## DECLARATION

This research paper is my original work and has not been presented for a degree in any other university.

7/9/2001

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This Research paper has been submitted for examination with our approval as university supervisors.

7/9/2001

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## ACKNOWLEDGEMENTS

My foremost thanks go to the Education Foundation of the Japanese Sasakawa Young Leaders Fellowship Fund (SYLFF) for funding my graduate studies at the University of Nairobi. I also thank the African Economic Research Consortium (AERC) for funding my research. I am grateful to the University of Nairobi Administration at large for providing an enabling academic environment that paved way for my timely completion of the programme. Particularly so, I wish to extend my gratitude to the Director of Post Graduate Studies, the Chairman of the Department of Economics and all economics lecturers under whose able instructions and guidance this study came to fruition.

I wish to particularly single out my research supervisors: Dr. W. S. K. Wasike and Prof G. M. Mwabu for their tireless efforts, quick and up to date feedback to my various preliminary drafts of the research project (from the proposal stage through fieldwork to write-up phase) with an interest of seeing me complete successfully on time. I am also grateful to all those people of goodwill who assisted me in the acquisition of the study materials. Special thanks go to Engineer Mwangi of the Nairobi City Council for his efforts in providing me with reading materials.

Last but not least, I wish to extend my appreciation to my relatives, and in particular my sister Margaret Wangeci, my husband Stanley Githinji, together with our daughter Leah Wanjiru who provided moral support and inspirational nourishment in times of despair and withered hope.

Regardless of the foregoing, I should hasten to add that any remaining errors or omissions found in this paper rest solely with me.

**ABSTRACT**

In Nairobi, water vending is an important complement to the City Council's piped water supply system. The inefficiency and general inability to supply water at cost by the Nairobi City Council water authorities and service agencies has led to a growing backlog of unserviced consumers. This paper is based on a study designed to investigate sources of household water, evaluate factors that determine households' choice of water sources, and the nature of water vending in Nairobi's Ngando sub-location.

Data for the research was collected from secondary sources, and from surveys of both small-scale independent water vendors and households in Ngando. Random samples of vendors and households were interviewed using structured questionnaires. The resultant primary data was analysed using descriptive statistics, and maximum likelihood and ordinary least square estimation methods.

The study findings indicate that Ngando households source water from institutional supply, vendors, boreholes and wells, with vendors taking over 70% of the market share. Secondly, maximum likelihood analysis of determinants of household choice of water sources show that household size and income have significant effects on water source selection probabilities. Furthermore, education, the volume of water used per day, and the daily cost of water exert significant impacts on the probabilities of choosing particular water sources. The direction and magnitude of the impacts of individual attributes on the probabilities of choosing specific water sources is quite variant. The size of the household, for example, exerts a negative influence on the probability of choosing vendors as the main source of water but exerts a positive influence on the probability of choosing boreholes and wells. The impact of education on the probability of choosing specific water sources is negative with respect to vendors but positive in the case of boreholes and wells. The third finding is that the poorest households in Ngando pay the most for water both in absolute amounts and in terms of the percentage of their income spent on water; on average, the water bill constitutes 11% of households monthly expenditure.

While indicating the importance of water vending to Nairobi's low income residential suburbs, these results lead to the conclusion that households using greater quantities of water or who have to travel greater distances in search of water are relatively more likely to use water from an institutional supply. More generally, the likelihood of choosing alternative water sources is influenced by the source-specific attributes, such as proximity to the source, human capital attributes, household's composition, the expenses on water, and the volume of water that is used. In terms of policy implications, there is need (a) to improve the business environment for the small-scale private water operators, (b) to encourage private-public sector partnerships in water supply to engender more competition between the piped water system and the water vendors; and (c) for Kenya's public authorities (especially the Nairobi City Council and the Ministry of Local Government) to pay more attention to its regulatory functions (through appropriate laws, regulations, institutions and incentives) to protect consumers from unsafe water.

# CHAPTER 1: INTRODUCTION

## 1.1 Background of the Study Area

Water supply projects in Nairobi are traditionally based on piped systems, either with public taps or with private household services or with both wells and hand pumps. Both of these approaches to providing water services have been extensively studied (North and Griffin, 1993; Altaf et al, 1991; Altaf et al.,1992). There is, however, a third approach to service delivery, which is seldom explicitly recognized or incorporated in design or investment decisions of water authorities: private water vending which is a major practice in Ngando sub-location.

Ngando sub-location, one of –sub-location in Riruta administrative location of Nairobi District, is an area of about 23,921 people with 7,747 households; it covers an area of about 3.2 square kilometers (Central Bereau of statistics, 2001). The area lies along Ngong Road, which parallels Naivasha Road and starts from Dagoretti corner northwards up to the beginning of Ngong forest.

There are about five private primary schools (namely, Ngong Forest, Mwangaza Accademy, Ngando Baptist, Wisdom care, Menjor Junior) and about two secondary schools (namely, Lenana Boys high school and Enos secondary school. There is also a technical institute for the clothing and design, the Lak Creative College. The area is composed of 12 churches belonging to different denominations, some are registered, and others are not. The majority of houses in Ngando sub-location are constructed of iron sheets with iron sheets roof although corrugated metal roofs and masonry walls are becoming increasingly common.

The area is composed of five residential estates whereby the normal renting amount for a single room is Ksh.1000 per month; this is in exclusion of water and energy expenses. Very few households use electricity as a source of energy and this means that many people use wood energy for cooking from the nearby forest and occasionally paraffin for lighting.

The area lacks proper waste disposal methods, for example; sewage is left in the open and this increases the pollution of the environment. In fact, to make the matters worse, there is a whole estate of about 200 people that has no latrines and so residents are forced to go and help themselves in the nearby forest. Over 50 per cent of the population are Kikuyus and Kambas and the remaining 50% is composed of mixed tribes; these are Luo, Luhya, Masai etc. Education levels in Ngando are above average because about three-quarters of the population has attended school. About 50 per cent have at least primary schools education level. A few who are not educated lacked school fees and others engaged in vending water instead of going to school. This information is based on my field survey. A railway line passes through the area and serves as a main means of transport; there are also vehicles along the Ngong and Naivasha roads, which are commonly used by people.

More than 70 per cent of the water consumed in Ngando sub-location is purchased from vendors. The water-vending business is at pick in the morning hours and towards evening time. This is because some people may try to avoid hauling water under the sun whereas others engage in other activities. Some vendors have regular customers, highly valued because they provide a steady source of revenue, particularly during the rainy season. Vendors extend credit to regular customers and may charge lower prices in the rainy season, which may be as low as one Kenya shillings per 20-litre jerrican. During periods of shortage, vendors do not increase the price charged to regular customers. Vendors sell the 20- litre jerrican at Ksh10 during the wet season but sell the same container at Ksh15 during the dry season. There is a marked difference in the profitability of water vending in the rainy and dry seasons. The Ministry of Local Government has set up some regulations regarding water vending.

First, vendors using tanks should paint the tanks on both sides to ensure cleanliness of the water; secondly, vendors using tanks should each pay about 120,000 shillings per year; this money is to be paid in three months installment whereby each tank holder pays 40,000 shillings. Unfortunately, these rules have not been formalized by the Nairobi City Council (NCC). There are no rules that govern the activities of the other water vendors, i.e., the ones using bicycles, carts and the ones using manual labour. The area has a long tradition of water shortage; recently some wealthy men dug boreholes and wells to supply water to people of Ngando sub-location. The boreholes are about 240 meters deep and the wells are about 30 feet dip. The wells are shallow and the water they supply is salty and therefore not fit for human consumption; a few people use the water for other household chores but not for drinking. The water from the boreholes is normally treated by the NCC authorities and has to undergo several tests before it is declared to be good for human consumption. Some of these boreholes use electricity to pump water, so when there is no electricity, generators are used. However, some boreholes are not connected to the electricity lines and hence generators are used throughout to pump water which is a slower and a more time consuming process than when using electricity. Pulleys are used to draw water from the wells. The boreholes are serving people with water at a rate of Ksh5 per one jerrican of 20 litres and the same jerrican costs Ksh3 from the wells. There is also an old borehole, which was organized and set up by the then Ministry of Water Development in

1989; currently the Department of Water Development (DWD) is under the Ministry of Environment and Natural Resources. It served people only for a short time and thereafter stopped because of political interference; at times it is in operation and other times it is not. It is a small structure with a corrugated metal roof and walls surrounding a single tap, which the operator controls by hand. It is however subject to frequent break- down because of poor management and hence it is not reliable. A number of people wait for rainy seasons so that they can get plentiful water. The area has clay-like soil so that some water is left standing in some grounds when the rain stops. This standing water, when it turns greenish, is used by a few people to wash clothes. The area has unreliable rainfall. It receives a bi-modal rainfall pattern with long rains being received between March and May and short rains between October and December. The short rains are more reliable than the long rains (Kenya-Belgium Water Development Programme, 1990).

Most vendors carry water in 20 litres plastic jerricans, transported by either cars, bicycles, or by carts. Most of the carts carry six 20-litre jerricans weighing 120 kilograms. The cart wheels are equipped with bells which jingle when the carts are moving, and vendors make most of their sales while pushing their carts through the estates looking for customers; almost anywhere in Ngando a person can within minutes hear the bells and hail a vendor. Often several vendors appear. A bicycle outfitted for vendors can carry four cans. Vendors using lorries with big tanks of about 8000 litres to about 15000 litres transport water in more distant locations, and on slopes, which are difficult to reach with a fully loaded bicycle or a cart. A few of the vendors carry the water on their backs, i.e., the 20 litre jerricans and sell to people at the rate of Ksh10 per the 20-litre jerrican.

## 1.2 Statement of the Problem

In the past, a number of efforts such as International Conference on Water and the Environment (ICWE), United Nations Conference on Environment and Development (UNCED), International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD) have taken place in order to ensure that there is enough and safe water for every Kenyan. The message highlighted by all these efforts is that water availability is increasingly limited to the extent that there is no room for sub-optimal management if sustainable economic development is to be achieved. However, water from the Nairobi City Council does not meet the needs of every person in Nairobi. This is because there are few water sources in Nairobi. Again, water authorities and service agencies often fail to raise enough funds to cover essential operations, and there is often a growing backlog of unserviced consumers. In such situations water vending becomes important. In fact, people in squatter and slums in Nairobi are already being served by vendors who take water from a source that is available and then deliver it in containers to households or fill household containers from their vehicle tanks. Though vendors are rendering a valuable service to these people, they may sometimes sell water from polluted sources or fouled containers and this means water vending can be a financial burden and a health threat to people. Unfortunately, water vending in Nairobi and in particular in Ngando sub-location has received little attention in the published literature. This study gives more attention to water vending market in Ngando sub-location and seeks to understand the government regulatory framework for the water vending in Ngando sub-location. It also discusses possible solutions to the problem of water shortage in the study area.

## 1.3 Objectives of the Study

The main objective of this study was to evaluate the market for water vending in Nairobi's Ngando sub-location in terms of operations by independent small-scale water-selling entrepreneurs and household choice decisions. The specific objectives are:

1. To examine the determinants of households' decisions to get water from particular sources.
2. To evaluate the role of water- vending as a complement to the Nairobi City Council's piped water system.
3. To determine household valuation of water services compared to existing vendor prices, and the value of time spent collecting water for Ngando area.
4. To make policy recommendations on the government regulatory framework for the water-vending industry predominated by private operators.

## 1.4 Hypotheses of the Study

The hypotheses of the study are:

- Characteristics of a water source (i.e. proximity, reliability, quality) play a significant roles in influencing decisions to choose specific sources of water than household socio-economic and demographic profiles (e.g. household size, income).

- Average willingness to pay (WTP) for a litre of water is significantly higher than existing water charges.

  $H_o$: WTP/ LITRE = PRICE/LITRE

  $H_a$: WTP/ LITRE ≠ PRICE/LITRE

  Where: WTP/LITRE = Willingness to pay for litre of water beyond which the household cannot afford, and PRICE/LITRE = Price of water per litre.

## 1.5 Significance of the Study

Water vendors serve millions of people in Nairobi and may offer a more convenient service than is available from public hand pumps or public taps. Water vending has received little attention in the published literature and professionals in the water resources field have ignored water-vending impact. This is because water is seen as an indication of the failure of water institutions to provide an adequate service (for exceptions see Adrianzen and Graham, 1974; Antonium, 1979; Fass, 1982; and Suleiman, 1977).

Although this is an accurate assessment of the situation, vending is worthy of study for the following reasons; (1) vending will continue to exist in Nairobi for the foreseeable future due to severe shortages of capital for piped systems or for wells and hand pumps; (2) vending may in some circumstances prove to be an appropriate solution to water shortage; (3) information on water vending practices, particularly on costs and charges, may be useful for traditional water supply planning decisions.

## 1.6 Scope of the Study

The study covers the whole area of Ngando where about 61 randomly selected households were interviewed together with about 42 vendors that supply the households with water. Direct observations and interviews through questionnaires were applied in the study. Furthermore, information on the different water sources in Ngando were gathered to determine the most popular water source and model reasons influencing households' choice of water sources.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

The state of water provision services in a community can have a significant effect on the quality of life of the inhabitants. Many people and particularly women in Nairobi spend a significant portion of their day hauling water from sources to their homes. Enhanced access to environment improving services such as water provision can yield substantial benefits in the form of productive time saved.

Different options for improved water delivery services such as yard taps, handpumps, and standposts result in varying amounts of time saved because they cut out the need to haul water from more distant sources. People moving into slums and squatter settlements on the fringes of rapidly expanding urban areas must often rely on vendors until the piped system is expanded, if ever. In cases where there are other water sources, people may have sufficient income to afford vended water at least part of the time and thus obtain some relief from the daily burden of carrying water from a distant source to the household. The principal benefit of water vending to the consumer is thus that it provides a significant saving of time compared to fetching water from other sources.

There are, however, other social benefits of water vending. Vending is labour intensive. The principal cost of a simple water vending method (i.e., one without motorized vehicles) is typically the labour of the vendors themselves; the social opportunity cost of which may be very low. The capital costs of such water vending systems are much lower than for piped systems and usually require much less foreign exchange. Vending often provides significant employment in communities with few other opportunities (at least in the short term). The technology used in most vending systems is relatively simple and can be maintained locally.

While water vending is ubiquitous in Nairobi, it takes many forms and is organized in many different ways. All systems have one or more of the following three types of vendors:

(1) Wholesale vendors who obtain water from some source and sell it to the distributing vendors.

(2) Distributing vendors who obtain water from a source or a wholesale vendor and sell it to consumers door- to door.

(3) Direct vendors who sell water to consumers coming to the source to purchase water.

In Kenya direct vendors sell water from kiosks where the water is dispersed from a distributing system. An individual can be both a wholesaler and a direct vendor, selling to distributing vendors and to customers directly. A distributing, wholesaler or direct vendor may obtain water directly from a source or from a piped distributing system. A distributing vendor may in addition use a vehicle to get water from source directly or from a wholesale vendor. Customers may get water by pipeline, from a distributing vendor, or by walking to a public tap, a direct vendor (kiosk) or a source. The focus of this study is on distributing vendors, those small-scale entrepreneurs who sell water to households directly.

Prices for water may be set competitively or controlled at any of several possible points in a vending system. Any of the three kinds of vendors may be formally or informally organized, or operate independently. The prices distributing vendors receive may be set in a competitive market, while they may buy water from wholesale vendors with monopoly power. Alternatively, wholesale vendors may compete freely, but distributing vendors may be organized to control prices. Water from a public tap is generally free, but, when attended, the direct vendor makes a charge.

However, the amount that a household spends on an improved water service depends on numerous factors, including what other water sources are available; household water expenditures are not some fixed percentage of income. Many cities in developing countries do not have well run water utilities, and in such cities, there is increasing evidence that the poor pay large amounts for water provided through these kinds of informal water markets. For example, a study of water vending in Port-au-Prince, Haiti, found that in the dry season many of the urban poor spend 20 percent of their income on water. In Tegucigalpa, Honduras, it was found that many poor households spend 8 percent of their income on vended water in the rainy season and 12 percent in the dry season. In Addis Ababa, Ethiopia, the urban poor spend up to 9 percent of their income purchasing water from vendors. Water vending is also widespread in such cities as Lima, Peru; Karachi, Pakistan and Jakarta, Indonesia (Whittington et al 1990).

## 2.2 Access to Water Resources, Utility Rights-of-way and Water supply

Estimates suggests that one third of the world's population does not have access to uncontaminated water. However, only 45% of the population in Kenya is estimated to have uncontaminated water. A large proportion of this population is in the developing world where there are major difficulties in accessing improved water for domestic purposes. This is despite vigorous attempts, including the inauguration of the United National Water and Sanitation

Decade in 1981, to address water related problems. Most past efforts had a basic-needs approach, based on the assumption that the majority of those without access to good water were poor and therefore unable to pay for improved services. It was argued then that such people could have access to water only with subsidies from central and local governments. This led to the development of unreliable water services at minimum costs with little attempt to incorporate the wishes of the potential beneficiaries. As a result, most of the rural areas in developing countries are now littered with dysfunctional, unreliable or hardly used water schemes. In Cote d'Ivoire and Kenya only a third of the population reported to have access to improved water sources actually use them, and that the number of community water schemes abandoned annually approximated those being newly commissioned (Briscoe et al., 1990).

Despite the preponderance of community water projects, more prosperous households still find it necessary to invest in private water sources to ensure quality and reliability, while the poor, for whom the communal water and schemes present the only hope for accessing improved quality water, are pushed back to traditional sources which are costly in health, time and in some cases, direct pecuniary terms.

In recent years, poor households in the developing countries have shown a willingness to pay for improved water services provided such services have demonstrable improvements over traditional sources. Such improvement should include not just the quality but also the reliability of the service. For this reason, pre-investing water studies need to be tailored towards identifying water service levels that rural households both require and are able to pay for given their peculiar environmental and social-economic conditions. Such studies are imperative precursors to the development of water management reforms, such as privatization, that are now considered crucial for promoting sustainable grassroots development. If such management approaches involve underwriting the full cost of water distribution, wasteful use of water is likely to result. Furthermore, water management approaches promote peculiar water use habitats which, in turn, lead to specific resource exploitation styles that have specific environmental impacts. This argument underscores the importance of developing water management structures that drew from information on the existing water fetching and use characteristics.

## 2.3 Choice of Water Sources and Time Spent Collecting Water

Kimuyu (1998) tried to study and analyze water sources and use in Machakos district in 1998. In so doing, four groups of communities in this district (Wanzauni, Siathani, Kyua and Kola) were purposely selected from whom 226 households, about 55 from each community, were randomly sampled. Data were then collected through the administration of a structured questionnaire to sampled households heads. The questionnaire sought to generate information on household structure and human capital attributes, water procurement and application characteristics, episodes of water-related diseases, an assessment of existing communal water schemes, willingness to accept compensation for loss of traditional water sources, and socio-economic profiles.

From the information collected, it was found that reasons for choosing a water source are; nearness where by the distant to water source increases for all communities during the dry season, quality of water, reliability of water, multiple uses at source, and lack of an alternative. All these factors were found to be significant in all the four communities. Kimuyu further modeled choices of water sources by households using an indirect utility function.

The results revealed that household size, female proportion, female household head, distant to source, daily water source, reasoning ability score and the household expenditure significantly account for choices related to the sources of water. Further examination of the results indicate that household expenditure and the household head's gender do not exert significant influences on the choices related to the main sources of water. In other words, households headed by females are just as inclined to choose different water sources, as are those headed by males. Similarly, differences in the household prosperity do not influence the relative probabilities of choosing different water sources. Differences in the household sizes, the proportion of females in a household heads reasoning ability, levels of household water use and distances to the main source however exert significant impacts on the probabilities of choosing alternative sources of water.

Kimuyu later gathered information on how people value different water sources to the communities. In so doing, he used contingent valuation method and later estimated results for the willingness to accept compensation for the main source of water. The ordinary least squares regression results showed that, although the model performs disappointingly regarding goodness of fit, it is evident that the size of the household and the distance to the main source during the dry season exert significant positive impacts on the willingness to accept compensation for the loss of the main source. The coefficients of other variables (water use, income, community project, and community dummies) included in this valuation model are not significantly different from zero and, therefore, do not count.

The results from the contingency analysis of the relationships between exposure to water-related diseases and communities and water sources were statistically significant. The results further reveal a greater incidence of exposure to water related diseases for the households relying on piped water and roof catchment and dams and ponds. The latter category of sources mirror the fact that dams and ponds, which are open sources, are more likely to contain vectors for water -related diseases, but the former two are inexplicable, except perhaps that the sources from which the piped water is extracted are themselves contaminated. The results also reflect the dominance of piped water in the piped water roof catchment category. The relationship between the exposure to water-related diseases and the different communities shows that while more than a half of the households in Kyua reported incidences of these diseases, about a quarter of households in Kola similarly reported these incidences. The communities, therefore, exhibit important variations in the exposure to such diseases.

In conclusion, he ran a regression on the determination of domestic water demand. The results reveal that the household size, the proportion of females in a household, female headship, a household head's reasoning ability and a household's expenditure exert positive impact on the domestic demand for water. The positive impact of the size of the households simply confirms the intuition that the larger the household, the greater the level of water use. The proportion of females has both supply and demand effects since water collection is a female activity. A similar explanation can be offered for female headship. A positive impact of the household head's reasoning ability suggests a direct relationship between reasoning capacity and progressive behaviour. The variables exerting negative impact on the demand for water include the number of children in a household and the distance to the source of water and hence concluded that the demand for water is growth elastic within the prosperity threshold in which these communities operate.

Wittington et al (1990a) attempted to value the time that people spend collecting water using a small town in Kenya-Ukunda. The people of Ukunda collected water from three sources, these are; from vendors, from kiosks, and from a well. The study presented two methods (discrete choice theory, and randomly utility theory) of estimating the value of the time spent hauling water based on revealed willingness to pay (WTP). The study interviewed 69 randomly selected households and the interview showed that 43 households chose a kiosk, 17 chose vendors and 9 chose open wells. In the first part of the study, the following attributes were assumed to determine utility; (1) the price of water, (2) collection time per litre, (3) and taste.

The estimates on the value of time were consistent with the data on the average number of women in different groups of households. Because women were collecting about 75% of the water fetched by households in Ukunda, one would expect that households with more adult women, having a greater labour supply for hauling water, would be less likely to purchase water from vendors. This was, in fact, the case. Households using vendors averaged only 0.88 women, while households using kiosks averaged 1.44 women, and households using open wells averaged 1.78 women.

The analysis presented was a static one, which used cross-sectional data and so cannot be used to predict trends. Attempting to do this would require the use of a more complex time series analysis.

## 2.4 Studies on Private Water Vending

The activity of informal water vending has both advantages and disadvantages to poor communities in the developing world. On the negative side, the distribution of water by vendors is expensive, irrespective of whether vehicles are powered by people, animals or engines. In addition, it is generally the case that households served by vendors pay higher charges for water than those directly connected to a piped water system. Beyond cost considerations, vending sometimes is linked to health problems as hawkers may sell from polluted sources or from fouled containers.

Positive features of water vending are that it furnishes a valuable service for communities in urban areas with no access to piped water. It provides a significant saving of time compared to fetching water from other sources. Other positive features of water vending as an informal activity concern its labour-intensiveness and thus job creation impact and the fact that the simple technologies of water vending systems can be readily maintained on a local basis. In low-income urban settlements, private and community-managed vending kiosks often compete with each other. Let us now consider some of the studies on water vending in developing economies.

Whittington et al (1990) conducted a fieldwork for the Onitsha (a market town in Nigeria) water vending and willingness to pay (WTP) surveys in July 1987. They used questionnaires to interview five categories of people: these are, (a) tanker truck drivers; (b) manager and attendants of borehole; (c) small retail water vendors; (d) distributing vendors; and (e) households.

It was found that water vendors deliver more water than the public water utility and that revenues for vended water exceed revenues for water supplied by the public utility by a factor of 10. The results suggest that the utility could capture a larger share of the water market, even if tariffs are high enough to cover the full costs of supply. The study made it clear that, the WTP for a piped water system in Onitsha is surprisingly high and that a majority of households can afford to pay for a connection to a piped water system, even one which requires them to pay full economic costs. They would be better off than they would be by continuing to buy water from vendors because they would receive more water at a lower price. Hence on a annual basis, households in Onitsha are already paying water vendors over twice the operation and maintenance costs of a piped distribution system. It was further found that, during the dry season, households obtain approximately 2.96 million gallons per day (mgd) from the water vending system, for which they pay about US$28,000. In 1987, the public water utility was supplying about 1.5 mgd during the dry season, only 50 percent of the amount supplied by the water vendors. For this 1.5 mgd, the water utility only managed to collect about US$I, 100 in revenues. The private sector water vending system was thus supplying twice as much as the public system, but it was collecting about 24 times as much as revenue. In the rainy season, it was found that, the sales of private water vendors were still ten times the amount of revenue collected by the water utility.

Again the results of the households survey indicate that, people perceive the water available from tanker trucks and small retail water vendors to be in quality than the water available from the existing limited public system. Therefore in order to increase its market share, the water utility must not only offer lower prices than the vendors but also provide a higher quality product.

From a study on 'vending machine water not so good', in Los Angeles, it was found that vending machine drinking water often carries much higher bacteria levels than typical tap water. It was found that, ninety three percent of vending machines had bacteria levels 163 times higher than domestic tap water. Again it was found that fifteen percent of the machines tested advertised 'purified' water, but sixty two percent of those contained dissolved solids exceeding state limits (Antonovich, 1998).

Whittington et al (1989) tried to analyse water-vending activities in Ukunda, which is a village located 40 kilometers south of Mombasa in the Kwale district. The fieldwork consisted of four activities; these are, (1) observations at kiosks, handpumps and open wells; (2) interviews with kiosk owners; (3) interviews with water vendors; and (4) mapping out vendor routes. They used the questionnaires to gather information about the vendor's socioeconomic background employment history, costs and sales, pricing and other business practices, and future developments in the vending business. Ten of the kiosk owners were interviewed to elicit information on their business and their opinions on water vending. Again some enumerators followed vendors all day and recorded (a) the time, location and volume of each fill up at a kiosk, (b) the time, location and price of each sale, and (c) whether the sale was cash or credit. The numerator also asked each buyer how much water was purchased on average each week. Over a six-day period vendors were followed for an entire day fifty times, and 887 actual sales were observed. It was then assumed that, it is possible to model households' decisions regarding which water source to use and the question of whether it is justified to install additional hand pumps in a village such as Ukunda, which already had a water vending system.

Collignon (1999) did a study on the roles of the private sector in serving provision for the poor. The study concentrated on five different countries. These are, Niangolo, Kayes, Bobo Dioul, Port-au-pri. From the study, it was found that small private operators (carriers, standpipe managers, truckers, etc.) play an extremely important role in providing drinking water. It was also found that, in the period from the 50s to the 70s, when many African cities' growth was beginning to take off, municipalities played a direct role in water distribution, managing the operation of the network and billing subscribers, etc. Faced with a chronic deficit, most municipalities ceded the responsibilities for water service companies to a national state-owned enterprise. However, in most countries, the municipalities continued to manage standpipes for some years to ensure a free, minimal public service for the poorer segments of the population paid for through general municipal taxes (trading licenses, market taxes, land taxes, etc.). Over the last decade, however, municipalities have gradually abandoned the direct operation of standpipes, since fiscal revenues could not cover costs. Municipalities have let the standpipes gradually close down or they lease the standpipes to private managers. This means that, for the last ten years, municipalities have been almost totally absent from the public provision of drinking water, even in the case of matters that would normally fall under their jurisdiction (planning of new investments, ensuring that specifications are followed, etc.).

The study also found that, the role played by the private operators is generally greater in small centers than in larger towns. This is in addition to the various jobs e.g. water carriers, tank managers, truckers, and drill operators that are created by the private operators. In conclusion however, the study help us to appreciate the important roles, which the informal sector plays in serving poor people and therefore emphasis was put on how to encourage the activities of private operators. This would be through activities such as promoting competition, guaranteeing legal security to operators, not prosecuting subscribers who resell water for example etc.

Collignon (2000) did a study on water and sanitation using ten independent sub-Saharan African countries, which are meant to be the poorest. This is because, the city public water services are particularly weak and piped water service is nonexistence or irregular in many residential areas, from the poorest to the richest. Also, city water authorities are caught in a vicious circle; poor service leads to poor payment of bills, and there is little incentive to seek better cost recovery in order to improve service and fulfill the terms of their contracts, which call for city-wide service. These countries are Benin, Burkina, Faso, Cote d'Ivoire, Guinea, Kenya, Mali, Mauritania, Uganda, Senegal, and Tanzania. From the findings, it was found that, the independent water providers have filled the service gap left by the city-wide water and sewerage agencies. This is because no family can live without water and independent water provides have every incentive to expand into areas left unserved by the city-wide authorities. These independent water providers have moved into every area and service level and are therefore playing an increasing role in extending physical infrastructure which has been encouraged in recent years by the trend toward privatization of state-run water agencies; they then represent one sector of the informal or unregistered economy that has always existed in the cities and that has seen its market expand along with that of the private sector as a whole. To add to this, even when a water monopoly is justified due to hydrological conditions, independent providers have successfully competed with city-water authorities to produce and distribute water. In every city there are private investors who have drilled boreholes and transport water to clients who can pay but who are served by the city-wide water company. In some ways better adapted to local physical conditions than the concessionaire, the independent providers are more likely to suffer from administrative harassment or policy constrains, such as restrictions on drilling or an outright ban on water production, intended to protect a sole water concessionaire. It was also found that, government attitude towards private sector have become more open in recent years and infact the current trend is in the direction of privatization of public services. However, over the last five years, three of the ten countries have completed the establishment of joint public-private (Guinea) or entirely private (Senegal, Cote d'Ivoire) water distribution companies. The same process is underway in several other countries (Uganda, Kenya, Benin, and Mali). In all cases, one entity is given exclusion rights to operate the city-wide piped water network and ownership is dominated by a large international corporation. In the absence of cooperation or partnership between the concessionaires and the independent providers, and in a policy environment, which favours the concessionaires and gives them sole right to lay pipe in public right-of-ways, the concessionaires have every incentive to drag their feet about extending the network to unauthorized areas. Instead, they let the independent providers take the risk of laying "illegal" pipes, and simply expropriate them once they decide to move into those areas i.e. with or without compensating the providers.

Wegelin (1997) did a study on community versus private water vending in Kibera, Nairobi. It was found that, water provision for the 500,000 residents in Kibera is organized through about 500 water kiosks. These kiosks are mostly run by individual private owners, but some are operated by water communities and women groups. These community kiosks usually sell their water at a lower price than the private owners. Yet, the price of water is the same for the private kiosks and the community kiosks. The cost of the connection to the city water network can be quite high as the distance to the nearest main for the connection can be up to 2 kilometres, but profits on the sale of water are such that this is easily earned back. The private kiosks usually sell at 1.50-2 Ksh per jerrican of 20 litre and the community kiosks at Ksh 1 per jerrican. The m3 price is Ksh 100. Thus, by giving a social tariff, the authority is basically sponsoring private owners, as the authority does not control the selling price of water at the kiosk. Where community groups own the kiosk, the profits are usually reinvested in infrastructure or services within the same area and are therefore controlling to be improvement of the living environment. The private owners are often absentee landlords who do not invest the profits in the same area.

## 2.5 Willingness to Pay and Water Investment Decisions

Some of the key factors that influence the willingness of communities to pay for services, and hence relevant to utility managers and investment decision-makers, can be summarized as: security of tenure, level of service, choice of technology, reliability, price of water, and connection fee.

**Security of Tenure:** A household which is unsure of its tenure will continue to pay to water vendors to meet its daily needs but the willingness to invest in a new and improved service depends directly on the security of tenure of the household.

**Level of Service:** One of the most important planning decisions concern the level of service. The new facility should provide a level of service better than the available options. For example, in one study in Kenya (Whittington et al., 1990), it was observed that households which used vended water tended to be further away from other sources and had fewer women among them.

**Choice of Technology:** Community involvement is important in the selection of technology so that the design that has been adopted is what the community wants, is prepared to pay for and is able to maintain.

**Reliability:** Vended water is usually quite a reliable source and a higher level of reliability is needed to wean away customers from the vendors, if they are operational in the area. A piped system that is not reliable enough would not only fail to attract customers but would often result in large unpaid bills due to a distrust which is difficult to remove even when the reliability of service improves later.

**Price of Water:** Price is, no doubt, the most important determinant of a household's decision to opt for a new source of supply. On the supply side, water pricing has been based on such established methods as marginal cost pricing or cost recovery. Prices determined by such methods however fail to capture the ability or the willingness of a household to pay for the services and whether it would avail the new services. A mismatch between the two often results in high-quality piped water systems bypassing large low-income settlements towards higher income destinations. Much work has been done in recent years to assess with certain degree of reliability the effective demand of communities for water services. The important lesson that has come out of this continuing exercise is the need to involve and enable the communities to assess their own effective demand (through, for example, community self-surveys) with the least support from external agencies. The resulting community consensus .could lead to firm commitments to contribute financially to improved services.

**Connection Fee:** The connection fee is often an important determinant of whether a household will connect to a municipal system by moving away from other sources. Surveys indicate that a large proportion of households tend to drop out beyond a nominal threshold (Wasike and Hanley, 1998). Paying of the connection fee in monthiy instalments together with the monthly water bill could improve its acceptability.

Wasike and Hanley (1998) did a study on the pricing of domestic water services in developing countries, a contingent valuation application to Kenya. In their study, they compared willingness to pay for water connections across spread and upfront connection charges. This was to respond to the question of how significant is the payment profile of initial cash connection charge in household willingness to pay (WTP) bids for individual water connections. The study applied primary data that was collected using questionnaires. From results got, numerous individuals stated that they would not pay for the stated improvement. Statistical tests on average willingness to pay measures for domestic water supply improvement across profiles of initial connection charges indicated that an inability to afford the cash portion of the connection charge is the main reason people do not hook up to the piped water system in Webuye, Kenya.

Further results indicated that households that were WTP on spread mode changed their mind and said they could not afford a private water connection when they were offered the case of upfront connection charges. In other words, both refusals to pay and zero bids increased when respondents were asked to state their maximum WTP for a private water connection if the connection costs were to be paid upfront. From tests of statistical equivalence of WTP over spread and upfront initial water connection charge profiles indicate that WTP (SPREAD) and WTP(UPFRONT) are significantly different from zero at 5% for both the monthly and annual bids for the improvement programme. It was further noted that individual water connections and public taps are not perceived by Third World households as close substitutes. Besides price variation between the two systems, families with more income and assets perceive public taps and any other water source as inferior goods. In conclusion, it was found that the piped water system ought to be made more reliable for households to decide in favour of using either the standpipes or private connections. Webuye residents found it reliable to dig wells close to homes more attractive than the alternative of unreliable tap water relatively far from most houses.

## 2.6 Water Policy and Water Supply in Kenya

### *2.6.1 National Water Policy*

At the moment, the Ministry of Water Development co-ordinates activities through a labyrinth of other organizations. But there is to date no explicit water policy. The Water Act (1952), presently under review, is the primary policy guide on water development. This Act charges the Water Resources Authority[1] 'with the formulation of water-related policies and the management of the country's water resources. The public policy orientation is that water is a basic need and an essential resource for socio-economic development. For this reason, water resources are considered government property, and the authorisation for the right to use the resources is vested with the Minister of Water. Current policy framework documents suggest that amendments of the Water Act, in order to address national water policy paper is also underway (Government of Kenya, 1996b). A national water policy is also under preparation, and a comprehensive investment plan for the rehabilitation and the extension of existing water supply schemes is being implemented[2]. There are also efforts to encourage community-based water management (Masua and Makokha, 1997 and Kenya Belgium Water Development Programme, 1996).

### *2.6.2 Access to Clean Water*

Access to safe water and sanitation directly determines the health outcomes of a community. Recent studies (FAO 1995, Howard Humphreys, 1985,) show that significant water and sanitation improvement can reduce the incidence of diarrhoea by 22%, roundworms by 28%, schistosomiasis by 73%, and guinea worms by 73%. During the world water day (March 22,2001), it was estimated that in Kenya only 49 percent of the total population has access to clean water. In the same day, the Minister for Water Development said that water is one of the

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[1] The Water Resource Authority, established under the Water Act, investigates water resources, makes recommendations regarding the improvement, preservation, conservation, utilisation and the apportionment of water, surveys the existing consumption and demand for water, prepares estimates for future water requirements for different parts of Kenya, and formulates proposals for meeting current and future water demand.

[2] Other relevant legislation includes the lakes and rivers Act which governs the management and the protection of

most threatened resources and health is one of each person's most precious resources. The Minister said that, about 1,500 million people worldwide lack safe drinking water and at least five million deaths can be attributed to infections caused by water-related diseases, for example, cholera and typhoid. Therefore water related infections are a major cause of mortality as was recently evidenced by the typhoid outbreaks in Embu and its environs. Therefore the minister in charge of water affairs has come up with a slogan: 'Conserve and sustain quality water for better health of the present and future generations'. The provision of clean water has significant positive externalities; best realized when the provision is universal. However, access to drinking water depends on its general availability and the effectiveness of the methods of its distribution. When one is in outdoors- one needs to drink water to stay healthy (at least one gallon per day). The only question is, 'Is the water safe for drinking?.' This is because safe water is critical to everyone's health, and the safety of your water cannot be taken for granted. In U.S.A., alone, a country where most people assume their water is safe; over 1,000,000 people become sick each year from consuming contaminated water. The only way to ensure a safe water supply is to test the water and treat the problems found since the more you know about water and what contaminants it may contain, the better equipped you are to make the right decisions. Some contaminants pose immediate health risks, while others are more of a long-term threat (American water service article, 1998).

However only 45% of Kenyans have access to clean water. Generally, households living in medium and high potential part of the country are considered to have access to safe water if they can get 20 litres of clean water daily from sources within a kilometer away. In the low rainfall area, this distance increases to four kilometers. Kenyans living in planned urban areas have relatively greater access to safe water, the proportion of those having such access being estimated at 93% in the high class residential areas, but dropping to 53% for slum dwellers. For the rural Kenya, the proportion of households with access to clean water is a paltry 32.50%. These averages mark huge differences for households resident in different regions of the country as shown in Table 2.1.

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river courses and lakes, water (the water undertakers) rules, and the local government Act.

Table 2.1: Access to safe water in Kenya

| Province | % of households with access to safe water |
|---|---|
| *Nairobi* | 96.20 |
| Coast | 59.20 |
| Rift Valley | 46.10 |
| Central | 45.50 |
| Western | 42.90 |
| Eastern | 35.10 |
| Nyanza | 28.10 |
| North.Eastern | 16.90 |
| Rural | 32.50 |
| Urban | 93.30 |
| **Kenya** | 44.90 |

Source: Central Bureau of Statistics (1994)

### *2.6.3 Water Treatment Procedures*

The Nairobi City Council (NCC) has made a number of tests to the water supplied by the boreholes and especially the ones in Ngando sub-location and have found that, the water is good for human consumption. The tests are as follows:

The test-pumping, that is used to determine the pumped-borehole-efficiency. This is done by getting the borehole efficiency curve, i.e., efficiency percentage against extraction. However, in a good borehole, the decrease of efficiency with increasing extraction should be low and in a less good borehole, the efficiency decrease will be higher. It is essential when comparing boreholes for a decision upon future use to take into the picture the maximum extraction and corresponding drawdown plus the borehole efficiency at that extraction. This is because, a low efficiency will endanger the future life of the borehole because it is sign of high losses in screen or a gravel packing which eventually will lead to incrustation and clogging of the screen or the gravel packing. However, increased extraction from the ground may be washed out when the flow velocities in the ground increases. In the Nairobi area the water is in general, of good quality except for the fluoride content, which is sometimes high and often varies from borehole to borehole. It is therefore necessary to combine test-pumping with a quality follow-up. In another test, (step-drawdown), the water turbidity should be observed frequently during the test by the pump attendant so that a breakthrough of sand, silt etc., will be noticed.

At the end of each step, a water sample should be taken for analysis of turbidity and fluoride content. The last sample should be fully analysed according to the standard procedure for drinking water. This is because; the water analysis is of great importance not only for the use of the borehole itself but also as a design factor for the water supply system where blending proportions and blending techniques are involved. It is good to note that, boreholes which give water of good quality especially a low fluoride content and the ones situated near mains of the water supply net is given a higher priority. After these tests, the water has also to be treated. So the treatment process is as follows: chemical coagulation followed by clarification by flocculation and settlement, rapid gravity sand filtration, disinfection with chlorine and pH correction. The chemicals used in the treatment are;

- Alluminium sulphate; primary coagulant
- Calcium sulphate; for floc weighting or alternatively Calcium hydroxide; to provide sufficient carbonate alkalinity for reaction with the coagulant
- Sodium carbonate; to provide sufficient carbonate alkalinity for reactions with the Alluminium sulphate coagulant at such times that the water contains insufficient carbon dioxide to react with any lime addition without creating an undesirably high pH value.
- Polyelectrolyte; to aid coagulation (floc toughness)
- Pre-chlorination; to reduce soluble organics
- Post-chlorination; for disinfection
- Post sodium carbonate; for final pH control.

These chemicals are used as shown in Table 2.2

It is important to note that the Nairobi City Council has four water treatment plants: Kikuyu springs, Sasumua, Kabete, and the Ngethu treatment works. Some of the treatment works are very old and have in the past been rehabilitated. The Ngethu treatment plant is the biggest and the most recent phase11 of the plant is currently under construction. This plant is expected to treat the additional water from Thika Dam (Mwangi, 1996).

Table 2.2: Water Treatment Procedures

| | Alluminium | Gypsum or Lime | Soda ash | Polyelectrolyte |
|---|---|---|---|---|
| Design Doses | | | | |
| Maximum rate(mg) | 100 | 50 | 50 | 1 |
| Average annual rate(mg) | 20 | 10 | 18 | 0.2 |
| Solution tanks | | | | |
| Number | 2 | 3 | 3 | 3 |
| Nominal capacity of each container($m^3$) | 30 | 30 | 30 | 5 |
| | (approx.200g/1) | 10%(100g/1) | 10%(100g/1) | 0.5 % |

(Polyelectolyte is further diluted to 0.1% by injection of carrier water into the dose delivery lines)

Chlorinators

| Chlorinator rate (kg/hr) dose | | Maximum amount of water that can be treated at max. rates($m^3$/day) |
|---|---|---|
| Max. | 18 | 144,000 |
| Min | 0.9 | |

Note: Each tank should take 8 hours to empty at maximum dose rates for design capacity flows.

Source: Howard Humphreys (1985), "Third Nairobi Supply Project, Treatment and transmission", City Council Report, Nairobi

## *2.6.4 The Nairobi Water Market*

### 2.6.4.1 Water Demand in Nairobi

Earlier projections indicate that, the urban area of Nairobi is served by a pipe water distribution system, which supplies about 217200m$^3$/day (normal maximum rate). A preliminary 24-hour test carried out in Feb. 1985 indicated that 163700m3/day was entering the city's distribution system. The Chania2 Scheme, which was completed at the end of 1985, increased the available water supply by about 80000m3/day. Prior to the completion of Chania2 Scheme, normal maximum supply was constrained to about 137000m3/day, which was insufficient to meet the real water demands of the city. In addition, some areas of the city were still being supplied with water from the boreholes, either as their only source of supply or to supplement supplies from the main extension. The estimates indicate that, about 101,000 to 121,000 people were not served by the city water supply system by 1985 and therefore boreholes played an important role.

The total volume of water supplied to the main system of Nairobi (normal supply rate) has been constant at about 132000m$^3$/day since the late 1970s until mid-1983. Over the same period (1979-1983) billed water consumption has fluctuated between 106000 and 118000m$^3$/day without exhibiting an underlying upward trend. The resulting unaccounted for water was then estimated at between 11% and 20% of total input, which would be an excellent performance of international standards.

Table 2.3: Nairobi-Water Demand Projections-medium

| Category | Medium projections | | | | | |
|---|---|---|---|---|---|---|
| | 1975 | 1981 | 1984 | 1985 | 1995 | 2010 |
| Population (000s) | | | | | | |
| Total | 733 | 954 | 1104 | 1162 | 1950 | 3860 |
| Served with Water | 604 | 851 | 983 | 1035 | 1853 | 3667 |
| Consumption(1000s m$^3$/day) | | | | | | |
| Total consumption | 78.1 | 110.7 | 111.8 | 132.1 | 261.4 | 596.7 |
| Total demand | 93.8 | 132.4 | 190.3 | 203.2 | 326.7 | 745.8 |

Source: Howard Humphreys, (1985), Population and water demand projections for Nairobi. City Council report Nairobi

From Table 2.3, the medium projection shows that total demand is expected to increase from an estimated 203000m3/day in 1985 to 327000m3/day in 1995 and 746000m3/day in 2010, at average annual growth rate of 4.9% between 1985 and 1995 and 5.7% between 1995 and 2010. The apparently low growth rate between 1985 and 1995 is accounted for water from its current high level falling to 20% production in 1995. Direct consumption by consumers is predicted to grow at 7.1% between 1985 and 1995. These results show that, in order to provide supplies to Nairobi a new source must be developed without delay if continuity of supplies to the city is to be assumed. Detailed planning should commence immediately (Howard Humphreys, 1985).

In January 22-25, 1996, a seminar on integrated water resources management in Kenya was held which came up with further discussions on the Nairobi water projections. From this, it was found that the demand for water in the city will exceed supply in the years around 2008 to 2010. Also, the waste water generated is currently estimated to be more than the existing treatment capacity; the remedy currently being undertaken is to expand the resources by construction of water tunnels and treatment works and by expansion of the main supply, pipes, general supply systems, sewerage systems, and treatment works. The Nairobi City Council is also encouraging community partcipation in the provision of water and sanitation services. There is therefore a consensus that some services should be privatized and the modalities of implementing these proposals are currently being studied. Further estimations of population and the water demand were estimated thereby revealing the results in Table 2.4.

Table 2.4: Population, past and future projections (in thousands)

| 1967 | 1979 | 1980 | 1985 | 1995 | 2000 | 2010 |
|---|---|---|---|---|---|---|
| 509 | 828 | 897 | 1145 | 1800 | 2270 | 3360 |

Source: Mwangi (1996)

From Table 2.4, the population of Nairobi is growing at 7.5 percent per annum. This rapid population creates an increasing demand for food, industry, employment, and infrastructure facilities and therefore, analyzing the present and the future population patterns in Nairobi is therefore extremely important in defining the needs of water and sewerage services. Domestic users constitute the largest category of consumer. Commercial users make up the second most important category, accounting for 16 percent of current consumption (see Table 2.5)

Table 2.5: Categories of Water consumers in Nairobi

| Category of consumer | Number (in thousands) | Percentage of Total Consumers |
|---|---|---|
| Domestic | 1430 | 63 |
| Commercial | 136 | 6 |
| Industrial | 182 | 8 |
| Institutional | 250 | 11 |
| NCC/W&Sd | 45 | 2 |
| Unaccounted | 227 | 10 |
| Total | 2270 | 100 |

Source: Mwangi (1996).

In 1988, 90 percent of the population had a water supply; by 1995, 95 percent, where it will remain to 2010. Consumer consumption is predicted to grow 6.1 percent a year from 1985-1995. As shown in Table 2.6, the projected total demand for water is expected to increase from an estimated 189,900m$^3$/ day in 1985 to 296,700m$^3$/day in 1995 and 555,700m$^3$/day in 2010. This assumes an average annual growth rate of 4.8 percent between 1985 and 1995 and 4.3 percent between 1995 and 2010. The unaccounted for water was estimated to be 30 percent in 1988, 25 percent in 1993, currently it is estimated at 20 percent. This is expected to be reduced further as rehabilitation of the old water pipes continues.

Table 2.6: Water Demand Projections (1000m$^3$/day) by Consumers Category

| CATECATEGORY | 1985 | 1995 | 2010 |
|---|---|---|---|
| Dome | 84.1 | 151.3 | 285.1 |
| Commercial | 20.6 | 30.8 | 56.6 |
| Industrial | 12.6 | 28.8 | 55.1 |
| Institutional | 17.5 | 26.8 | 47.9 |
| Unaccounted | 54.8 | 59.0 | 111.2 |
| Total Demand | 189.6 | 296.7 | 555.9 |

Source: Mwangi (1996).

2.6.4.2 Water supply and infrastructure in Nairobi

The Nairobi water supply includes both surface and groundwater sources. The existing water supply from surface water is from four main sources: Kikuyu springs, Ruiru Dam, Sasumua, and the Ngethu/Thika Dam. The last two are the major sources of supply (Table 2.7). Some consumers, such as industries, institutions, and even some domestic consumers use groundwater. Groundwater generally moves from west to east, reflecting the topography of the area and the prevailing rainfall and recharge patterns. The recorded water levels indicate the water table to be deep under most of Nairobi. In Karen, the depth is from 20 to 35 meters; in Langata, it is between 70 to 100 meters; in Spring Valley, it is from 15 to 25 meters, and in Kamiti, it ranges from 15 to 60 meters in depth.

The city is divided into three main supply areas: upper, middle, and lower. Areas in the upper zone are supplied with water by pumping, while the middle and lower zone are supplied by gravity. Reservoir storage is required to balance peak demands and also act as a reserve against short duration failures of source water for fire fighting and mains flushing. It has been designed to provide twelve hours of the average daily demand for gravity supplies or eighteen hours for pumped supplies.

Table 2.7: Estimated Water Supply

| SOURCE | CURRENT NORMAL SUPPLY RATE (1000M$^3$/day) |
|---|---|
| Kikuyu Springs | 4.8 |
| Ruiru | 14.2 |
| Sasumua | 45.8 |
| Ngethu/Thika Dam | 275.2 |
| Total | 340 |

Source: Mwangi (1996).

Most of the city has an adequate distribution system except for some of the eastern parts of the city, in Dandora and Embakasi. Plans are however underway to expand the distribution system. However, in order to meet the water demand of the rapid increasing population, the expansion of water resources supply systems and construction of new treatment works should continue. Also more attention should be given to the provision of water in the informal settlement by encouraging communities to participate. Rehabilitation of the old city is being carried out and investigation of the possibility of using groundwater sources is being carried out (Mwangi, 1996).

## 2.7 Urban Water Supply Coverage

Urban water supply coverage has actually decreased between 1990 and 1994 in parts of the developing world, an indication of urban growth but also of deterioration of existing systems (Table 2.8). This coverage includes house connections and access to public standpost, managed by the water utility. The overview below gives some more insight in the division between the two types of supply. The people, who are not covered by public network, are dependent on private wells or boreholes, rivers or springs, vendors or neighbours (Table 2.9).

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Table 2.8: Urban water supply coverage in 1990 and 1994

| Area | 1990 | 1994 |
|---|---|---|
| Latin America | 90% | 88% |
| Asia and the Pacific | 83% | 84% |
| West Asia | 87% | 98% |
| Africa | 67% | 64% |

Source: Water Supply and Sanitation Sector Monitoring Report, WHO, WSSCC and Unicef, 1996

Table 2.9 Percentage of urban population connected to city network or dependent on communal water points

| City | Houseconnection | Public tap |
|---|---|---|
| Jakarta (1991) | 30% | 30% |
| Delhi (1992) | 53% | 37% |
| Phenom Penh (1992) | 70% | - |
| Casablanca (1997) | 80% | 17% |
| Ouagadougou (1994) | 38% | 17% |
| Conakry (1989) | 20% | 5% |
| Buenos Aires (1993) | 80% | - |

Source: Lyonnaise de Eaux

These percentages do not reflect the intra urban differences and do not show the desperate water situation existing in many low-income urban areas. Actual access to safe drinking water is likely to be lower than is reflected by the above percentages due to intermittent supply. Many residents augment the water provided by the utility with water from other sources. In general, access to utility provided water supply is dependent on location and income and different for different segments of society.

High-income consumers are able to meet their water requirements at individual household level by being connected to the municipal water supply system or by installing their own facilities such as wells, boreholes or rainwater harvesting systems. The service level is usually in-house multiple taps. Water demand management options applicable for this group are in house retrofitting and out-of-house water saving measures. Water pricing measures may only be effective in combination with extension awareness raising campaigns, as rich people tend not to save water because of cost. Residents of low-income urban areas are rarely consumers at individual household level. The type of water supply system depends on the type of settlement with regard to legal status and security of tenure, and the location within or outside the city limits. However, residents of low-income urban areas often only obtain infrastructure services if they have the ability to form community-based organizations (CBO) of local residents. Only as a community based organizations can they negotiate with local authorities.

## 2.8 Water Demand Management Issues in Low-income Areas

One of the assumed results of Water Demand Management is that the increased availability of water will lead to a more equitable distribution of this water, and thus enhance access of the poor to water supply services. Experience in water supply services to the urban poor, shows that some of the measures taken to facilitate access in fact makes the water more expensive for the poor and that a more equitable distribution needs an active, community focused strategy. Aspects that play a role in the development of such a strategy are legal conditions, water conservation measures, tariff setting, public information and demand responsiveness.

### *2.8.1 Regulations Regarding Retail sale of Water.*

In some places resale of water is restricted by law or by utility. Reasons for the restrictions vary from the impossibility to serve customers in an illegal area and free distribution at public standpost to the argument that profit made by formal or informal vendors should rather be made by the utility itself. Profits in the vending systems, especially where the access to the vending market is restricted, can be enormous.

The vending systems may be controlled by people working in the utilities itself. Therefore deregulation of water sales and easing of supply constraints that could substantially lower both hauling costs and the price of water, may be very difficult to realize as this would threaten the interest of powerful groups (Lovei and Whittington, 1991). On the other hand, vending systems are a source of income generation for many otherwise unemployed people, and profits for these 'small' vendors tend to be not very large. Their prices are a reflection of the price per unit at source, time spent on hauling water and the waiting times at the water point.

With or without restrictions, vending systems are serving millions of customers in cities in developing countries. The differentials in the cost of water vary from city to city and are dependent on various factors such as access to alternative sources and control and competition of the resale market.

Table 2.10 Diffentials in the cost of water in selected cities

| City | Price ratio |
|---|---|
| Abidjan | 5:1 |
| Dhaka | 12:1 to 25:1 |
| Kampala | 4:1 to 9:1 |
| Karachi | 28:1 to 83:1 |
| Lagos | 4:1 to 10:1 |
| Lima | 17:1 |
| Nairobi | 7:1 to 11.1 |
| Port-au-Prince | 17:1 to 100:1 |
| Surabaya | 20:1 to 60:1 |
| Tegucicalpa | 16:1 to 34:1 |

Source: World Bank, World Development Report, 1988

### *2.8.2 Water Pricing Measures*

One of the measures taken to promote water conservation and at the same time increase access and equitable in water provision, is the establishment of different forms of tariff setting. In a progressive block tariff system, the first 5 to 10 m3 have a low, subsidized tariff and the following blocks have an increasingly higher tariff. The rationale for the system is to promote water saving practices with all households and to ensure that low-income households can afford to use an amount of water that is necessary to keep themselves and their environment healthy, typically 20-25 litres /cap/day. The effects of this system, however, can be adverse for the poor in specific circumstances that are quite common throughout cities in the developing world. The first of these is that many low-income families do not have their own connection and buy water per bucket at a neighbour's house. With the resale, the neighbour will end up in a higher tariff bracket and will adapt the price per bucket. A second is that many low-income families do not have an individual water connection, but live in compounds with more families or in apartment buildings where individual families have one or more rooms. These people often all share one water meter and the communal water bill ends up in the highest tariff block because of the high number of users. The sharing of one water meter may be the result of utility policy to install one meter per building or may be the result of an attempt to save on the connection cost or meter rent.

### *2.8.3 Water Conservation Measures*

High rates of unaccounted for water are common in many cities in developing countries, reaching extreme levels of 40%-60% of the water produced, representing critical water and financial losses. Of the total unaccounted for water, an estimated 50% is caused by leakage, usually the result of either lack of maintenance or failure to replace aging systems. Where utilities are focusing on the reduction of leakages, they usually concentrate on the technical aspects of leakage control. Reporting of ground leakages by the public, would assist in leak detection and thus reduction of losses. Yet, for people to inform a utility on leaks, requires not only awareness of the need to report, but also information on where to report and motivation to do this reporting. The contrary is usual: a leak is welcomed as a source of free water and is likely to go unreported as long as possible.

Similarly, illegal connections can be expected to go unreported if residents do not feel responsibility for the system or a sense of being disadvantaged by these connections. For a utility, it is extremely difficult to get an overview of the incidence and number of illegal connections in a densely populated low-income area, where houses are not numbered and a maze of small footpaths form the roads. Another conservation measure to low-income areas is metering of public supplies. This is of importance because, free, non-managed public taps have an extremely short life span and are a source of much wastage. They also do not reflect the principle of water as an economic good.

### *2.8.4 Public Information and Demand Responsive Approaches*

It has for long been assumed that communities do not know their infrastructure needs-especially low-income communities. Thus decisions have been made on assumptions by engineers and planners and not on actual information and understanding of household water demand. It is increasingly being recognized that this top-down approach has been the reason for the failure of many initiatives and that communities have to be involved in the decision making process on the water supply system based on their demands. Approaches to project design which incorporate such features are also known as Demand Responsive Approaches (DRA), which is based on four principals: (1) Water has to be managed as an economic as well as a social good (2) Management has to focus on the lowest appropriate level (3) A holistic approach to the use of water resources has to be adopted (4) Women have to play a key role in the management of water.

# CHAPTER 3: METHODOLOGY

## 3.1 Theoretical Framework:

The water collection decision process can be captured in a model that seeks to describe probabilities of choosing alternative water sources. Underlying the decision to use a particular water source is a utility function. Microeconomic theory suggests that consumers choose such quantities of goods and services that maximize satisfaction provided such consumers keep within a budget constraint. Among other things, the solution to this constrained optimisation problem generates the first order conditions which can then be exploited to generate demand structures describing decisions regarding quantities of consumed as function of given prices and consumers' incomes.

The combined effect of improved lifestyles, growing population and diminishing water supplies are assumed to exacerbate competition for water resource (Tsur and Dinar, 1997). For the types of rural households that are the objects of this study, utility pursuits are not conventional since other constraints come into play. Existing water- demand literature assumes that households choose between alternative water sources on the basis of the optimisation of conditional, indirect utility functions corresponding to alternative sources. Obviously such utility, in each case, depends on the water procurement variables such as the time and the pecuniary costs of obtaining water from a given source, the perceived quality of the water so obtained, household income, and a vector of other social- economic variables. Since we are often unable to observe the full complement of relevant utility components, the constructed utility functions are invariably stochastic.

For rural households with consumption decisions that are interwoven with production decisions and whose labour inputs are between different household chores, utility maximization is subject to a larger set of constraints than otherwise, so that a correspondingly larger set of arguments enters the resulting demand functions. As mentioned in the literature, further modifications are necessary when households face discrete rather than continuous choices, such as a narrow range of water sources. A discrete choice can therefore be exploited as an alternative theoretical framework for analyzing household preferences. This framework offers a shortcut to the derivation of demand funetions using first order conditions, so that researchers going the discrete choice route can apply the utility function directly.

As demonstrated in Whittington et al (1990), households i will choose water source k from among M alternative sources if, and only if, the household utility derived from such a source at least matches that from other sources, that is,

$U_{ki} \geq U_{ji}$ where j=1,2,3...M. It is further assumed that these indirect utility functions are well behaved regarding convexity. We can represent utility derived from chosen water sources as functions of different argument groups such as household tastes/preferences and water source attributes. The former can be composition, and age structure, as well as human capital attributes (for instance, educational achievement and reasoning ability scores), asset ownership, expenditure patterns and incomes. Water source attributes may include the distance from the homestead, water quality, reliability and price. It has been argued that conceptually, such an indirect utility function translates the attractiveness of different sources into scalars that can then be maximised through water source-related choices. Since sources are different with regard to important attributes, they can be assumed to yield different relative utilities.

As argued earlier, a household chooses water source k if and only if the utility outcomes cannot be improved by choosing a different source. Consequently, the probability that a household i will use water source k is equivalent to the probability that the conditional indirect utility from other source, $U_{ki}$, is greater than the conditional indirect utility from other sources, $U_{oi}$. Letting $Pr=U_{ki}-U_{oi}$ where $U_{oi}$ represents the highest indirect utility from alternative water sources other than k, then the probability that household i will use source k will be >o.

Assuming mutual exclusivity between alternative water sources, this state of affairs leads to a multiple-choice model of a qualitative nature. The multinomial logit framework is useful here. As demonstrated in Maddala (1983), suppose $X_{ij}$ denotes a vector of the characteristics for water source j as perceived by household i and $y_i$ a vector of household i's individual attributes. The probability for household i to choose water source j can be expressed in a mixed multinomial logit equation as follows:

$$P_{ij} = \quad \exp[X_{ij}\beta + Y_i\theta_j] / \Sigma_{k=1} \exp[X_{ik}\beta + Y_i\theta_k] \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where the βs represent the relative valuations or weights that households attach to alternative sources of water and the θs are impacts exerted by different household attributes in choosing source j over source_k provided j≠k. We interpret the expression representing the exponential power of the numerator $(X_{ij}\beta + Y_i\theta_j)$ as describing the utility level enjoyed by household i in choosing water source j. The linear form of such utility function can then be expressed as $E(U_{ij}) = X_{ij}\beta + Y_i\theta_j + E(\in_i)$

$$= X_{ij}\beta + Y_i\theta_i \quad \text{.................................(2)}$$

Since the error term is assumed to be $N(0,\sigma)$.

Considering equation (2), $P_{ij}$ can be interpreted as proportion of utility or benefits expected from water source j of the total expected utility derivable from the entire assortment of alternatives available to households. When household i does not expect any benefit from the rest of the set except j, then $P_{ij}$ can be assumed to take on a unit value. If no benefits are however expected from alternative j, then $P_{ij}$ assume a zero value. Hence as $P_{ij}$ approaches a unit value, the greater the relative utility household i can expect to derive from choosing water source j and therefore the greater the likelihood for the household i to choose water source j. Since the utility derived from source j by household i is assumed to be $U_{ij}$, then the estimation of the parameters in the utility function require the maximisation of the likelihood function of the form;

$$L = \prod_{i=1}^{N} \prod_{j=1}^{M} P_{ij}^{Q_{ij}} \quad \text{.............................................(3)}$$

Where $Q_{ij}=1$ if household chooses water source j and 0 otherwise, and $P_{ij}$ is the probability that household i chooses water source j. M and N represent the number of alternative water sources and the sample size, respectively. Note that the term $Q_{ij}$ in the equation3 is the dependent variable in the estimation model. Changes in the utility indices that are affected by household and water-source attributes can be translated into the implied probabilities.

The probability of choosing a particular water source in the current study is determined by household size, number of years of education, distance to a water source, volume of water that is used by a household, daily cost of water and the household's level of income.

Household size has a positive or a negative influence on the probability of choosing a particular water source. This is because larger households may prefer water sources that supply them with enough water and of good quality and this means that the probability of choosing water from that source is increased. On the other hand, the probability of choosing water from for example vendors may decrease. This is because, water from vendors may be more expensive as compared with water from other sources which are far; larger households may consist of more mature people who can afford water from far distant sources. This means that, the probability of choosing water from that vendors for instance may decrease.

Number of years of education has a positive or a negative influence on the probability of choosing a particular water source. This is because, households with more educated people, may put into consideration many factors before choosing a particular water source. Each water source may have its disadvantages and its advantages. For instance, the water of a particular source may be unclean but it may be nearer to people. In that case, the probability of choosing water from that source will be determined by a household depending on which factor is more important to it than the other. So, if the water quality factor is of more importance, then the probability of choosing water from that source is reduced. Alternatively, if distance to a source factor is of more importance, then the probability of choosing water from that source is increased.

Distance to a water source is expected to have a negative influence on the probability of choosing a particular water source. This is because, people will always prefer sources of water which are near them such that getting water takes the least time. This means that, the farther away a water source is, the fewer the people who consume water from it. On the other hand, the nearer a water source is to people the more the number of people who consume water from it.

Volume of water used by a household may have a positive or a negative influence on the probability of choosing a particular water source. Considering other factors such as the quality of water, a particular household though using larger quantities of water may have a negative influence on choosing water from a particular source. This is because, the water from a particular source may be unclean because it is drawn from unclean sources and therefore not good for human consumption; this reduces the probability of using water from that source. On the other hand, if a household consumes more quantities of water and the water is brought to the doorstep, then the probability of choosing water from that source is increased.

Daily cost of water can have a positive or a negative influence on the probability of choosing a particular water source. This is because, if water from a particular source is more expensive than from the other sources, then the probability of choosing water from that source may decrease. On the other hand, if a particular water source is the most convenience and most reliable, then the probability of choosing water from that particular water source may increase even if there are larger daily water expenses.

The households level of income can a positive or a negative influence on the probability of choosing a particular water source. A household with higher income levels may prefer a water source that supply it with enough water to fill its swimming pool for example. Hence, the probability of choosing water from that source is increased. On the other hand, a household may consider factors such as the quality of water and therefore if water from a particular source is unclean, then the probability of choosing water from that source is decreased.

All the difficulties associated with the linear probability model point to the need for alternative model specifications. The most serious set of difficulties arises from the fact that predictions may lie outside the (0,1) interval. The obvious solution to the problem is to transform the original model in such a way that for all x, predictions will lie in the (0,1) interval. The constrained form of the linear probability model achieves this goal. Since our primary concern is to interpret the "dependent" variable in our model as the probability of making a choice (given information about the individual's attributes), it is reasonable to utilize some notion of probability as the basis of the transformation. The requirement of such a process is that it translate the values of the attribute x, which may range in value over the entire real line, to a probability which ranges in value over the entire real line, to a probability which ranges in value from 0 to 1. We would also like the transformation to maintain the property that increases (or decreases) in the dependent variable for all values of X. The resulting probability distribution might be represented as follows:

$P_i = F(\alpha+\beta X_i) = F(Z_i)$ .................(4)

Where F= a cumulative probability function.

Under the assumption that we transform the model using a cumulative uniform probability function, we get the constrained version of the linear probability model, $P = \alpha + \beta X_i$. Numerous alternative cumulative probability functions are possible, this study has considered the normal since the probit probability model is associated with the cumulative normal probability function.

From the current study, the probability of contracting a water-related disease is influenced by daily cost of water, sources of water, quality of water supplied by vendors, volume of water that is used by a household and the employment level of the spouse.

Daily cost of water is expected to have a negative or a positive influence on the probability of contracting a water-related disease. Considering other factors such as the quality of water, the probability of contracting a water-related disease may increase or decrease. For

instance, if water from vendors is of poor quality, then the probability of contracting a water-related disease may increase irrespective of the larger daily cost of water.

Sources of water may have a positive or a negative influence on the probability of contracting a water-related disease. This is because, some sources of water may be surrounded by unclean environments such as uncovered sewage, poor drainage facilities, which may contaminate the water and hence increase the probability of contracting a water-related disease. This may be the opposite for the water sources that are surrounded by clean environment meaning that the probability of contracting a water related disease is decreased.

Quality of water supplied by vendors may have a negative or a positive influence on the probability of contracting a water-related disease. This is because, if water that is sold by vendors is of poor quality i.e.it is drawn from unclean sources and is not treated, then this will increase the probability of contracting a water- related disease. On the other hand, water drawn from clean sources and is treated will decrease the probability of contracting a water related disease.

Volume of water that is used per day may have a negative or a positive impact on the probability of contracting a water- related disease. This is because, the water may be drawn from unclean sources and hence increases the probability of contracting a water-related disease. Again, the water may be drawn from clean sources meaning that the probability of contracting a water-related disease is decreased.

The employment level of the spouse may have a negative influence on the probability of contracting a water- related disease. This is because, households with employed spouses can afford to raise money to treat the water before it is taken. This means that the probability of contracting a water-related disease is reduced. The opposite happens in case where the spouse of the household is not employed.

Number of years of education is expected to have a negative influence on the probability of contracting a water-related disease. This is because, educated people may want to draw water only from clean sources or buy treated water meaning that the probability of contracting a water-related disease is reduced. On the other hand, people who are not educated may draw water from any source without caring if it is treated or not. This means that, the probability of contracting a water-related disease may increase.

According to the current study, Willingness to pay (WTP) for a container of water beyond which the household could not afford is determined by, household size, volume of water

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According to the current study, Willingness to pay (WTP) for a container of water beyond which the household could not afford is determined by, household size, volume of water

used per day, distance to the source of water, household's daily cost of water, household's level of income, and the number of years of education.

Household size is expected to have a positive or a negative influence on the WTP for a container of water beyond which the household cannot afford to pay. This is because, larger households are expected to consume larger quantities of water. However, considering the amount of income a household receives, the WTP for a container of water may decrease in poor families but increase in families receiving larger amounts of income.

Volume of water used per day may have a negative or a positive influence on the WTP for a container of water beyond which the household cannot afford to pay. First, it can be argued that households with larger amounts of income can afford to pay for water even at double, three or more times the current price and this impacts positively on the WTP for a container of water. On the other hand, households with larger income levels have wider range of options. This is because, they may not necessarily use water from only one source and so if the price of water from a particular water source is increased because of may be water shortage, the particular household may not be affected. This is because the household can draw water from other sources.

Distance to a water source is expected to have a negative influence on the WTP for a container of water beyond which the household cannot afford to pay. This means that, people may prefer water from far distance sources because it is less expensive that water from near sources. The water brought at the doorstep is expected to be more expensive because the piece includes the transport costs for example.

Household's daily cost of water is expected to have a positive or a negative influence on the WTP for a container of water beyond which the household cannot afford to pay. This is because, households that spend much of their income on water may want to pay less per litre of water in order to reduce the daily expenses on water. On the other hand, if other factors such as water reliability and water quality are considered, then a household could be WTP more for a container of water though spending larger amounts of income on water.

Household's level of income is expected to have a positive influence on the WTP for a container of water beyond which the household cannot afford to pay. This is because, the particular household can afford to meet its other expenses and still save some money. This is unlike in other households where the household spends all the income that is received and nothing is saved.

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Number of years of education is expected to have a positive influence on the WTP for a container of water beyond which the household cannot afford to pay. This is because, people with higher education levels are well informed and may understand the importance of the valuation.

The study considers that the volume of water used by a household is determined by household size, distance to the source of water, household's level of income, and the employment level of the spouse.

Household size is expected to have a positive influence on the volume of water that is used by a household. This is because, as the household size becomes bigger, the more the volume of water that is consumed by the household. The opposite applies; the smaller the household size, the lesser the volume of water that is consumed by the household.

Distance to a water source is expected to have a negative influence on the volume of water that is used by a household. This is because, people will always prefer sources of water which are near them such that getting water takes the least time; in fact, a number of people find it better when the water is in their houses.

Household's level of income is expected to have a positive influence on the volume of water that is used by a household. This is because, as the household's income increases, some households may decide to have for instance swimming pools in their homes, others may decide to rare more animals such as cattle, and others may engage in other income generating activities such as irrigation of idle lands. All these activities and others not mentioned increases the volume of water that is used per day.

Households that have employed spouses may consume more quantities of water than the ones without employed spouses. This is because, as discussed earlier, the income size of the household is expected to increase and so the particular household may engage in other activities where water is consumed and this increases the volume of water that is consumed by the household.

### 3.2 Specification of Empirical Models

The study considers the following four models

(a). $P_{ij} = \exp[X_{ij}\beta + Y_i\theta_j] / \Sigma_{k=1} \exp[X_{ik}\beta + Y_I\theta_k]$

Where the βs represent the relative valuations or weights that households attach to alternative sources of water and the θs are impacts exerted by different household attributes in choosing source j over source k provided j≠k.

$X_{ij}$ consist of water source attributes, i.e.,

Distance to a water source, expected to have a negative influence on the probability of choosing water from a particular water source.

Daily cost of water expected to have a negative or a positive influence on the probability of choosing water from a particular water source.

$Y_I$ consist of;

Household size, expected to have a negative or a positive influence on the probability of choosing water from a particular water source.

Number of years of education, expected to have a negative or a positive influence on the probability of choosing water from a particular water source.

Volume of water that is used per day, expected to have a negative or a positive influence on the probability of choosing water from a particular water source.

Household's level of income, expected to have a negative or a positive influence on the probability of choosing water from a particular water source.

The expression representing the exponential power of the numerator $(X_{ij}\beta + Y_i\theta_j)$ describes the utility level enjoyed by household i in choosing water source j.

(b). $P_i = F(\alpha + \beta X_i) = F(Z_i)$

Where:

$P_i$ = The probability of contracting a water-borne disease which is 1 if one has contracted the water-related disease and 0 otherwise.

F = a cumulative probability function.

α = the intercept term.

β = respective variable coefficients

$X_i$ consist of daily cost of water expected to have a negative or a positive influence on the probability of contracting a water-related disease

Water sources (vendors, boreholes, wells, institutional supply) expected to have a negative or a positive influence on the probability of contracting a water-related disease

Quality of water supplied by vendors expected to have a negative or a positive influence on the probability of contracting a water-related disease

Volume of water that is used by a household expected to have a negative or a positive influence on the probability of contracting a water-related disease

Employment of the spouse expected to have a negative influence on the probability of contracting a water-related disease

Number of years of education expected to have a negative influence on the probability of contracting a water-related disease

(c). Vwatda=F( Hsize, Dist, Incom, Spouseem)

$$Vwatda = b_o + B_1 hsize + B_2 dist + B_3 income + B_4 spouseem + E$$

Where:

Vwatda =Volume of water that is used per day

Hsize= Household size, expected to have positive influence on the volume of water that is used by a household.

Dist = Distance to the source of water, expected to have a negative influence on the volume of water that is used by a household.

Incom = Total household income, expected to have a positive influence on the volume of water that is used by a household.

Spouseem=Employment of the spouse, expected to have a positive influence on the volume of water that is used by a household.

E is the error term and the bs' represent the respective variable coefficients and $b_o$ is the intercept term.

(d). WTP= f(Hsize, Vwatda, Dist, Waterexpe, incom, eduyr)

$$WTP = a_o + A_1 hsize + A_2 vwatda + A_3 dist + A_4 waterexpe + A_5 incom + A_6 eduyr + E$$

Where:

WTP= Willingness to pay for a container of water beyond which the household cannot afford.

Hsize= Household size, expected to have a positive or a negative influence on the WTP for a container of water beyond which the household cannot afford.

Vwatda=Volume of water that is used per day by a household, expected to have a positive influence on the WTP for a container of water beyond which the household cannot afford.

Dist = Distance to the source of water, expected to have a negative or a positive influence on the WTP for a container of water beyond which the household cannot afford.

Waterexpe = Households daily cost of water, expected to have a positive or a negative influence on the WTP for a container of water beyond which the household cannot afford.

Eduyr = Number of years of education, expected to have a positive influence on the WTP for a container of water beyond which the household cannot afford.

Incom = Household's level of income, expected to have a positive influence on the WTP for a container of water beyond which the household cannot afford.

E is the error term and the $A_s$' represent the respective variable coefficients and $A_0$ is the intercept term

## 3.3 Estimation Techniques

The study applied several estimation methods. Probit method was used to analyse the factors influencing contraction of water-related diseases and the use of water from particular sources. Ordinary least square method was used to analyse the willingness to pay for a container of water, and the factors that influence the volume of water that is used by a household per day.

## 3.4 Data type, Sources and Survey Instruments

The study used primary data, gathered at Ngando area. However, the fieldwork for this study was conducted during the wet season of May and June 2001. There were observations at kiosks, hand pumps and open wells; there were also observations of water- vending activities like use of bicycles, tanks and so on to find the most commonly used method of transporting water. Owners of boreholes and wells were interviewed to gather information such as, the depth of the borehole or well, the water treatment procedures and the number of regular distributing vendors they have. In total, 127 distributing vendors were reported. Questionnaires were used to gather information such as the vendors' socioeconomic background, employment history, costs and sales, pricing and other business practices. See appendix A, for details on the vendors' questionnaire.. Questionnaires were also used to gather information such as the households' socioeconomic background, employment history, and volume of water used per day. See appendix B, for details on the households' questionnaire.

### 3.5 Sample size and the Sampling Procedures

Out of a total of 7,747 households in the study area, 61 were interviewed. These 61 households were randomly selected and the interviewer went door to door interviewing households with the help of questionnaires. The study also interviewed 42 vendors out of 127 vendors. The 42 vendors were randomly selected. However, vendors were interviewed at water sources during the morning hours and towards evening hours when majority of them were available. This is because, majority of vendors work in the morning hours and then relax in the afternoon or engage in other businesses. The target of the study was to interview 80 households and 60 vendors but it was not possible because of time and budget constraints.

# CHAPTER 4: EMPIRICAL RESULTS

## 4.1 Introduction

## 4.2 Vendors and Households Surveyed

### *4.2.1 Profiles of Vendors and Households*

The majority of the vendors were male (95.2%) with an average age of 28 years. A few females (4.8%) also engage in this business of vending water; their average age was 33 years. To some vendors (7.1%), water vending was a full-time occupation while more than 50% engaged with other businesses after vending water such as running a bar, running a kiosk, others work at night as watchmen and so on. These other businesses earn them about Ksh 2500 per month on average which amounts to Ksh 7501 per month when added to the one from the vending activities. These small-scale entrepreneurs who spend the whole day vending water can earn as much as Ksh 15000 per month. The majority of vendors are married (83.3%) with smaller families consisting of about four persons; their education level is above primary level; and a small percentage has reached college level (2.4%). From the cross tabulations results of gender and the age, vendors do retire from the business of vending water as they become old. Again, as vendors earn more income in total, the less they engage in the vending business.

Most respondents interviewed were married and came from households with an average of three people; of the interviewees, 80.3% were with a mean average age of 28 years. More than 40% have at least primary education. Over 50% of the spouses have attained secondary education. A number of the households engage in businesses in order to earn their living whereas a few (4.8%) are still learning and about 27.4% are housewives who wait for their husbands to provide for their families. About 70% of the spouses are employed and earning about Ksh. 4001 per month on average. From the cross tabulation results, the volume of water used per day is higher in households that have employed spouses.

### *4.2.2 Water Supply Situation*

Vendors obtain water directly from the main boreholes (about 95.2% and a small percentage 4.8% obtains it from the wells). The water that they sell comes from the same sub-location where a few wealthy people have dug boreholes and wells. The boreholes are normally opened for 24 hours and the operators alternate after every 12 hours. The wells operate for 12 hours, i.e., from 6.00 a.m to 6.00 p.m.

Table 4.1 shows that most vendors carry water in 20 litre plastic jerricans; a few use the 25 and 60 litre jerricans to transport water. Containers of 8000 litres to 15000 litres are also used occasionally to transport water. The main form of transport employed by vendors is the bicycle (Table 4.2).

Table 4.1: Volumetric capacity of the containers used to carry water by vendors

| Container Capacity (in litres) | Frequency (%) | Cumulative frequency (percent) |
|---|---|---|
| 20 | 34 (80.9) | 34(80.9) |
| 25 | 2(4.8) | 36(85.7) |
| 60 | 1(2.4) | 37(88.1) |
| 8000-15000 | 5(11.9) | 42(100.0) |
| Total | 42(100.0) | |

Source: Field survey

Table 4.2: Forms of transport used by vendors to carry water

| Form of Transport | Frequency(%) | Cumulative frequency (percent) |
|---|---|---|
| Bicycle | 31(73.8) | 31(73.8) |
| Cart | 4 (9.5) | 35(83.3) |
| Lorry | 5 (11.9) | 40(95.2) |
| Manual Labour | 2 (4.8) | 42(100.0) |
| Total | 42(100.0) | |

Source: Field survey

A bicycle outfitted for vendors can carry four 20-litre cans. Carts are also used to transport water. Most of the carts carry six 20-litre jerricans weighing 120 kilograms. The cart wheels are equipped with bells which jingle when the carts are moving to attract customers, and vendors make most of their sales while pushing their carts through the estates looking for customers; almost anywhere in Ngando a person can within minutes hear the bells and hail a vendor. Often several vendors appear. Moreover, there are lorries and trucks on which tanks of about 8000 litres to 15000 litres are mounted to transport water. The lorries are used for more distant locations and on slopes, which are difficult to reach with a fully loaded bicycle or a cart. A small percentage of vendors (4.8%) use manual labour to transport water; they use the 20-litre jerricans. Vendors prefer shorter distances to the sources of water. From the cross tabulations results, it can be seen that as the distance increases, the fewer the number of vendors willing to spend their time on vending activities.

There are several reasons why vendors choose boreholes as the main water source. First, the water from the boreholes is treated and hence seen as clean water, secondly, water from the borehole is the most reliable and convenient; and thirdly, the water from the boreholes is the nearest to vendors in Ngando sub-location.

### *4.2.3 Water Demand-Consumption Situation*

Households were asked to state the amount of water that they consume/use per day in litres. As shown in Table 4.3, most households use 60 litres of water per day. The results of the volume of water that is used per day are dispersed and vary from 20 litres to 175 litres of water. In total 4060 litres of water are used per day by households.

Table 4.3: Volume of water used per day

| Volume of water Used per day(in litres) | Frequency(%) | Cumulative frequency (%) |
|---|---|---|
| 20 | 3 (4.9) | 3 (4.9) |
| 40 | 12 (19.7) | 15 (24.6) |
| 50 | 1 (1.6) | 16 (26.2) |
| 60 | 25 (41.0) | 41 (67.2) |
| 75 | 1 (1.6) | 42 (68.8) |
| 80 | 9 (14.8) | 51 (83.6) |
| 100 | 6 (9.8) | 57 (93.4) |
| 120 | 2 (3.3) | 59 (96.7) |
| 160 | 1 (1.6) | 60 (98.3) |
| 175 | 1 (1.6) | 61 (100.0) |
| Total | 61 (100.0) | |

Source: Field survey

OLS regression results for the determination of the volume of water used per day are represented in table 4.4. Only 37% of the variations in volume of water consumed is accounted for by explanatory variables. However, it is evident that the household size, the income level of the households and the employment of the spouse exert significant positive impacts on the volume of water used per day though at different levels of significance. Distance to water source exerts a negative impact on the volume of water used per day. As demonstrated earlier, there is a positive correlation between the household size and the volume of water used per day. Also, a positive significant correlation exists between the volume of water used per day and household's level of income.

Table 4.4: Determinants of volume of water used per day

| Variable | Parameter estimates | t-ratios |
|---|---|---|
| Intercept | 15.716 | 1.566 |
| Household size | 7.496*** | 3.967 |
| Distance to the source | -4.233 | -0.537 |
| Income | 1.994E-0.3** | 2.226 |
| Employment of the spouse | 3.922** | 1.965 |
| No. of observations = 61 | | |
| F (4, 56) = 8.08 | | |
| Prob > F = 0.000 | | |
| R-squared = 0.3660 | | |
| Adj.R-squared = 0.3207 | | |
| Root MSE = 24.01 | | |

Source: Based on data from field survey

**. Estimated coefficient is significant at 5% level.

***. Estimated coefficient is significant at 1% level.

## 4.3 Source of Water and Source-Choice Determinants

### *4.3.1 Sources of Water for Households*

As seen in the literature review, one reason that many households do not have infrastructure connections in their homes is that they live in places where they do not have the option of connecting to a utility network (i.e., no network service exists in their neighborhoods)[1] (Wasike and Hanley, 1998; Komives et al., 2000; Wasike and Kimenyi, 2001). Households without in-house connections often obtain water in many other ways. Even households with water connections may obtain water from more than one source. Some households used unimproved water sources, such as rivers and streams. Others chose from a range of informal, private, or improved community water sources (e.g. yard taps, public taps, wells, water vendors, or rainwater collection).

Table 4.5 shows that most people (73.8%) use water from the vendors; 14.8% rely on water from the boreholes, 4.9% rely on water from the well and 6.6% rely on water from the institutional supply. Water from vendors is reliable, convenient and of good quality.

Table 4.5: Sources of water for Ngando households

| Sources | Relative frequency | Percent |
|---|---|---|
| Vendors | 45 | 73.8 |
| Boreholes | 9 | 14.8 |
| Wells | 3 | 4.9 |
| Institutional supply | 4 | 6.6 |
| Total | 61 | 100.0 |

Source: Field survey

Most vendors (95.7%) get treated water from the main boreholes and therefore the water is believed to be good for human consumption. Boreholes in Ngando sub-location are few and therefore many people cannot reach them. Water from the wells is not treated and therefore not fit for human consumption. A few people who draw water from them use it for other domestic chores like cleaning clothes and so on. A few women whose husbands work at the institution use water from an institutional supply; however, the water is supplied to them freely.

How do households choose their water sources? Generally, proximity to a source is the main reason for choosing a source of water. This reason is however mentioned by about 37.7% of the households (table 4.6). Sometimes the water is brought at the doorstep and so less energy is required. The majority of people prefer short distances to source of water and hence the further the source of water the fewer the people who draw water from it. Other reasons for

[1]It should be noted that some such households may have consciously made this choice, i.e., located their home in a

choosing a water source include; its availability, convenience, reliability and the price charged at the source (Table 4.6).

Table 4.6: Reasons for choosing water sources

| Reason | Frequency | percentage |
|---|---|---|
| Nearest | 23 | 37.7 |
| Lack of alternative | 13 | 21.3 |
| Affordable | 5 | 8.2 |
| Convenience and reliable | 20 | 32.8 |
| Total | 61 | 100.0 |

Source: Field survey

At times, water is bought from a wholesale vendor but the distance covered is small. The majority of people travel 0.5 kilometers to get to the source in about 30 minutes. From the cross tabulation results, the source of water is preferred to others because lesser time is taken to draw the water. So actually, though there is a serious problem of water, wholesale vendors who get water from the main boreholes and then settle somewhere (store water in the tanks and then sell to people from there), have tried to lessen the problem of water in Ngando sub-location.

### *4.3.2 Modelling Household Choice of Water Sources*

Using the institutional water supply as the reference source, the response functions for the other alternative water source groups are interpreted relative to institutional water supply. Estimation results on factors influencing household choice of water source are presented in Table 4.7. It can be seen that distance to the source of water and the household level of income do not influence the relative probabilities of choosing different water sources. Differences in the household sizes, the number of years of education, the volume of water used per day, the daily cost on water exert significant impacts on the probabilities of choosing alternative sources of water.

The direction of the impacts of individual attributes on the probabilities of choosing specific water sources is quite variant. The size of the household, for example, exerts a negative influence on the probability of choosing vendors as the main source of water but exerts a positive influence on the probability of choosing the boreholes/wells water sources. Put another

place without access because rents or land values were cheaper there.

way, the household size reduces the relative probability of choosing water from a vendor relative to an institutional water supply. Alternatively, the household size increases the relative probability of choosing water from a borehole/well relative to institutional water supply. This means that larger households are more likely to choose institutional water supply rather than water from vendors but are less likely to choose institutional water supply rather than water from boreholes/wells. The coefficient of the household size is, however, only significant at 5% level for the water from vendors. Put another way, larger households are significantly less likely to rely on water from vendors relative to institutional water supply.

The impact of the number of years of formal education on probabilities of choosing specific water sources is negative in vendors but positive in the boreholes/wells. In other words, the number of years of education reduces the relative probability of choosing water from vendors but increases the relative probability of choosing water from boreholes/wells. However, the coefficient of the number of years of formal education is significant at 5% level for the water from vendors is significant at 10% for the water from boreholes and wells. This means that, households with a larger proportion of educated people are significantly more likely to choose institutional water supply rather than other water sources. Similarly, households with a larger proportion of educated people are significantly less likely to choose institutional water supply rather than other water sources.

The distance to the source of water impacts negatively on the probability of choosing all sources of water. In other words, the farther away a water source is, the less likely are households to choose it relative to the other sources. The level of households' income impacts negatively on the probability of choosing all sources of water. This means that, households with higher income levels are less likely to use water from the institutional water supply, which is supplied, freely relative to the other water sources.

The volume of water used per day reduces the relative probability of choosing water from vendors but increases the relative probability of choosing water from an institutional water supply. This means that households that consume greater quantities of water are more likely to choose institutional water supply rather than water from vendors but are less likely to choose institutional water supply rather than water from boreholes and wells. This is because the water from vendors is more expensive than the water from the boreholes and wells. The coefficient of the volume of water used per day is, however, only significant at 10% for the water from vendors.

The daily cost on water increases the relative probability of choosing water from vendors relative to institutional water supply, but reduces the relative probability of choosing water from boreholes/wells relative to institutional water supply. The coefficient of the daily cost of water is however, significant for the water from vendors and from boreholes/wells at 5% and at 10% levels of significance respectively. This means that households with larger water expenses per day are significantly less likely to choose institutional water supply rather than water from vendors. Alternatively, households with larger water expenses per day are significantly more likely to choose institutional water supply rather than water from the boreholes/wells.

These results lead to the conclusion that households using greater quantities of water or who have to travel greater distances in search of water are relatively more likely to use water from an institutional supply. More generally, the likelihood of choosing alternative water sources is influenced by the source-specific attributes, such as proximity to the source, human capital attributes (for instance the household number of years of education), a household's composition, the expenses on water and the volume of water that is used.

Table 4.7: Maximum likelihood estimates of water-source response functions

(Figures in parentheses are t-ratios)

| Variable | Water sources | |
|---|---|---|
| | Vendors | Boreholes/wells |
| Intercept | 4.9 | -3.691 |
| | (3.338) | (-2.891) |
| Household size | -0.317** | 0.124 |
| | (-2.127) | (0.842) |
| Number of years of formal | -0.146** | 0.142* |
| education | (-2.005) | (1.886) |
| | -0.416 | -0.486 |
| Distance to source | (-0.758) | (-0.937) |
| | -0.020* | 0.019 |
| Volume of water used per day | (-1.61) | (1.479) |
| | 0.062** | -0.059* |
| Daily cost of water | (2.49) | (-1.930) |
| | -1.90 | -0.121 |
| Income | (-0.829) | (-0.534) |
| Log likelihood ratio | -24.532 | -24.592 |
| No. of observations | 61 | 61 |
| Chi2 ($\chi^2$) | 18.99 | 11.31 |
| Prob > Chi2 (($\chi^2$) | 0.0042 | 0.0793 |
| Pseudo $R^2$ | 0.279 | 0.187 |

Source: Field survey

Note: Water use is measured in litres, water expenses in Ksh and the distance to the source in kilometers.

*. Estimated coefficient is significant at 10% level.

**. Estimated coefficient is significant at 5% level.

## 4.4 Vending Business and Institutional Framework

### *4.4.1 Starting and Operating Costs*

Small-scale providers of infrastructure services are proving to be more responsive than utilities to needs of poor consumers. This true for delivery of water services by tanker and private vending as is the case in transport services by minivan, or electricity through mini-grids or household solar panels (Wasike and Kimenyi, 2001). They make their services affordable to the poor by using cheaper technology or permitting flexible payment. Regulators are customarily hostile to these alternative providers. The interests of the poor would be better served if regulators treated them as valid service providers and brought them under a regulatory umbrella.

The prices charged for vended water are largely determined by free market forces. The vendors are not organized and entry into the business is easy. During both the dry and the rainy seasons, the vendors buy water from the boreholes for Ksh 5 per 20-litre jerrican. During the rainy season, 76% of vendors' sales are at the rate of Ksh10 per 20-litre jerrican increasing to Ksh 15 in the dry season. This is because, some of the water sources may dry up and therefore vendors may be forced to draw water from far distant sources. The same container costs Ksh3 from the well and is sold at Ksh7 in the wet season and Ksh 10 in the dry season. The piped water system is unreliable and vendors do not patronize it.

Social pressures among the vendors appear to keep the price from falling much below Ksh10. During the dry season, a zonal pricing is much more developed and widespread. The price increases the farther the distance from the source. Some vendors have regular, highly valued customers because they provide a steady source of revenue, particularly during the rainy season. Vendors extend credit to regular customers and may charge them lower prices. At times, a vendor may offer a jerrican of water freely to the customer who buys the highest quantity of water in a day. Prices in the rainy season may decrease to Ksh7 per 20-litre jerrican for such reliable customers and, during periods of shortage, vendors do not increase the price charged to regular customers to the market level.

Most vendors' sales to households were for 3 jerricans per day. Profitable business required larger deliveries. The average vendor made about 30 sales per day requiring 7 to 8 trips to boreholes daily. Most vendors sell water in a relatively small portion of the village.

However, despite the fact that vendors supply most water in Ngando, there are no rules that govern their activities. In fact, as mentioned earlier, entry into the business is free and one can run it at his or her own risk. Though this is the case, a few vendors who use tanks to transport water are required under the Nairobi City Council (NCC) bylaws to paint their tanks on both sides to maintain the cleanliness of water and then pay an operation levy of about Ksh10,000 per month. It was unfortunate to learn from the survey that, these few rules have not been formalized by the city council.

### *4.4.2 Constraints to Private Water Vending*

The main constraint to water vending in Nairobi's Ngando sub-location is high operation costs. This is because there is stiff competition and so a number of the small-scale entrepreneurs try to wake up very early in the morning and work the whole day: Secondly, poor road infrastructure in Ngando has a negative effect on operations of the small-scale water entrepreneurs as it constrains the transportation of water especially during the rainy season. Also, electricity is not connected to some water sources and hence it becomes costly in terms of finance and time to use diesel generators to pump water at boreholes. There are also poor roads for non-motorized transport and so vendors using bicycles and the ones using carts operate at high risk of being knocked down by vehicles; because of stiff competition in the business, a number of vendors operate with few customers and end up making little money from the business.

To some vendors especially the ones using tanks, they face constraint of high starting capital as well as harassment from the Nairobi City Council. There is also a constraint of difficulty in obtaining water. This is because there are only two main boreholes which supply water in the whole sub-location leading to longer queuing times. To add to this, the newly constructed borehole (two months prior to the fieldwork period), is not connected to an electric line and hence it can only use a power generator; there is also the problem of default of payment from the customers. People may want the water yet they do not have money at that time. At times, if the debt belonging to a customer is so big, the customer may migrate to a different residential estate where it may be difficult to be traced by the particular vendor. So with all these constraints, vendors use the measures discussed below to ensure that their business does not collapse.

### *4.4.3 Coping Strategies*

Most vendors ensure that before they transport the water to customers, they are already paid; they also ensure that they save whatever they get from the business as well as from the other businesses in order to survive in times of difficulties; some vendors have acquired fixed premises while those using tanks make sure that they are well connected to the Nairobi City Council so that their business is not stopped abruptly; during period of illiquidity, a few of the vendors rely on borrowing loans from friends and others borrow from their banks.

The water vending business in Ngando sub-location is characterised by high competition engendering the need for vendors to employ specific measures in order to compete in the industry. These measures are include: ensuring that the water transported is drawn from clean sources and is treated; taking water to people's door steps; charging low prices and giving regular customers some extra benefits such as giving water on credit (see Table 4.8).

Table 4.8: Strategies for coping with competition

| Strategy | Relative frequency | percent |
|---|---|---|
| Clean water | 14 | 33.3 |
| Take water to the doorsteps | 11 | 26.2 |
| Extra benefits to customers | 13 | 31.0 |
| Lower charges | 4 | 9.5 |
| Total | 42 | 100.0 |

Source: Field survey

## 4.5 Cost of Water and Willingness to Pay

### *4.5.1 Household Expenditure on Water*

Majority of households (93.4%) carries water using the 20-litre jerrican, a small percentage (4.9 %) use the 25 Litre jerrican and 1.6% use the 60-litre jerrican to carry the water. Evidently, the price of water from the vendors increases during the dry season, (see Table 4.9). This is expected because some of the water sources may dry up during the dry seasons and therefore vendors get water from far distances. However, prices from other water sources remain the same even during the dry season.

Table 4.9: Prices of water from different water sources for different container capacities

| Container Capacity | Vendors | Boreholes | Wells | Institutional supply |
|---|---|---|---|---|
| | | Wet season | | |
| 20 | 10 | 5 | 3 | 0 |
| 25 | 12.50 | 7 | 4 | 0 |
| 60 | 30 | 15 | 9 | 0 |
| | | Dry season | | |
| 20 | 15 | 5 | 3 | 0 |
| 25 | 19 | 7 | 4 | 0 |
| 60 | 45 | 15 | 9 | 0 |

Source: Field survey

Table 4.10 shows that, the households' expenses on water per day range from Ksh 0 to Ksh 60 with the highest percentage of the households spending Ksh 15 per day on water. In total households spend Ksh 1178 on water per day, which amounts to Ksh 35340 per month.

Households' income per month ranges from Ksh 2001 to Ksh 15000. The majority of households earn Ksh 4001 per month and a small percentage (4.9 %) of the households earn Ksh 15000 per month. However, all households earn Ksh 321,053 in total per month and on average Ksh 6282 is earned by households (see table 4.11). Evidently, tables 4.10 and 4.11 show that 11% of the total households' income is spent on water per month.

Table 4.10: Households' expenses on water per day

| Cash | Relative frequency | Percent |
|---|---|---|
| 0 | 2 | 3.3 |
| 5 | 3 | 4.9 |
| 9 | 1 | 1.6 |
| 10 | 2 | 3.3 |
| 12 | 4 | 6.6 |
| 14 | 4 | 6.6 |
| 15 | 13 | 21.3 |
| 20 | 9 | 14.8 |
| 1 | 4 | 6.6 |
| 25 | 6 | 9.8 |
| 28 | 2 | 3.3 |
| 30 | 6 | 9.8 |
| 40 | 2 | 3.3 |
| 45 | 1 | 1.6 |
| 60 | 1 | 1.6 |
| 61 | 1 | 1.6 |
| Total | 61 | 100.0 |

Source: Field survey

**Table 4.11: Distribution of households' income per month**

| Income Groups | Frequency (%) | Cumulative frequency (percent) |
|---|---|---|
| 2001 | 9 (14.8) | 9(14.8) |
| 4001 | 22 (36.1) | 31(50.8) |
| 7501 | 21 (34.4) | 52(85.2) |
| 12501 | 6 (9.8) | 58(95.1) |
| 15000 | 3 (4.9) | 61(100) |
| Total | 61(100.0) | |
| Minimum = Ksh 2001 | | |
| Maximum = Ksh 15000 | | |
| Mean = Ksh 6287 | | |

Source: Field survey

### *4.5.2 Value of Time Spent Collecting Water*

Time taken to collect water (that is, travel time and queing time) ranges from 0 time to 45 minutes. About 11 percent of households spent no (i.e zero time to collect water). This is because the water is brought to their doorsteps by vendors. The majority of households take 30 minutes to collect water (See table 4.12). If the average monthly income (Ksh 6282) is considered, then an average value of time spent on collecting water in Ngando is Ksh 15.70 per hour. For a sub-location having 7,747 households, this figure (taken together with the actual cost of water) represents a very high cost of accessing water services.

Table 4.12: Time taken in minutes to collect water (Travel and queue time)

| Minutes | Frequency (%) | Cumulative (%) |
|---|---|---|
| 0 | 7 (11.5) | 7 (11.5) |
| 3 | 1 (1.6) | 8 (13.1) |
| 5 | 4 (6.6) | 12 (19.7) |
| 10 | 6 (9.8) | 18 (29.5) |
| 15 | 4 (6.6) | 22 (36.1) |
| 20 | 8 (13.1) | 30 (49.2) |
| 25 | 6 (9.8) | 36 (59) |
| 27 | 1 (1.6) | 37 (60.7) |
| 30 | 18 (29.5) | 55 (90.2) |
| 35 | 1 (1.6) | 56 (91.8) |
| 40 | 2 (3.3) | 58 (95.1) |
| 45 | 3 (4.9) | 61 (100.0) |
| Total | 61 (100.0) | |
| Minimum = 0 | | |
| Maximum = 45 | | |
| Mean = 20.82 | | |
| Std. Deviation = 12.61 | | |

Source: Field survey

### *4.5.3 Cost of Treating Water and Incidence of Water-Related Illnesses*

From the field survey, about 60 percent of the households reported that the quality of water supplied by vendors is of fair quality. About 36 percent of the households reported that vendors supply poor quality water. However, though this is the case, from table 4.13, 62.3% of the households treat the water but 37.7 % do not undertake any treatment costs. The cost of treatment has a wide range and starts from Ksh5 to Ksh25 per day. The majority of the households spend Ksh 20 to treat water per day. About Ksh 633 is spent on treating water per day by households. The daily cost of treating water is 6% of the total households' income per day. The 62.3% of the households treat water through boiling. Some of the other households reported that, they take the water after any particle has settled down while a few reported that, they take water by faith because they lack money to undertake the treatment costs. However, because of not treating the water, 37.7% of the households are found to have suffered from water-related diseases (table 4.14). A positive correlation exists between the cost of treating water and the number of people who suffer from water-related diseases. The majority of the households that boil water have at least primary school education level.

The probit results for exposure to water-related disease show that, the three water sources (vendors, boreholes, institutional supply) exert a significance negative impact on the number of people who contract water-related diseases; therefore contracting water-related diseases is a source-specific phenomenon. However, the coefficient of water from well and the coefficient of the other variables included in this analysis are not significantly different from zero. Households drawing water from vendors are more likely to suffer from water-related diseases than households drawing water from the other sources. This is expected because from the field survey, water from wells where vendors get water is not treated and hence not fit for human consumption.

Table 4.13: Households' expenses on treating water per day.

| Cost of treating Water per day | Relative frequency | Percent |
|---|---|---|
| 0 | 23 | 37.7 |
| 5 | 3 | 4.9 |
| 7 | 1 | 1.6 |
| 8 | 1 | 1.6 |
| 10 | 7 | 11.5 |
| 13 | 1 | 1.6 |
| 15 | 3 | 4.9 |
| 20 | 15 | 24.6 |
| 25 | 7 | 11.5 |
| Total | 61 | 100.0 |
| Total amount of money spent on treating water per day = Ksh 633 | | |

Source: Field survey

Table 4.14: People who have suffered from water-borne diseases

| No. of sufferers | Frequency | Percent | Cumulative (%) |
|---|---|---|---|
| 0 | 38 | 62.3 | 38(62.3) |
| 1 | 7 | 11.5 | 45(73.8) |
| 2 | 8 | 13.1 | 53(86.9) |
| 3 | 7 | 11.5 | 60(98.4) |
| 4 | 0 | 0 | 60(98.4) |
| 5 | 1 | 1.6 | 61(100.0) |
| Total | 61 | 100.0 | |

Source: Field survey

Table 4.15: Probit results for exposure to water-related diseases

| Variable | Estimates | t-ratios |
|---|---|---|
| Intercept | 1.901558 | 1.57 |
| Daily cost of water | 0.0212 | 0.88 |
| Water from a vendor | -1.998** | -2.47 |
| Water from a borehole | -2.38** | -2.29 |
| Water from a well | -1.63 | -1.27 |
| Water from an institutional supply | -2.62** | -2.21 |
| Quality of water supplied by vendors | 0.207 | 0.50 |
| Volume of water used | | |
| Per day | 0.003 | -0.31 |
| Employment of the spouse | -0.67 | -1.50 |
| Number of years of education | -0.015 | -0.27 |

Log likelihood Ratio = -36.89614

No. of observations = 61

Chi2 ($\chi^2$) = 7.05

Prob > Chi2 ($\chi^2$) = 0.6324

Source: Field survey

Note: The dependent variable assumes a unity value for households reporting attack from water –related diseases, and zero otherwise.

**. Estimated coefficient is significant at 5% level.

### *4.5.4 Willingness to Pay versus Water Charges*

To shed light on the various discussed above issues and bearing in mind the daily water uses by the people, the households were asked the maximum amount of money they would be willing to pay for the container of water beyond which the household could not afford.

The results summarized in table 4.16 indicate that majority of households are willing to pay Ksh 5 daily for a container of water. However, the valuations are highly dispersed and vary from Ksh 0 to Ksh 120. On average, households are willing to pay more than Ksh9 daily for a container of water. The daily average valuation of Ksh120 is more than the daily expenses on water in these households but more than four times the daily wage rates in these households. In total, households are willing to pay Ksh 540 daily for an improvement of a water source, which amounts to Ksh 16200 in a month. The monthly average valuation of Ksh 16200 is 5% of the total households' income per month.

Table 4.16: Households' WTP for a container of water beyond which the household could not afford

| Maximum willingness To pay | Frequency (%) | Cumulative frequency (%) |
|---|---|---|
| 0 | 2 (3.3) | 2(3.3) |
| 3 | 3 (4.9) | 5(8.2) |
| 4 | 1 (1.6) | 6(9.8) |
| 5 | 22 (36.1) | 28(45.9 |
| 7 | 6 (9.8) | 34(55.7) |
| 8 | 5 (8.2) | 39(63.9) |
| 10 | 14 (23.0) | 53(86.9) |
| 11 | 4 (6.6) | 57(93.4) |
| 20-30 | 3 (4.9) | 60(98.4) |
| 120 | 1 (1.6) | 61(100.0) |
| Total | 61(100.0) | |

Source: Field survey

Table 4.17: WTP for a litre of water beyond which the household could not afford

| Responses | Frequency (%) | Cumulative (%) |
|---|---|---|
| Current price is the highest | 42 (68.9) | 42 (68.9) |
| 1.5 the current price | 11 (18) | 53 (86.9) |
| Twice the current price | 6 (9.8) | 59 (96.7) |
| Three times the current price | 1 (1.6) | 60 (98.4) |
| Four times the current price | 1 (1.6) | 61 (100.0) |
| Total | 61 (100.0) | |

Source: Field survey

From table 4.17, 68.9 percent of the households reported the first option, i.e., current price was the highest. This means that they were willing to continue paying the current water price. Some households argued that, the current price was the highest and therefore it should be lowered. To emphasize on this, few of the households reported that the price for the 20-litre jerrican from the borehole should decrease to Ksh 2. The argument was that, by so doing, the price charged by water vendors should also go down. About 20 percent of the households reported that they were willing to pay one and a half the current water price and 9.8 percent reported that they were willing to pay twice the current price. However, one household reported to be willing to pay three times the current price and another one reported to be willing to pay four times the current price. From the field study, every household, however, expected that the water would not be free (i.e. no one reported that the price of water should be zero except to mention that the price should be lowered).

Further results indicate that, from the 42 households who reported the first option, 22 earn Ksh 7501 per month, 3 earn Ksh 12501 and 3 of these households earn above Ksh 15000. Households' average income per month in Ngando sub-location is Ksh 6287 and this means that 28 households earn above average household income per month in Ngando sub-location. About 14 of these 42 households earn Ksh 4001 per month which is the average income earned by most households in Ngando sub-location. No household earning Ksh 2001 per month reported the first option.

Of the 11 households who reported the second option, 5 of them earn Ksh 7501, 2 earn Ksh 4001, 2 earn Ksh 12501 and 2 earn Ksh 2001 per month. From the 6 of the households who reported the third option, 2 earn Ksh 7501, 3 earn Ksh 4001 and 1 earns Ksh 2001. However, the two households who reported the fourth and the fifth option earn Ksh 2001 and Ksh 4001 respectively.

Clearly, as the level of income earned by households decreases, the more the households are willing to pay more for a container of water. Households earning larger amounts of income are willing to pay less amounts of money for a container of water than those households that earn less amounts of income.

The specific hypothesis in this section is that average willingness to pay (WTP) for a litre of water is significantly higher than existing water charges thereby reflecting a true preference for the good being valued. It is important to determine the statistical significance of this hypothesis. To do this we employed two tests (Student's *t*-test, and a paired-rank Wilcoxon test) to assess the one sub-hypothesis.

$$WTP/LITRE = PRICE/LITRE \quad \text{versus} \quad WTP/LITRE \neq PRICE/LITRE$$

Where;

WTP/LITRE = Willingness to pay for litre of water beyond which the household cannot afford

PRICE/LITRE = Price of water per litre.

The results of the tests of statistical equivalence of WTP per litre and Price of water per litre are shown in table 4.18. The null hypothesis $H_o$: WTP/LITRE = PRICE/LITRE is rejected at the 5% significance level. This applies to the two tests that the study considered. This means that hypothesis of equal means in *t*-test and of equal medians in the case of Wilcoxon tests are rejected. So as is shown in Table 4.18, support is given for the alternative hypothesis that WTP/LITRE ≠ PRICE/LITRE. This means that, the willingness to pay value for a litre of water reflects the true preference for the price of water. The paired-rank Wilcoxon non-parametric test uses the median as a measure of both average WTP per litre and average Price of water per litre.

Table 4.18: Results of tests of the hypothesis on price of water on household WTP for a container of water beyond which it could not afford; Student's t, and Wilcoxon test.

| Test Null hypothesis ($H_o$) | *t*-statistic Decision (*t*) | Wilcoxon test Decision (*p*-value) |
|---|---|---|
| WTP/LITRE = PRICE/LITRE | 2.881 | 3.398 |

Source: Based on data from field survey

Note: All tests are two-sided and all decisions on $H_o$ are at 95% level.

OLS regression results for the determinants of these valuations are summarized in Table 4.19. From table 4.19, only 22% of the variations in WTP is explained by the explanatory variables. The model performs disappointingly regarding goodness of fit, but it is evident that the daily cost of water and the volume of water used per day exert significant positive impacts on the WTP for a container of water beyond which the household would be unable to pay. Income level of the household exerts a positive impact on this valuation. The coefficients of other variables included in this valuation model are not significantly different from zero.

Table 4.19: OLS results for WTP for a container of water beyond which the household could not afford

| Variable | Estimates | t-ratio |
|---|---|---|
| Intercept | 3.462 | 0.370 |
| Household size | 1.795 | 1.382 |
| Volume of water used per day | 0.229** | 2.167 |
| Distance to the source of water | -4.177 | -0.886 |
| Daily cost of water | 0.628*** | 2.703 |
| Income | 1.287 | 0.648 |
| Years of education | 0.748 | 1.319 |

No. of observations = 61

$F(6,54) = 2.51$

Prob > F = 0.032

R-squared = 0.218

Adj.R-squared = 0.131

Root MSE = 14.099

Source: Based on data from field survey

Note: **. Estimated coefficient is significant at 5% level.

***. Estimated coefficient is significant at 1% level.

## 4.6 Discussion of the Results

### *4.6.1 Determinants of Choice of Water Sources*

The directions of the impacts of individual attributes on the relative probabilities of choosing specific water sources are quite variant; similar results have been found by Kimuyu (1998) though with different water sources. However, the volume of water used per day exerts significant impact on the probabilities of choosing specific water sources. The distance to all water sources exerts negative effect on the probability of choosing a water source. Households prefer water vendors because they take less time to collect water from them and at other times the water is brought at their doorsteps; similar results are found in Ukunda, (see Whittington et al 1990, Whittington et al 1990a, see also, Bruzelius, 1979 and Yucel 1975). Households preferred open wells to the kiosks because the collection time for open wells was less than for the kiosks. This was done through the travel cost method but the current study applies the contingent valuation method.

Education level is found to be significant for household choices of water sources; similar results are found in other studies, (e.g. Whittington et al 1990a; Kimuyu 1998). This is to say, households headed by a person with more education attributes are more likely to choose better quality sources of water than other households headed by a person with less education.

The coefficient of the daily cost on water exerts a positive and significant impact on the water from vendors. However, this can be explained by the fact that, people in Ngando sub-location have few alternative water sources and therefore they prefer water from vendors, which is reliable and convenient; this is irrespective of the prices charged by water vendors. However, according to Whittington and workers (1990a), the same coefficient had a negative significant impact but a positive significant impact was found in Kimuyu (1998). According to the Whittington et al paper, people of Ukunda had numerous water sources as compared with those of Machakos (Kimuyu's paper) and therefore the more money is spent on collecting water from a particular source, the fewer the people who would use water from that particular source.

The coefficient of the household's size exerts a negative significant effect on the choice of water from a vendor. This can be explained by the fact that, the larger the household, the more the adult people who could afford to draw water from far distant sources. This is similar to results of Whittington et al 1990a but is different from Kimuyu's. Kimuyu found the coefficient of household size insignificant in all the water sources he considered. The coefficient of the household size exerts a positive significant impact on the volume of water used per day; similar results are found in other studies (Kimuyu, 1998, Whittington et al 1990a).

The probit results reveal that, contracting water-related diseases is a source-specific phenomenon unlike in Kimuyu' study where contracting water-related disease was found to be a location-specific phenomenon. This is because different locations in Machakos district have different water sources with different water-related diseases. For example, households in Wanzauni draw water from the Thwake, which is part of the drainage system from Machakos town, so more people from this part contract water-related diseases as compared to others in other locations.

### *4.6.2 The Water Vending Business*

The study shows that the water vendors deliver more water to households than the public water utility since the piped water system is not reliable. See Whittington et al 1988 for similar results. In Kibera, a low-income area in Nairobi, water provision for the residents is organized through about 500 water kiosks, which are run mostly by individual private owners, and some are operated by water communities and women groups (Wegelin, 1997). In Ngando sub-location, there are no water communities neither women groups running water kiosks, in fact the existing boreholes have been dug by particular individuals but not by groups of individuals. However, the business of vending water is highly competitive with no participants making supernormal profits. Water vending is done by both males and females and they retire from the business as they become old. Vendors draw water from the boreholes and wells that have been dug by wealthier people in Ngando sub-location. However, other water sources and in particular piped water system are not reliable and therefore vendors do not rely on them. Similar results have been found in Ukunda and in Kibera (Whittington et al 1989 and Wegelin, 1997). Most vendors engage in other business activities after vending water. This is because they do not make good returns on their investment and hence the importance of government intervention. In Ukunda, vendors were making fair return on their investment but did not make exorbitant profit and therefore government regulation was found to be unnecessary (Whittington et al, 1989). As they earn more revenue from the two income sources, the more they are unlikely to engage in water vending business. Different results are found in Ukunda, (Whittington et al, 1989) whereby the water vending business is done by males alone with an average age of thirty years; for all but one person, water vending was a full-time occupation. However, in Whittington et al (1989), it is not indicated if the vendors retire from the business when they become old.

Water vending business is not organized and entry into the business is free. There are no rules that guide the operations of vending water. The few rules that have been imposed on vendors using lorries with big tanks have not been formalized by the city council authorities. Different results were found in Nigeria. In Nigeria, the vast majority of residents obtains its water from an elaborate and well organized water vending system, selling 2.96 million gallons per day for which they pay about US$ 28000. At the same time, the public water utility was supplying about 1.5 million gallon per day for which they collected US$ 1,100. Thus the water vending system was providing double the supply and collecting 24 times as much revenue as the water utility, (Whittington et al 1988).

Some vendors have regular customers to whom they extend credit and charge them lower prices. The water vending business is more profitable during the dry season when the price of water per litre increases (see Whittington et al, (1989) for similar results). Vendors use different types of containers to transport water ranging from 20 litre jerricans through 25 litre jerricans, 60 litre jerricans and 8000 litre tanks to 15000 litre tanks. The lorries using these tanks are for more distant locations and on slopes, which are difficult to reach with a fully loaded bicycle or a cart. Different results were found in Ukunda where vendors were found to use the 20 litre jerricans only to transport water and bicycles were used on slopes and for long distances, which were difficult to be reached by a fully loaded cart. (Whittington et al, 1989).

Vendors face several constraints in the vending business and in particular constraints of poor roads and lack of enough electricity to pump water from boreholes for example. In Tegucicalpa, because of problems of water and electricity distribution in the city network, water is distributed to different parts of the city at different hours. This information is communicated effectively so that kiosks are opened at different, but fixed times, and women can adjust their domestic management to these hours (Espejo et al 1993). From the field survey, though there are problems of water and electricity distribution in the city wide network, the information is not communicated effectively and electricity is cut abruptly. Therefore vendors tend to waste time before they adjust to other activities they had not planned.

### *4.6.3 Household Resource Expenditure on Water Services*

Findings on resource expenditure on water shows that 5% of the total household income is spent on water per month. People of Ngando sub-location feel neglected by the government and lack trust in government water supply systems. However, more trust is in small-scale private water entrepreneurs who supply them with water. i.e., Boreholes and wells that have been dug by few wealthy people are the ones that supply people of Ngando with water. Similar results were found in Webuye (Wasike and Hanley, 1998). In Webuye, residents found reliable dug wells close to homes more attractive than the alternative of unreliable tap water relatively far from most houses. From fieldwork survey, a number of respondents reported to have been asked in the past by the City Council authority to pay each Ksh 300 for starting a water project but unfortunately, the project was not started and no money was refunded back to people.

Though there is problem of water in Ngando sub-location, only Ksh 15.70 per hour is taken to collect water by households. This can be explained by the fact that in Ngando sub-location, the problem of water has been lessened by the distributing vendors who collect water from the main boreholes for example and distribute to people. In Ukunda, a village located 40 kilometres South of Mombasa town, households were found to take US$0.38 per hour to collect water which was very close to the average household income of Ukunda people. This is because, being a rural area, the water sources are likely to be far and therefore time taken to collect water could be high. Willingness to pay results for a container of water indicates that, the daily average valuation is more than the daily wage rates in these households. Other studies found similar results (See Kimuyu, 1998; see also, North. and Griffin 1993 in their study on willingness to pay for water in Philippines). Further results show that, no one expected water to be free, this is because, no one reported that the price of water should be zero except to mention that the price should be lowered. Similar results were found in Webuye (Wasike and Hanley, 1998). In Webuye, no one expected water connection in that area to be free because no one bid zero. (In North et al (1993), households in all income groups (low, middle and upper) recorded a willingness to pay value, which was above half of their monthly wage rates. The volume of water used per day and the daily cost on water exert positive significant impacts on this valuation. Distance to source of water exerts a negative impact on this valuation. Similar results were found in Philippines though only among the upper income group, (see North and Griffin 1993). According to Kimuyu 1998, the same variable though in dry season, i.e. distance to dry season source, had a positive significant impact on the valuation of water improvement in Machakos district. The number of years of formal education exerts a positive impact on this valuation, which shows that households with people of higher education are willing to pay more for an improvement of a water source than households with people of lower education. In Kimuyu (1998) and North et al (1993), this variable was not considered as a factor influencing the willingness to pay for an improvement of a water source.

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# CHAPTER 5: POLICY RECOMMENDATIONS AND CONCLUSIONS

This paper has presented results from a study on water vending in a low-income area of Kenya's Nairobi City. By and large the results show that communities can be important partners in the water and sanitation sector. As consumer groups, communities, irrespective of their income status, can play a significant role in ensuring cost recovery and, thereby, sustaining investments in the sector. As 'informal' service providers, communities can supplement the role of formal service providers and can build useful partnerships with the public and private sectors, particularly in addressing the service needs of low-income settlements. Communities can also play an important role in improving the efficiency of service provision and management in the sector.

## 5.1 Improving the Business Environment for Private Water Vending

Water vending is a valuable service for people in Ngando sub-location. Although vending does not provide a level of service comparable to house connections from a well-run piped distribution system, it is far superior to the piped system that is currently unreliable and almost non existence . Still, however, there are many constraints to the water vending industry. There is need, therefore, to improve the business environment for the sector. In particular, the government should improve road infrastructure especially for non-motorirized transport. Moreover, vendors get water mainly from the boreholes. Some of these boreholes are not connected to electricity lines and so vendors tend to expend more time while using other means like diesel generators. Vendors take little time to draw water when there is electricity. It would be good if the electricity charges are lowered so that they are affordable by a number of people and also lower the prices of inputs (such as diesel, fuel, generators) to enable a vendor make profit and remain in the vending business. From the data on the cost of treating water, most households use paraffin in order to boil the water; so the government should try to reduce the price of paraffin.

Although households are spending significant resources in water- vending system, few entrepreneurs in the system are making supernormal profits. A relatively free market in water vending exists. This is so from the point of purchase to the point of delivery. The boreholes/wells owners and the water vendors are receiving adequate incomes, but none is extracting large monopoly rents. Thus, if the water authority has established a reasonable price to be charged to and by the boreholes/wells owners, there is little economic justification for (a) regulating either the price the vendors charge their customers for water or (b) licensing the vendors or imposing other restrictions on entry into the vending business.

The private water system supplies more water to people in Ngando sub-location than the public water system. The government should provide an incentive-structure for the small private entrepreneurs (e.g. loan and credit schemes) to facilitate the vending businesses. Such small private entrepreneurs are looked down upon by banks especially if they want to borrow loans; the government should therefore encourage them in whichever way possible. Many households have trusted these small entrepreneurs more than the government in the improvement of the situation of water in Ngando sub-location. Some respondents reported that, government cannot solve the problem of water in Ngando sub-location and so the best thing is to encourage the small private entrepreneurs who do supply them with water. This is because the government has tried in the past to install piped water and even hand pumps without much success. For example, in 1989, the city council authority had decided to put up a Guinness water; through the project, a tank of more than 50000 litres was constructed where the water could be stored after been drawn from other sources, and therefore serve people of Ngando sub-location. The project served people only for one year and then it stopped because of poor management and political interference. From the data on level of education, more than 50% of the people in Ngando sub-location have at least primary school education and at least 12% have attained college level. This shows that, such projects can be well managed if they are started again.

## 5.2 Creating Diversity in Choice of Water Sources

Although government regulation of vendors does not appear to be justified when there is a competitive market in vended water, improvement of a water system, such as provision of yard taps, may be necessary. More vendors engage in other income-generating activities in addition to water vending. However, from the data on the income spent and received from the water vending and from the other businesses, most people in Ngando sub-location can afford yard taps or even house connections. Therefore, in situations such as this, the information on the water vending system can serve as a useful indicator of a community's ability and willingness to pay for a yard tap distribution system for example. The fact that yard taps do not already exist in Ngando sub-location indicates an inability on the part of the community or water authority to regulating either the price the vendors charge their customers for water or (b) licensing the vendors or imposing other restrictions on entry into the vending business.

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In Ngando sub-location, the piped system exists but it is unfortunate because it does not supply water to people. i.e., the piped water system supply water to town people only but not to the village people. So it would be better for the water authority to see that these piped systems, given their propensity to deliver higher health benefits, provide water to village people and extend them even to the peoples' houses. From earlier discussion, the government should not intervene in the water vending business. However, though this is the case, it is important for the government to intervene in some special cases. To emphasize on this, Whittington (1989) points out that vendors sometimes sell water from polluted sources or polluted containers. The government should therefore regulate the quality of water vended by ensuring that the water is drawn only from clean/treated water sources; the containers carrying water are clean, and a pristine environment surrounding the water sources. This will maintain the cleanliness of water supplied by vendors. To add to this, water uses in a river basin or aquifer are interdependent, which is to say that users impose 'externalities' on others that they ignore in their own decisions (e.g., discharging polluting effluent into a well causes harm, inconvenience and costs to other well users). In some respects water is a 'public good' in the sense that it is impractical to exclude users or beneficiaries, and therefore impossible to charge for. Where this is the case, private investment will not be forthcoming. In both these respects, water is prone to 'market failure,' which implies that some public involvement is called for. Water from the wells also has a higher likelihood of being a health risk. This is because, majority of vendors in Ngando sub-location obtain their water from boreholes where the water is normally treated; a few of the households who use water from the wells use it only for other household chores but not for drinking.

The government should sink more boreholes in Ngando sub-location and treat the water before people use it. Sinking more boreholes can weaken the monopoly power of the borehole owners and hence reduce the price charged to the people. The government should also introduce rain catchment technologies in Ngando sub-location. In so doing, the problem of water shortage would be lessened.

## 5.3 Protecting Water Consumer Welfare Through Appropriate Regulations

Small-scale providers of infrastructure services are proving to be more responsive than utilities to needs of poor consumers. This true for delivery of water services by tanker and private vending as is the case in transport services by minivan, or electricity through mini-grids or household solar panels. They make their services affordable to the poor by using cheaper technology or permitting flexible payment. Regulators are customarily hostile to these alternative providers. The interests of the poor would be better served if regulators treated them as valid service providers and brought them under a regulatory umbrella.

Though most of people in Ngando sub-location draw water from the vendors, it is unfortunate to learn from the survey that there are no rules that govern their activities. This is especially so for the vendors using bicycles, carts and the ones using manual labour. The government should not overlook the works of these vendors; in fact they render a valuable service to the people of Ngando sub-location. So the government should recognize these small private entrepreneurs so that their business is organized. From earlier discussion, water-vending business in Ngando sub-location is not organized and entry into the business is free, i.e. vendors work at their own risk. The government should set rules to govern the water vending activities and see to it that they are effectively enforced, i.e., the government should control the activities of water vendors. Through this, the water vending business would be improved. It is unfortunately to learn from the survey that the few rules that have been put to vendors using lorries are not formalized. For instance, vendors should have licences, which should be issued in transparent manner in order to improve the water vending business.

## 5.4 Concluding remarks

In conclusion, the findings from this study have important implications for water planning in Nairobi, not only with respect to water vending, but also with regard to willingness to pay for improved water services. People in Ngando sub-location are willing and able to pay substantial amount of money for water from vendors. Vendors in Ngando sub-location sell more than 70 per cent of the total water consumed in Ngando sub-location. A survey of vending practices in area can be a useful indicator of a community's ability and willingness to pay for an improvement of water services. The case study shows that the prices vendors charge for water are high because hauling water manually is expensive. In Ngando sub-location, vendors were not making a fair return on their investment and so they engaged in other businesses in the course of the day.

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# APPENDICES

## APPENDIX A:

## QUESTIONNAIRE FOR SMALL-SCALE WATER PROVIDERS

**Questionnaire Number.....**

## INTRODUCTIONS

My name is Pauline N. Mwangi, a student at the University of Nairobi. I am collecting data for a study on provision of water by small-scale entrepreneurs in Nairobi. You have been randomly selected to participate in this study. Please I request you to answer the following questions as truthfully as possible. All information collected under this research will be treated in strict confidence.

## SECTION A: DYNAMICS OF WATER VENDING

1. When did you start this business of water vending? (Year)

2. Where does the water you sell come from: [ ] sub-location (name)
   [ ]Location (name)
   [ ]District (name)
   [ ]Others (specify)

3. Also specify whether it is obtained from a borehole, River, etc.

4. Is this your nearest source of water?[ ]YES [ ]NO

5. How far is it from your home in kilometers? [ ______] Km

6. How long do you take to travel to the source and how long do you queue for the water? (Hours, minutes)

7. What is the capacity of the container you use to carry water from the source mentioned above? [ ] litres

8. How much do you pay for that container when it is full of water at the source?

9. How many such containers of water (on average) do you sell in a day?

10. How much do you charge this container when it is full of water. (Dry season ……
Wet season……..)

11. How do you transport water? Using bicycle, cart, tank etc.

12. How many regular customers do you have and you charge them the same price like others.

13. Is the water you sell treated (from the source) for bacterial infection or so?

[ ] YES [ ]NO

14. If "NO", do you treat before you sell it to people,( yes or no) If yes what mechanisms do you use to treat your water? -

______________________________________________

______________________________________________

______________________________________________

15. Why don't you sell water from other sources?

______________________________________________

______________________________________________

______________________________________________

16. How much of your time, in hours per day, do you spend on water vending activities?
[______] hours per day

17. Apart from water vending, do you have any other source of income?
[ ] YES [ ] NO

18. If "YES", what is your average income per month from the other income-generating activities?

[ ] Below Ksh 2,500/=
[ ] Between Ksh 2,501- Ksh 5,000/=

[ ] Between Ksh 5,001-Ksh 7,500/=
[ ] Between Ksh 7,501-Ksh 10,000/=
[ ] Between Ksh 10,001-Ksh 12,500/=
[ ] Between Ksh 12,501-Ksh 15,000/=
[ ] Over Ksh 15,000/=

## SECTION B: OPERATIONAL CHARACTERISTICS AND REGULATIONS

19. Are there guidelines/regulations/rules set by the depatment of water development that govern the operations of vending activity. [ ] YES [ ] NO

20. If "YES", list them:

21. In your view, which of these guidelines/regulations/rules in question 20 are necessary and which are not?

22(a) Do you have a licence for selling water in Ngando sub-location?

[ ] YES [ ] NO

22(b) If "YES", how much did you pay for the licence in kshs? [____] /=

23. What constraints do you face in this vending activity?

[ ] High starting capital as compared with other businesses.
[ ] High operation cost
[ ] Harassment from city council authorities
[ ] Difficulty in obtaining water
[ ] Inadequate road infrastructure provision for non-motorized transport
[ ] High rate of default in payment for water
[ ] Poor road infrastructure

24. What measures do you employ to ensure that your business does not collapse?

[ ] Borrow loan from somewhere (specify)
[ ] Acquired fixed premises
[ ] Well connected to the city council (i.e. rent-seeking) so that your license is not cancelled abruptly
[ ] Prepayment for water from source
[ ] Careful saving of income from the water vending activity.
[ ] others , specify ............

25. What measures do you use in order to compete with other water providers?

[ ] No competition
[ ] Offer low price
[ ] Take water to the people's doorsteps
[ ] Maintain the cleanliness of water (may be you get it only from clean sources)
[ ] Your regular customers enjoy extra benefits e.g. Lower charges

26. Suggest measures that should be taken (either by the Government or city council authorities) to improve the business environment for water vending activities in Ngando sub-location.

a. ______________________________________________

b. ______________________________________________

c. ______________________________________________

d. ______________________________________________

**SECTION C: SOCIO-ECONOMIC AND DEMOGRAPHIC PROFILE**

27. Gender [ ] Male
[ ] Female

27. Age: [ ]Below 25 years
[ ]25-30 years
[ ]31-34 years
[ ]35-40 years
[ ]41-44 years
[ ]45-50 years
[ ]51-54 years
[ ]55-60 years
[ ]Over 60 years

29. Marital status: [ ] Married
[ ] Single
[ ] Others

30. What is your education level? [ ] No formal education
[ ] Primary (specify year)
[ ] Secondary (specify year)
[ ] College (specify year)
[ ] Others (specify)

31. What is your total income per month? (Both from water vending and other income sources)
[ ] Below Ksh 1000
[ ] Ksh 1001-Ksh 3000

[ ] Ksh 3001-Ksh 5000
[ ] Ksh 5001-Ksh 10000
[ ] Ksh 10001-Ksh 15000
[ ] Above Ksh 15000

32. How many members constitute your household (including children and yourself)?

[_____] members

## APPENDIX B:

## QUESTIONNAIRE FOR THE CONSUMERS OF WATER FROM INDEPENDENT SMALL SCALE ENTREPRENEURS

**Questionnaire Number....**

## INTRODUCTIONS

My name is Pauline N. Mwangi, a student of the University of Nairobi. I am collecting data for a study on provision of water by small-scale entrepreneurs in Nairobi. You have been randomly selected to participate in this study. Please I request you to answer the following questions as truthfully as possible. All information collected under this research will be treated in strict confidence.

## SECTION A: WATER SUPPLY SITUATION

1. How would you rank the problem of insufficient water supply in this area as compared with other areas in Nairobi:

   [ ] Very serious    [ ] Serious    [ ] Not a problem

2. What is your main source of water?
   - [ ] Vendors
   - [ ]Borehole
   - [ ] Well
   - [ ] Institutional water supply
   - [ ] Personal tap/faucet
   - [ ] Others, specify

3. Is this your nearest source of water?[ ] YES    [ ] NO

4. How far is it from your home in kilometers? [_____ ] Km

5. Which of the following reasons best explains why you do not use water from other sources? Please rank them from the <u>best</u> explanation (Rank 1) to the <u>least</u> reason (Rank 5 ).
   - [ ] Other water sources are not available in Ngando ( No alternative)
   - [ ] I cannot afford them ( water from current source is affordable)
   - [ ] The current water source is the most convenient

[ ] Poor (untested) water for household consumption
[ ] Other reasons: specify

## SECTION B: RESOURCE EXPENDITURE ON COLLECTING WATER

6. Please indicate the total time you spend travelling to your main water source as well as the time you take to queue for water. [ ] Hours and [ ] minutes

7. What is the capacity of the container you use to draw water from the source mentioned above? [____] Litres

8. How much do you pay for that container when it is full of water? Ksh [ ] /=

9. How many such containers of water do you use (a) per day? [ ] containers.
(b) per week [ ] containers

10. What maximum price would you be willing to pay for the container of water beyond which your household will be unable to afford? Choose one of the following options:

[ ] Current price is the highest
[ ] 1.5 times the current one
[ ] Twice the cuirrent one
[ ] Three times the current price
[ ] Four times the current price

11. How would you rank the quality of the water obtained from vendors?
[ ] FAIR [ ] POOR

12. Is the water you use treated (from the source) for bacterial infection or so?
[ ]YES [ ] NO [ ] NO ANSWER

13. If "NO", what mechanisms do you use to treat your water and how much do you spend on this?

14. Has there been a history of water borne diseases such as typhoid or cholera after

drinking this water? [ ]YES [ ] NO

15. If "YES", how many people in the house have suffered from these diseases in the past?...

16. Suggest measures that should be taken to improve your access to clean water supply.

[ ] lower the price of water per litre
[ ] Ensure licensing is done in a transparent manner
[ ] Control the activities of water vendors to ensure quality water is supplied.
[ ] End corruption in the water industry
[ ] Provide cheap availability of water treatment facilities
[ ] Bring back the piped water system
[ ] Inspection of water storage facilities
[ ] Improve infrastructure
[ ] others, specify ....

## SECTION C: SOCIAL -ECONOMIC AND DEMOGRAPHIC PROFILE

17. Gender: [ ]Male
[ ]Female

18. Age: [ ] Below 25 years
[ ] 25-30 years
[ ] 31-34 years
[ ] 35-40 years
[ ] 41-44 years
[ ] 45-50 years
[ ] 51-54 years
[ ] 55-60 years
[ ] Over 60 years

19. Marital status: [ ] Married
[ ] Single
[ ] Others

20. What is your education level? [ ] No formal education
[ ] Primary (specify year)
[ ]Secondary (specify year)
[ ] College (specify year)
[ ] Others (specify)

20. If married, what is the education level of your spouse?

[ ]No formal education
[ ]Primary (specify year)
[ ]Secondary (specify year)
[ ] College (specify year)
[ ] Others (specify)

22. Which of the following occupations best explain your day-to-day activities that you engage in to earn your living / meet living expenses?

[ ] Public / Government sector
[ ] Teaching including lecturing / tutoring at College / University
[ ] Business
[ ] Other

23. Is your spouse employed?[ ]YES [ ] NO

24. Which of the following income categories best represents your total household income per month?

[ ] Below Ksh 1,000 /=
[ ] Between Ksh 1,001- Ksh 3,000/=
[ ] Between Ksh 3,001-Ksh 5,000 /=
[ ] Between Ksh 5,001-Ksh 10,000/=
[ ] Between Ksh 10,001-Ksh 15,000/=
[ ] Above Ksh 15,000 /=

25. What is the total number of members of your household (including children and yourself)

[______] members.