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Case Report

A Case Study on Water Supply Access and Demand Using Descriptive Statistical Methods

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Abstract: Of the various natural resources necessary for human survival and good health, provision of adequate water supply is a major challenge to many municipalities not only in Kenya but Africa as a whole. In 2000, an estimated one-sixth of the world's population was without access to improved water supply with the majority of these people living in Asia and Africa. This study reports a cross-sectional survey that sought to establish the water supply situation among households living in the high, middle and low income areas within the municipality of Naivasha in Kenya. Data from a random sample of 385 households was obtained from the residential areas with secondary and primary data obtained from the Naivasha Water and Sanitation Company. Primary data was collected on water access, alternative water sources, water quality, per capita water use and cost of water. The data were collected using questionnaires, scheduled interviews, and observations and analyzed using descriptive statistics. Our results indicated that only 63% of respondents used improved sources of water. Further, there was no significant difference between the amounts of water used per person per day across the three income levels. Water demand in Naivasha outstrips supply and people resort to using boreholes which have more reliable supply. The study showed that the respondents were able to access water as per the minimum required quantities postulated by the WHO guidelines. However, the middle and low income groups spend more than the stipulated proportions of their income on water. There was no significant difference between the water used by households across the income levels. The usage was significant depending on the number of household members and the amount of household activities that require water use per day. Households that could not afford their water requirements forced them to reduce water usage thereby compromising hygiene. This study shows that access to safe water still remains a challenge and the overall achievement of the Millennium Development Goal (MDG) of halving the proportion without access to safe water may be hampered by challenges of urbanization and rapid population growth. It is recommended that more effort be made to increase access to safe water to mitigate the various inequalities described here and to reduce incidences of water related diseases.

Keywords: Water Access, Water Demand, Per Capita Water Access, Cost of Water

1. Introduction

Water supply is the process of self-provision or provision by third parties in the water industry, commonly a public utility, of water resources of various qualities to different users. Water is indispensable component for all forms of life being needed in almost all human activities. Access to safe freshwater is regarded as a universal human right. The MDG7 has set a target of halving the proportion of people without access to safe drinking water by 2015 (Kundzewicz et al., 2007). Sustainable management of freshwater resources has gained importance at regional and global scales with integrated water

resources management now becoming the new paradigm shift in sustainability of water resources (Maurya et al., 2013, Maurya et al., 2014).

This paper will outline the special needs for safe drinking water in developing countries such as various parts of Africa and Asia and then locate the present study in the Naivasha municipality in Kenya as a case-study example. The results of a survey of random samples from a stratified socio-economic population will then be analyzed to show the adverse effects on a small population of local demand on limited water resources. Finally, recommendations will be made for improvements to populating access to quality ware resources. Some statistical methods to be used in this paper have been previously applied in different versions of research work (Maurya & Jaggi et al., 2015, Maurya & Singh et al., 2015).

2. Demands on Available Water

Various activities need water supply for operations including residential/domestic, commercial, recreational, industrial and agricultural which consume the largest amount of available water. Food and agriculture are the largest consumers of water, requiring one hundred times more than that required for personal needs. Up to 70% of the water removed from rivers, lakes, and groundwater goes into irrigation, about 10% used in domestic applications and 20% in industry (Lenntech Water Treatment & Purification Holding B.V., 2009). Globally, water for household consumption accounts for less than 10% of the overall human water use and so this use does not pose a major threat to natural freshwater availability. This is in comparison to agriculture, and industry which account for a combined 90% of water use (Kundzewicz et al., 2007).

Previous studies by the WHO/UNICEF (2010) on time to collect water by households indicate that those spending more than half an hour per round trip progressively collect less water, and eventually fail to meet their families' minimum daily drinking-water needs. Additionally, the economic costs of having to make multiple trips per day to collect drinking water are massive. In various countries, particularly in Eastern Africa, more than a quarter of the population spends more than half an hour per round trip to collect water. Previous surveys conducted in this context show that water collection trips of over 30minutes are most prevalent in Africa and other arid countries outside of Africa. Limited access to water in Africa is not mainly a resource issue, but one of poor management, pollution and wastage, and lack of facilities except in Northern and Southern Africa. In most African countries, over 50% of the water supply is wasted or unaccounted for. Therefore Africa is unlikely to reach the drinking water and sanitation MDG target as will be explained in the following sections of the paper.

3. Study Location

The study was carried out in Naivasha Municipality which has a shallow basin fresh water lake and is situated 80kms.northwest of the Kenyan Rift Valley. It is positioned at an altitude of 1890m between the longitude 36^{o}20'E and latitude 0^{o} 45'S and covers an area of approximately 100km^2.The population has rapidly grown from 7,000 persons in 1969 to 376,243 in 2009 (Republic of Kenya, 2010). The land use changes since independence (in 1963) have led to rapid growth in population, human settlement, intensive commercial farming, tourism and geothermal production. These changes have placed intense pressure on natural resources in the water shed threatening the sustainability of Lake Naivasha. The municipality is in mainly a semi-arid environment with a bi-modal rainfall distribution with long rains between April- June and short rains between October and November. The area receives an average of 600mm. of rainfall annually.

Lake Naivasha is a fresh water lake in the Rift Valley and was declared a Ramseur site in 1995. Its watershed is mainly a semi-arid environment with scarce surface and underground water resources. The area around the lake has witnessed major land use transformation following colonization of Kenya. At the beginning of the 1900s the land use in the watershed changed from pastoral economy to large scale white settler farming and since independence the area has experienced rapid land subdivision (Mireri, 2005). The population has greatly increased around the lake, resulting in a proliferation of unplanned settlements lacking basic amenities such as water, sanitation and waste disposal programmes. The lack of water in these settlements forces residents to use the lakeshore for domestic water, laundry and livestock watering (Bechtet al., 2006).

4. Materials and Research Methods

The study provided a cross sectional survey targeting households living within the municipality. It utilized questionnaires, interviews and observations as well as utilized both primary and secondary data as per requirement and feasibility of our present case study. It captured information on the current situation of water supply and sanitation. This information included the water supply situation from 2007, the sanitation modes used by the population living in various types of settlements, water conservation methods and the potential for improving the situation.

According to an economic survey done by the Kenya National Bureau of Statistics (2014), the National income bands were Kshs.0-23,672 for the low income, Kshs. 23,673-119,999 for the middle income and Kshs.120,000 and above belong to the high income. Further, from the preliminary studies, the population followed a similar pattern (Table 1 below). There are more people in the middle and low income than there are in the high income bands. Therefore, the sampling frame followed this pattern of population distribution in identifying households to be interviewed.

Stratified random sampling was, therefore, used with households stratified by level of income into low, middle and high income groups. A preliminary survey was undertaken to further assist in determining the sampling frame and then

simple random sampling was used to administer questionnaires among the three classes of households. Randomization was achieved by assigning numbers to households and selecting every 5th household for interview.The study sought to determine household water supply situation.

Table 1. *Sample size distribution in income levels.*

	Low Income	Middle Income	High Income	Total
Number	322	47	16	385
%	83.63%	12.21%	4.16%	100%

5. Water Access and Demand

Access to water remains a major challenge to residents of Naivasha as the Water and Sanitation Company can only supply 2,700m^3 out of the 6,400m^3 required demand by the Municipality. As previously noted, the main reason for the deficit is because of high rate of population growth. The alternatives to water supply are boreholes and rainwater harvesting although these alternatives are not able to adequately meet the demand. Some partnerships have been formed between the public sector, private sector, NGOs and research institutions in order to provide alternative water sources that complement the services provided by the water company. These initiatives are evident in peri-urban settlements that are particularly faced with problems of water supply (USAID & WSUP, 2011) such as Mirera and Karagita, where a non-profit partnership works to bring sustainable solutions to water problems in low income areas.

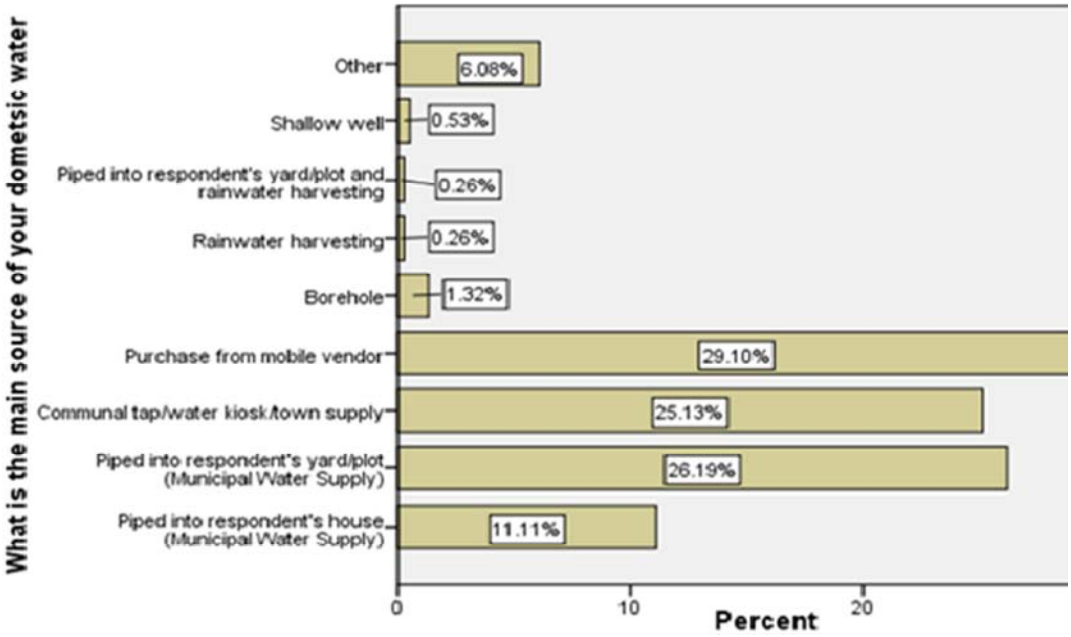

Figure 1. *Main Sources of water for domestic use.*

Survey data (Figure 1) indicates that 29.1% of respondents purchased water from mobile vendors for their daily household needs and 26.19% had water piped into the yard/plot while 25.13% used a community tap/water kiosk. Only 11.11% of respondents had their water piped into the house. The main source of water for the respondents living in high income areas was mostly water purchased from vendors although they were the majority among those who used piped water. The low income groups mostly sourced their water from mobile vendors (30.4%) and community taps or water kiosks as shown by 28.8% of respondents. The main source of water for the middle income group was water piped into their yards as shown by 50% of the respondents.

It was noted that purchasing water daily from mobile vendors or water kiosks was costly to the respondents in the middle and low income areas as they ended up spending a considerable amount of their income to buying water. However, due to the irregular supply of water, the study found that even respondents in high income areas could sometimes buy water from mobile vendors.

Table 2. *Cross tabulation of main source of domestic water and level of income.*

Main source of domestic water	Level of income			Total
	Low	Middle	High	
Piped into respondent's house (Municipal Water Supply)	30	8	4	42
Piped into respondent's yard / plot (Municipal Water Supply)	73	23	3	99
Community tap / water kiosk / town supply	91	4	0	95
Purchase from mobile vendor	96	9	5	110
Borehole	4	0	1	5
Rainwater harvesting	0	1	0	1
Piped into respondent's yard/plot and rainwater harvesting	1	0	0	1
Shallow well	1	1	0	2
Other	20	0	3	23

Based on survey data given in above Table 2, we can find Pearson *chi*-square=49.618[a], *df*=16, *p*=0.001. Besides, it is fairly easy to observe from Table 2 that a significant difference was found in the main source of water for domestic uses in the three income levels within the municipality. The low income groups mostly purchase water from mobile vendors because they are unable to meet the cost of water connection to their houses and also their areas of residence are not served with the water piping from the water company.

There being perennial water problems within the municipality, the reticulation of water systems do not cover all areas of the municipality and this accounts for inability to access piped water for some areas. Most probably, pipes were laid many years back before newer residential areas developed for the low income (slums) and the high income suburbs. The piped water, however, was found to be irregular in supply and the high income group also depended on mobile vendors although they were the majority among respondents who indicated that they mostly used piped water. Respondents in Lakeview, a high income residential area, indicated that their piped water supply was regular although they supplemented with drums to store water. The middle income respondents mostly used water that was piped into their yards.

From this study, 63% of the respondents use improved sources of water. In Kenya about 53 percent of the water provided by small-scale providers comes from "improved sources" (UNDP, 2011). The study therefore showed that many people in Naivasha use water from improved sources. Further, overall only 57% of households in Kenya use water from sources considered safe (GoK, 2007). The ability of mobile vendors, such as pushcarts and tanker trucks, to obtain water from a variety of sources allows them to supply water in times of shortage. This, however, also introduces an information gap regarding the quality of water sold, as end users have little means of verifying the safety of the water they purchase. Inferior quality pipes used by illegal connections break easily, and initially safe water can thus be contaminated by garbage, other toxic residuals, and impure external water flows (UNDP, 2011).

6. Per Capita Water Use

Results on the daily water usage in Naivasha (Table 3) show variation between income brackets. They show that the average daily usage was 21, 22 and 23 litres per person daily for the low, middle and high income brackets respectively. The results indicate that there is no significant difference between the amounts of water used per person per day in the three income levels (*p*=0.829). Though there is huge intra income variation in water usage, the results herein indicate that water is truly a basic commodity which, if accessible, income doesn't greatly influence consumption. This could imply that water use in households is mostly significant depending on the number of household members and the amount of household activities that require water use per day. More washing and cooking within a household will require more water overall in a household. According to the WHO/UNICEF Joint Monitoring Programme (2000) reasonable access to water is described as a person accessing an average of 20 litres per day. The present study shows that the respondents were able to access water as per the required quantities. However, the number of household members and the cost of accessing the water brought the challenge of a household's ability to fully meet the water requirements of each member considering the income levels of the three groups.

Table 3. *Comparison between water quantities used per day.*

	Water used per person per day					
Level of income	**Number**	**Minimum**	**Maximum**	**Mean**	**Std. Error**	**Std. Deviation**
Low	227	2.50	57.14	20.906	0.683	10.284
Middle	33	3.57	59.05	21.505	2.003	11.506
High	9	2.86	60.95	22.934	6.180	18.539

F= 0.187, *p*= 0.829.

7. Cost of Water

The results (Table 4) show that the low income consumers spend 12% while the middle income ones spend 15.7% and the high income groups spend 2.7% of their income on water. The people in the higher income group were able to meet their households' needs because of their ability to pay for water but those in the low and middle income had to find ways of meeting their needs either by using water minimally or finding alternative ways of conserving the water they got by re-using and by delaying some activities so that they were only done at intervals during the week such as washing clothes and the water re-used for cleaning the floors and toilets.

Table 4. *Comparison of cost of water per month against monthly income.*

	Cost of water used per month			Monthly income within group
	Number	**Mean**	**% of income**	
Low	148	1592.736	12%	5,000-20,000
Middle	14	4713.571	15.7%	20,001-40,000
High	6	1358.333	2.7%	40,001-50,000

From above table, it is evident that for the high income group, their percentage household expenditure on water was within the acceptable range and therefore this group may not be affected much. However, this expenditure was found to be higher than the recommended range for low and middle income households given that the household had to buy food and pay for shelter among other basic needs. On average,

households in Kenya spend 11% of their income on water (UNDP, 2011). This means that many people who cannot afford water to fully cater for their households' needs are forced to cut down on water usage so as to meet other needs and this compromises the hygiene of the households leading to the spread of water borne and water-washed diseases. Also, the sanitation situation of households is compromised due to the inadequate amounts of water required to keep sanitation systems clean. According to Water Governance Project Partners (2009), households should not spend more than 5% of their income on water. In turn, the statistics indicate that households would most likely cut on their expenditure on water by purchasing lesser quantity than their daily demand, purchasing water from cheaper sources or engaging in water harvesting. However, the ultimate effect is a reduction in overall household welfare due to the high cost of water.

8. Discussion

The present study established that access to water supply and sanitation in Naivasha municipality remains a major challenge. It revealed that only 63% of the residents are able to access improved water sources. However, the average water usage per person did not differ much between the low, middle and high income areas. On the amount of income used on water expenditure per household, the study showed that people in the middle and low income areas spend more than the recommended percentages of their income on water. The low income people spend 12% of their income on water, the middle income consumers spend 15.7% and the high income ones spend 2.7% of their income on water. The high income group expenditure was within the recommended range of 5%. Kenya's vision of ensuring water and sanitation are available and accessible to all by the year2030 still faces challenges of achievement and this means that by extension, Kenya might not attain the MDG target of halving the proportion of the population without access to safe drinking water and basic sanitation due to challenges of urbanization and rapid population growth. The inadequate access to safe drinking water may result in the worsening of hygiene standards and proliferation of diseases due to water storage and use of alternative water sources. Furthermore, the low and middle income groups will continue spending more than the required amounts of their household income in the purchase of water for domestic use.

9. Conclusion

This paper has outlined the special needs for safe drinking water in developing countries such as various parts of Africa and Asia and has then located the present study in the Naivasha Municipality in Kenya as a case-study example. The results of a survey of random samples from a stratified socio-economic population were analyzed to show the adverse effects on a small population of local demand on scarce water resources.

It is recommended that current water sources should be used optimally and alternative sources developed and used sustainably so that disparities in expenditure on water can be mitigated. Rainwater harvesting should be encouraged so that water is treated and stored for future use. For example, the Water Company could partner with private stakeholders who could jointly invest in the reticulation of water to new and un-served areas so that more residents can access water.

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