoja	1538.27	3902.62	388.571	4291.191	0.36

The study found that 26.2% of households bought drinking water in the 15 - 20-liter packaging, 30.8% of households bought drinking water in 10-liter size packaging, while 16.0% of households purchased bottled water in the smaller packaging of 350 ml - 450 ml bottles as shown in Figure 6 below. The study found that households that buy bottled water in larger quantities may experience cost savings.

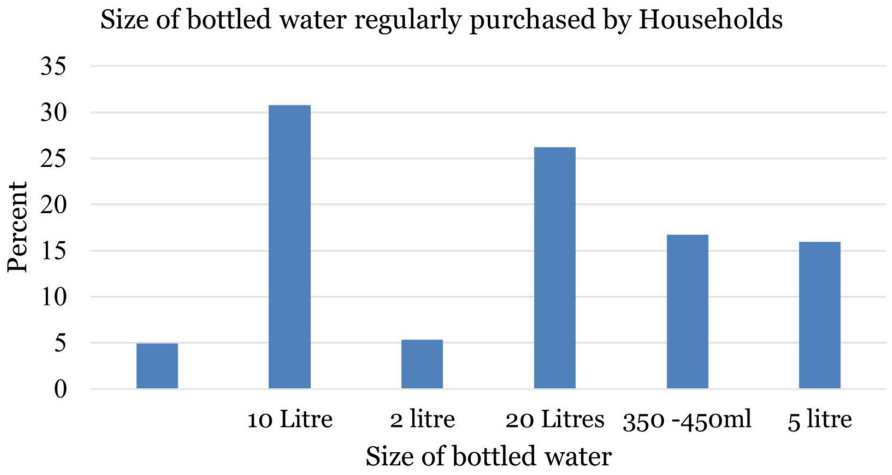

Figure 6. Size of bottled water regularly purchased by Households.

6. Sensitivity Analysis

A sensitivity analysis was conducted to test the impact of the discounting rate on the study conclusions. Table 5 below shows the scenarios that were used in the sensitivity analysis.

Table 5. Sensitivity analysis for the discounting rate.

Area	BCR using 5%	BCR using 10%	BCR using 13%
Umoja I	0.31	0.31	0.31
Innercore	0.39	0.31	0.39
Umoja II	0.39	0.39	0.39
Umoja	0.39	0.36	0.36

A sensitivity analysis was conducted to test the impact of time on the study conclusions. Table 6 below shows the scenarios that were used in the sensitivity analysis.

Table 6. Sensitivity analysis for time.

Area	BCR 30 years	BCR 40 years	BCR 50 years
Umoja I	0.31	0.31	0.31
Innercore	0.39	0.31	0.39
Umoja II	0.39	0.39	0.39
Umoja	0.39	0.36	0.36

Hutton and Haller (2004) indicate that assumption used in estimating annualized and recurrent costs in household water interventions range from 30 to 50years, which informed the reasoning and the references for the choice of time for the sensitivity analysis. Therefore 30 years and 50 years were used for the alternative scenarios. A discounting rate of 5% and 10% was used for the alternative scenarios. The sensitivity analysis verifies that the main study conclusions are independent of the model

7. Discussion

Parag et al. (2023) indicate that bottled water consumption is influenced by convenience, taste, unavailability of clean water for drinking its association with status and modern lifestyle influenced by messaging. On the other hand, a study by Nyarko, Odai, Owusu, & Quartey (2008) in Accra found that a majority of households relied on bottled water (31%) as a coping mechanism due to poor drinking water supply. The study also found that the highest percentage of bottled water consumers (40%) were the middle-income households and the high-income households (35%). In Umoja, the study found that 38% of households reported to consume bottled water and several aspects were likely to relate to the prevalence of bottled drinking water consumption including availability of bottled water, convenience of bottled water, trust in bottled water safety and taste of bottled water. More higher income households also tended to consume bottled water with 80% of households with income of more than Ksh. 50,000 consuming bottled water regularly. He et al. (2008) emphasize on the price effect of bottle size. The study found that bottle size impacts factors such as convenience and price of bottled water. The larger the bottle size, the cheaper the unit price. This has also been observed in this study where larger bottle sizes retailed at cheaper unit prices than smaller bottles and were more frequently purchased by households. Massoud et al. (2013) indicate that low-income communities incurred a cost of up to 26% of their income in purchasing bottled water while this study found that households spend an average of 5.74% of their income on bottled water purchase. The study found that 54.2% of respondents were neutral about their susceptibility to drinking water related illnesses, and a BCR OF 0.36. According to Hutton and Varughese (2016) in areas with unreliable drinking water sources, bottled water provides health benefits, thus the benefits outweigh the costs of bottled water consumption. In high income countries where there is reliable supply of drinking water, bottled water is often not cost-effective compared to tap water, with the costs outweighing benefits such as taste/convenience and is viewed as more of a luxury good (Bouhlel et al., 2023).

8. Conclusion

The study suggests that bottled water consumption in Umoja is viewed as a practical choice and a socially preferred one, strongly shaped by socioeconomic and perceptual factors. Although only 38% of households actively consume bottled

water, a significant majority (73%) express a preference for its consumption, indicating perception of its superiority in terms of safety, taste, and convenience. The study results indicated that economically, bottled water consumption is not justifiable with benefit-cost ratio of 0.36 at the household level, respondents are willing to expend 1.8% to 7.5% of their income on bottled water which they perceive as higher quality drinking water. This willingness to pay indicates a trust in bottled water. The study proposes that any sustainable intervention should go beyond infrastructural solutions and include interventions in social and behavioral aspects such as consumer trust, preferences, and norms that influence household decisions.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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