QUALITY OF VENDED WATER AND ITS IMPLICATIONS ON PRICE AND HEALTH RISKS ON THE HOUSEHOLDS IN MSIMBAZI SUB CATCHMENT, DAR ES SALAAM- TANZANIA

BY

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DECLARATION

This thesis is my original work and has not been presented for a degree or any other award in any other university.

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DEDICATION

This work is dedicated to my beloved family for their undivided support and prayers.

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ABBREVIATIONS AND ACRONYMNS

BH:	Bore Hole
CEP:	Country Environment Profile
Cl-:	ChlorideI
CT:	Car Tankers
DAAD:	*Deutscher Akademischer Austausch Dienst* (German Academic Exchange Service)
DAWASCO:	Dar es Salaam Water and Sewerage Corporation
DCC:	Dar es Salaam City Council
DPSIR:	Drivers, Pressure, State, Impacts and Response
DUCE:	Dar es Salaam University College of Education
EC:	Electrical Conductivity
EEA:	European Environment Agency
FC:	Faecal Coliforms
IWRM:	Integrated Water Resource Management
JICA:	Japan International Cooperation Agency
MBB:	Molecular Biology and Biotechnology
N02:	Nitrite
NAWAPO:	National Water Policy
NH_3:	Ammonia
NO_3-:	Nitrates
NTU	Nephelometric Turbidity Unit
PC:	Push Carts
PH:	Potentiality of Hydrogen
SO_4:	Sulphate

SPSS: Statistical Packages for Social Sciences

SWOT: Strength Weakness Opportunities and Threats

TBS: Tanzania Bureau of Standards

TC: Total Coliforms

TH: Total Hardness

TSS: Total Suspended Solids

TW: Tap Water

TZS: Tanzanian Shilling

UDSM: University of Dar es Salaam

UN: United Nations

UNCHS: United Nations Centre for Human Settlements

UNESCO: United Nations Education Scientific and Cultural Organization

UNICEF: United Nations Children's Fund

WHO: World Health Organization

ABSTRACT

Inadequate piped water supplies in urban centres is a growing problem; making communities resort to buying vended water. In recent years, vended water has become a major source of drinking water in most of the urban areas in the world. This study assessed the quality of vended water and its implications on price and health risks to households in Msimbazi sub catchment Dar es salaam, Tanzania. It involved assessing the physical, chemical and micro-biological quality of the vended water from different sources and comparing the findings with the World Health Organization (WHO) Guidelines for Drinking-water Quality and the Tanzania Bureau of Standards (TBS) water quality. Specifically, the study (i) Investigated the sources and quality of vended water vis- a- vis its related health risks in Msimbazi sub catchment. (ii) Examined factors influencing price variations of vended water (iii) Determined measures necessary to improve water service provision by vendors. Data was collected using structured Questionnaires administered to the vended water sellers, users at households and owners of the community water kiosks and boreholes from different point sources of the vended water. Key informants from the Dar es Salaam Water and Sewerage Corporation (DAWASCO) were interviewed. Additionally, laboratory analysis of the water samples was done for Potentiality of Hydrogen (pH), Microbial quality (Total Coli forms (TC) and Faecal Coli forms (FC)), Turbidity, Electrical Conductivity (EC), Nitrates $N0_3$–, Ammonia- Nitrogen NH_4-N, Nitrite $N0_2$-, Chloride Cl–, Temperature, Total Suspended Solids (TSS), Sulphate SO_4, Total Hardness (TH) and Colour. Information on sources of vended water was obtained through observation. Secondary sources of data such as review of available literature relevant to the problem under study were utilized to validate research findings. Data obtained was analyzed using qualitative and quantitative methods. The quantitative techniques included descriptive statistics such as cross-tabulation, frequencies, percentages and means were done using Statistical Packages for Social Sciences (SPSS) software version 18.0 and Microsoft office Excel 2007. The qualitative analysis included the use of Strength Weakness Opportunities Threats (SWOT) analysis of water vendor and the existing publc water utility DAWASCO in water service provision. The study found that water from all vendor categories namely: Car Tankers (CT), Push Carts (PC), Tap Water (TW) and Bore Hole (BH) had Total Coli forms (TC) and Faecal Coli forms (FC) beyond the WHO and TBS standards posing high risk of diseases and other health related problems. In addition, BH vended water was of low quality with the highest TC of 1600 MPN/100ml against the TBS acceptable limit of 1 to 3 MPN/100ml and zero levels of FC. Although the physical chemical parameters of turbidity, pH and TSS, TH, NO_3, NH_4-N, were within the standards, the Cl–, SO_4, $N0_2$-, EC and colour were not. Furthermore, the study found that dependence on sole source by DAWASCO, inadequate water infrastructure exacerbated the water shortages thereby affecting the pricing. Likewise, high electricity pump running costs, distance from the source and transport charges contributed to the variation in pricing of vended water. Though observations from the study area showed few signs of success in the provision of water services by the vendors, these were extremely fragmented and uncoordinated. This study suggested the following mitigation: the recognition of vendor roles by government and other water authorities, the formation of their associations and boosting sober collaboration with other water sector stakeholders. The study puts forward the following recommendations: the review of the water sector policy, creation of partnerships with utilities and water vendors, addressing the rampant water shortages by DAWASCO and, expanding and drilling deep boreholes.

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

According to human rights based approach, water is regarded as a common good and essential for human life. An opposing view is based on the premise that there is an economic and other cost implicit in the production of water for human needs which can only be met through fiscal means (Allen *et al*., 2006). Water also remains the single natural resource in the 21st century, which is most sought; given that continued growth of population and economies depend on the quality and quantity of the fresh water (Wolfe, 2003).

In many parts of the world water is recognized as the critical problem which is associated with the failure of the governments to provide this basic resource to the large population. It is this scenario which has caused vended water to be an alternative source of water to majority of the urban population, where the scarcity of supplies or lack of infrastructure of the government utilities limit access to suitable quantities of safe drinking water. Yet, vended water has been associated with outbreaks of diarrheal disease (Hutin *et al*., 2003). This problem affects the poor majority and most recently urbanized communities who have little prospect of getting connected to the utilities distribution networks.

Globally, water vending is probably as old as human society and trade, and is often taken as a symptom of a failure of the piped systems, which still provide water to only a minority of the urban dwellers in many parts of the world. According to Kjellen and McGranahan (2006), those who buy water from vendors are classified as not having reasonable access to an improved water supply. WHO/UNICEF (2000) consider vended water as un-improved source of water. This perception towards vended water coupled with other constraints such as pricing variation, water quality, supply related constraints, legal constraints and limited management capacity have hindered any initiatives to improve water provision through water vendors (McGranahan *et al*., 2006).

Although it is difficult to estimate the percentage of the world's population that relies on vended water, it is clear that in many cities and smaller urban centres in sub-Saharan Africa and in low income nations in Asia and Latin America, water vendors play an important role in meeting water needs; perhaps more than large scale water companies (UN-Habitat, 2005). This may be in terms of the number of people they reach, and especially the low income households they serve. For instance, in-house or yard connections vendors are estimated to reach some 43 per cent of the urban population in Africa, and 77 per cent in both Asia and Latin America (WHO/UNICEF, 2000).

The situation of water in Tanzania, specifically Msimbazi sub catchment in Dar es Salaam is not different. Most of its population relies on vended water which comes from different sources. For instance in Ilala District of Msimbazi sub catchment, an estimated 51% of the households are not getting their drinking water from municipal piped systems; also 9% of households are using unprotected and un safe water sources while the rest are getting their drinking water from other sources including vended water (Water Aid, Tanzania, 2005). Furthermore, in many cases vended water has been associated with outbreaks of diarrheal disease (Hutin *et al*., 2003). It is quite likely that handling of vended water –for instance, pouring water from one vessel to another (which is not necessary in a piped supply) may exacerbate the risk of contamination. This situation is compounded in cases where there are leakages, illegal connections, and illegal settlements. The latter is likely to experience differences of water prices from time to time, even when consumers are not assured of the quality of that water.

1.2 Statement of the Research Problem

Dependence on vended water has been increasing and witnessed in many parts of the Dar es Salaam City and Msimbazi sub catchment in particular. It is estimated that about 50% of households in Msimbazi sub catchment depend on vended water and other sources including protected and unprotected wells (Water Aid, Tanzania, 2005). This dependence has been attributed to the failure of the Government water utilities to cope with high population pressure and the demand for water for social and economic needs. Although the vended water prices are ironically most likely to be very high compared to that offered by the Government and vary day after day, it generally constitute very low quality compared to Government water utilities. For instance, in Kinondoni and Ilala Districts of Msimbazi sub catchment there are regular outbreaks of water related diseases such as diarrhoea, cholera, and dysentery which may be attributed to the consumption of the contaminated water. Additionally, far from vended water being considered as unregulated water business and not adding any value to the Government water utilities in Dar es Salaam, there is little known about the quality assurance procedures as well as water quality awareness among the water vendors and their customers. Therefore, with this dilemma in mind, this study sought to assess the quality of vended water and its implications on price and health risks in Msimbazi sub catchment Dar es Salaam, Tanzania.

1.3 Justification of the Study

This research study assessed the quality of vended water and its implications on price and health in Msimbazi sub catchment Dar es Salaam, Tanzania. The basis of conducting this study was guided by the fact that, Msimbazi sub catchment is one of the areas in Dar es Salaam City with the largest number of households depending on vended water. For instance, over half (51%) of the household in Ilala District in which this sub catchment is situated getting their drinking water from municipal piped systems (Water Aid, Tanzania, 2005). The main concern regarding vended water is its quality that has been associated with health risks and price variation. Moreover, there is lack of good understanding on what kind of measures that can be employed by water vendors to develop and improve service provision (Cudjoe and Okonski, 2006). This study sought to fill these gaps in knowledge. The issue of price is critical for two reasons. One is that it affects consumption – as most of the people cannot afford high priced water. Secondly, the fact that majority will go for cheap water and may compromise their health conditions. This study sought to establish the link between price, water quality and human health risks in Msimbazi sub catchment.

1.4 Research Questions

This research study was guided by the following research questions:

i. What are the sources of vended water vis-a-vis related health risks in Msimbazi sub catchment?
ii. Are there variations in the price of vended water in Msimbazi sub catchment?
iii. What are the bottlenecks to water vendors in the provision of water services in Msimbazi sub catchment?

1.5 Research Objectives

1.5.1 General Objective

The overall objective of this study was to assess the quality of vended water and its implications on price and health in Msimbazi sub catchment in Dar es Salaam, Tanzania.

1.5.2 Specific Objectives

i. To investigate the sources and quality of vended water and any related health risks in Msimbazi sub catchment.

ii. To examine factors influencing price variations of vended water.

iii. To determine measures necessary to improve water service provision by vendors

1.6 Significance and Anticipated Output

Owing to the fact that the water vendors play a vital role in serving majority of the population who are not connected to public water utilities in Msimbazi sub catchment, Dar es Salaam, Tanzania, this study sought to carry out an assessment of the quality of the vended water and its implications on price and on human health. This information is vital since the study findings will add to the inventory of knowledge and documentation on water quality, price implications and its associated human health impacts. Additionally, the study will provide useful knowledge on water quality awareness to vendors and communities of Msimbazi sub catchment. Further, the study findings will add valuable information on the quality of vended water and price variation indicators for the Msimbazi sub catchment and guidance for policy makers that may contribute to designing and recommending best mitigation measures to reduce problems associated with water quality and its implications on price and related health risks.

1.7 Scope and Limitations of the Study

The study was conducted in Msimbazi sub catchment that captures two districts of the three Dar es Salaam City covering an area of 260km^2 . The study concentrated on the quality of vended water on the basis of WHO Guidelines definition for Drinking Water Quality (WHO, 2006). The study also involved the analysis of the water samples for chemical, physical and microbial quality from different sources of vended water as well as investigating the factors of price variations of vended water.

In terms of limitations, the study faced one limitation which was lack of awareness concerning the quality of vended water among some respondents, including the water vendors themselves. This limitation was ameliorated by taking the vended water samples for laboratory analysis.

1.8 Operational Definitions of the Terms and Concepts

1.8.1 Vended Water/Water Vending

The WHO Guidelines for Drinking Water Quality (WHO, 2002, 2006) do not include bottled water or packaged water in its category or definition of vended water but instead restricts only to households or at ‘collection points’. Kjellen and McGranahan (2006) generally refer to water vending as any form of water sale and suggest that utilities which charge for water can, strictly speaking, be referred to as water vendors.

This study defines water vending, restricting only to households or at collection points that deliver and sell water to their customers while operating out of formalized system of water provision. Most of the distributing water vendors carry water in their containers on the pushcart and are referred as pushcart vendors. Other distributors carry larger volumes of water in the tanker trucks referred as ‘Car tankers’.

1.8.2 Sub catchment

Sub catchment means an area of land within which all waters flow to a single river system. A sub-catchment in this study is Msimbazi of Wami Ruvu Basin, Tanzania that drain into the Indian Ocean. Natural and human systems such as bush land, farms, dams, homes, plants, animals and people can co-exist in a sub catchment.

1.8.3 Integrated Water Resource Management (IWRM)

Integrated Water Resource Management (IWRM) may be defined as a process which promotes the co-ordinate development and management of water, land and related resources in order to maximize the resultant economic, social and environmental welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP, 2004).

1.8.4 Price

A value that will purchase a finite quantity, weight, or other measure of a good or service.

1.8.5 Price Variation

This is the change in the price of a stock or security from the previous trading days close to the current day's close. Price change over a period of time such as day-to-month or past 12 months are also commonly used time periods, and is generally computed as a percentage change.

1.8.6 Health

The term health simply refers to a state or condition of the body to be free from diseases or a state of being well. This study defined health based to water, therefore the health water related refers to water utilization and its contribution to good or ill.

1.8.7 Quality

The term quality in this study is directly related to water quality which describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

1.9 Organization of the Thesis

This thesis is organized in five chapters (Figure 1.1). It starts with background to the study in chapter one. In addition, the definition of problem, and research objectives, the significant of the research and definitions of key operational terms are addressed. Chapter two presents the literature review, where a general review of current knowledge relevant to the research topic is provided. Chapter three describes the methodology used in this research, the analytical tools applied, and data collection techniques and in depth analysis. Subsequently, chapter four presents the results and discussion. Chapter five gives an overall summary of the research findings and conclusions.

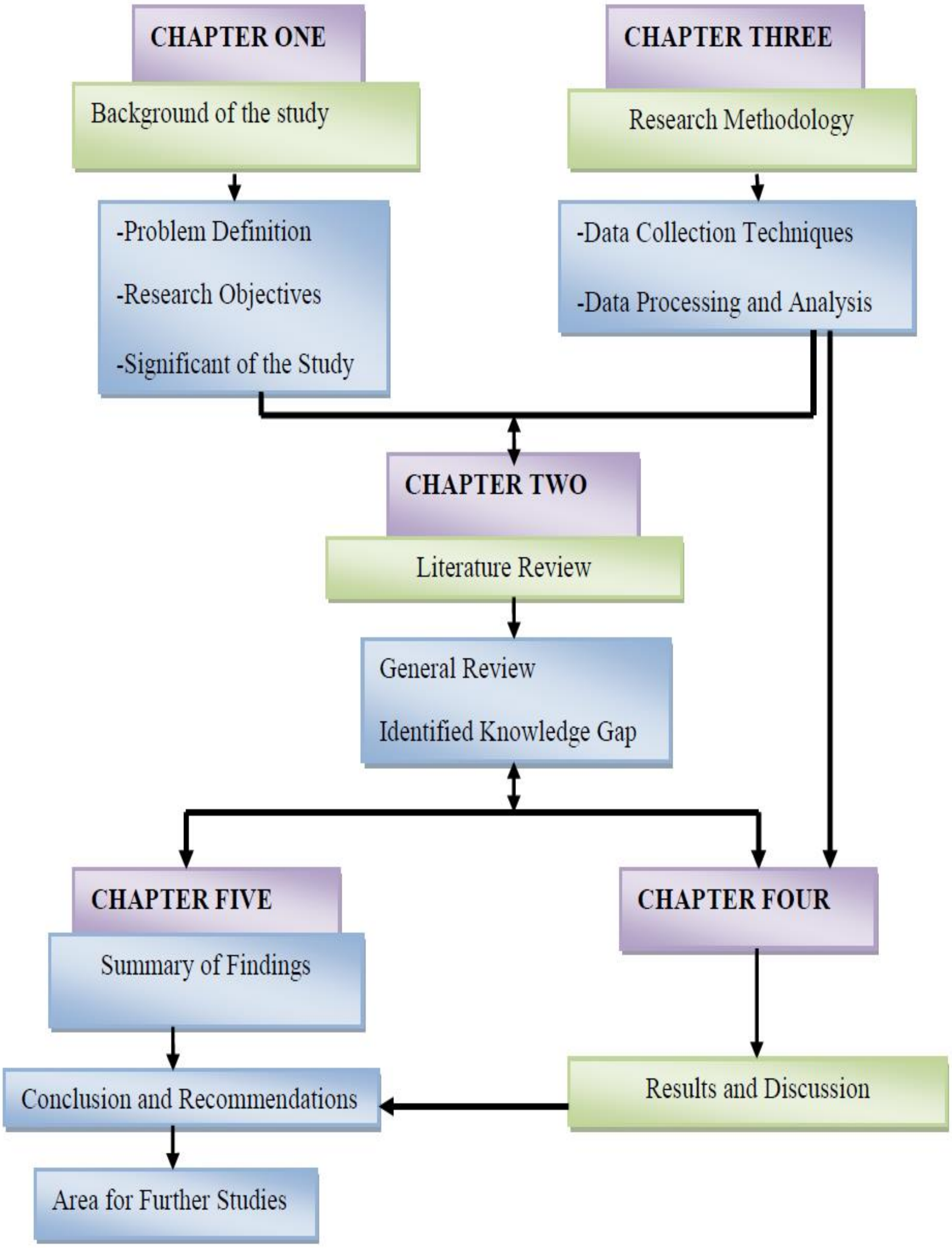

Figure 1.1: Thesis Structure (*Field Survey*, 2012)

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews the works done by scholars on the quality of vended water and its implications on price and health. It also identifies research gaps of the research study. This chapter presents literature on; overview of vended water, water vendor categories, vended water sources and associated health risks, factors for price variations of vended water, measures necessary to improve water service provision by vendors and corresponding conceptual framework.

2.2 An Overview of Vended Water

Vended water is common in many parts of the world where scarcity of water supply or lack of infrastructure limits access to suitable quantities of drinking-water (WHO/UNICEF, 2000). In the context of these Guidelines, water vending does not include bottled or packaged water.

Although water vending is more common and involves a greater diversity of distribution in developing countries, it also occurs in developed countries, but both the quality and adequacy of supplies can vary.

Recognition of the vast numbers of households in low income countries which depend on vended water has recorded increased growth since the 1980s apart of the quality problems associated with such water. One earlier study to examine water vending was conducted by Zaroff & Okun (1984). These researchers noted that water vendors were most active in areas that had multiple barriers to piped systems or where the utility-supplied water was inconvenient. Barriers to constructing piped systems included difficulty terrain to access with piping, high costs of utilities, squatter settlements that are not officially recognized, rural areas where housing is widely spread and peri-urban areas that spring up too quickly for utilities to keep pace.

The problem of access to piped water was also seen to be serious in urban areas. The World Health Organization (2000), estimates that about 20-30 percent of urban residents in Latin America, Africa, and Asia lack access to potable water, a situation that causes a greater percentage of the urban population to rely on vended water as the alternative source of water. For some African cities, vended water has become the major mode of access to drinking water (Table 2.1).

Table 2.1: Mode of Access to Drinking Water in Selected African Cities in 1999

City / Country	Public connection (%)	Private standpipes (%)	Other private providers (%)
Kampala-Uganda	36	5	59
Dar es Salaam-Tanzania	31	0	69
Conakry-Guinea	29	3	68
Nouakchott-Mauritania	19	30	51
Cotonou-Benin	27	0	73
Ouagadougou-Burkina Faso	23	49	28
Bamako-Mali	17	19	64

Source: (Collignon & Vezina, 2000)

Apart from the African cities, governments worldwide are now recognizing, accepting and, in some cases, encouraging the vital role water vendors play in providing access to drinking water to some of the most vulnerable populations (Crane, 1994; Moran & Batley, 2004).

2.3 Studies on Quality of Vended Water

There have been considerable studies on quality of vended water in different parts of the world. A number of studies reviewed for this assessment suggest that vended water tends to be of poor quality, but they have not supported this conclusion with tangible evidence or empirical data (Crane, 1994; Albu & Njiru, 2002; WSP, 2005; Hammond *et al*., 2007). Two unpublished studies were found which discuss water quality parameters; the first is a survey conducted by the Aquaya Institute and the Dian Desa Foundation in Yogyakarta, Central Java, in September 2007 (Albert *et al*., 2008), in which water samples from kiosks in Central Java were analyzed and found to be good for drinking. The other unpublished study, from Ghana, compared factory-sealed water sachets with hand-packaged sachets and found the hand-packaged sachet water to have significantly more bacterial contamination (Okioga, 2007).

Consumer perception on quality of vended water also varies widely. In a study from urban Nigeria, consumers considered vended water to have better water quality and chose vended water for drinking and cooking while using water from other sources, such as hand-dug wells, surface water and rainwater, for cleaning. However, the Nigerian study did not include any water quality analysis to confirm this perception (Whittington *et al*., 1991). Furthermore, the same Whittington *et al*. (1989) in the study of water vending quality and willingness to pay for water in Onitsha, Nigeria, stated that many water vendors who purchase water from tanker trucks and water vendors resell by buckets to individuals in Nigeria are the ones who exacerbate the risk of contamination and reduction of the water quality. They further argued that on annual basis, households in Onitsha pay water vendors over twice the cost of piped water. In contrast, Solo (2003) reported vended water in Argentina to be less expensive than utility supply but thought to be inferior because of the sulphur content that had not been removed.

2.4 Vended Water Categories

The types of water vendors can best be described using three broad categories: wholesale vendors, distributing vendors and direct vendors (Collignon & Vezina, 2000; McGranahan *et al*., 2006).

2.4.1 Wholesale Vendors

Wholesale vendors may own a borehole or may buy water in bulk either from private borehole owners or from utility companies. These vendors own or rent tanker trucks with large capacity which allows them to sell bulk quantities of water to small-scale vendors.

2.4.2 Distributing Vendors

Distributing vendors interact with the consumers usually door to- door, and make up the majority of the small water enterprises (Collignon & Vezina, 2000). The majority of distributing vendors are water carters who tend to be young, migrant men from rural areas who need little investment to get started. They carry the water in carts drawn by hand, animals, bicycles or motorbikes. Hand-carrying water vendors haul water in buckets or other smaller containers by hand, without carts or animals, and earn very small wages. Once abundant throughout many low-income cities, vendors hauling water by hand are declining in number as more use carts to haul the water (Collignon & Vezina, 2000). Hand-carrying and hand-carted water vending tend to be the most physically taxing but are often among the most easily entered businesses requiring little funds for start-up. Distributing vendors typically sell water in volumes varying from bucketfuls or 20-litre jerry-cans to their consumers. Some vendors also distribute drinking water in single use disposable plastic sachets (Ampofo *et al*., 2007).

Tankers or Car tankers may also be used by distributing vendors, delivering water to wealthier households that have large storage tanks or to large facilities such as hotels, schools or restaurants. Tankers are also used during festivals and special events such as weddings to supply large quantities of drinking water. Distributing vendors tend to charge the highest price since they delivering to the door and serve peak demands for people who have little time for water collection or can pay for the convenience (Snell, 1998).

2.4.3 Direct Vendors

Direct vendors have consumers come to them. They also tend to charge mid-range prices and are in greatest demand where well water is of poor quality or is too expensive (Snell, 1998). In many urban areas in low income countries where utilities reach only a portion of the population, direct vendors can be dominated by households with piped water supply connections that resell the water to households without connections, thereby extending the reach of the public utility either legally or illegally.

Water kiosks are another type of direct vendor commonly found in Africa and Asia (Kjellen & McGranahan, 2006; McGranahan *et al*., 2006). There is a variety of kiosk models presented in the literature although a water kiosk is generally described as a stationary water sales point with an operator who monitors the quantity–and in rare instances the quality–of water sold and collects payments. Kiosks may be divided into two categories based on water source: those that are extensions of public utilities and those that are erected from private or community-owned water sources. Kiosks are often used by the poorest households and allow the purchaser to control the volume of water purchased and total cost since the purchaser travels to the water and does not require additional services such as door-to-door delivery (Collignon & Vezina, 2000). Some 'kiosks' are solitary stand posts with no treatment of the water, while other kiosks are more elaborate, having a shelter along with various types of water treatment devices. Water treatment ranges from simple cartridge filters or sand filters to more advanced system such as chlorination (McIntosh, 2003; McGranahan *et al*., 2006; Albert *et al*., 2008). Water may be sold from kiosks directly into water vessels brought by customers or in pre-packaged containers supplied by the kiosk operator.

Moreover, a survey conducted in September 2007 by the Aquaya Institute and the Dian Desa Foundation in Yogyakarta, Central Java, also reported kiosks that provide washing stations for water containers to decrease the likelihood of contamination being introduced during transport and storage (Albert *et al*., 2008). Furthermore, while men dominate most of the vended water sector as carriers, carters and truckers, women may often be found as kiosk operators (McGranahan *et al*., 2006). Apart from that, Kariuki & Schwartz (2005) further analyzed the organizational forms of small scale water providers/ water vending which include:

i) Piped networks Operators with smaller networks of 5 to 50 connections who are more likely to have legal status. These are typically owned by individuals and might have started with borehole or water wells and later connect to neighbours.

ii) Point sources which include kiosks which also may hold simple license or permits for abstracting ground water or operating kiosks. Most of these operate in areas where public utility has no connections. Some of them remain informal because of legal or administrative constraints rather than by their own choice

iii) Mobile distributors such as, trucks or car tankers and push cart street vendors. These may have a transport license but in most cases they do not hold a permit to sell water. Push cart street vendors as a category of mobile distributors are crucial in distributing water. They may purchase water from tankers, kiosks or public utility pipes and deliver to the customer by the jerry cans via pushcarts. These operators may or may not be the owner of the vehicle/equipment used to distribute water. Many of them rent carts on daily, basis for instance. This form of water vending is very common in Dar es Salaam city Tanzania.

For the purpose of this study, the three forms or categories of water vending analyzed by Kariuki & Schwartz (2005) were considered with the exception of the bottled and sachets water, since majority of recently urbanized and peri - urban communities rely on them for their daily water consumption.

2.5 Vended Water Sources and Associated Health Risks

In Msimbazi sub catchment vended water is a growing alternative source of water which is caused by the increasing water supply problems. Dar es Salaam’s water situation is problematic since the infrastructure is worn out, the water is insufficient, and environmental health problems abound (Kjellen, 2006). It is estimated that, in Ilala District of this sub catchment about 40% of the households buy water for drinking from vendors, and about 9% of the households are using unprotected and un safe water sources (Water Aid in Tanzania, 2005).

On the other hand, WHO/UNICEF (2000) reported that water vendors use a range of sources both protected and unprotected, Due to the unregulated nature of their work most of the water sold to the public are not of potable quality, a situation that spurs up water borne diseases. Significant evidence which exists is that quality changes in such circumstances may be extreme and respond to the extent of handling (Quick *et al*., 1999). Furthermore, in many cases, the consumers are not aware of the source of water and there may be significant concerns about the quality of water (Lloyd *et al*., 1991). In most cases this situation increases the risk of water related diseases. For instance, in 2006 about 8,700 cases of cholera were reported in Dar es Salaam, of which 42.8% were in Ilala 32.5% in Kinondoni, and 24.7% in Temeke (Edward *et al*., 2006).

Additionally, poor hygiene in the home is potentially a significant source of drinking water contamination and may increases the water related health problems. In many cases, contamination significantly increases from source to household (WHO, 1997). This is of particular concern in communities without reliable piped water to dwellings which, therefore, rely upon water storage containers carried by vendors. Evidence is accumulating for both the impact of such contamination on human health and for the effectiveness of interventions at this level in protecting and improving human health (Semenza *et al*., 1998). For instance studies in Ghana showed that the quality of water in tanker trucks collecting water from utility hydrants was the same as piped water in Kumasi and only marginally less good in the capital Accra. To add on that, also the study from Ghana and Uganda by Howard and Luyima (2000) showed that the quality of water supplied by vendors, such as those selling from jerry cans or small fixed tanks, is much worse for human use and represents high degraded water quality.

In Dar es Salaam City and Msimbazi sub catchment, DAWASCO is a sole provider of water supply and sewerage services as well as the main source of the vended water. Water supplied by DAWASCO mainly comes from the Ruvu River, but the production capacity is not sufficient to supply Dar es Salaam city population and Msimbazi sub catchment areas in particular.

This situation causes a large population and especially the urban poor to rely on non-conventional and in most cases unofficially recognized means such as water vendors who fetch water from different sources such as boreholes, wells, springs and rivers (Allen *et al*., 2006). The above findings lack sufficient information on these sources of the vended water in terms of their suitability and impacts for human consumption. This study investigated the sources of vended water in Msimbazi sub catchment and tested its quality as well as assessed its impacts for human health.

2.6 Factors for Pricing Variation of Vended Water

In most of the early studies, water vendors were considered to be exploiting vulnerable populations by charging extravagant prices where alternative water sources were scarce. Prices were reported to be up to 40 times that charged by water utilities in areas where the utility supplied the water which was then trucked or carted to neighbouring areas beyond the water lines (Zaroff & Okun, 1984). Though still significant, recent evidence suggests much less disparity between the prices of vended water and utility supplied water. Kariuki & Schwartz (2005) found that water collected from point sources and sold through vendors cost up to 4.5 times utility water while water delivered door-to door cost up to 12 times utility-supplied water. In this case, water vendors do not have access to the subsidies that support most water utility systems; it is not surprising that vendor's products are more expensive. Several studies account for the higher cost of vended water over utility supplied water due to the labour-intensive nature of water vending coupled with the added cost of vended water arising from the additional service of providing water in a variety of quantities without the advantages of economies of scale (Snell, 1998; Solo 1999; McIntosh, 2003). There have been efforts to regulate vended water but the evidence suggests the fixed-price approach is often not successful.

Moreover, as these water vendors, provide a demand-driven water supply which allows basic water service to be sustainable without the input of subsidies. Private water vending is a competitive business in most areas and prices are set to cover costs (Solo, 1999). At times when money is needed for their business, vendors typically raise funds from informal sources to finance the purchase of equipment such as carts, trucks or kiosks. The sources of financial support include personal savings, family members, community savings clubs, informal money lenders and loans from suppliers (Collignon & Vezina, 2000).

Though many of the studies reviewed for this assessment discussed the need for financial services to small local water vendors to expand access to potable water, there was little evidence on effective utilization of micro financing schemes (Snell 1998; Solo 1999; McIntosh 2003; Winpenny 2003; Mehta & Virjee, 2003). Truckers are often the only type of water vendor able to access formal loan programmes, since there is a tangible asset to support the loan (Snell, 1998). Other vendors often obtain credit through informal sources that may charge between 5 and 10% interest per month (ADB, 2003).This situation also causes the price of vended water to vary.

Kjellén & McGranahan (2006) argued that different types of vended water vary in their price and these variations depend on the distance from where water is drawn and its availability. The influence of other factors such as water quality, customer loyalty as well as water availability are noted by Njiru (2004). Nonetheless, these factors affect most the urban poor who are excluded from conventional infrastructure of the Government water utilities. In Msimbazi sub catchment for example, pushcart water vendors usually operate from more or less fixed stations, and adhere to the current price in the area. This is when the level of piped and borehole supply, the sources of the vendors' water, operate at the normal level accessibility. However, if there is a break in the system, or extreme seasonal drought, the vendors become 'price hikers', doing their best to eke out a higher return from the suddenly volatile market (Kjellen, 2000).

The above studies didn't factor in the quantity of water supplied by the utilities as one of the factors of the price variation. This study focused on the quantity as well as investigated other factors for the price variation in Msimbazi sub catchment.

2.7 Mitigating Measures for Water Service Provision Development

In most Cities of the developing world, including in Africa, the urban population is rising much faster (5 – 9% per annum) than the rate at which infrastructure services are being extended. In part, residential population growth occurs through increases in existing settlement density. More visible, and problematic from an infrastructure perspective, is the rapid expansion of informal settlements at the peri-urban fringe, and on marginal or illegally occupied land. In many cities, such settlements – which almost inevitably lack sufficient conventional water supply infrastructure - are home to substantial proportions (as high as 40 or 50%) of the total urban population (UNCHS, 1996).

Water utilities, that provide water services through conventional distribution networks terminating with connections at the customers' premises, are not keeping up with this population growth. Utility problems are typically widespread: they range from insufficient funds for operations and infrastructure, human resource constraints, unnecessary or inappropriate politicization, inappropriate tariffs, disputed land tenure and inadequate infrastructure capacity.

In the context of rapid urban growth and problems within and external to water utilities, many customers end up un-served or under-served by the water utility responsible for service delivery in the City, a situation that causes water vendors move in to fill the essential water supply service gap. Not surprisingly, utility service coverage as percentage of population is decreasing in many Cities. In some (for instance Mombasa, Kenya and Khartoum, Sudan) the percentage relying at least partly on water vendors service is as high as 75% (Albu & Njiru, 2002).

Recent studies confirm that water vendors often provide useful services valued by their customers (Forrest, 1999; Wegelin-Schuringa, 1999; Collignon, 2000; Njiru & Smith, 2002; Njiru & Albu, 2004). In the eyes of the customer, satisfaction with water services combines characteristics such as quantity, quality, reliability, frequency, payment system, convenience and price. Apart from extending water services to settlements that have little prospect of being supplied through conventional distribution systems, water vendors may even be more convenient for poor households in informal settlements – for example, in terms of reliability or ability to make daily cash payments - than conventional metered and billed connections.

Private sector management of water utilities does not necessarily diminish the role played by these water vendors either. Factors which make water vendors to be prominent in urban informal settlements include major obstacles to infrastructure provision by formal private operators too. In this context, water vendors can be efficient – providing water when and where people need it, in quantities they can afford, while creating local employment opportunities that keep cash within the local economy (Albu & Njiru, 2002).

Although the crisis of water services, particularly in informal settlements, demands a flexible and innovative response from water utilities and regulatory authorities. An important option is therefore to recognize the existing and often well-established local small scale private sector players, and support them particularly through partnerships with utilities, in order to improve water services provision to all (Njiru, 2004). McGranahan *et al*., (2006) suggested different mitigating measures to improve water service provision by the vendors such as; removing constraints on water supply, reducing water tariffs for vendors, building trust and cooperation, improving relations between vendors, water utilities and the formation of associations. Furthermore, Njiru & Sansom (2003) emphasizes that, the partnership will help the water vendors to meet the population increasing water needs, overcome the financial limitation and the prevailing economic situation which are the key constraints to water vendors. Collignon & Vézina (2000) noted that by recognizing and regularizing the activities, roles and institutional position of independent providers, and by facilitating intermediation, coordination and partnership between city wide operators and independent providers, municipal and national authorities can set the stage for better delivery of water services to the urban poor. The above findings lack information on the implications of water policy in mitigating the bottlenecks hindering the water vendors in service provision. Accordingly, this study examined the relationship between the existing water policy and water vendor’s developments in service provision.

2.8 Conceptual Framework

This study has adopted the Drivers, Pressure, State, Impacts and Response (DPSIR) framework developed by European Environment Agency (EEA, 1998). The DPSIR framework has been modified to provide more appropriate means for assessing the quality of vended water and its implications on price and health (Figure 2.1).

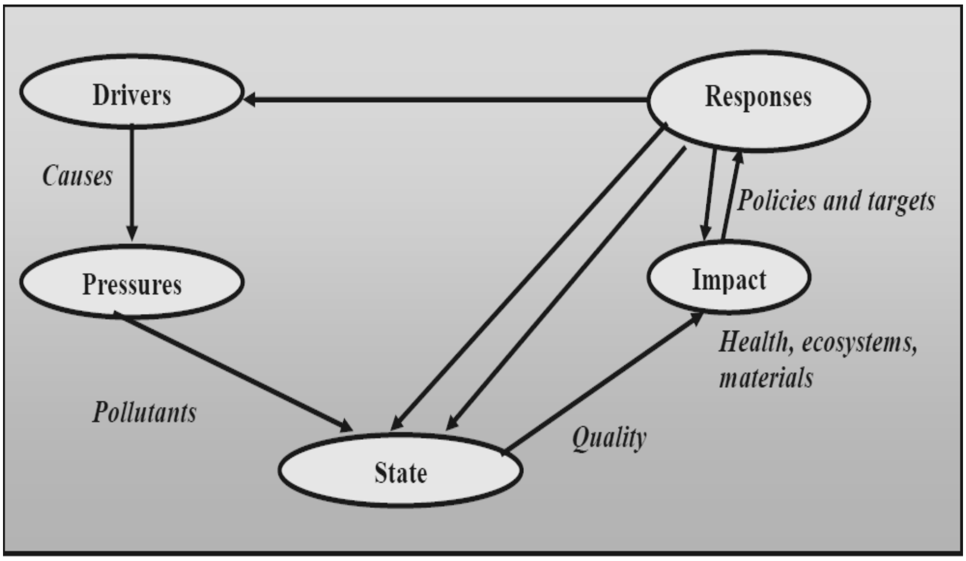

Figure 2.1: The DPSIR Assessment Framework (Adapted from EEA, 1998)

In this study vended water in Msimbazi sub catchment is influenced by the drivers such as illegal connection, leakage, poor infrastructure, urbanization, unplanned settlement and change of lifestyle. These drivers are triggered by the pressure in form of increase in demand for the water due to population growth and inability by utility to supply water thus causing the vended water to become the alternative source of water. The state of this business include: decrease of the water quality due to transportation facilities as well as taking water from unprotected sources and all these lead to effects in terms of human health problems such as diarrhoea and paying water vendors over twice of the cost of piped water. To reduce the severity of the impacts various mitigation measures or responses can be taken, these include reforming water rights, construction of small rain water storage reservoirs (Shaghude 2006), controlling illegal connection and leakage, subsidized water prices, as well as partnership, will help the water vendors to meet the population increase water needs (Njiru & Sansom, 2003); as well as maintaining the quality and price variations of the vended water and its associated health risks.

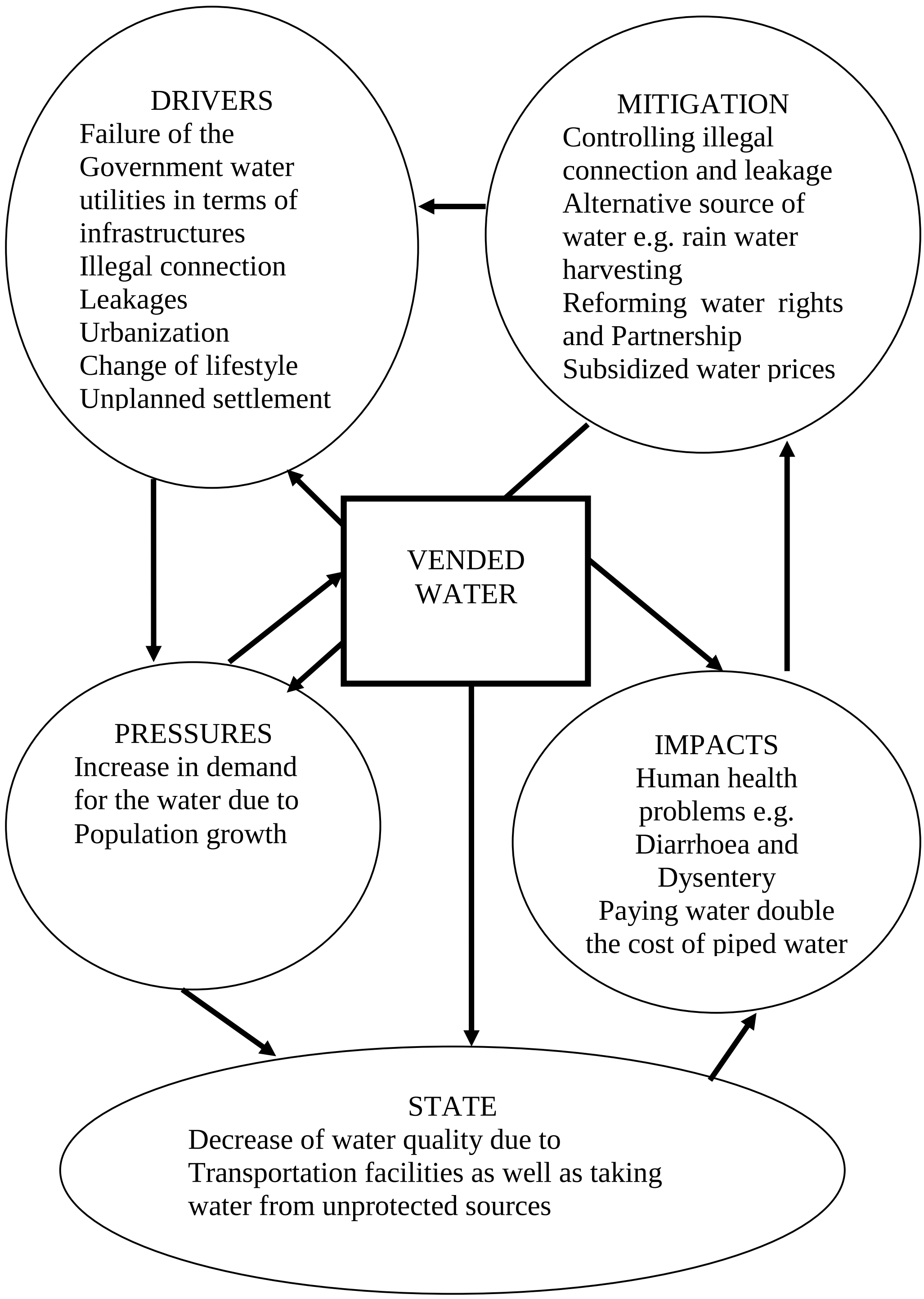

Figure 2.2: The Conceptual Framework for Quality of Vended Water and Its Implications on Price and Health in Msimbazi sub catchment Dar es Salaam-Tanzania (Adopted and Modified from EEA, 1998)

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study Area

3.1.1 Administrative Units and Population

The study area is located at latitudes $6^{\circ}\ 76^{\prime}$ and $7^{\circ}\ 8^{\prime}$South of the Equator and between longitudes $39^{\circ}\ 02^{\prime}$ and $39^{\circ}\ 34^{\prime}$ East of Greenwich (Figure 3.1). The Msimbazi sub catchment fall under Wami Ruvu Basin and originates 35 kilometres off coast in Pugu forest, with the catchment area of approximately 260km^2 (Hobbelen, 2001). This sub catchment passes through Kinondoni and Ilala Districts of the Dar es salaam City. According to City Profile of Dar es Salaam (2004), Msimbazi sub catchment has the total number of 414,384 households in which Ilala District has 150,515 households and Kinondoni 263,869 households. Most of the people live in the lowlands and depend directly or indirectly on agriculture for their livelihood.

3.1.2 Soil and Vegetation

Msimbazi sub catchment soil range from deep poorly drained heavy clay soils to moderate drained medium textured stratified soils (Kebede & Nicholls, 2010). The main sub catchment has the soil which is mixed with alluvial deposits, sand, silt and clays. The main natural vegetation in valley includes coastal shrubs, coastal swamps and mangrove trees (CEP, 2006). Other vegetations that are found in the sub catchment includes; coconut trees, tree crops along the roads and sub catchment, vegetables, cereals, tubers and perennial crop such as sugarcane (CEP, 2006).

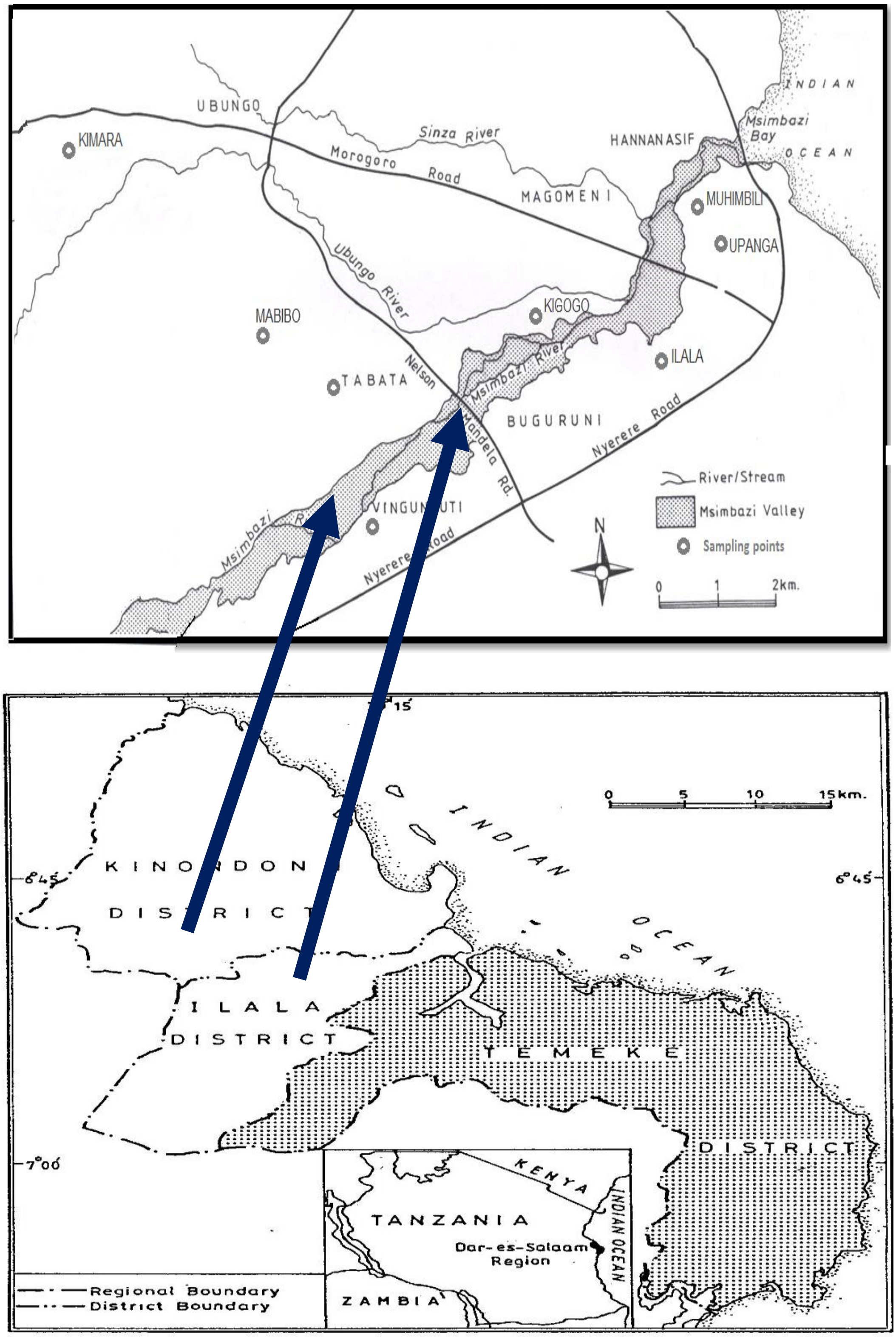

Figure 3.1: The Map of the Study Area. Source: Survey and Mapping Division, Ministry of Housing and Human Settlements in Tanzania, (2008)

3.1.3 Climate

Msimbazi sub catchment experiences mainly modified equatorial type of climate. It is generally hot and humid throughout the year with an average temperature of 29°C. The hottest season is from October to March during which temperature can rise up to 35°C. It is relatively cool between May and August, with temperature around 25°C. There are two main rain seasons: a short rain season from October to December and along rain season between March and May. The average rainfall is 1000 millimetres (lowest 800 mm and highest 1300 mm). Humidity is around 96% in the mornings and 67% in the afternoons. The climate is also influenced by the south-westerly monsoon winds from April to October and north-westerly monsoon winds between November and March. The city is divided into three ecological zones, which are the upland zone comprising the hilly areas to west and north of the city, the middle plateau and the low land zones (DCC, 2004; DCC & JICA, 2007).

3.1.4 Land Use

Msimbazi sub catchment is characterized by varieties of land use. The main prevailing land use in the sub catchment is settlement, with a great majority of the population living in unplanned and informal settlements (UN-Habitat, 2009). Other land use activities include agriculture for green vegetables and industries such as MUZRAH (soap and detergents industry), FIDA (agriculture processor wholesellers and exporters), OK (footware and rubber products industry), Vingunguti Abattoir, Tanzania and China Friendship Textile, Maxon industry (paper manufacturer), SPENKO (waste disposal stabilization ponds) and sand mining for construction (Dar es Salaam Master Plan, 1979).

3.2 Sampling Methods and Procedures

The sample for this study were drawn using a non probability sampling method called convenience sampling and a probability sampling method called systematic sampling. Convenience sampling was applied to water vendors and DAWASCO officers who were selected based on their willingness to participate in this study, while systematic sampling was employed to households and all sources of vended water. In systematic sampling sources of vended water such as municipal taps, boreholes and community kiosks were selected at regular intervals of every second tap, kiosk or borehole after a random start. Likewise, using the same systematic sampling household members selected at regular intervals of every two households after a random start. Furthermore, households were selected in relation to the areas where water samples were taken. A total number of 50 water samples were collected form the four sources which were CT, PC ,and BH and TW . The samples were collected in sterilized bottles and transferred to the laboratory in a cool box and analyzed for pH, Microbial Quality (total and faecal coli forms), Turbidity, Electrical conductivity, Nitrates, Nitrites, Ammonia- Nitrogen NH_4-N, Sulphate, Temperature, Total Suspended Solids (TSS), Chloride, Total Hardness (TH) and Colour.

The sample size of the study was based on the total number of households which was 414,384 in the study area. The sample size was calculated using the following formula adopted from Glenn (1992).

$$n = \frac{N}{1 + N(\alpha)^2}$$

Where n = sample size, N = total number of households, α = margin of error set at 10%.

Using substitution method using the above formula was, the sample size was computed as follows:

$$\text{Sample Size} = \frac{414{,}384}{1 + 414{,}384(10\%)^2}$$

= 99.99

The formula gives 99.99. Since there are not decimal in number of households the study sample size was approximated to 100 households.

3.3 Methods and Instruments of Data Collection

The study employed both primary and secondary methods of data collection. Primary data were collected through laboratory analysis, questionnaires, interview guide, observation as well as field photos. On the other hand, secondary data were collected from the City Profile for Dar es Salaam, (2004). on the number of household for Ilala and Kiondoni District of Msimbazi sub catchment.

3.3.1 Primary Methods of Data Collection

3.3.1.1 Laboratory Analysis

The laboratory analysis examined the quality of vended water from different types of water vendors. The water samples were analyzed for physical-chemical parameters and Microbial analysis. For the physical-chemical parameters such as Turbidity the turbid meter was used for the analysis and the results were reported in Nephelometric Turbidity Units (NTUs). pH meter was used for pH test. The electrode of the meter was rinsed with distilled water and buffer solution was used to calibrate the meter. Conductivity meter was used for the EC measurement. The meter was set to conductivity mode and was standardized with distilled water in accordance with the instruction manual.

Other physical-chemical parameters such as the TSS test was performed where by the settleable solids were removed first and the TSS test conducted. 100ml of the liquid was passed through a 0.45µm pore pre-weighted filter paper and the final mass of the filter paper after oven drying at temperature of 103°C-105°C was measured and the TSS (in mg/l) calculated. Titration method was used for the chloride and the units used for its analytical results was mg/l. Further, Temperature was measured using the normal glass thermometer expressed in degrees centigrade °C and the Colorimetric method analyzed the Colour parameter. Spectrophotometric method was performed for the analysis of Nitrate/Nitrites. Likewise the Colorimetric method was applied for the Ammonia- Nitrogen parameter, A gravimetric method for Sulphate and Total hardness was obtained by titrating a sample solution with a 0.01 N of ethylenediaminetetraacetic acid (EDTA) solution by using Eriochrome black T indicator, until the color changes from purple to pure blue.

For the Microbial analysis including both the TC and FC parameters the Normal Method of analysis called Membrane Filtration was used to detect the micro organisms present in water.

3.3.1.2 Interview Guide

Interview guide was used to record information from the key informants from DAWASCO on the mitigation measures that can be employed to enhance the water vendors in water service provision (Appendix V).

3.3.1.3 Observation

Observation method was employed to capture information on the existing water resource base, and activities carried out prior and after treatment from DAWASCO and involved the researcher, two research assistants and three experts from DAWASCO water treatment plants (Appendix VI). A digital camera was used to record information. This helped in understanding not only the quality assurance procedures of water supplied by DAWASCO but also the quantity of treated water supplied to Msimbazi sub catchment.

3.3.1.4 Questionnaires

The study considered the data on the factors of price variations of vended water, cases of health risks and complications associated with vended water and the numbers of households affected. These were collected using questionnaires (Appendix I, II, III and IV).

3.3.2 Secondary data

Secondary data were collected from City Profile for Dar es Salaam, (2004). on the number of household for Ilala and Kiondoni District of Msimbazi sub catchment.

3.4 Data Processing and Analysis

This study employed both qualitative and quantitative data analysis methods. The first step in data processing consisted of editing and checking for completeness and relevance of the questionnaire responses, interview guide, laboratory analysis results and secondary data. Then, data was considered for the consistency of the responses given and data obtained. Data collected from DAWASCO key informants, water vendors, households, sources of vended water and secondary data were transcribed and content analysis employed on such qualitative data.

3.4.1 Qualitative Analysis

The qualitative analysis utilized SWOT analysis in assessing the SWOT of Water vendors in water service provision. Furthermore, the respondents were examined on the factors of price variations of vended water. The survey established their knowledge of the existence of vended water the price variation and the factors that led to the same.

3.4.2 Quantitative Analysis

Quantitative analysis involved the laboratory analysis for physical, chemical and micro-biological qualities of the vended water. Similarly, the sources and quality of vended water and any related health risks in Msimbazi sub catchment were investigated and the findings compared with the WHO Guidelines and TBS. Furthermore, other descriptive statistics such as; cross-tabulation, frequencies, percentages and mean were also employed on such quantitative data. The analyses involved the use of SPSS software version 18.0 analyses and Microsoft Office Excel 2007. The raw data was coded and entered in the SPSS for each of the categories of respondents namely: Borehole Water Suppliers, Distribution Water Vendors and Household with Tap connections. An analysis using SPSS was done for descriptive statistics pegged on each of the study objectives. The study then exported the same data to excel for not only easier manipulation but also variety in the formatting in the presentation of the figures and tables.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This research study sought to assess the quality of vended water, its implications on price and health risks to households in Msimbazi sub catchment Dar es Salaam, Tanzania. The study respondents included distribution water vendors, DAWASCO officers, as well owners of the boreholes and deep wells and household members in Msimbazi sub catchment from whom samples were collected. Results on the quality of vended water and its implications on price and health risks in Msimbazi sub catchment are presented and discussed in this chapter.

4.2 Vended Water Sources

This research study sought to identify the sources of vended water from residents and water vendors. Respondents (water vendors) were asked the sources of the vended water that they sell. The research findings are presented in figure 4.1 below:

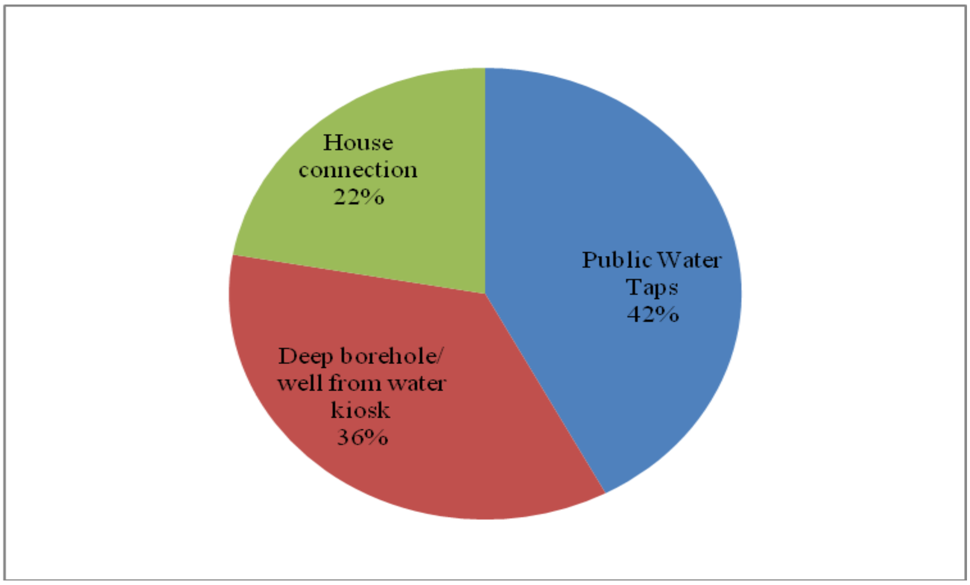

Figure 4.1: Identified Vended Water Sources in Msimbazi Sub-cathment (*Field Survey*, 2012)

The findings presented in Figure 4.1 indicate that 42% of the water vendors obtained their water from the public water taps, 36% from deep boreholes/water kiosks and the remaining 22% got their water from DAWASCO water connected to houses / house connection.

4.3 Water Vendors in Msimbazi Sub catchment

The study investigated the types of water vendors in Msimbazi Sub-catchment. The research findings indicated the existence of the following categories: Mobile water vendor distributors such as push cart street vendors (Plate 4.1) and trucks also known as Car tankers (Plate 4.2). There were also point sources which included kiosks (Plate 4.3), many of them were connected to Boreholes and piped networks operators at household level (Plate 4.4).

4.3.1 Hand Push Carts Vendors

The study findings through the survey revealed that the hand push cart vendors moved around in carts as evidenced in plate 4.1. These hand push vendors load a number of containers. Depending on the capacity and/or size of the cart, these categories of vendors push carts often ranging from four to twelve containers. This study ascertained that the hand push vendors served the informal settlement with no other options of water provision in the Msimbazi sub catchment. As many of the informal residents are poor, they pay higher prices for water provision. This observation is supported by the study done by Kariuki & Schwartz (2005); which confirmed that the informal settlement residents as well as those from remote regions and slum areas which are difficult to access through conventional means always pay higher prices than normal tariff provided by water utility.

There were distribution vendors who went to the consumers, usually door to- door, carrying water in carts drawn by hand, animals, bicycles or motorbikes. Hand-carrying water vendors haul water in buckets or other smaller containers by hand, without carts or animals, and earn very small wages. This finding is also confirmed by literature that many low-income cities vendors hauling water by hand are declining in number as more use carts to haul the water (Collignon & Vezina, 2000).

Plate 4.1: Push Carts for Water Vendors at Buguruni Area (*Field Survey*, 2012)

Given the closed nature of these jerry cans (Plate 4.1), it would be difficult to wash and clean them thus free the dirt that could otherwise promote the growth of bacteria that are causing disease. Although the study observed that vendors cleaned their jerry cans using sand particles, leaves, small gravel, brush and soap; hygiene guarantee remained questionable.

4.3.2 Car Tanker Vendors

From the survey, it was not possible to get the exact number of track vendors since the business is not regulated. The truck drivers responded that the trucks are privately owned and operated. Majority owned a single truck and a few of them owned up to three or four trucks. Tanker vendors mostly supply water to high income residential areas, big hotels and construction sites. A water tanker vendor is presented in plate 4.2.

Plate 4.2: Car Tankers for Water Vendors at Kimara Area (*Field Survey*, 2012)

The research study also observed car tankers on rental, for instance, on special occasions where vended water was required in huge amounts. This observation is similar to that of Snell (1998) who holds that tankers are mainly used during festivals and special events such as weddings to supply large quantities of drinking water.

Analysis of questionnaires showed that the means of cleaning and disinfecting water tankers are below the WHO standards. The Car Tanker respondents reported the usage of detergents and sometimes water only and water with soap though they complained about their affordability , availability and cost of the detergents. WHO recommends that tanks have to be drained, scrubbed in all internal surfaces using mixture of detergents and water, and finally to be washed in all internal surfaces to remove all the traces. This is done to ensure the water stored in the tank does not become contaminated by dirt or trace of the substance of the tank (Davis & Lambert, 2002)

4.3.3 Water Kiosks

Throughout the study, it was observed that other water vendors operated water kiosks, where they sell water from a shallow well, a borehole while others use tankers to support this source. Some household consumers, carry water to their homes themselves from the water kiosk (Plate 4.3).

Plate 4.3: Water Kiosk in Vingunguti Area of Msimbazi Sub catchment (*Field Survey*, 2012)

There is a variety of kiosk models presented in the literature; but a kiosk is generally described as a stationary water sales point with an operator who monitors the quantity and in rare instances the quality of water sold and collects payments. This study found two categories of kiosks based on the water sources; those that are extensions of public utilities (Plate 4.4) and those that are erected from private or community-owned water sources. Kiosks are often used by the poorest households, especially those who are not able to afford the utility connection cost.

Plate 4.4: Household Stand Pipes type of Kiosk at Tabata Area of Msimbazi sub catchment (*Field Survey*, 2012)

The study found that many of the water kiosks do not provide a place for washing the customer water storage devices. Additionally, they sold water directly into water containers brought by customers. The significance of this is that it is a health risk since such mechanisms can accelerate the rate of contamination. Similar conclusions were made in a survey conducted in September 2007 by the Aquaya Institute and the Dian Desa Foundation in Yogyakarta, Central Java. This survey recommended that kiosks that provide washing services decreased the likelihood of contamination.

4.4 Quality of Vended Water Sources Based on Laboratory Analysis

The study investigated the quality of vended water sources in Msimbazi sub catchment. An elaborate laboratory analysis was done for micro-biological and physical chemical parameters analysis with the objective of investigating the quality of water used by vendors and households in Msimbazi sub catchment.

4.4.1 Micro-bial Parameters Based on TC and FC

Vended water samples from various sites of the study area were taken to investigate the Total Coliforms (TC) and Faecal Coliforms (FC). The findings are presented in table 4.1 below:

Table 4.1: The Total and Faecal Coli Forms in Water in Msimbzai Sub-catchment

SAMPLE CODE /LOCATION	TOTAL COLIFORMS (MPN/100ml)	FEACAL COLIFORMS (MPN/100ml)
Car Tankers' (CT) Water		
Mabibo Hostel	33	9
Tabata Kimanga	26	14
Kimara Stop Over	33	7
Tabata	33	11
Push Carts (PC) Water		
Kigogo	7	2
Ilala Boma	540	5
Buguruni Malapa	350	33
Tap Water (TW)		
Upanga	2	0
Muhimbili 1	4	0
Muhimbili 2	11	4
Borehole (BH) Water		
Tabata Liwiti	17	0
Ilala Boma	1600	7
Vingunguti	2	0
WHO Standardized ranges	0	0
TBS Standardized ranges	0	0

Source: (Field Survey, 2012*)*

Table 4.1 indicates a Total Coliforms (TC) ranging from 26 to 33 (MPN/100ml) while the Faecal Coliforms (FC) ranged from 7 to 14 MPN/100ml for the Car Tankers (CT) samples. Similarly, water samples from the taps had the least TC recording a low of 2 MPN/100ml and highest of 11 MPN/100ml. In contrast to the TBS (Table 4.2) and WHO standards, these findings indicated that tap water was the safest for human consumption. However, the acceptable WHO and TBS ranges refute the usage of water with TC. Equally, the findings indicate that the source of vended water for car tanker vendors was water taps. Likewise, these finding point toward the fact that the car tanker owing to difficulty in logistics of cleaning them, contributed to water being rendered more impure with increasing TCs.

There were outliers (abnormally high ranges from the ordinary) from the samples. Borehole water sample from Ilala Boma recorded the highest TC of 1600 MPN/100ml followed by the push water carts sample from Ilala Boma at 540 MPN/100ml. These are results from the same location except for the type of distributor vendors. The implication of these findings is that water obtained from Ilala Boma is unsafe for human consumption. Furthermore, the study findings interestingly did not indicate a direct proportion between TC and FC. For instance the push cart water sample for Ilala Boma was 540 MPN/100ml and recorded a relatively low Faecal Coliforms of 5MPN/100ml contrasted to Buguruni Malapa push cart water sample which reported TC of 350 MPN/100ml and a higher FC of 33 MPN/100ml. Although WHO standardized FC and TC recommendations for drinking water is 0 MPN/100ml, all the water samples analyzed in this research study detected high levels of both TC and FC except for one tap water sample at Upanga area which indicated a satisfactory TC and FC according to TBS as presented in table 4.2

Table 4.2: TBS Total and Faecal Coliforms Classification

Class of piped water	Total Coliforms counts per (MPN/100ml)	Faecal Coliforms count per (MPN/100ml)
Excellent	0	0
Satisfactory	1-3	0
Suspicious	4-10	0
Unsatisfactory	More than 10	1 or more

Source: (TBS, 1997)

The TC and FC findings showed that water from boreholes and water vended with Push Carts (PC) and Car Tankers (CT) was unsatisfactory and highly contaminated by the TC and FC. The rate of micro-biological contamination in water from hand PC vendors was higher than the vendors with car tankers. This situation is may be accounted for by the fact that most of the pushcart water vendors are depended on boreholes as their source of water than the truck water vendors. Additionally, the contamination levels varied depending on the hygiene observed, the type of storage facilities used, means of cleaning of the storage facilities, modality of treatment of the water from the source and water vendors.

In Dar es Salaam City and Msimbazi sub catchment in particular most of the vended, water sources are not adequately treated to remove all the contaminant bacteria and this situation contributed to water being rendered more impure with increasing TCs and FCs (Table 4.1).

4.4.2 Physical Chemical Parameter Analysis

Analysis of physical chemical parameters of different samples sites is indicated in table 4.3. These results show that most of the physical chemical parameters tested were within the TBS and WHO water quality standards except for nitrite. Other exceptions include, Chloride which is only within the TBS and above the WHO standards ranges as well as Electric conductivity (EC) and colour.

Table 4.3: Analyzed Physical Chemical Parameters of Msimbazi Sub Catchment Water

Sample code from different sources and areas	Physical Chemical water quality parameters											
	pH	**EC (μS/cm)**	**TEMP (^{O}C)**	**TSS (mg/L)**	**TUR (NTU)**	**COL (Pt.co)**	**TOTAL.TH**	**Cl (mg/l)**	SO_4 (mg/l)	NO_2-N (μg/l)	NO_3-N (mg/l)	NH_4-N (mg/l)
Car Tankers (CT) Locations												
Mabibo	6.6	668*	28	2	5	39	10.3	346.6*	41.294	3.494*	0.057	0.091
Tabata Kimanga	7.58	104*	25	8	14	75*	26.7	44.3	9.991	3.493*	0.075	0.069
Kimara Stop Over	7.21	169*	28		8	12*	22.2	73.7	9.8	6.197*	0.793	0.018
Push Carts (PC) Locations												
Kigogo	6.91	95.5*	28	0	7	53*	59.06	26.6	11.895	2.722*	0.118	0.034
Ilala Bungoni	7	97*	28	3	8	31	40	66.7	9.78	4.653*	0.072	0.049
Bungurun i Malapa	6.8	101*	28	8	5	32	40	66.8	9.357	6.583*	0.124	0.069
Tap Water (TW) Locations												
Upanga	7.18	522*	28	0	7	49	10.8	199.1	28.604	21.641*	0.563	0.024
Muhimbil i 1	7.25	261*	28	0	11	92*	20	110.6	28.815	6.916*	0.135	0.048
Muhimbil i 2	7.18	239*	26	8	12	88*	21.1	110.6	31.248	7.741*	0.116	0.026
Borehole (BH) Locations												
Tabata Liwiti	6.73	1122*	28	10	10	97*	7.5	390.8*	83.278	4.653*	0.413	0.023
Ilala Boma	6.97	836*	28	0	1	1*	7	228.6	44.496	6.197*	0.864	0.054
Vingungu ti	6.32	1095*	28	0	3	32	8.1	361.4*	70.059	21.115*	0.666	0.029
WHO Standardized Range	6.5-8.5	3	-		5-50	>15	500	250	250-500	0.50	50	35
TBS Standardized Range	6.5-9.5	3	-	500-2000	5-25	1.5-50	500-600	200-800	200-600	0.5	10-75	2

Source: (Field Survey, 2012)

Key: * Values that exceed WHO and TBS standards

Table 4.3 above presents the research findings of the laboratory analysis of water samples taken from various locations of Msimbazi Sub Catchment. These samples were taken from car tankers, push carts, tap water and borehole water vendors. The findings imply that the quality of some of the water is doubtful and consequently not fit for human consumption. This is evidenced by the non compliance to the standardized TBS and WHO ranges.

4.4.2.1 Potentiality of Hydrogen (pH)

Table 4.3 indicated a fairly similar pH levels for all the water samples with the lowest level being recorded from Vingunguti borehole water at pH level of 6.32 and the highest recorded at Tabata Kimanga at pH 7.58. The BH water samples recorded generally the lowest pH of 6.32 at Vingunguti, 6.73 Tabata Liwiti and 6.97 at Ilala Boma. On the contrast, Tap Water (TW) recorded the highest pH of 7.25 recorded from Muhimbili Sample 1; Muhimbili Sample 2 and Upanga recorded same results of 7.18. These findings of pH of TW samples are fairly similar and controlled pointing towards possibility of the water coming from the same source. Further, water samples from PC recorded the lowest pH of 6.8 from Buguruni Malapa, 6.91 from Kigogo and the highest pH of 7 from Ilala Bungoni. The PC findings in general indicated fairly same levels which can be attributed to obtaining from the similar source of the water that they vended.

The pH results for Car Tanker (CT) vendors recorded a high pH of 7.58 from Tabata Kimanga, 7.21 from Kimara Stop Over and a low pH of 6.6 from Mabibo. The results of the water samples are significant in the sense that they can help deduce the water vendor sources. Similarly, although not a single parameter; this research study infers that vended water with same pH was from the same source. The minimal variations could be attributed to the water handling by the respective vendors.

In most natural waters, pH is controlled by the carbon dioxide-carbonate-bicarbonate equilibrium system. Increased carbon dioxide concentration will lower the pH, whereas a decrease will cause it to rise. The pH value of water may also be affected by domestic sewage (generally neutral or slightly alkaline), industrial wastes (may be strongly acidic or alkaline depending on the type of industry). The results presented in table 4.3 indicated that most of the pH values from BH, TW, CT and PC were within the TBS (6.5 - 9.5) and WHO (6.5 - 8.5) ranges of Drinking Water Quality Standards.

4.4.2.2 Electrical Conductivity (EC)

The study analyzed the water samples from different locations for Electrical Conductivity (EC). Table 4.3 shows the highest EC levels in Bore Hole (BH) water samples. Among them was the sample from Tabata Liwiti which recorded the highest EC of 1122 µS/cm followed by Vingunguti of (1095) and Ilala Boma (with the lowest EC of 836 µS/cm). The lowest EC of water samples ranged from 95.5 to 101 µS/cm and were recorded in Push Cart (PC) water samples. Car Tankers (CT) from Tabata Kimanga recorded 104µS/cm and 169 µS/cm for Kimara Stop Over, respectively. Additionally, CT samples from Mabibo were comparatively high, recording 668 µS/cm, implying that the sample may have originated from the BH water.

Tap Water (TW) findings also indicated the highest Electrical Conductivity (EC) of water. The lowest EC were recorded from the samples from Push cart (PC) ranging from 95.5 to- 101)(µS/cm. Generally, the results presented in table 4.3 indicated that most of the EC values from BH, TW, CT and PC were above the TBS and WHO recommended values (which is 3.0 µS/cm.) of the Drinking Water Quality Standards.

The significance of higher EC as recorded in the BH samples indicates high dissolved salts were present in the water sample. For instance, salty water conducts electricity more rapidly than purer water. Electrical conductivity is routinely used to measure salinity and this is why EC were recorded very high from many BH in the study area. Furthermore, depending on the types of salts presents, salinity can increase the level of water clarity.

4.4.2.3 Temperature

The importance of temperature as a determinant of physical chemical parameters of water quality is derived mainly from its relationship with other water quality parameters. Most of these relationships have a bearing on the aesthetic aspects of water quality; some are indirectly related to health. The palatability of drinking water is to some extent also dependent on temperature and with greater values could lead to the development of unpleasant tastes and odors. For drinking water, temperature may affect its quality, through the microbiological characteristics whose growth and survival during the treatment and even distribution depending on the types of the piping material. In this case the water temperature at the tap is the most important parameter. The cumulative effect of the water temperature between the water treatment and the tap is more important. For the water treatment processes, temperature aids in the retention of a chlorine residual by reducing the rates of reaction leading to hypochlorous acid removal.

This study recorded and analyzed the temperatures of the various vended water samples. The findings indicated that for the samples analyzed, 90% had temperature greater than 25^{O}C (Table 4.3). The recommended temperature for drinking water is

$25^{O}C$ according to UK standards (Tebbut, 1998). There is no guideline set by WHO and TBS on temperature levels for drinking water.

4.4.2.4 CT Water Quality Parameters

Samples from Car Tankers (CT) were tested for different parameters and the results are presented in table 4. 4 below:

Table 4. 4 CTs' Water Quality Parameters at Mabibo, Tabata and Kimara Area of Msimbazi Sub catchment

CAR TANKER (CT) SAMPLES				STANDARDS	
PARAMETERS	CT-Mabibo	CT -Tabata Kimanga	CT Kimara Stop Over	WHO	TBS
Chloride	346.6	44.3	73.7	250	200-800
Sulphate	41.294	9.991		250-500	200-600
Nitrite	3.494	3.493	6.197	0.50	0.5
Nitrate	0.057	0.075	0.793	50	10-75
Amonia Nitrogen	0.091	0.069	0.018	35	2

Source: (Field Survey, 2012)

The findings show the Car Tankers (CT) with the various parameters and their levels in the samples that were analysed in the laboratory. Among the present parameters tested and analysed were chloride, sulphate, nitrogen nitrite, nitrates and ammonia. Although the levels of Ammonium-Nitrogen, nitrates and Sulphate were similarly low and negligible; the nitrites in all the samples recorded were above the TBS (0.5 mg/l) and WHO (0.50 mg/l) standard levels. Nitrites in drinking water with values greater than the recommended limits may indicate the presence of sewage pollution in such water and is of questionable quality; this is because there is a stricter limit for nitrites in drinking water. Many cases where nitrites which exceed the recommended limits are associated with the carcinogenic effects.

On the other hand, chloride levels were equally considerably high with Mabibo CT reporting 346.6 mg/l the highest levels above the WHO accepted standard of 250 mg/l though within the TBS standard range of 200- 800 mg/l. Chloride concentration in water may increase during the treatment process if chlorine is used for disinfection purposes. Nonetheless, Tabata Kimanga CT (44.3 mg/l) and Kimara Stop over CT (73.7mg/l) reporting considerably fairly similar amounts of chlorides. Chloride is also an indicator of pollution when present in higher concentration (Singh *et al., 2009*).

4.4.2.5 P C' Water Quality Parameters

A laboratory analysis of Push Cart (PC) water samples was done and the findings are presented in table 4.5

Table 4.5 PCs' Water Quality Parameters at Kigogo, Ilala Boma and Buguruni Area of Msimbazi Sub catchment

PUSH CARTS (PC) SAMPLES				STANDARDS	
PARAMETERS	PC-Kigogo	PC- Ilala Boma	PC-Buguruni Malapa	WHO	TBS
Chloride	26.6	66.7	66.8	250	200-800
Sulphate	11.895	9.78	9.357	250-500	200-600
Nitrite	2.722	4.653	6.583	0.50	0.5
Nitrate	0.118	0.072	0.124	50	10-75
Ammonia Nitrogen	0.034	0.049	0.069	35	2

Source: (Field Survey, 2012)

All the samples tested for nitrites recorded abnormally high ranges above the TBS and WHO accepted standard of 0.5mg/l. This is indicated that, the water might be polluted by sewerage. Furthermore, the remaining tested physical chemical parameters as presented in Table 4.5 were all within not only the TBS but also the WHO recommended limits.

4.4.2.6 Tap Water Quality Parameters

Tap Water (TW) was analyzed in the laboratory for it components. The Findings are presented in table 4.6.

Table 4.6 Tap Water Parameters in Relation to TBS and WHO Standards

TAP WATER SAMPLES				STANDARDS	
PARAMETERS	Upanga	TW-Muhimbili1	TW-Muhimbili2	WHO	TBS
Chloride	199.1	110.6	110.6	250	200-800
Sulphate	28.604	28.815	31.248	250-500	200-600
Nitrite	21.641	6.916	7.741	0.50	0.5
Nitrate	0.563	0.135	0.116	50	10-75
NH_4-N	0.024	0.048	0.026	35	2

Source: (Field Survey, 2012)

The samples were taken from TW in three locations namely; Upanga, Muhimbili 1 and Muhimbili 2. The findings indicate that all the physical chemical parameters were within the accepted standards of WHO and TBS except for the nitrite levels which was above both the WHO and TBS standard acceptable ranges of, 0.5mg/l.

4.4.2.7 Boreholes Water Quality Parametes

The study collected water samples in different locations from different Boreholes in Msimbazi Sub catchment. The findings are presented in figure 4.2.

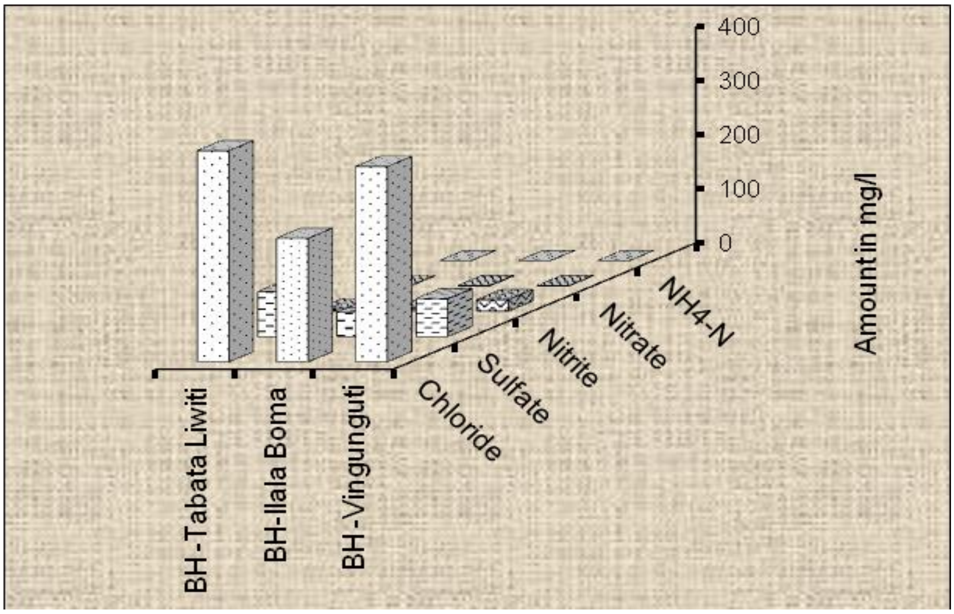

Figure: 4.2 Bore Holes (BH) Water Quality Parameters (*Field Survey*, 2012)

The BH water samples from Tabata Liwiti and Vingunguti possed similar and same highest levels of Chloride. This is evidenced by the finding from Vingunguti and Tabata Lawiti. Likewise, the chlorides for namely; Tabata Liwiti (390.8 mg/l) and Vingunguti (361.1 mg/l samples were higher than the WHO acceptable standard (250mg/l). This situation is associated with the sewage pollution, although high levels of chloride does not pose any health hazard to humans but it affects water as it will begin to taste salty and, will become increasingly objectionable as the concentration rises further.

All the samples tested for nitrites recorded abnormally high levels above the TBS accepted standard of 0.5 mg/l and WHO of 0.50 mg/l. Although other physical chemical parameters parameter had relatively low ranges, the findings indicate that the sulphate levels taken from the borehole water samples were fairly higher than those of other water samples; namely: CT, PC and TW.

4.4.2.8 Turbidity, TSS and Colour

Turbidity is a measure of the amount of light scattered and absorbed by water because of the suspended matter in the water. Turbidity affect how far light can penetrate into the water. Measures of turbidity are not measures of the concentration, type or size of the particles present, though turbidity is often used as an indicator of the total amount of material suspended in the water called **total suspended solids**.

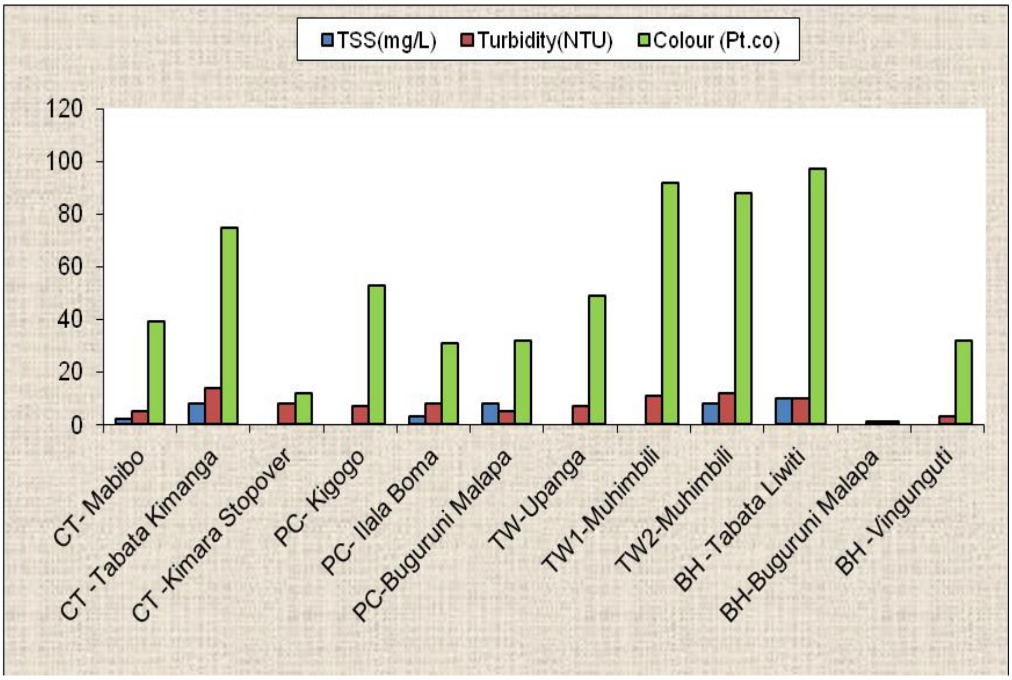

Figure 4.3: Total Suspended Solids,Turbidity and Colour (*Field Survey*, 2012)

Water samples analyzed for turbidity ranged from 1 to 14 NTU. Car Tanker (CT) water samples found at Tabata Kimanga recorded the highest turbidity of 14 NTU while the Tap Water (TW) at Muhimbili 2 turbidity was 10 NTU and the TW sample for Muhimbili 1 it was 11 NTU. The Borehole (BH) water from Buguruni Malapa recorded lowest turbidity of 1 NTU. Other BH samples at Tabata Liwiti and Vingunguti recorded 10 NTU and 3 NTU respectively. Though the findings of turbidity were different in the various types of vended water, in all the sample levels it was within the acceptable TBS and WHO standards.

According to WHO (2001), turbidity can have a considerable effect on the microbiological quality of drinking water. Furthermore, fine particles suspended in water carry harmful bacteria and attached contaminants such as toxic material. This is a concern for drinking water, which often requires disinfection with chlorine to kill harmful bacteria.

For the case of **TSS,** this research study found that the level of Total Suspended Solids (TSS) found in all water samples from car tankers, boreholes, push carts and tap water were not greater than the permissible limit for both WHO and TBS.

Colour is one of the most immediately apparent attributes of a number of drinking water and one that, together with visual clarity, strongly influences human aesthetic perception and recreational use of water. Colour of water is a guide to its composition and is increasingly being used to infer water quality, particularly suspended solids. From the four types of water vendors (cat tankers, boreholes, push carts and tap water) samples analyzed for colour some were within to permissible limit of TBS which is 1-50 and WHO >15 (Table 4.3), except for Ilala Boma Borehole which was 1Pt.co and Kimara Stop Over car tanker which was 12 Pt.co. were not within the WHO standardized ranges as well as Tabata Liwiti (BH), Muhimbili 1 and 2 (TP), Kigogo (PC) and Tabata Kimanga (CT) exceeded the acceptable ranges of TBS respectively.

4.4.2.9 Total Hardness (TH)

The study made an analysis which assessed TH. The findings are presented in figure 4.4.

Figure: 4.4 Total Hardness (TH) of the Samples (*Field Survey*, 2012)

The operational guideline for hardness in drinking water is set at between 500 and 600 mg/L as calcium carbonate by WHO and 500 mg/L by TBS. According to TBS 500 mg/L is the limit level. Although the Laboratory results shows that hardness values were within the set guideline values of both WHO and TBS (Table 4.3), this study found that hard water has a tendency to form scale deposits and can form excessive scum with regular soaps. However, certain detergents are largely unaffected by hardness. In addition, hardness in excess of 500 mg/L in drinking water is reported to be unacceptable for most domestic purposes. Although there is no health-based guideline value proposed for hardness according to (WHO, 1993), the degree of hardness in water may affect its acceptability to the consumer in terms of taste and scale deposition.

4.5 Vended Water and Associated Health Risks

This study investigated vended water in relation to the associated health risks. Elements of health risk in Msimbazi sub-catchment ranged from poor water quality, inadequate cleanliness of the storage facilities, difficulty in cleaning the water storage facilities and the unprotected water sources.

4.5.1 Vended Water Health Risk Elements

4.5.1.1 Poor Water Quality

This research study observed that poor quality of vended water supplied to consumers was the source of increasing health associated risks. This conclusion arises from the laboratory analysis which indicated that the quality of vended water was poor and thus posing a health risk due to high Total Coli forms and Faecal Coli forms as presented in table 4-1. The high TC and FC was more observed in many BH and PC as they showed an abnormally high TC and FC levels thus posing a high health risks. This was evidenced from the boreholes that were not covered and they are located near pit latrines or cesspit. This study found that during the rain seasons waste materials from pits penetrates to these boreholes and hence pollutes water and consequently accelerates increasing of water related diseases such as typhoid, dysentery.

A survey study observed that during rainy season residents open their toilets and cesspits to open spaces and to drainage systems. Similar observation was made by the Adamsen & Orio (1992) who noted that poor water quality has been reported to cause water borne, water-washed or water-related diseases in Dar es Salaam City. Another study observed that Dar es Salaam experiences problems related to adequate supply of safe drinking water due to rapidly increasing population (Dahi & Wedel-Heinen, 1992). The population determines not only the quality but also the quantity of water consumed by the people. The rapid increase in population of Dar es Salaam city coupled with poor sanitary and sewerage systems and use of pit latrines threaten the quality of piped and ground waters (MTNRE, 1994; JICA, 1991). Also, as water infrastructures for most of Dar es Salaam water supplies and sewage systems are old this caused the leakage of water and through this drinking water contamination is rampant in terms of bacteria apart from those who have a tendency to grow and re growth in piped systems such as *legionella.* Bacteria and other microorganisms get into drinking water supplies, sometimes causing epidemics in unplanned cities like Dar es Salaam (Ngole *et al.*, 1978; Quick *et al.*, 1999). Similarly, respondents in this study confirmed that vended water was associated with diseases including Cholera, typhoid, and dysentery.

4.5.1.2 Cleaning of Water Storage

This study observed difficulties and inadequacy in the cleaning of the water storages. Similarly, the frequency and the efficiency of the means of cleaning the water tanks and jerry cans were revealed as the factors for the vended water lacking quality, since the inside part of the jerry cans seemed not to be easy to clean by hands. This caused the growth of algae in tanks and Jerry cans and *legionela bacteria* in piped systems since these water pipes are not easier to be cleaned and in one way or another this situation contributes in lowering the quality of water delivered by water vendors in the study area. The consequences posed health risk to the users of the vended water in Msimbazi sub catchment area.

4.5.1.3 Unprotected Water Sources

Although this study observed that in Msimbazi sub catchment DAWASCO is the sole provider of water supply and sewerage services as well as the main source of the vended water, there were some semi-autonomous water utilities too with unprotected sources. Furthermore; the unprotected sources were problematic since they are a health risk , a situation that spurs up water borne related diseases.

4.5.1.4 Poor Water Infrastructure

The study found that the DAWASCO infrastructure used to supply water in Msimbazi sub catchment was made of both plastic and iron type. The condition of the existing water infrastructure was not good. In some areas it was observed to be very old, a situation that caused leakages experienced in many places, in most cases this accelerated health risk to supplied water. Furthermore, this observation was supported by the study done by Kjellen (2006), who reported that Dar es Salaam's water situation is problematic; the infrastructure is worn out, the water is insufficient, and environmental health problems abound. From the above argument, however, water quality problems and related health risks cases are expected to increase due to increasing water demand and rapid urbanization in Msimbazi sub catchment.

4.5.2 Vended Water Related Diseases

Surveyed respondents reported their family members suffering from water related diseases. Futhermore, the findings on the identified diseases are presented in figure 4.5.

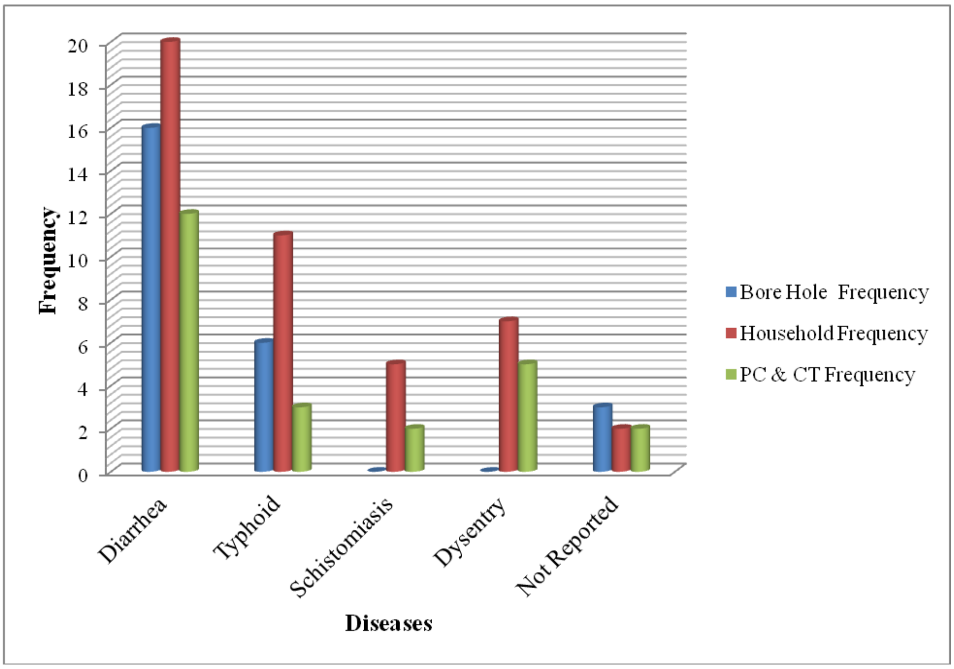

Figure 4.5: Diseases Associated with Vended Water (*Field Survey*, 2012)

The findings presented in Figure 4.5 above indicate the respondents that reported their families experienced ill health as a result of using the vended water. The diseases reported were diarrhoea, typhoid, schistomiasis and dysentry. There were respondents who did not report any disease related with the vended water to their families probably due to ignorance of such associations. Diarrhoea was the most frequent water related disease reported. Literature shows that diarrhoea is caused mainly by the ingestion of pathogens, especially in unsafe drinking-water, in contaminated food or from unclean hands. Similarly, Prüss & Corvalán (2006) report that inadequate sanitation and insufficient hygiene promote the transmission of these pathogens. They hold that about eighty-eight per cent of cases of diarrhoea worldwide are attributable to unsafe water, inadequate sanitation or insufficient hygiene. Contaminated water serves as a mechanism to transmit communicable diseases, such as diarrhoea, cholera, dysentery, typhoid and guinea worm infection. World Health Organization, (2008) estimates that in diarrhoeal disease claimed the lives of 2.5 million people.

4.6 Vended Water and Pricing

4.6.1 Knowledge of Vended Water Price Variations

Respondents were asked question that tested their knowledge of the price variations of vended water. All the respondents were unanimous on confirming that the price of vended water varied. In addition, the respondents were examined for knowledge of the factors contributing to the variation of the prices of vended water in relation to the sources.

4.6.2 Pricing Variation and Source

Respondents were surveyed on whether the prices varied according to the sources of vended water. They were asked the pricing of the different sources of vended water. The findings are presented in table 4.7.

Table 4.7 Vended Water Pricing in Relation to Sources

SOURCE	PRICE IN TSH PER 20 LITRES
Push Carts	400
Boreholes	200
Car Tankers	250
Tap Water	100

Source: (Field Survey, 2012)

Table 4.7 indicates the pricing of vended water per volume of 20 litres in relation to their sources. The findings indicate that the prices varied from the cheapest Tap Water source of Tsh 100 to the most expensive of Push Carts of Tsh 400. In addition, Borehole cost Tsh 200. From the findings, TW was the best priced for the respondents. Unfortunately, given the poor water infrastructure, respondents have to opt for vended water from other sources namely: Boreholes, Push Carts and Car Tankers.

4.6.3 Factors of Vended Water Price Variations

The study examined the factors determining or contributing to the price variations of vended water. The findings are presented in figure 4.6 below:

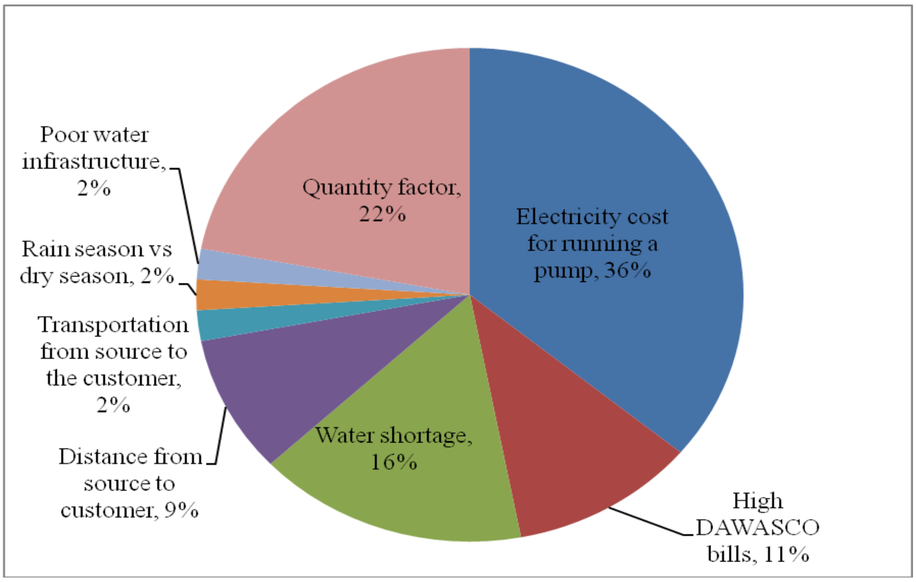

Figure 4.6: Factors Contributing to Vended Water Price Variations (*Field survey*, 2012)

4.6.3.1 Electricity Pump Running Costs

Figure 4.6 indicate a huge majority 36% attributed price variations of vended water to the electricity pump running costs, especially from the borehole owners. This situation made the vendors to raise their price as the source price changed due to electricity problems. Most of the electricity in Dar es Salaam City and Msimbazi sub catchment in particular is hydro-based. This means that it depended largely on river water levels which result from rainfall. In recent years Tanzania has suffered from inadequate electricity and there have been rampant black outs even when hydroelectric power is not used, the use of generators which need oil is equally costly, if not more expensive. This explains why electricity pump costs contributed enormously to the vended water price variations. The impact of Hydro Electric Power (HEP) point towards alternative sources of power for vended water, for instance, the use of solar for electricity.

4.6.3.2 Water Shortage

The findings indicate that 16% reported water shortage being a factor of price variation. The water shortage can be attributed to the sole dependence of DAWASCO on the Ruvu River. Similarly, water shortages could be accounted for by other drivers such as failure of the Government water utilities in terms of infrastructures, illegal connections, leakages resulting from worn out infrastructure, rapid urbanization insatiable water demand, changes of lifestyles which harm the environment and the unplanned settlements which affect, in one way or another, the water levels.

4.6.3.3 Quantity factor

Based on the research findings quantity was also a factor for the vended water pricing variation as evidenced by the 22% of the respondents in Figure 4.6. This research study investigated the quantity of water produced and supplied by the DAWASCO and found that 2.8 million litres of the water are produced and supplied per day from the main storage reservoir of the DAWASCO to Dar es Salaam City against the demand for instance, DAWASCO estimates that around 50% of the City population is supplied water through its piped systems. This situation shows the inadequacy in the quantity of water supplied.

In addition, this study investigated the quantities of water vended per day required for households, by determining in litres what was sold to the households. The results are presented in table 4.8.

Table 4.8: Demand of Vended Water Per day by Domestic Water Users

Litres sold per day	Frequency	Percentage %
0-50	0	0
51- 100	3	7
101-150	11	24
151-200	13	29
201-300	10	22
301-500	4	9
501- 700	3	7
701- 1000	1	2
Above 1000	0	0
	45	100

Source: (Field Survey, 2012)

Results presented in Table 4.8 indicate that none of the households needed less than fifty litres of water per day. This was equally true for the highest supply category of above 1000 litres. The majority (29%) of the respondents needed 151 to 200 litres as 24% of them required 101 to 150 litres per day for their household. Additionally, 22% of the respondents needed 201 to 300 litres per day for their households. The demand for vended water kept decreasing as the volumes of water supplied increased. These research findings point to the effect that water is an essential commodity for domestic and households as evidenced by the minimum requirement of fifty plus litres.

4.6.3.4 High DAWASCO Bills

11% of the respondents associated the pricing variation of vended water to high DAWASCO bills. They were unhappy not only about the high DAWASCO bills but also the unsystematic nature of these bills. The bills were estimated and sometimes in an exaggerated manner. Paradoxically, the respondents hardly got the water supply though they were indebted to pay the bills. The vendors utilized the gaps in the DAWASCO billing system to thrive in their business of selling water. The unsystematic billing system meant that the respondents had no option but to use vended water.

4.6.3.5 Distance

This study found that the prices varied in relation to distance as evidenced by the 9% of the respondents, since the vendors transport their water for long distances to their customers thereby providing a value added service. In addition vendors reported that sometimes they have to look for water from other sources when they lack to secure water from the public water kiosks. In that regard, failure to secure safe water cannot be primarily attributed to their lack of commitment to access safe sources. In some of the areas, water is received occasionally or while others not connected at all, which makes vendors to look for other sources accessible to them in order to serve their customers.

4.6.3.6 Poor Water Infrastructure, Transportation and Rain vs Dry Season

The remaining 6% of the respondents reported (in equal proportions of 2%) three other reasons that contributed vended water price variations. 2% of the respondents held that the pricing variations of vended water in Msimbazi Sub catchment were caused by the poor water infrastructure. These findings are confirmed by Kyessi (2005) who notes that in Dar es Salaam there is a failure of the conventional approaches and basic infrastructure to reach many of the urban population, particularly fringe areas of formal and informal settlements, where nearly 70 per cent of the city‘s population lives. Furthermore 2% reported on transportation from the source to customer also contributing much to variation of the price of the vended water and the remaining 2% of the respondents associated the pricing variation of vended water to Rain vs Dry Season.

4.7 Measures Necessary For Vendors Development in Service Provision

Means that could be used by the water sta keholders in particular DAWASCO, the water vendors .and the goverment were investigated. Table 4.9 shows the findings:

Table 4.9: Means of Enhancing The Water Vendors in Service Provision

Means	Frequency	Valid Percent	Cumulative Percent
Check on running cost	1	2.2	2.2
DAWASCO put standard price which vendors can afford.	1	2.2	4.4
Government to improve and expand water and road infrastructure	10	22.2	26.7
DAWASCO to expand water infrastructure and drill deep boreholes	9	20.0	46.7
Deep wells and boreholes should be increased by the government	1	2.2	48.9
Pre-selling Treatment of vended water	7	15.6	64.4
Loan provision to vendors	1	2.2	66.7
Loans provision vendors form associations	4	8.9	75.6
Prevent illegal connection of water	2	4.4	80.0
Review of the water sector policy	3	6.7	86.7
Public taps to be expanded near to vending station by DAWASCO	1	2.2	88.9
There should be a specific area for taking water	1	2.2	91.1
To be recognized by the government water authorities	4	8.9	100.0
Total	45	100.0	

Source: (Field Survey, 2012)

4.7.1 Informal Settlement Management

The study observed the rise of the informal settlement as a common scenario in Msimbazi sub catchment. There are unofficial settlements at the peri-urban fringe and on marginal or illegally occupied land. The land they occupy is hardly surveyed and even if it were, it has been assigned for other purposes such as industrial rather than for human settlement. The residents in these informal settlements lack sufficient conventional water supply systems. Similarly, scholars have observed that informal settlements are home to substantial proportions (as high 50%) of the total urban population (UNCHS, 1996).

4.7.2 Improve Water Infrastructure

The study observes that the urban population is rising much faster than the rate at which infrastructure services are being extended. There is need for a proportional expansion of the existing water infrastructure to accommodate the rapid growing residential population in the urban cities. Similarly, the existing infrastructures have to be maintained well so that wastages resulting from negligence, leakage of pipes are dealt with efficiently.

4.7.3 Pre-selling Treatment of Vended Water

The study investigated the vendor suppliers including DAWASCO on whether they pre-treated their water before selling it to vendors and other households or not. The findings are presented in table 4.10.

Table 4.10: The Pre-Selling Treatment of Vended Water

Pre-selling Treatment	**Frequency**	**Valid Percent**
Yes	17	64.0
No	8	36.0
Total	25	100.0

Source: (Field Survey, 2012)

The results in Table 4.10 above portrays that 64% that is more than half of the 25 respondent suppliers treated their water before selling it to vendors and other households in contrast to the 36% who did not. Although these results indicated the 64% of the respondents pre-selling treating of water appears to be good news, the manner and the effectiveness in which it was done is what causing a problems.

4.7.3.1 Pre-selling Treatment Methods of BH, CT and PC

Further the study explored the pre-selling methods used by the Borehole owners, Car tankers and the push carts. The findings are presented in figure 4.7.

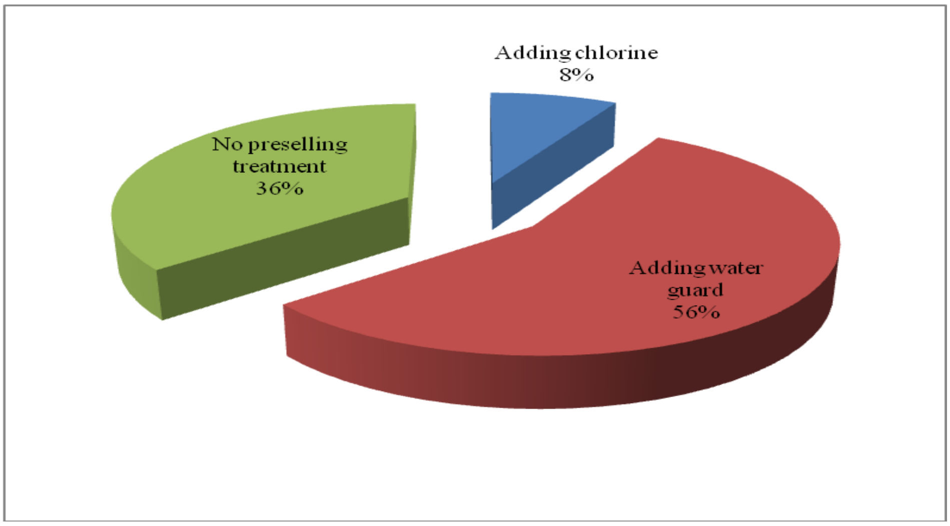

Figure 4.7: Pre-Selling Vended Water Treatment Methods (*Field Survey*, 2012)

The research findings presented in figure 4.7 indicates that more than half 56% of the BH, CT and PC water suppliers added water guard as 8% added chlorine as a form of treatment to the water before selling it to the distribution vendors and other households. Although a cumulative percent of 62% of the respondents treated the water, the question remains towards the type or methods of treatment made the water fit for human consumption. This stems from the fact that mere adding of chlorine or water guard may not gurantee full elimination of the micro-biological impurities. Additionally, nearly 36% of the rest of the respondents did not treat their water making it prone to diseases and bacterial infections.

In addition, the findings indicated that most of the shallow wells in Msimbazi Sub – catchment are in a bad condition for human use (especially for drinking) compared to deep wells storage reservoirs. Although most deep wells storage reservoirs were observed to be covered (plate 4.5) about 90% of the shallow wells are uncovered in the area of study. The situation was not bad in all areas as there were some covered deep well sources (Plate 4.5).

Plate 4.5: Covered Deep Well at Tabata Liwiti Area (*Field Survey*, 2012)

Plate 4.5 shows covered deep well located in Tabata Liwiti area. This indicates some attempts of safety for consumers in terms of usage.

4.7.3.2 Pre-selling Treatment by DAWASCO

The study investigated, through in depth interview with a key informant, the treatment of water. One of the key informants was Dar es Salaam Water and Sewerage Company (DAWASCO). The status of treated water storage reservoirs for DAWASCO treatment plants was considered. This study established that there was an elaborative water treatment processes which was done as indicated in plate 4.6.

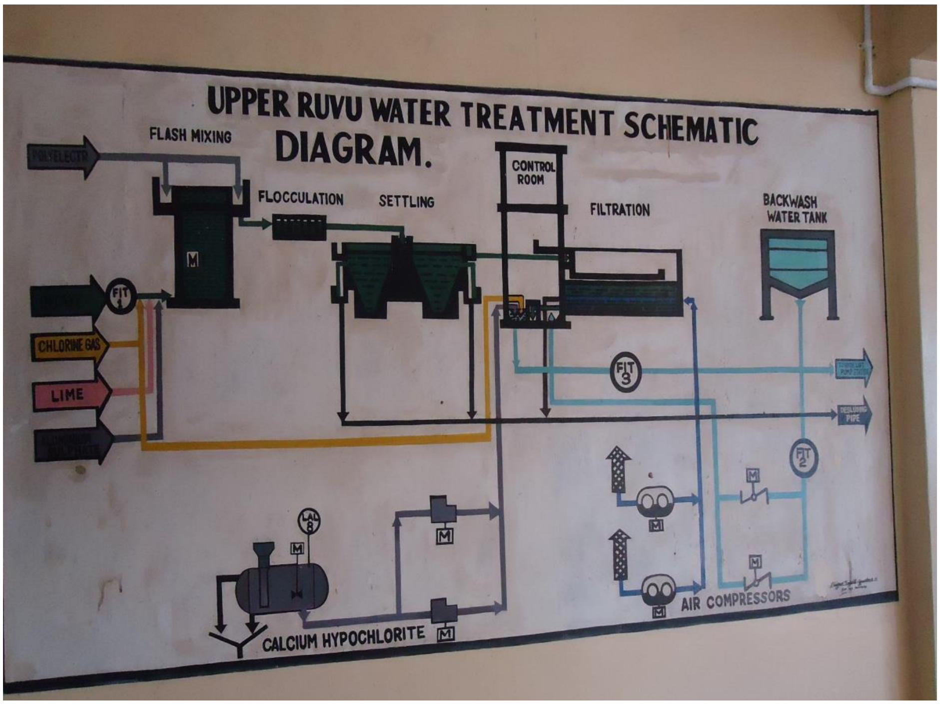

Plate 4.6: Upper Ruvu Water Treatment Schematic Diagram (*Field Survey*, 2012)

This detailed process includes but is not limited to flash mixing, flocculation, filtration, backwashing settling and air compressing all controlled. The treated storage water reservoirs of the DAWASCO treatment plant was in a good state in contrast to Msimbazi sub catchment boreholes/ deep wells and shallow wells storage reservoirs.

Through interviews some of the respondents from DAWASCO reported that they treated the water by adding chlorine. This method of adding chlorine does not necessary mean that the water is safe for drinking. This is due to the fact that there are long unmonitored transport distances, leakage and worn out water infrastructure.

4.7.4 Addressing the Water Utility Issues

There were some water utility problems in Msimbazi sub catchment. They ranged from insufficient funds for operations and infrastructure, human resource constraints, unnecessary or inappropriate politicization, inappropriate tariffs, disputed land tenure and inadequate infrastructure capacity. As such, if any meaningful steps in the water sector are to be made then it would be paramount to address these utility problems.

Private sector management of water utilities does not necessarily diminish the role played by these water vendors either. Factors which make water vendors to be prominent in urban informal settlements present major obstacles to infrastructure provision by formal private operators too. As mainly reported by Albu and Njiru, 2002), water vendors can be efficient – providing water when and where people need it, in quantities they can afford, while creating local employment opportunities that keep cash within the local economy.

4.7.5 Regulatory Authorities' Innovation and Creativity.

This study observed that there is need for regulatory authorities to be innovative and creative in order to promote a flexible and innovative response to meet the water demands of Msimbazi sub catchment. An important option is therefore to recognize the existing and often well-established local small scale private sector players, and support them particularly through partnerships with utilities, in order to improve water services provision to all. In addition, this study established that policy makers failed to acknowledge that in absence of communication and dialogue with water vendors, they neglect the poor and deprive them accessibility to safe water.

Furthermore, in most cases, in Tanzania policy makers tend to look for outside options (such as privatizing services to large utilities) as solutions and ignore water vendors who are already providing water services to those not reached by the utility. They do not acknowledge that reforming their economic and institutional structures to include these informal actors would have widespread economic and social benefits.

4.8 SWOT Analysis

This study conducted Strengths, Weaknesses, Opportunities and Threats (SWOT) of vendors and the existing water utility DAWASCO in water service delivery. The findings are presented in table 4.11.

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Table 4.11: SWOT Analysis of Water Vendors

SWOT ANALYSIS ITEMS	WATER VENDORS	EXISTING WATER UTILITY (DAWASCO)
Strengths	✓ Fill the water supply gap left by utilities in unserved low informal settlements ✓ Employment generation ✓ Assessment and recognition of water vendors emphasized by the revised water policy ✓ Community Water supply management practice supported by water policy ✓ Community- based approach recognized and supported by water utility.	✓ Financial Capabilities due to donor support ✓ Government subsidies ✓ Efficiency Technology ✓ Employment generation ✓ Formally recognised water utility providers ✓ Planned and sustainable expansion is possible

Weaknesses	✓ Lack of water resource and poor technology ✓ Lack of continuous supply from utilities ✓ Inadequate capital ✓ Partnership/Formal interaction with utility is not existing ✓ Lack of job security ✓ Formal recognition by policy is lacking ✓ Lack of formal recognition and political interference issues in management of those practices ✓ Weak financial and general management ✓ High cost of electricity compared to income especially to boreholes owners ✓ Lack of association for community managed water supply systems	✓ Subject to macroeconomi crises ✓ Not taking consideration the needs of the poor ✓ Higher water billing systems ✓ Donor and budget dependent financing ✓ Donor and budgetdependence financing ✓ Weak financial and general management

Opportunities	✓ Affordable water charges from utility ✓ Serve more people ✓ Self cost financing ✓ Water market is large ✓ Ability to serve a huge/ bigger population ✓ DAWASCO in ability to meet the demand ✓ Mutual working partnership with utilities ✓ Good relationship with customers ✓ Formation of vendors association can help them to fight for their needs ✓ Separations of management from operations to enhance efficiency ✓ Improvement / increase of capacity and efficiency in the existing facilities e.g. boreholes	✓ Donor's funding support ✓ Lack of competition in service delivery ✓ Existing ready market for water products ✓ Loanable by financial institutions ✓ Trusted custodians water utility ✓ Available large water market

Threats	✓ Lack of political and institutions support ✓ Increase of household connections ✓ Legal restriction e.g. not to be formaly recognized by the policy ✓ Persistence of illegal connection ✓ Lack of strong independent regulatory frameworks ✓ Inadequate transparency and formal recognition ✓ Extension of utility networks especially to the community boreholes water supply.	✓ Lack of strong regulatory framework ✓ Lack of social support due to high prices ✓ Persistence of illegal connection ✓ Bad depts. resulting from unpaid bills from household and institutions ✓ Unscruplous workersq

Source: (Researcher own Construction, 2012)

After performing the SWOT analysis, it has been noted that the option of partnership between Water Vendors and the DAWASO compensate for the weaknesses and threats of the two in their own. In part of the weaknesses, can be minimized through the formation of association of vendors and utility to enhance natural water points which will help to ensure the standards of services provided. The association of vendors and utility will help to regulate the application of the price given which should be set according to the distance from collection standpoint established by the DAWASCO. The price paid by vendors at the collection standpoint to that of selling according to the distance will be publicly known through this association.

Also as the piped water supplies demanding more capital, The policy option of Utility and water vendors, will provides potential opportunities for providing and expanding quality water services to customers. Threats can also be mitigated through long term measures such as strengthening regulatory and institutional framework, reviewing of water sector policy and establishing clear policies with regards to water service provision through water vendors and controlling of mushrooming informal settlement

From the above SWOT analysis, the findings show that the water vendors have strengths and opportunities to develop and improve their service provision to meet the demand required by their customers though vended water framework needs to be reworked to make it not only reliable option but also an attractive one for the customers.

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the Findings

This study broadly examined quality of vended water and its implications on price and health in Msimbazi sub catchment Dar es Salaam - Tanzania. Specifically, the study investigated the sources and quality of vended water vis-à-vis its related health risks and examined the factors of price variations of vended water and assessed the mitigation measures intended to enhance the development of water vendors in the provision of water services. Empirical tools used in conducting the survey in the field were: questionnaire, key informant interview guide as well as observation method.

In summary, the research study findings include:

i) The quality of vended water in many BH, CT and PC was of low quality as evidenced by the unacceptable contamination levels of Total Coli forms (TC) and Faecal Coli forms (FC) that were observed. The situation of questionable low water quality especially from these sources means that the users stand high risk of diseases and other health related problems.

ii) There are serious water shortage as the demand exceeds what is supplied. The water shortage can be attributed to the sole dependence of DAWASCO on the Ruvu River and her inadequate water infrastructures. Consequently, the water shortage has fuelled and justified the high vendor water pricing. Likewise, other complex drivers such as illegal connections, leakages resulting from worn out infrastructure, rapid urbanization, changes of lifestyles among others contributed to increased water shortages.

iii) There are opportunities and strengths for the development and improvement of the water vendors to make them stable and significant stakeholders in the water industry. Notwithstanding, the persistent threats and weakness under the current framework do not work favourably for the water vendors and customers alike.

5.2 Conclusions

This study concludes that vended water in Msimbazi sub catchment is of poor quality. This is evidenced by the high contamination levels of Total Coli forms (TC) and Faecal Coli forms (FC) which was beyond the acceptable standards stated by WHO and TBS as indicated in the water samples and this is associated with water related health risks and diseases for instance, diarrhea, dysentery, shistomiasis and typhoid to the families of the respondents. However most of the physical chemical parameters of the vended water tested are within the WHO and TBS acceptable limits except for nitrite. Other exceptions include, Chloride which is only within the TBS and above the WHO standards ranges as well as Electrical Conductivity and Colour.

The vended water pricing varied, fuelled by the high demand and water shortage. In addition, price variation was caused by the high electricity pump running costs, the high DAWASCO bills, and distance / transportation from the source to the customer as well as the rain vs dry season variations and the poor infrastructure.

Current measures enhancing the development of water vendors in the provision of the water services are inadequate. This is evidenced by the non existence of water vendors associations that could boost collaborations and stakeholder participation in the water sector; especially in the review of the water sector policy. Similarly, the failure of the government and water authorities to recognize the water vendors, the inadequate utilities and water vendor partnerships makes the vendors appear alien in the sector. In addition, the rampant shortages have to be addressed by DAWASCO through drilling deep boreholes and expanding public vending taps near vending stations.

5.3 Recommendations

Based on the findings of this study, the following recommendations are made to policy makers, DAWASCO officers, different water institutions, water stakeholders and respondents alike in Msimbazi sub catchment:

i) Institutionalization of water vending by the policy makers. This would help the regulation of water quality to acceptable standards and pricing.

ii) Review of the Water Sector Policy. This should be a participatory process involving all water stakeholders (the Ministry of Water, DAWASCO, end users, and vendors) to legalize the vended water business and setting plans for the standardization of the vended water price.

iii) Extension of Water Infrastructure by DAWASCO and all other water stakeholders, including water points for improving the water availability and the improvement of water service provision by the vendors.

iv) Formation of water vendor association: This will encourage the vendors to form their association among others. The presence of associations will ensure collaboration among the water vendors in water service provision and development

v) Utility and Water Vendors Partnership: The partnership between the utility and water vendors could help in enhancing the development of water vendors in provision of water services and ensure full participation of beneficiaries in planning, construction, operation, maintenance, and management of community based water supply schemes.

vi) Water Quality Monitoring by Tanzania Bureau of Standards (TBS): There is a need of TBS setting monitoring strategies of the quality of water on different sources in order to minimize the health water related risks. This may require to review the institutional frameworks.

vii) Monitoring of Mushrooming Informal Settlements: To mitigate water services provision and price variation.

viii) Iimproving the existing water infrastructure aa a means of mitigating the inadequate water provision to the residents of Msimbazi catchment and minimization of the rampant price variations.

5.4 Further Research in the Study Area

The study emphasized on the quality of vended water and its implications on price and health in Msimbazi sub catchment Dar es Salaam - Tanzania. Further studies should put attention on the following research areas in order to help the policy makers and researchers alike in mitigating the existing gap of knowledge and practice in relation to vended water and its implications:

i) The assessment of the mitigation measures for vended water vis a vis water quality and health risks.

ii) Measures of efficient and effective quality of vended water control

iii) The role of competitive pricing , quality and the politics of vended water

iv) Evaluating the means of expanding water ownership, infrastructure and conservation of vended water sources

v) Harmonisation of WHO and TBS standards

vi) Evaluating the harmonization of quality and quantity of vended water.

vii) Efficient mechanisms of consolidating vended water stakeholders' efforts

viii) Harmonization of private and public sector partnership in vended water service provision

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APPENDICES

Appendix I: Questionnaire for Households with and without Tap Connection

PREAMBLE

Dear Sir / Madam,

Hello. My name is Ngondo Jamila, Master's student at Kenyatta University (Registration Number: (I56EA/20395/2010).

I would appreciate your contribution to this study dealing with quality of vended water and its implications on price and health risks on the households in Msimbazi sub catchment Dar es Salaam- Tanzania. Any answers provided will be kept strictly confidential, according to research regulations of Kenyatta University. Thank you for your willingness.

GENERAL INFORMATION OF THE INTERVIWER	
NAME OF THE INTERVIEWER	
ID NUMBER OF THE INTERVIEWER	

RESPONDENT INFORMATION	RESPONSE	GRADES FOR THE RESULTS
Name of the ward		1 Complete 2 Uncompleted
Name of the sub-ward		
Name of the street		
Name of the Respondent		
Gender		
Education level		

SN	QUESTION	ANSWER	CODES	REMARKS
1	What is the main source of water for your household?	Public water taps	1	**If from public water taps proceed up to question number 16. But if from vendors go to question number 17**
		House connection	2	
		Boreholes near by	3	
		Water vendors	5	
		Msimbazi sub catchment	6	
2	If from Public water taps are you supplied water by DAWASCO?	Yes	1	
		No	2	
3	If YES ,Do you get this water frequently or by rationing	Frequently	1	
		By rationing	2	
4	If by rationing, how many days per week?			
5	Do you sell this water?	Yes	1	
		No	2	
		Sometimes	3	
6	If YES, to whom do you sell?	Vendors with car tankers	1	
		Push cart vendors	2	
		Household with no connection	3	
		Others specify………… …….	4	
7	Is the price for the water you are selling change time to time?	Yes	1	
		No	2	
8	If YES, what makes it to change?			
9	Do you facing any complaints related to price issues from your customers?	Yes	1	
		No	2	
10	If YES, can you mention a few?			

11	How do you treat water for household use before drinking?	Settling	1
		Boiling	2
		Filtration	3
		Adding water guard	4
12	Do you have the habit of cleaning your water storage devices/ facilities	Yes	1
		No	2
13	Have any family member suffered from water related diseases?	Yes	1
		No	2
14	If YES what a type of disease?		
15	Is that water supplied by DAWASCO enough for your daily requirements?	Yes	1
		No	2
16	If NOT enough, what is the alternative source of water for your daily needs?	Water vendors	3
		Msimbazi sub catchment	2
		Rain water harvesting	3
		Others, specify	4
17	If from a water vendor, what a type/ category of vendor?	Vendor with PC	1
		Vendor with CT	2
		Vendor with TW connection	3
		Vendor with BHwater kiosk	4
18	If from a water vendor with TWconnetion,how much do you pay per 20 liter jerry can?	50Tsh	1
		100Tsh	2
		200Tsh	3
		300Tsh	4
		Above 300	5
19	If from water vendors with PC, how much do you pay per 20 liter jerry can?	100Tsh	1
		200Tsh	2
		300Tsh	3
		400Tsh	4
		Above 400Tsh	5

20	If from a Borehole owner, How much do you pay per 20 litre jerry can?	50Tsh	1
		100Tsh	2
		200Tsh	3
		300Tsh	4
		400 Tsh	5
		Above 400Tsh	6
21	If from water vendors with CT, how much do you pay per 20 liter jerry can?	50Tsh	1
		100Tsh	2
		150Tsh	3
		200Tsh	4
		250 Tsh	5
		Above 250Tsh	6
22	If from a vendor, do you know where the water you are buying comes from?	Yes	1
		No	2
23	If YES where?		
24	Is the price of water you are buying from vendors varies?	Yes	1
		No	2
25	If YES do you know what is causing the variation of price?		
26	How do you treat your water before drinking?	Settling	1
		Boiling	2
		Filtration	3
		Adding water guard	4
27	Do you have the habit of cleaning your water storage devices/ facilities	Yes	1
		No	2
28	If YES, how many times per month	Once	1
		Two times	2
		Three Times	3

Appendix II: Questionnaire for Distribution Water Vendors

SN	QUESTION	ANSWER	CODES	REMARKS
1	What is the main source of water for your household?	Public water taps	1	**If from public water taps proceed up to question number 25. But if from vendors go to question number 19**
		House connection	2	
		Water kiosk	3	
		Neighbours water tap connection	4	
		Water vendors	5	
		Msimbazi sub catchment	6	
		Deep wells	7	
		Shallow wells	8	
2	If from Public water taps are you supplied water by DAWASCO?	Yes	1	
		No	2	
3	If YES ,Do you get this water frequently or by rationing	Frequently	1	
		By rationing	2	
4	If by rationing, how many days per week?			
5	Do you sell this water?	Yes	1	
		No	2	
		Sometimes	3	
6	If YES, to whom do you sell?	Vendors with car tankers	1	
		Push cart vendors	2	
		Household with no connection	3	
		Others specify…………….	4	
7	Is the price for the water you are selling change time to time?	Yes	1	
		No	2	

8	If YES, what makes it to change?		
9	Do you facing any complaints related to price issues from your customers?	Yes	1
		No	2
10	If YES, can you mention a few?		
11	How do you treat water for household use before drinking?	Settling	1
		Boiling	2
		Filtration	3
		Adding water guard	4
12	Do you have the habit of cleaning your water storage devices/ facilities	Yes	1
		No	2
13	If YES, how many times per month	Once	1
		Two times	2
		Three Times	3
		Others specify………	4
14	What do you use to clean your storage devices/?	Soap	1
		Water only	2
		Don't wash	3
		Disinfectant	4
15	Have any family member suffered from water related diseases?	Yes	1
		No	2
16	If YES what a type of disease?	Diarrhea	1
		Dysentery	2
		Typhoid	3
		Schistosomiasis	4
		Other specify……….	5
17	Is that water supplied by DAWASCO enough for your daily requirements?	Yes	1
		No	2

18	If NOT enough, what is the alternative source of water for your daily needs?	Permanent deep wells near by	1
		Shallow well nearby	2
		Water vendors	3
		Msimbazi sub catchment	4
		Rain water harvesting	5
		Others specify……….	6
19	What a type of vendor	Vendors with Truck	1
		Vendors with pushcarts	2
		Others specify………	3
20	If from water vendors with push How much do you pay per 20 liter jerry can?	100-200Tsh	1
		200-300Tsh	2
		400-500Tsh	3
		Above 500Tsh	4
21	Do you know where the water you are buying from vendors comes from?	Yes	1
		No	2
22	If YES where?		
23	Is the price of water you are buying from vendors varies?	Yes	1
		No	2
24	If YES do you know what is causing the variation of price?		
25	How about the quality of water from vendors?	Excellent	1
		Very Good	2
		Good	3
		Not Good	4
		Don't know	5
26	If NOT Good, what makes it not to be good?	Color	1
		Salt	2
		Turbidity	3
		Others, specify………	4

27	How do you treat your water before drinking?	Settling	1
		Boiling	2
		Filtration	3
		Adding water guard	4
28	Do you have the habit of cleaning your water storage devices/ facilities	Yes	1
		No	2
29	If YES, how many times per month	Once	1
		Two times	2
		Three Times	3
30	What do you use to clean your storage devices/?	Soap	1
		Water only	2
		Don’t wash	3
		Disinfectant	4
31	Have any family member suffered from water related diseases?	Yes	1
		No	2
32	If YES what a type of disease?	Diarrhea	1
		Dysentery	2
		Typhoid	3
		Schistosomiasis	4
		Others specify………………	5

Appendix III: Questionnaire for Borehole Water Suppliers

PREAMBLE

Dear Sir / Madam,

Hello. My name is Ngondo Jamila, a Master's student at Kenyatta University (Registration Number: (I56EA/20395/2010). I would appreciate your contribution to this study dealing with the quality of vended water and its implications on price and health risks on the households in Msimbazi sub catchment Dar es Salaam- Tanzania. Any answers provided will be kept strictly confidential, according to research regulations of Kenyatta University. Thank you for your willingness.

GENERAL INFORMATION OF THE INTERVIWER	
NAME OF THE INTERVIEWER	
ID NUMBER OF THE INTERVIEWER	

RESPONDENT INFORMATION	RESPONSE	GRADES FOR THE RESULTS
Name of the ward		**1 Complete** **2 Uncompleted**
Name of the sub-ward		
Name of the street		
Name of the Respondent		
Age		
Sex		
Education level		

SPECIFIED INTERVIEW	PUT A TICK
CAR TANKERS	
HAND PUSHCART	
OTHER ,SPECIIFY	

S/N	QUESTION	ANSWER	CODES
1	What is the source of water you are selling?	Public water taps Deep borehole/ well from water kiosk Shallow borehole/ well from water kiosk House connection Msimbazi sub catchment Others, specify…………………..	1 2 3 4 5 6
2	If from the Borehole/ well is the owner of that source treat his/ her water?	Yes No Don't know	1 2 3
3	If YES, how did the owner treat that water	Filtration Adding water guard Others, specify……………………	1 2 3
4	Is the price of water from the source keep on changing?	Yes No	1 2
5	If keep on changing, do you know what makes it to change?	Yes No Don't know	1 2 3
6	If YES, What makes it to change?		
7	Is the price of water you are selling varying too?	Yes No	1 2
8	If YES what factors causing the price to vary?		
9	Do you treat the water after buying?	Yes No	1 2
10	If YES how do you treat your water before selling?	Adding chemical reagents Others specify…………	1 2
11	Do you aware about the issue of water quality?	Yes No Don't know	1 2 3
12	If Yes specify		

13	Are you facing any difficulties in service provision to your customers?	Yes No	1 2
14	If YES which difficulties		
16	Do you have the habit of cleaning your water storage devices/ facilities	Yes No	1 2
17	If YES, what do you use to clean your storage devices?	Detergent Brush Water only Don’t wash	1 2 3 4
18	How many days per month do you clean your car tanker?		
19	Do you facing any problems in service delivery		
20	What do you think to be done so that you can develop in service provision?		

Appendix IV: Questionnaire for Borehole Water Suppliers

PREAMBLE
Dear Sir / Madam, Hello. My name is Ngondo Jamila, a Master's student at Kenyatta University (Registration Number: (I56EA/20395/2010). I would appreciate your contribution to this study dealing with quality of vended water and its implications on price and health risks on the households in Msimbazi sub catchment Dar es Salaam- Tanzania. Any answers provided will be kept strictly confidential, according to research regulations of Kenyatta University. Thank you for your willingness.

GENERAL INFORMATION OF THE INTERVIWER	
NAME OF THE INTERVIEWER	
ID NUMBER OF THE INTERVIEWER	

RESPONDENT INFORMATION	**RESPONSE**	**GRADES FOR THE RESULTS**
Name of the ward		**1 Complete** **2 Uncompleted**
Name of the sub-ward		
Name of the street		
Name of the Respondent		
Sex		
Education level		

S/N	**QUESTION**	**ANSWER**	**CODES**
1	What types of vendors are buying in a greater extent to your borehole?	Push cart vendors Car truck vendors Others, specify……………	1 2 3
2	Do you do any treatment before selling water to vendors and other households?	Yes No	1 2
3	If YES, how do you treat your water?	Adding chlorine Adding water guard Filtration Others, specify……………… …	1 2 3 4
4	Do you have the habit of cleaning your borehole	Yes No	1 2

5	If YES, what do you use to clean your borehole?	Detergent Adding water guard Don't clean	1 2 3
6	How many Pushcarts vendors do you serve per day?		
7	How many car tankers vendors do you serve per day?		
8	Are you facing/ receiving any complaints from your customers concerning the water you're selling?	Yes No	1 2
9	If YES, what are those complaints		
10	Is the water you are selling having salt taste?	Yes No	1 2
11	Do you use this water for drinking or other uses?	Drinking Other uses specify……………....	1 2
12	If for the other uses, where do you get water for drinking?	From Public tap connection Car tankers vendors carrying DAWASCO water Push cart vendors carrying DAWASCO water Water kiosk nearby selling DAWASCO water Msimbazi sub catchment	1 2 3 4 5 6
13	How do you know that the water you are buying is from DAWASCO?	None salt taste Others, specify	1 2
14	Have any family member suffered from water related diseases?	Yes No	1 2

15	If YES, what a type of disease?	Diarrhea Dysentery Typhoid Schistosomiasis Others, specify…………………	1 2 3 4 5

Appendix V: Interview Guide for DAWASCO

PREAMBLE

Dear Sir / Madam,

Hello. My name is Ngondo Jamila, Master's student at Kenyatta University (Registration Number: (I56EA/20395/2010). I would appreciate your contribution to this study dealing with quality of vended water and its implications on price and health risks on the households in Msimbazi sub catchment Dar es Salaam- Tanzania. Any answers provided will be kept strictly confidential, according to research regulations of Kenyatta University. Thank you for your willingness.

i. How do you supply water which comes from the same source for Dar es Salaam city?

ii. How many litres you produce per day?

iii. Do you get any complaints from your customers concerning water shortage? Or not getting water and they are connected to the service

iv. If YES, can you mention a few?

v. How do you treat the water you supplied?

vi. Which type of infrastructure do you use to supply water?

vii. What do you think could be a source of contamination to the treated water you supplied?

viii. Do you get any complaints from your customers concerning the issue of water lacking quality?

ix. If YES, Specify

x. Apart from complains to your customers, do you get any problems in water service provisio?.

xi. What means do you use to ensure that there is no contamination in treatment plant

xii. Is DAWASCO aware about vended water?

xiii. Are water vendors registered?

xiv. Do you think these vended water play any role in helping DAWASCO in terms of covering the gap in water supply?

xv. If YES, What is the plan of the DAWASCO to develop these small enterprises in water service provision?

xvi. Apart from that did DAWASCO meet Water vision in water distribution and service?

xvii. If Yes to what extent?

Appendix VI: Observation Guide for DAWASCO and Other Point Source Water

i. What is the status of treated water storage reservoirs for DAWASCO treatment plant?

ii. What is the status of the boreholes/ deep wells and its storage reservoirs in Msimbazi sub catchment?

iii. Are the storage reservoirs in Msimbazi sub catchment areas and DAWASCO covered or uncovered?

iv. How much water is stored in DAWASCO treatment reservoir before the distribution process?

v. How is the existing condition of water infrastructure of DAWASCO in Msimbazi sub catchment?

vi. What is the distance between the point source water and sanitation facilities e.g. latrines in Msimbazi sub catchment areas?