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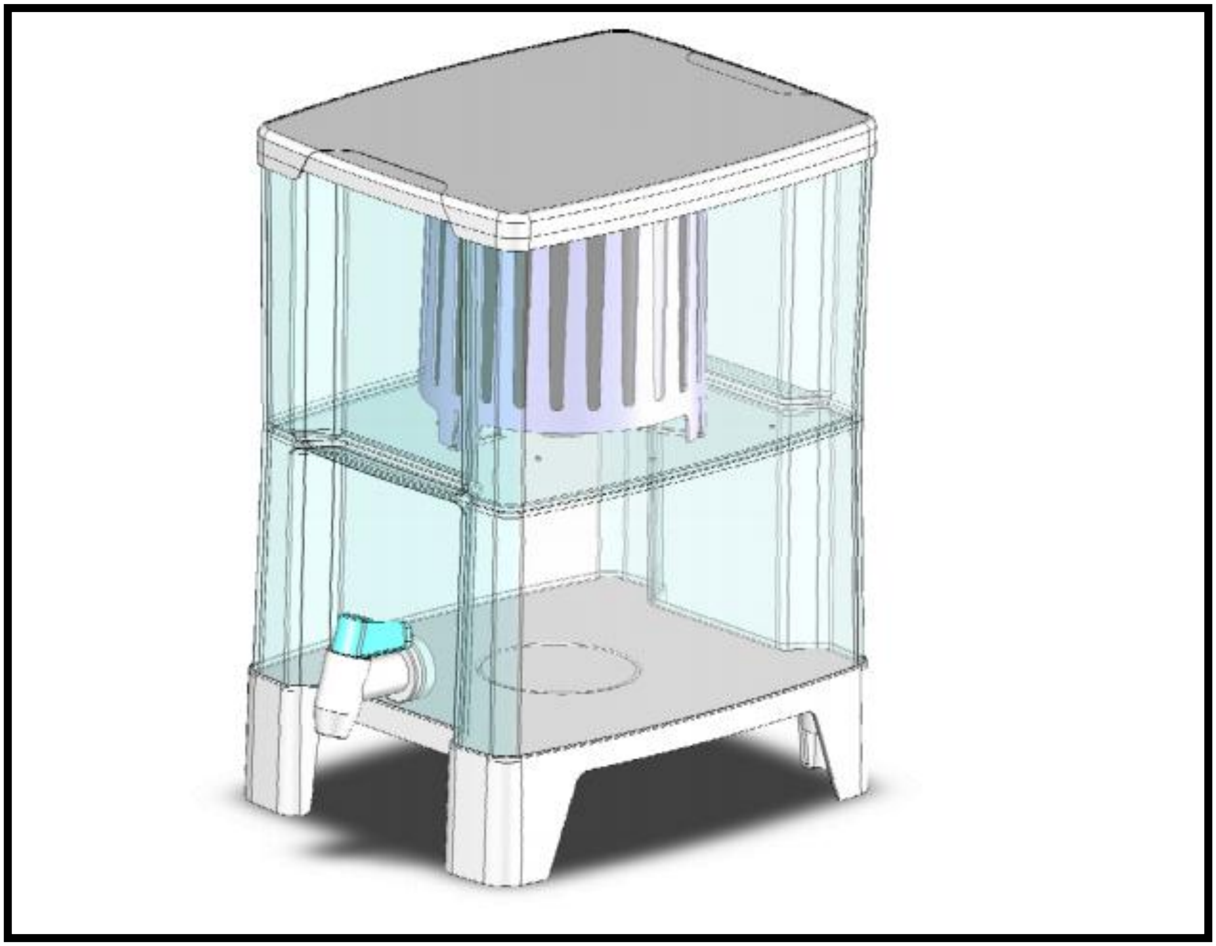

End user Perception and Willingness-to-Pay for Gravity Driven Membrane Disinfection in Nakuru -Kenya

Fumbi Cresent Job

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Master of Science Thesis

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Abstract

Contaminated drinking water is a major cause of high morbidity and mortality in Kenya as in many other low income countries. Gravity Driven Membrane (GDM) technology has been developed to improve access to potable water for the mid and low income users. ` In order to pave way for successful adoption and scaling up of GDM, this research focuses on assessing the user-perceptions of GDM technology in Nakuru Kenya through willingness to pay (WTP) surveys. In the survey, basic attributes (storage capacity, price, effectiveness and flow rate) of a hypothetical GDM household filter were systematically varied to evaluate the effect of such variations on the user acceptance of the technology. WTP for GDM filters is presented by different economic deciles of the population .WTP for different sub-populations such as tap water users and users of other water sources are compared. This will help GDM developers in developing designs that maximizes utility for users, setting prices that are appropriate for easy adoption and adopting appropriate subsidy structures to allow scale up, eventually improving access to portable water in Kenya.

Through multistage sampling, two clusters of population was identified; one in urban areas using tap water and the other in rural areas using surface water. WTP was elicited through a payment card during the household survey using a household questionnaire (n=300).

Results 93% of rural respondents considers drinking water sources to be unsafe due to contamination and high turbidity but only 43% treat it to improve quality . In contrast, in urban areas, water is considered safe by 52% and yet about 80% treat water before drinking. WTP for the poorest decile in both rural and urban areas was $6.25, while medians were $ 18.75 and $ 31.25 for rural and urban areas respectively. WTP for the richest decile was $ 50 in rural areas and $ 63 in urban areas. For some, WTP for the rural areas takes up to more than 50% of their monthly income compared to up to 30% for urban population. For both surface and "other" water users, the dependency of WTP on income is significant ($P<0.001$). Sanitation, gender, amount of water people drink also affects WTP. Purchase price, effectiveness of GDM and the flow rate significantly affects the choice of end users. Storage capacity of GDM on the other hand does not significantly affect the choice of end users.

The low levels of water treatment in rural areas are caused by complex interactions of inadequate awareness, low formal education; low income, high treatment costs, low availability of water treatment options, and social and religious factors operating in the society. A strong social demand has to be created for GDM to increase acceptance and make scale up successful.

Key words; Gravity driven membrane technology, willingness to pay, payment card, contigent valuation, end user perceptions, choice experiment.

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ACRONYMS

ANOVA-Analysis of Variance

BoP-Bottom-of-pyramid

CDC-Centers for Disease Control

CDN-Catholic Dioceses of Nakuru

CE-choice experiment

CFU-Colony Forming Units

CV-Contigent Valuation

DB-DC-Double Bound Dichotomous Choice

DHS- Demographic and Health Survey

DO-Dissolved Oxygen

EAWAG-Swiss Federal Institute for Aquatic Science and Technology

GDM-Gravity Driven Membrane

GoK-Government of Kenya

HWTS-Household Water Treatment and Safe storage

IFAD-International Fund for Agricultural Development

JPM-Joint Monitoring Program

KNBS-Kenya Bureau of Statistics

KWAHO-Kenya water for health organization

LIC-Low Income Countries

MDGs-Millennium Development Goals

MPN-Most Probable Number

NAWASCO-Nakuru Water and Sewerage Company

NGO-Non-Governmental Organization

NTU-Nephelometric Turbidity Units

NUV-Non Use Value

OHB-DC- One-half-bound dichotomous choice

POUs-Point-of-Use system

PPP-Public-Private Partnership

PSI-Population Services International

RP-Revealed Preference

SANDEC-water and sanitation in developing countries

SB-DC- Single Bound Dichotomous Choice

SODIS-Solar Disinfection

SP- Stated Preference

SSA-Sub-Saharan Africa

SUMAWA-Sustainable Management of rural Watersheds

TOC-Total Organic Carbon

TV-Total Value

UF-Ultra Filtration

UNDP-United Nation Development Program

UNICEF-United Nations Children's Fund

USAID-United States Agency for International Development

UV-Use Value

VIP-Ventilated Improved Pit latrines

WHO-World Health Organization

WTA-Willingness -to -Accept

WTP-Willingness-to-Pay

Chapter one

1.0 **INTRODUCTION**

1.1 Purpose

This chapter provides a general description of the water and sanitation situation facing the low income countries particularly Kenya. The chapter introduces the drinking water situation in Kenya and solutions which have been developed to address it. In particular, this chapter gives reasons why the drinking water situation should be a focus of concern both in the scientific and development world. The chapter also outlines the research objectives, outlines research questions, outlines the justification for the study, and hypothesis of the study. Chapter one therefore outlines the problem and explains why this study is necessary. The last part of the chapter outlines the contents of other chapters and how they link to each other.

1.2 Background

1.2.1 Global drinking water situation

Access to safe drinking water has been on the global agenda for decades and will remain increasingly relevant as a subject of debate even in the coming years. The relevance of access to safe drinking water in the world stems from three factors: the central role water plays in the socio-economic development; the geopolitical and economic variability of access to water; and the uncertainty of water availability. The uncertainty in drinking water availability is believed to result from climate change, increasing water contamination especially in Low income countries (LIC), increasing diversity and quantity of water available.

As of 2010, 89% of the world population had access to improved drinking water, which indicates an increase of 10% in the last 18 years (WHO/UNICEF, 2012). However, the number of people without access to safe drinking water in the world stood at 780 million (representing 11% of the world population), majority of whom live in Sub-Saharan Africa (SSA) (Figure 1.1). Only 61% of people living in SSA (where Kenya is geographically situated) have access to improved drinking water sources.

The Joint Monitoring Program (JMP) report of world health organization (WHO) and United Nations Children's Fund (UNICEF) indicates that based on this data, the world met its Millennium Development Goals (MDGs) target in 2010. The data shows that in the last two year, about one percent of the total population had access to improved drinking water source. In 2008, 13% of the world population did not have access to improved water. For SSA, only 60% had access to improved sanitation(WHO/UNICEF, 2010). Much of the improvement in access to drinking water noted in the last decade is attributed to the improvement in the most populous countries in the world: China and India. From the figure 1.1, SSA should be the focus of drinking water interventions for both the scientific and development world if the world hopes to significantly reduce the number of people without access to improved drinking water sources.

The Kenyan access to safe drinking water and improved sanitation is a mirror of the situation in SSA.

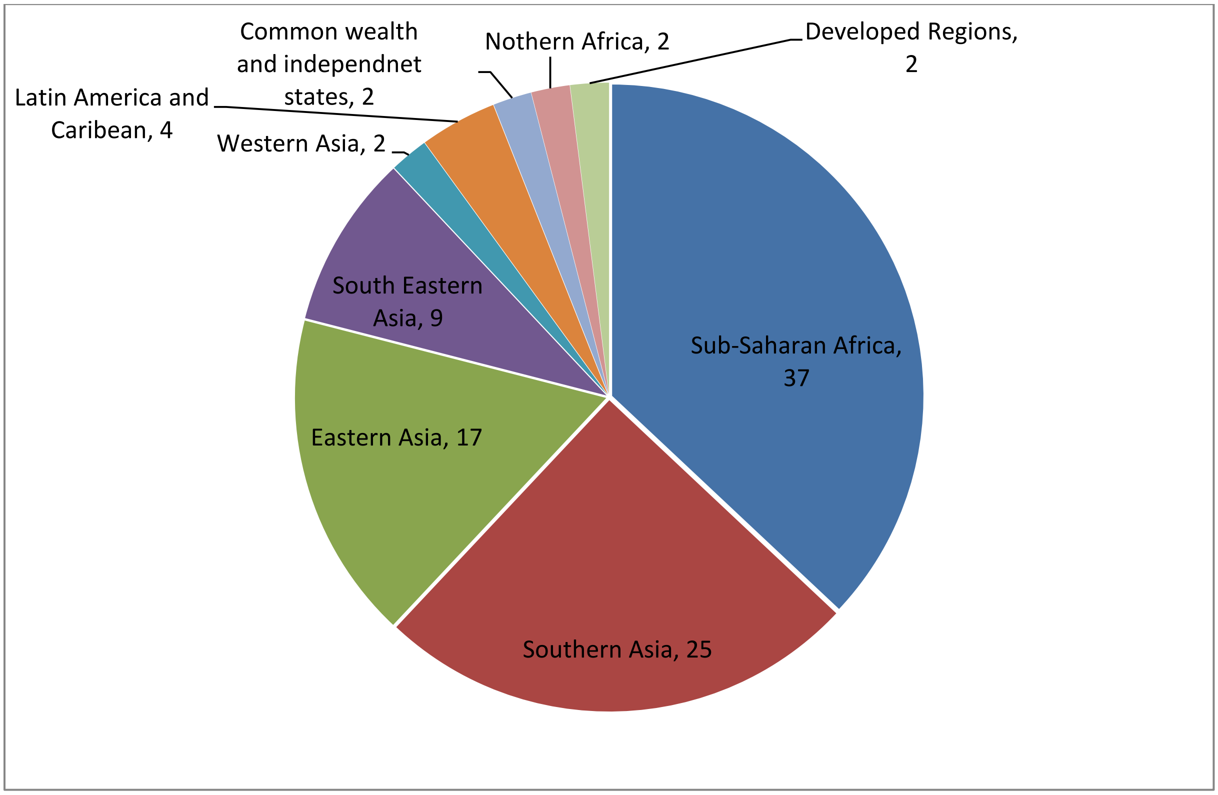

Figure 1.1 Percentage of world population lacking access to safe drinking water. Source: Adopted from WHO/UNICEF joint monitoring program report 2011

1.2.2 Drinking water situation in Kenya

In the JMP report on MDG progress released 2012, Kenya is among many SSA countries which have not made any progress in the access to safe drinking water or in provision of improved sanitation (WHO/UNICEF, 2012). Target 10 states "Halve, by 2015, the proportion of people without sustainable access to safe drinking water"

Recent government records put Kenya's coverage of access to safe drinking water at 74% (89% in urban and 49% in rural areas) (GoK., 2009, UNDP, et al., 2005). Either, this figure is innacurate or the situation has been declining with time. A study done by united states Agency for International Development (USAID) in collaboration with Kenya National Bureau of Statistics (KNEBS) in 2009 for instance puts Kenya's access to safe drinking water at even a lower level of 63% (USAID and KNBS, 2009).

On the other hand, the results of the Population and Housing Census (Figure 1. 2) shows that the number of people using unimproved drinking water sources (e.g., rivers, lakes, etc.) and unsanitary conditions for disposal of human wastes (e.g. uncovered pit latrine, buckets, cess pool and open defecation) especially in rural areas is still high especially i.e. 38% and 94% respectively (GoK., 2009, UNDP, et al., 2005). In slums the sanitation condition is dire with many people using hanging latrines and open spaces (Schouten and Mathenge, 2010). Poor sanitation is the leading cause of fecal contamination of drinking water in urban (Murage and Ndingu, 2007).

Percentage households by main source of water

	RURAL	URBAN
Pond/Dam	5.9	1.1
Lake	1.5	0.5
Stream	30.4	7.6
Spring /Well / Borehole	42.6	24.2
Piped into dwelling	2.2	14.2
Piped	13.4	38.4
Jabia /Rain/Harvested	1.3	0.7
Water Vendor	2.3	13.2
Other	0.4	0.1

Percentage households by main mode of Human Waste Disposal

	RURAL	URBAN
Main Sewer	0.2	19.5
Septic Tank	0.5	8.0
Cess Pool	0.1	0.7
VIP Pit Latrine	4.3	5.9
Pit Latrine (Covered/ Uncovered)	74.1	62.5
Bucket	0.1	0.6
Bush	20.7	2.6
Other	0.1	0.2

Figure 1.2 Percentage of Kenyan households by main source of water and means of human waste disposal. Source: GoK (2009)

1.2.3 Effects of present drinking water and sanitation in Kenya

The result of poor sanitation and lack of access to safe drinking water is three fold; One, there is high morbidity, especially among the poor households who drink untreated water in both rural and urban areas. Most of the infectious diseases including cholera, diarrhea and typhoid result from fecal contamination (Montgomery and Menechem, 2007, Peter-Varbanets, et al., 2010). In 2004, it was estimated that about 1.7million deaths (representing 3.7 % of all deaths) results from consumption of contaminated drinking water and poor sanitation (Ashbolt, 2004). Diarrhea, for instance is responsible for about 22% of pediatric deaths in the world (Tornheim, et al., 2010). In developing countries diarrheal diseases are among the leading causes of morbidity and mortality (Fewtrell, et al., 2005), 40% of which occur in Africa (Tornheim, et al., 2010). Closer home, in Bondo District of western Kenya, hospitalization with diarrheal diseases represent 11.2% of all admissions (Tornheim, et al., 2010). For children below age five, diarheal prevalence is about 3.5 cases per child per year in Kenya which is about 10% higher than the world average of 3.2 cases per child per year (Mirza, et al., 1997).

Second, most of the families spend a lot of financial resources on hospital bills, lose working hours and miss income opportunities due to preventable diarrheal diseases. This drags the affected families back into the deep holes of poverty. Third, the government has to invest heavily in the health sector leaving other sectors with lean budgetary allocations slowing down the country's development. To break this cycle of drinking water contamination, diseases and low productivity, solutions lie in household water treatment and safe storage (HWTS) systems being developed.

1.2.4 Solutions present to improve potable water in Kenya and the challenges

Several Point-of-Use systems (POUs) or HWTS have been promoted and (or) supplied in Kenya to help alleviate the problem of poor water quality with varying degrees of success. The popular ones are: boiling, filtration (bio-sand filters, ceramic filters, bio-sand filters and life straw filters), chlorination, flocculation/disinfection, and Solar Disinfection (SODIS).

However, effective use of these technologies especially filters is still low. A demographic and health survey done in Kenya recently (table 1.1) indicate that other than boiling and to some extent chlorination, the sustained use other POUs is very low (USAID and KNBS, 2009).

Treatment method	Urban	Rural	Total
Boiled	37.6	24.0	26.6
Chlorination	22.9	17.0	18.2
Filtration	1.7	0.6	0.8
SODIS	0.0	0.2	0.1
Decantation	0.1	0.4	0.4
Others	0.3	0.1	0.1
Non treatment	42	59.7	56.3

Table 1.1: Methods of drinking water treatment used in Kenya, Source; adopted form Demographic and Health Survey (DHS) (USAID and KNBS, 2009).

Sobsey (2008) attributes low use of these HWTS systems on several factors ranging from high investment and maintenance costs to ineffectiveness in improving water quality to the required community expectations. Luoto et al (2011) attributes low use of chlorinated POUs to the perceived residual chlorine and consequently its unpleasant taste or smell in drinking water. In a way the swelling number of POUs has had limited success penetrating the market and reducing the risk of pathogenic contamination in drinking water especially among the poor households in Kenya and many other parts of the world. According to the Citizen Report Card (CRC), water borne morbidity is still high and the mortality rates are still worrying among the poor urban households (CRC, 2007) and rural communities (Montgomery and Menechem, 2007, Murage and Ndingu , 2007).

Another POUs; Gravity Driven Membrane (GDM) filters for household drinking water has been developed as an appropriate alternative. The technology is based on the principles of ultra-low pressure ultra-filtration and flux stabilization. The ultra-low pressure needed for disinfection can be generated by gravity (pressure of 65 mbar) thus no pumping mechanism or peripheral equipment is required. Flux stabilization occurs because of bio-fouling thus the system does not require back flushing, cross flow or chemical cleaning of the filters (Boulestreau, et al., 2010, Peter-Varbanets, Hammes, Vital and Pronk, 2010, Peter-Varbanets, et al., 2011, Peter-Varbanets, et al., 2009).

Further, the technology can generate a water flux of 10 $Lh^{-1}m^{-2}$ ($24Lday^{-1}m^{-2}$) (Peter-Varbanets, et al., 2010, peter-verbenets, et al., 2011, Peter-verbernets, 2010) which meets the demand of 10-40 $Lday^{-1}$required for household systems (Sobsey, 2002) recomended by WHO. The technology has the potential to reliably treat surface water even with turbidity values of up to 600 NTU [1] (Boulestreau, et al., 2010).

1.3 Problem definition

The world over, many POUs have been promoted to help improve access to potable water. Many of POUs are however failing to reduce the disease burden in society because they are not perceived to be effectively treating water, because of aesthetic concerns, because of financial burden associated with their implementation, and because of maintenance difficulties that come with them. Membrane filtration on the other hand has been successfully used in the treatment of drinking water in high income countries (HIC). Ultra filtration (UF) membranes were found to be more effective in treating drinking water than the sand filters (Fewtrell, et al., 2005, peter-verbenets, et al., 2011, Schouten and Mathenge, 2010, WHO/UNICEF, 2010). GDM; one of the ultra filtration techniques, has been identified to potentially reduce diarrheal disease and by extension the socio-economic burdens that come with drinking contaminated water.

The relative effectiveness of GDM technology in treating drinking water for household use has been established by many studies (Boulestreau, et al., 2010, Peter-Varbanets, et al., 2010, Peter-Varbanets, et al., 2011, Peter-Varbanets, et al., 2009, Peter-verbernets, 2010). GDM operated at ultra-low pressure has the capacity to "provide at least 7-log removal of bacteria and 3-log removal of viruses" (peter-verbenets, et al., 2011), as well as all particulates from the drinking water. This effectively makes it a favorable POUs option since it has the potential to reduce diarrheal disease burden significantly. Also GDM technology does not require cleaning and its maintenance is limited to replacement of broken housing parts like taps. This makes it easy to use because its use does not require specialized skills.

Further, Peter-verbenets et al (2011) estimates that this technology can continuously be used for about 7-8 years (based on the life expectancy of the filters) making overall benefits of GDM technology to far outweigh its initial investment cost for households. With no training on use and less financial resources, GDM technology could be the key to future potable water provision among the poor communities in Kenya and around the world.

While the technical applicability of the technology has been established through comprehensive research, little is known about its ability to be fully integrated into the community. To start with there is lack of information about Willingness to Pay (WTP) for POUs (including GDM [2]), a

[1] Measurement of turbidity is NTU-nephelometric turbidity units
[2] GDM is about to be introduced into the market. The Kenyan market will be the first recipient

challenge to its commercialization and scaling up. There is also very no information concerning user perceptions of the technology (perceived effectiveness, storage capacity, flow rate and pricing). Finally, no study has been done to establish the relative acceptance of the technology in relation to the other existing POUs. Until these issues are investigated and their certainty established, efforts towards the adoption of GDM technology as a cost effective means of reducing diarrheal disease burden among the middle and lower income consumers may not yield much results.

1.4 Justification of the study

Previous studies on application of POUs have indicated that the socio-economic aspects need to be investigated to bridge the knowledge gap and to determine the demand for the technology in the market. For instance, a study done in Australia concluded that there is a clear knowledge gap on social drivers specific to adoption of decentralized drinking water systems for better policy development (Mankad and Tapsuwan, 2011). Luoto, et al (2011) insists that it is important to design and market POUs with an understanding of people's choices and aspirations. Also, Peter-verbanets, et al (2011) argues that for effective adoption of the GDM, it should be designed to meet the social, technical and economic needs of the target population.

Successful implementation of household drinking water treatment systems requires the integration of socio-economic, cultural and behavioral components that can foster behavior change (Sobsey, 2002). It is therefore important to carry out WTP studies for GDM and to understand the characteristics of any POUs that consumers will consider important during the critical moment of making purchase.

Integration of the "investigated" valuable characteristics in the design of GDM will not only improve the adoption rate of GDM when introduced in the market and make it easy to scale up; it will also improve the consumer utility. Overall the results of this research will be vital in understanding the dynamics of decision making for consumers of POUs and how to capitalize on these dynamics to improve the level of potable water access in the country.

Further, the establishment of WTP among different economic classes of the Kenya will help to design appropriate subsidy scheme for GDM to step up efforts of eradicating diarrheal diseases among the bottom-of pyramid (BoP) users. This study contributes to the growing body of knowledge on the application of POUs in society to reduce diarrheal prevalence in Kenya and the world.

The creation of a hypothetical market for a yet-to-be-introduced drinking water technology (GDM) which reduces water contamination introduces the question of valuation of clean water services for which information is currently unavailable. The results of this research can therefore be used by policy makers in establishing the demand for clean-safe water.

1.1 Research objectives

This research was designed with three main objectives i.e.

1. Document drinking water processes used in Nakuru County-Kenya
2. Determine the willingness to pay for a hypothetical GDM filter using payment card
3. To determine importance of different GDM characteristics on user choices

1.2 Research questions

To meet the stated objectives, several questions were formulated.

1.2.1 Research question 1

Since there little documented information about the drinking water treatment situation in Nakuru County, it was important to document water treatment methods known and used, water treatment and then willingness to pay for a water treatment technology. The basic question therefore becomes:

What is the WTP for the GDM technology among the people of Nakuru County?

This research question will be comprehensively addressed by a set of research sub-questions that focus on different variables for WTP for POUs. These sub-questions aim to address the drinking water treatment methods currently in use, the differences in the WTP for hypothetical POUs among the different classes and the factors that affect this WTP.

Research sub-questions

- What methods of drinking water treatment are used in Nakuru County?
- How much do the different economic deciles WTP for the GDM technology?
- What type of relationship exists between WTP and income?
- Is the WTP for GDM significantly different among users of different water sources in Nakuru County?
- What demographic factors affect WTP

1.2.2 Research question 2

How is the end user choice of GDM related to its variable characteristics?

This research question aims to establish whether or not the users' choice among hypothetical GDM filter is significantly influenced by variations of;

- Effectiveness of the filter in reducing diarrheal diseases
- Capital cost
- Treatment time
- Storage capacity of the filter

1.3 Hypothesis

1. There is a direct linear dependency of WTP on income
2. WTP for GDM is higher among surface water users than tap water users.
3. Storage capacity and price have a higher impact on choice of the filter by users than flow rate and effectiveness

1.4 Chapter Summary

Access to safe drinking water is a major issue of concern in the world. In Kenya particular, the issue needs immediate attention not just to achieve MDG 7 by 2015 but also to reduce the escalating water borne diseases and achieve socio-economic stability. There are several household water treatment systems that have been developed and introduced into the market but they have not been fully accepted and scaling up is a challenge. Successful introduction and scale up of GDM requires a careful study of the user perceptions of basic GDM attributes and the WTP for by the target population. To achieve this, the study aims to establish the current treatment methods in Nakuru County, the WTP for GDM and to establish characteristics of GDM relevant in making choices by end users.

1.5 Thesis outline

This thesis is divided into six chapters. Having introduced the background and significance of the research in chapter one, in chapter two a detailed discussion of the theories and concepts underlying drinking water treatment technologies and valuation of a water treatment technology are presented. Chapter two explains why GDM is an appropriate technology that can significantly reduce water related problems in Kenya. Also, it explains why GDM valuation is necessary at this point of its development and why Contigent Valuation (CV) was chosen.

Chapter three is a discussion of the methods, approaches and activities that were implemented in this research. It also describes the characteristics of the study area to put the study approach into context. The chapter also defines the sample frame, sampling procedure and sample size. Further, it details the design of the hypothetical market both for CV and choice experiment (CE).

Chapter four is an outline of the results that were obtained during this research exercise. The chapter presents socio-demographic characteristics of the study population. It presents the drinking water treatment situation in Nakuru, maximum[3] Willingness to pay (WTP) for different economic deciles of the population in rural and urban areas, the relationship between WTP and income and the socio-demographic factors that affect WTP in Nakuru County. Statistical models used in the analysis are and the coefficients are also presented.

[3]In eliciting answers, the researcher asked for the maximum willingness to pay. All the WTP values reported in this report henceforth means the Maximum willingness to pay.

Chapter five is an interpretation of the results presented in chapter four. It is a detailed discussion of the drinking water situation in Nakuru in relation to the rural and urban areas, the WTP and its relation with income, and other related factors in relation to rural and urban areas. Also included are the characteristics of GDM and how they determine choices of users. These discussions put the research findings into a wider context by pointing out their relevance in the drinking water sector.

Chapter six looks at the policy implications of the results both for drinking water supply in Nakuru County and the developers of GDM. It also summarizes the research findings and explores the research direction for drinking water provision. Further the chapter also explores development & implementation of GDM in relation to the results.

Chapter two

2.0 LITERATURE REVIEW ON POUs AND VALUATION APPOACHES

2.1 Purpose

The purpose of this chapter is to review factors and concepts that need consideration if GDM has to be adopted and the effects of such adoption in a concise conceptual framework. The chapter further reviews literature on drinking water technologies, their application in developing countries and the details the working of GDM technology in particular. Chapter two concludes by review of theories concerning CV and CE, and their application.

2.2 Conceptual framework

The acceptance of the GDM technology among the low and middle income population in Nakuru County forms the basis of its use to ensure safe drinking water. The acceptance of GDM technology is however subject to community perception based on two factors; the WTP for GDM filters and the User perceptions (based on its characteristics). WTP depends on socio-economic situation of the target population. The relative WTP for the GDM technology as compared to other technologies has a big influence on whether the technology can be accepted and therefore adopted or not.

The other important factor that will influence the use of GDM technology is the community perception on the technology and how this compares with the rest of POUs. (Mosler, et al., 2011, Sobsey, 2002). Among the most important perceptions that will influence acceptance of the technology is whether the technology is available, easy to use, and cost effective. Also the durability of the technology, its ability to meet drinking water demands of the people and its effectiveness in reducing the disease burden of the households are crucial characteristics that shape people's perceptions of the technology.

However, even when GDM filter are accepted, its use cannot be guaranteed as there are so many POUs in use that aim to guarantee safety of drinking water in Kenya including SODIS, chlorination[4] combined flocculation and disinfection[5],boiling and filtration(Mosler, et al., 2011, Peter-Varbanets, et al., 2009, Peter-verbernets, 2010, Sobsey, 2002).

Sustained use of GDM filters can therefore be pegged on its relative acceptance to other POUs. Upon its acceptance and adoption, GDM has the potential to improve water quality by reducing micro-biological contamination, reducing water turbidity and reducing chemical application into drinking water (Peter-Varbanets, et al., 2009, peter-verbenets, et al., 2011) which will improve the

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[4] Chlorination in Kenya is done by water service companies and sold in markets as water guard tablets or aqua tab sachets.

[5] Branded PUR

access to safe drinking water tremendously. In effect, improved access to safe drinking water will improve the socio-economic status of the population by reducing their medical bills on diarrheal illnesses and improving their health status.

Figure 2.1 shows a summarized schematic illustration of the different aspects and how they fit together in the adoption of GDM filters.

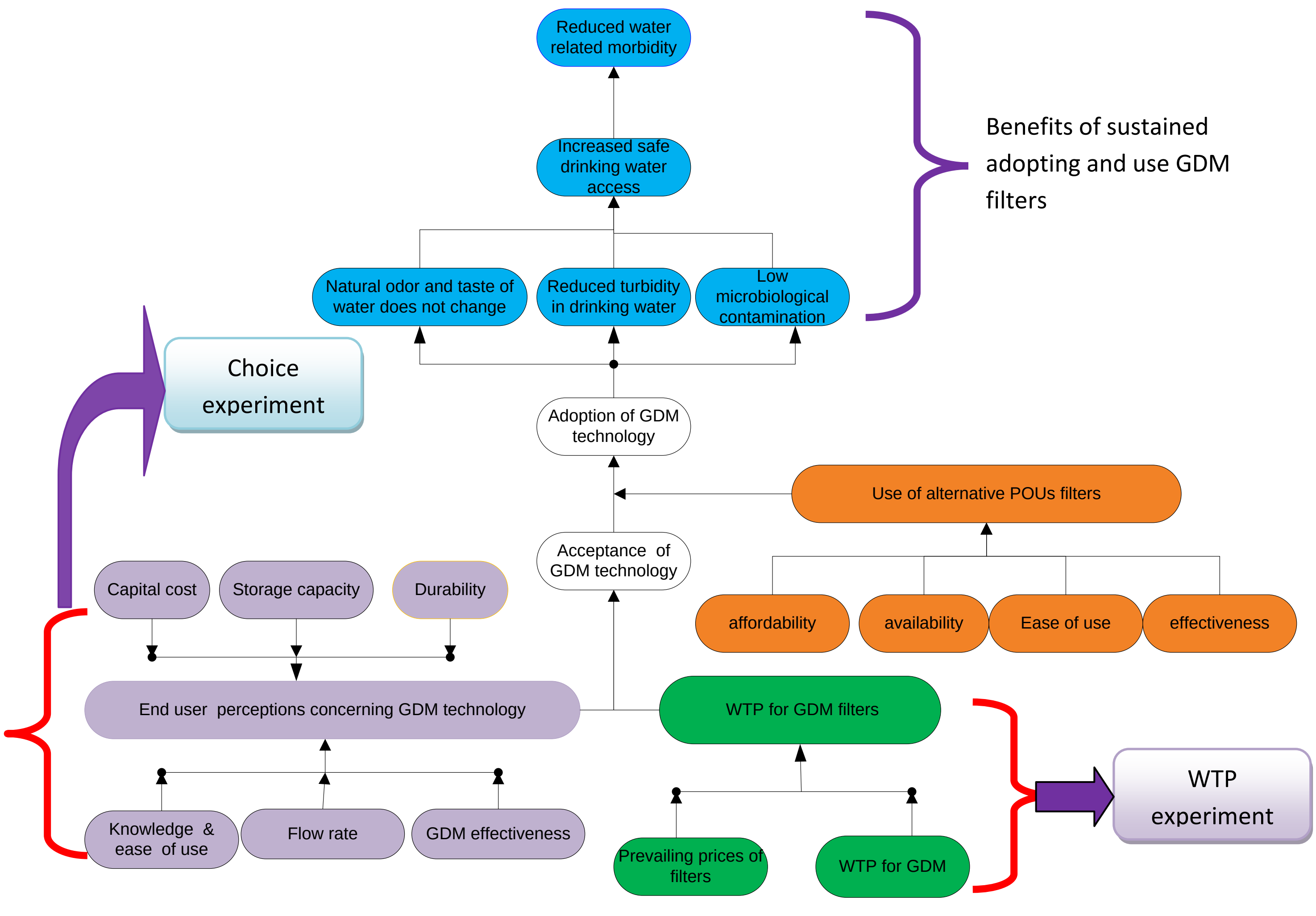


Figure 2.1: Schematic representation of the concept interaction in the use of GDM technology

2.3 Review of POUs for portable water in Kenya

To ensure that all its citizens have access to safe drinking water, the Kenyan government, development partners and other stakeholders are trying to connect as many consumers as possible to the central water system which is chlorinated and therefore 'safe' for drinking. This system has however been painfully slow to reach significant number of people especially in the rural areas where the cost of such installations are prohibitive and the returns on such investments are not fast enough to cover the costs (Peter-Varbanets, et al., 2009). From the housing and population census in

2008, only 16% were covered by the year 2009 (figure 1.2) by the central pipe water system (GoK., 2009) implying that the biggest population get water from other sources that are not automatically chlorinated and are potentially unsafe. Even for those who have access to the central system, research indicate that in some places of Nakuru town for instance, the biological water quality does not meet the levels of drinking (Kiruiki, et al., 2011). Also, services from the central system are not reliable and people have to rely on other sources which may not be safe. POUs become therefore very vital.

Even though a wide range of HWTS or POUs exists in Kenya, a large number of people boil drinking water (table 1.1). This method is unsustainable because it is energy intensive, there is potential for recontamination and causes indoor air pollution and associated health risks[6] (Peter-Varbanets, et al., 2009, Sobsey, 2002). Also spore forming pathogens may not be killed by heating water. Furthermore, water turbidity and taste concerns make its use among people not preferable.

Another method is SODIS which utilizes the heat of the sun and UV[7] rays to kills pathogens in drinking water (Meierhofer and Landolt, 2009, Peter-verbernets, 2010). Even though the method is cheap and easy to use, its application is limited by the number of sunshine hours and the availability of the bottles. Water turbidity also limits people using them and it's therefore not good for people using turbid water sources like rivers, lakes and springs.

Chlorination and combined flocculation & disinfection is widely used in Kenya (Luoto, et al.). This is because of the wide marketing and heavy subsidization of these products sometimes by international NGOs including WHO, UNICEF and Population Service International (PSI). Though very effective for treatment of contaminated water, these consumables are bought in small quantities making their use irregular (Albert, et al., 2010, Ashraf, et al., 2010). They also change the taste and smell of water and some people fear additional addition of chemicals in the water. This has greatly limited their use.

Filters on their part are increasingly penetrating the Kenyan market. The most common used filters are the ceramic filters[8] (figure 2.2 c). These are made from molded clay but impregnated with silver lining to disinfect microbes (Bielefeldt, et al., 2009, van Halem, et al., 2009). They can be locally produced and are relatively cheap. Ceramic filters are basically used the same way as the ceramic candle filters (figure 2.2 a). These types of filters can be made locally and their prices are relatively affordable to the target population. However, these filters are ineffective in removing viruses (Albert, et al., 2010, CDC and USAID, 2008), have a low flow rate, are fragile and need regular cleaning. Also ceramic filters have a life span of only about one year.

[6] Mostly respiratory infections
[7] Ultra-violet rays are shortwave radiations which kill bacteria and other pathogens with sufficient exposure.
[8] Locally branded as chujios

Ceramic candle filter

b) Life straw filters

c) Ceramic filters

Figure 2.2: Types of filters used in Kenya.

Another filter used in Kenya is the life straw filter (figure 2.2 b) that is able to remove all pathogenic organisms from the water. Life straw filters have very high flow rates but they do not have any water storage system. They need regular cleaning and have a life span of about 3 years. Though expensive, life straw filters are being distributed for free in Kenya by PSI and other NGOs[9].

Even though there is a growing number of POUs in the Kenyan market, studies done in Kenya indicate that many people prefer the use of filters to consumables like chlorination products because filters provide a platform for consistency in use because they are durable (Albert, et al., 2010) or because use of filters does not include chemical addition in water (Albert, et al., 2010, CDC and USAID, 2008). Figure 2.3 indicates results of the study in Nyawita (rural poor village in western Kenya) showing the preference for candle filters is more than the PUR or chlorination even though they are more effective than the candle filters. Also a recent study done in Dhaka-Bangladesh to assess the type of POUs consumers use indicated that the use of filters is significantly higher than the use of aqua tab, water guard and PUR because of the perceived residual chlorine smell in the drinking water (Luoto, et al., 2011).

[9] Organizations apply for carbon credit from the carbon market which is used to finance free life straw distribution.

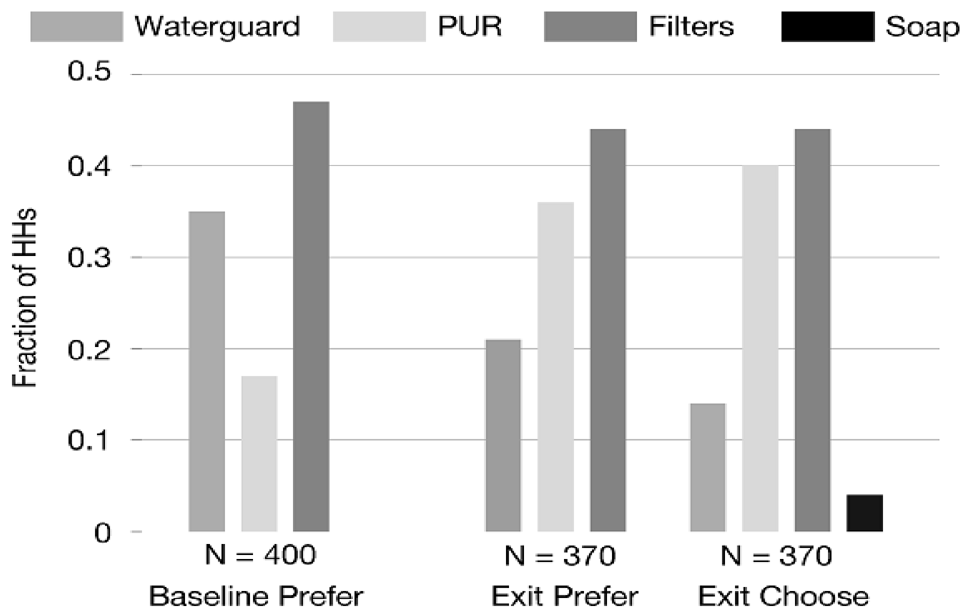


Figure 2.3: The reported preferred usage of different POUs in western Kenya. Source Albert et al (2010)

Even though there are several POUs in the market to reduce the consumption of contaminated water, high sustained adoption of these technologies has remained elusive especially among the poor households (Albert, et al., 2010). There was an attempt to rank the POUs based on their microbiological removal efficacy and their health benefits with the aim of recommending best technologies (Sobsey, 2002) but this has not translated into the adoption of the technologies by the Bottom of Pyramid user (BoP). It is therefore important to consider user perceptions based on POUs characteristics to inform policy makers and the industry on the best characteristics that need consideration in the design any POUs to increase the acceptability of POUs made by the target population.

2.4 GDM technology and its applicability in the study area

2.4.1 From membrane technology to GDMD technology

Water treatment has been done by membrane filtration but ultra-filtration (UF) (figure 2.4) membrane are preferred for drinking water because they have pore sizes that are small enough to ensure high-log removal of micro-biological water contaminants, particulates, protein, yeast, macro-molecules and colloids (Peter-Varbanets, et al., 2010) Unlike ceramic filters, GDM also removes viruses (Peter-Varbanets, et al., 2009, peter-verbenets, et al., 2011).

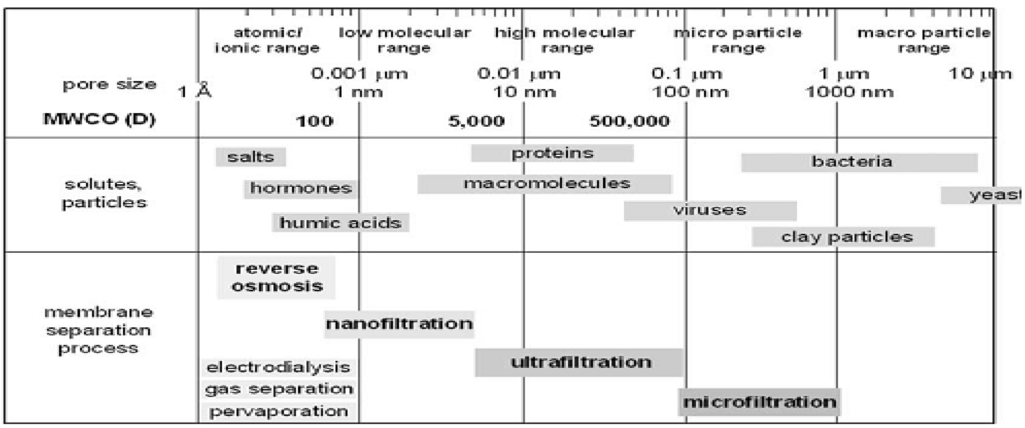


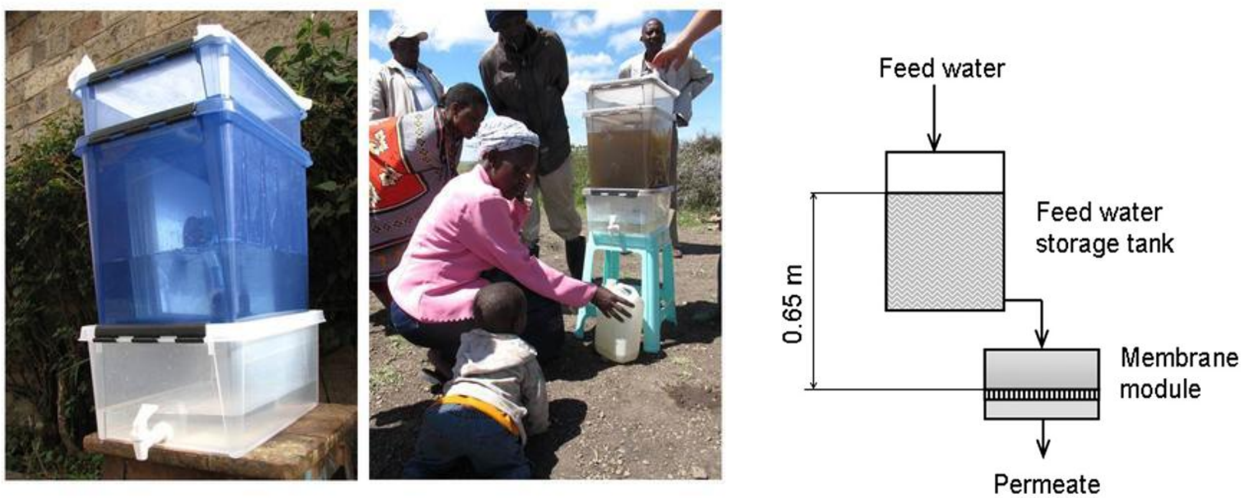
Figure 2.4: Filtration membrane sizes and their corresponding molecules that can be filtered Source: Maryna peter-verbanenets.

Filtration process needs a driving force of water to pass through the small pores. Such driving forces can be generated by pressure, electricity or gravity of the moving water (Peter-Varbanets, et al., 2009, Peter-verbernets, 2010). For small scale household water treatment, use of electricity or pressure would prove expensive especially among the middle income and lower income groups of society.

This makes GDM a viable alternative. Figure 2.5 a) shows first[10] protype of GDM filter that has been developed and is being tested in Kenya. The prototype has a cloth to remove large particulates and can be cleaned from time to time. It also has a feed-water-tank in which UF membrane filters are located. The mebranes are arranged vertically with awater collecting tube in-between to collect the filtrate (clean drinking water). The filtrate is then collected in a clean water tank thant has a tap.

[10] Second generation prototype(on the cover page) is still been designed and will also be tested in Kenya

Figure 2. 5b) indicates a schematic representation of the GDM prototype. Operated at a prssure head between 10-65 cm, enough pressure can be generated by gravity to eneble ultra-fitrattion.



a) b)

Figure 2.5 a) Membrane prototypes being tested in Kenya and b) Schematic presentation of the dead-end UF system. Source: Maryna peter-verbanets.

2.4.2 Operation and application of GDM

Generally, poor water quality reduces flux stabilization value. However, flux stabilization occurs in UF except when antifouling agents are added to water. Increased Total organic carbon (TOC) and a decline of Dissolved Oxygen (DO) to less than $1mgl^{-1}$ for instance reduce flux value when water passes through a filter (Peter-Varbanets, et al., 2010, peter-verbenets, et al., 2011, Peter-verbernets, 2010). Also, turbidity greater than 600 NTU significantly reduces the flux (Boulestreau, et al., 2010).

GDM technology opens a new era in HWTS systems because its design and application presents a host of advantages. To start with, GDM is durable (lasts 7-8 years with continuous uninterrupted use) based on the filter life span. In this regard, it is relatively cost-effective in the long run; a characteristic which could be attractive to many household users.

Also, with continuous use, GDM yields $4\text{-}6lh^{-1}m^{-2}$ which translates to ($98\text{-}124lday^{-1}m^{-2}$); enough for household drinking as recommended by WHO (Sobsey, 2002). Increasing the number of filter membranes increases the flow rate while reducing membrane filters reduces flow rate[11]. It does not have peripheral equipment; characteristic of conventional membrane filtration systems which presents huge operational costs (Peter-Varbanets, et al., 2009). It also does not need washing; back

[11] GDM filter design under testing by EAWAG has $0.5m^2$ of membrane filters and therefore is able to produce 50-60 litres per

flushing or chemical cleaning which otherwise could present additional operational costs and challenges especially for the Bottom-of-pyramid (BoP) users.

Further, GDM technology does not need pre-treatment of the feed water or post treatment of the filtrate; an operational requirement for some HWTS systems like SODIS, boiling and chlorination. This makes GDM easy to use and applicable for many natural surface water sources including rivers, boreholes, lakes, and springs and even dilutes waste water.

Literature reviewed in section 2.4 presents a good technology that has benefits for society. However, the implementation of this technology in Kenya will depend on the value the target population puts on it. The following section introduces the technique that was used to determine what value people put on GDM.

2.5 Contigent valuation (CV)

This is an economic valuation of non-market goods and services i.e. goods and services that do not have a price even though they offer utility. CV is survey based Stated Preference (SP) method used to evaluate the value society attaches to environmental services like renewable energy (Abdullah and Jeanty, 2011, Ku and Yoo, 2010, Ward, et al., 2011), environmental goods (Seip and Strand, 1992), water (Al-Ghuraiz and Enshassi, 2005) and recently even medicine (Waka and Omoyeme, 2010). CV can also be used to estimate the net economic benefits of improved water services by calculating the difference between the WTP and the actual cost of the services provided (Gunatilake, et al., 2007)

CV basically involves asking people how much they are WTP to avoid certain risks posed by environmental degradation or for private goods that are not yet in the market. CV also involves asking people how much they are Willing-to-Accept (WTA) for the loss of utility caused by destruction of environmental services. Being a survey based method involving asking people about their WTP or WTA, CV differs from Revealed Preference (RP) method that involves valuation of environmental services by observation of actual buying and paying in existing markets for environmental goods and services or in parallel markets.

To elicit the appropriate responses from respondents on their WTP for non-market or quasi-public good, a hypothetical market scenario must be carefully formulated and described to the respondent making the WTP value 'contingent' to the described market scenario. The WTP or WTA value therefore depends very much on the formulated hypothetical market scenario. In this research, the WTP for GDM indicates the maximum amount households are willing to sacrifice so as to avoid drinking contaminated water that may result to high diseases burden.

Other methods for valuation that could be used in establishing the value of GDM could be simulation of the market through RP exercise in which GDM is actually sold to people at different prices and its value established (Ashraf, et al, 2010). However, this method cannot be used for GDM valuation presently because GDM is still under design.

CV is based on consumer theory which is based on forces of demand and supply in the market. Increasing demand increases prices while increasing supply reduces prices at the same demand. Consumers choose goods that provide maximum satisfaction (utility). Overall utility has two parts i.e. direct and stochastic utility expressed as;

$$U_n=V_n+\varepsilon_n \qquad \text{eqn 2.1}$$

Where U_n is the overall utility, V_n is the direct utility which is a function of price (P), income (Y), demographic factors (S), and level of provision (Q). ε_n is the stochastic utility that is not observed and varies from individual to individual (Bateman, et al., 2001).

An individual exposed to any CV study has to choose between the level of provision of the good i.e. at level Q^0 (same level) or at an improved level Q^1 (Abdullah, 2009). For all positive WTP values reported, $Q^1>Q^0$. From eqn 2.1, this can be expressed as;

$$U_n=V(Y, P, S, Q^1) + \varepsilon_n > U_n=V(Y, P, S, Q^0) + \varepsilon_n \qquad \text{eqn 2.2}$$

To improve the level of provision from Q^0 to Q^1 households have to pay (C) for such improvement from their income Y i.e. Y-C. This is the maximum WTP for the good but is always limited by income and is a function of different factors. Households that have a positive WTP will have C more or equal to zero. Abdullah (2009) called C the bid used in CV.

$$0\leq C=C(Y, P, S, Q^0, Q1) =WTP \leq Y. \qquad \text{eqn 2.3}$$

The application of this bid function was not done in this study because WTP elicited using payment card is taken as that of open ended elicitation format and therefore does not depend on probability (Brouwer, personal communication)

2.5.1 Review of WTP studies for HWTS

In spite of the great interest on commercialization of HWTS in developing countries, there not enough literature on the WTP for these HWTS. However, Hastler, et al (2005), used CV and CE to estimate the non-marketed benefits of protecting ground water resources as compared to purifying ground water for drinking purposes. In the survey Double bound dichotomous choice was used for as the elicitation means for CV.

In another study, Yoshinda and Kenai (2007) compared the WTP for drinking water quality using averting expenditure method and CE. This study established the WTP for averting use of chlorine and tryhalomethane in drinking water. (Yoshinda and Kenai, 2007)(Yoshinda and Kenai, 2007)

2.5.2 Why CV valuation?

Just Like public or quasi public goods lack prices for market based valuation; GDM filters have not been in the market before, lack price and cannot be valued by conventional market systems which use prices. However to understand the value end-users attach to drinking water treatment and by extension to drinking safe water, it's necessary to attach value to GDM to inform policy makers on the available demand for sustainable provision of the technology. Also, CV helps in appropriate design of prices and subsidies based on the value the target population is WTP. Further users can acknowledge the value goods that do not prices have in their lives (Abdullah, 2009, Waka and Omoyeme, 2010).

Furthermore, in determining whether society will be better off with GDM filters, a cost benefit analysis needs to be done. To do this, the cost of production and distribution of GDM can be calculated. However, the benefits of this GDM to society cannot be quantified if there is no mechanism of getting the total value (TV) of GDM. To evaluate the TV both use value (UV) and Non - Use value is (NUV) of GDM needs to be evaluated. The UV of GDM includes treatment of water to avoid water related diseases, while the NUV include all the positive externalities of having GDM for water treatment. NUV can vary from society to society but generally include the social standing of having a functional water treatment system and the health benefits of not being the source of water borne diseases. These benefits (value) does not have recorded characteristics and can't be determined directly by Revealed Preference (RP) (Abdullah, 2009).

2.5.3 Elicitation formats in WTP

In WTP studies, there are several formats of eliciting responses from respondents. These include open-ended format, single bound dichotomous choice (SB - DC); One-and-half bound dichotomous choice (OHB-DC), Double Bound Dichotomous Choice (DB-DC**)**, iterative bidding game and payment card format. (Abdullah and Wilner, 2011, Ku and Yoo, 2010, Seip and Strand, 1992, Waka and Omoyeme, 2010, Whittington, et al., 1990, Yusuf and Adnan, 2005).

For the open ended format, respondents are simply asked how much they are WTP for a particular good. This method has been criticized because the respondents commonly display strategic behavior (free rider) i.e. their WTP value is much less than their actual WTP value because they know other people will pay for the good and they will continue using it. Strategic behavior is especially high if the good in question is a public good that is non-excludable and non-rival.

In SB-DC; a closed ended questionnaire in which respondents are asked if they are WTP a certain amount for a product with the bid values varying across respondents is used (Cooper, et al., 2002). This elicitation format has been inefficient because the results are based on the bid that is selected (bid selection bias). If bid selection is poor, the results will not reflect the actual WTP value of the respondent. Further, this elicitation formats produces so many non-responses and protest zeros because it's difficult for respondents to put a value on something whose price has never been seen before in the market. For instance if people are asked how much they are WTP for conservation of a forest, many people will find it difficult to answer because they cannot put prices directly to services provided by the forest even if they are beneficiary of forest services.

In DB-DC (an improvement of the single bound format), respondents are asked using a closed questionnaire consisting of a yes or no initial and follow up bid questions (Abdullah and Wilner, 2011, Al-Ghuraiz and Enshassi, 2005, Ku and Yoo, 2010, Seip and Strand, 1992, Waka and Omoyeme, 2010). Based on the first answer, they are either asked if they are willing to pay higher value (if the initial value is a yes) or pay lower value (if the initial value is a no). This method is more robust against poor selection of the initial bid (Cooper, et al., 2002).The second set of question comes as a surprise as the respondent is not told in advance. The responses are recorded as yes-yes, yes-no, no-yes and no-no. Some respondents may refuse to answer the asked questions. These are treated as protests which are recorded separately with the reason for protests. Though widely used, this format has been criticized because the response of the second bid may be inconsistent with the first bid and the prevalent problem of "yea saying". Also it requires a large sample size to reach same level of precision as payment card (Cooper, et al., 2002).

In iterative bidding game format, the interviewer changes the bids either higher or lower from the initial bid until the respondent's exact WTP is achieved. This method helps get the WTP of the respondent as the respondent is given the chance to reflect on the value of the good (Wattage, 2000). Application of this method is however also limited due to the starting bid bias. Also people tend to get tired or take the survey less serious and so there is a lot of yeah saying.

2.5.4 Payment card format

This method is proving to be an increasingly efficient way of eliciting WTP from respondents (Abdullah, 2009). It is gaining increasing application than the open ended, or the single bound dichotomous choice methodology (Waka and Omoyeme, 2010, Wattage, 2000). It maintains the characteristics of open ended questioning while at the same time increasing the response rate by providing visual aid on which many bids are exponentially distributed.

Increasing the number of cells (bids) for a range of values (exponentially) in a CV narrows down the range within which individual WTP value falls - this increases efficiency of payment card (Kerry, 2000). This is because for people whose actual WTP is low, small differences in the values on the payment card (bid ranges) has a significant implication on the income. This is not so for those people whose income is high and therefore whose WTP is significantly high.

This method presents different values to the respondents which indicate the different points on the demand curve. By giving a wide range of values, the bias of starting bid is significantly reduced and offers the respondents a contextual format of valuation other than open valuation offered by open ended format (Wattage, 2000).

Payment card has several methodological biases that may undermine its usefulness in practical application. These methodological biases and how they were minimized in this study are discussed below.

- Starting point bias - this bias occurs when the starting point bid is too low or too high than what the respondent expects. The result is that researcher gets either too high or too low values thus so many outliers. Abdullah (2009) argues that a symmetrical and balanced design of the CV will reduce this bias. The design of this study had many bids with well distributed bid ranges. This was aimed at reducing this bias.

- Strategic bias - occurs when respondents give low WTP values than the good or service is actually worth to them hoping that others are going to pay for it and they will free ride. This is common with public goods where excludability in use is not possible. This was not possible for this research because GDM was presented in the hypothetical market design as a private good that is excludable and competitive.
- Number of cells - In this research, the starting bid was Ksh 0 and was distributed up to more than. Ksh 15000. Further, the design included 36 bids that were balanced. This provided a large range for a starting bid to have significant effect on the final outcome. It's argued that a higher number of cells or bids displayed on a payment card, may be confusing to the respondent (Cooper, et al., 2002). However, an experiment in which three different cell numbers were used to determine the difficult of answering based on the number of cells of the payment card was carried out by Kerr, (2000). Results indicated that respondents did not have significant difficulty in answering when cards had more cells in them (Kerr, 2000). Also this researcher could not find literature that specifies the number of bids to be used in such a research.

2.6 Choice experiment

Using the choice experiments (CE) methodology, product choices with a wide range of variable characteristics are modeled, not just estimating the WTP for single product (Ku and Yoo, 2010) but also estimating the marginal WTP for each of the characteristics of a product. This is because consumers derive utility not from the product but rather from the different attributes that the products provide (Birol and Das, 2010). Changing the characteristics or attributes of GDM can therefore elicit the choice of respondents on GDM based on the best characteristics of GDM that increases consumer's utility. The theory underlying choice experiment is the discrete choice theory which assumes that;

- Decision makers make a choice among different alternatives goods that have different attribute (characteristic) levels.
- Utility maximizing behavior is probabilistic in nature i.e. rational individuals will select the best alternatives to maximize their utility (Abdullah, 2009).

An individual's (n) utility (U) would therefore be defined by the number of alternatives present (j), i.e.

$$U_{nj}, \text{ where } j=1...j. \qquad \text{eqn 2.4}$$

Abdullah who cites McFadden (1986) further argues that this total utility has two components i.e. deterministic part (V_{nj}) that can be measured by the observer and stochastic part (ε_{nj}). The total utility of an individual n can therefore be expressed as

$$U_{nj} = V_{nj} + \varepsilon_{nj} \qquad \text{Eqn 2.5}$$

The deterministic part of the decision makers' utility is a factor of the GDM attributes levels of storage capacity, time of treatment, effectiveness and price. The stochastic part of decision maker's utility has no influence because it varies between individuals and circumstances. When presented with different options, a decision maker will make the choice that maximizes utility. Assume that the choice is m then the choice can be expressed as a probability when utility of m is greater than the utility obtained by j i.e.

$$P\,(V_{nm} + \varepsilon_{nm} > V_{nj} + \varepsilon_{nj}) \qquad \text{eqn 2.6}$$

Further (Carlsson and Martinsson, 2008) argues that a linear random utility function can be assumed. From eqn 2.4

$$U_{nj} = V_{nj} + \varepsilon_{nj} = \beta\alpha_j + y\,(I_n - C_{nj}) + \varepsilon_{nj}, \qquad \text{eqn 2.7}$$

Where α_j = vector attribute of alternative j, β = corresponding parameter vector, I_n = income, C_{nj}= cost associated with alternative j, y =marginal utility of income, ε_{nj} = the error term

Given the eqn 2.3, It's possible to model the marginal WTP for any attribute of GDM by calculating the ratio between attribute coefficient and the price (Abdullah, 2009, Carlsson and Martinsson, 2008).

This research was however restricted to qualitatively evaluating the effect of varying characteristics of GDM (storage capacity, flow rate of GDM, effectiveness of GDM expressed as the diarrhea prevalence and the purchase price of GDM) on the choices that end-users make.

2.7 Chapter Summary

There are different water treatment methods in use in Kenya. Continuous utilization of these POUS cannot be guaranteed because of the individual disadvantages associated with each. However boiling and chemical water treatment in Kenya is still the most popular but its use is irregular. The use of filters is gaining popularity because they are durable, have no residual chlorine in drinking water and offer the possibility of regular use. GDM entry into the scene brings with it a host of advantages including; high effectiveness, high durability thus cost effective in the long run, and easy to use. GDM is a promising invention that could increase access to portable water in LIC.

CV is a good method for valuing GDM as its able to capture both the use and non use values of GDM, it's able to assess the value people associate with drinking clean water, and because there is no information about GDM in the market meaning a hypothetical market has to be created. Among the different elicitation techniques used in CV, DB-DC and payment card methods are the most popular because with careful design, they give reliable results. Though there are biases and limitations of payment card methodology, the researcher in the design tried as much as possible to minimise the effect of these design limitations.

Choice experiments are based on discrete choice theory and can be used in determining the utility and the marginal WTP the decision maker gets from each of the different characteristics by modelling the linear random utility of each of the characteristic of the good in question. However, this research was limited to the qualitative description of the effect each characteristic has on the choice of the GDM. Having outlined the theories underlying this research, the next chapter introduces the methods and approaches used in designing the research and how the research was executed.

Chapter three

3.0 **RESEARCH APPROACHES AND METHODOLOGY**

3.1 Purpose

The objective of this chapter is to present a brief review of the socio-economic characteristics of the study area, discuss methodological theories used in this research and describe the research approaches used. Section 3.1 presents the context of Nakuru County in terms of its socio-demographic characteristics. Section 3.2 presents the study design by describing the sampling frame, sample unit and sampling procedure used in this study. Section 3.3 presents the design of CV and CE used. Descriptions of CV design presented include the description of hypothetical market scenario setting, design of payment card for data elicitation and its relevance. In this section also, CE design is described especially the making of choice attributes. Section 3.4 discusses the focus group discussions that were held and the contributions the discussions had. Section 3.5 describes the structure of the questionnaire that was used during the research, and its significance in the overall research results. The last sections describe the role of pre-tests and pilot surveys that were carried out and the way survey was conducted.

3.2 Study sites: Nakuru County in Kenya.

Nakuru County (fig 3.1) is one of the 47 counties in Kenya. It is located in the Rift valley province of Kenya (between longitude 35° 28'E and 35°36'E and latitude 0°31'S and 1°10'S). The county covers about 7200 km^2 and borders Baringo, Kericho, Laikipia, Nyandarua, Narok, Kajiado and Kiambu counties.

Figure 3.1: Location of Nakuru County in Kenya: Source Nakuru district strategic plan 2000-2005

Generally, temperatures vary from 24-29 °C and the average annual rainfall is about 1000mm. The rainfall pattern is bimodal and this has an effect on the source of drinking water in the county.

During the rainy season water harvesting is prominent as the local leaders encourage such practices. Further several small dams have been constructed to act as reservoirs for water. Most of the people in Nakuru engage in agriculture especially wheat, potatoes, barley and livestock production. Of importance to note is the fact that many people are venturing into water vending business where they get river water and sell it, normally without treatment, to people in town especially in Njoro and Molo. This has been necessitated by drying boreholes and long dry spells believed to be caused by the continuous destruction of Mau forest complex; the biggest water tower in Kenya. Table 3.1 summarizes the socio-demographic characteristics of Nakuru County in relation to Kenya.

Characteristics	Nakuru county	National level
Total population (2008)	1,630,934	38,610,097
%Rural population (2008)	53.1	67.2
%Urban population (2008)	46.9	32.8
Household number (1999)	327,797	4,489,890
Household mean size (2010)	5.0	4.2
Percentage Poverty levels (2002)	43	45.9
Population growth rate (2002)	3.4	2.2
Improved water source (2010)	57.7	60.2
Improved sanitation (2010)	27.0	24.3

Table 3.1: Socio-demographic characteristics of Nakuru County and National level Source: several; GoK, Abdullah S (2009), USAID and KEBS (2010) Nakuru district development plan (2000-2005), World development indicator.

3.3 Study Design

3.3.1 Sample frame and sampling unit

Sample frame is a list of all the study population from which a sample is drawn for analysis. The sampling frame for this study included all households in rural areas of Njoro who were using surface water for drinking. In Nakuru municipal district, the samplings frame included all households who had access to the piped water system.

Households were taken as the sample unit because in most cases all household members share a single drinking water source. Decision making on water treatment in a household is therefore made by the household head on behalf of all the household members. An attempt to get accurate numbers of households in a rural village from the local administration was not fruitful. When asked the total number of household, the local administrator said;

"They are so many, it's impossible that you can interview all of them"

The complete lack of information makes definition of sampling frame and the sample size difficult. However, some sort of a sampling frame could be made from the information given in Nakuru district offices (in November 2011) as indicated in table 3.2.

District	Area	Total population	Mean household number	Estimated number of households
Nakuru municipality	Kaptembwa	12937	4.8	2752
	Bondeni	94655	4.1	23084
	Shabab	17151	4.5	3897
	Kiamunyi	12183	3.8	3206
	Section 58	40045	4.0	10011
Njoro	Njoro	50750	5.4	9398
	Nessuit	13488	6.0	2248

Table 3.2: Demographic characteristics of selected areas in Njoro and Nakuru Municipality Districts (2005) Source: Modified from Nakuru district development plan data

3.3.2 Sample size

Calculation of the sample size is an important aspect of any research to improve precision and accuracy. According to Abdullah (2009) who cited Salant and Dillman (1994), several factors need to be considered when calculating the sample size including;

- The population size (in this case the number of households in the area)
- The sampling error that is required in the survey
- The variation in the population with respect to the characteristic under investigation.
- Number of sub-populations that exist in the whole population based on the characteristic of interest.

The household number of Nessuit (table 3.2) was not reliable as it was based on information of 2005. For rural areas under study, only one sub-population was present i.e. those people using surface water. The margin of sampling error was therefore increased as doing so reduces the sample size effectively reducing survey costs (See equation 3.1).

To calculate the sample size for the surface water users, the formula proposed by International Fund for Agricultural Development (IFAD) for health research was adopted i.e.

$$N = \frac{t^2 \times p(1-p)}{m^2} \qquad \text{Equation 3.1}$$

N = required sample size
t = confidence level at 95% (standard value of 1.96)

p = percentage of people expected to use GDM at a given price (0.5)
m = margin of error of 8%

P was assumed to be 50% because as a conservative number for the worst case scenario, it yields the highest sample size. Although, this margin of error was considered relatively high, research budget constraints could not allow reducing the margin of error.

For urban areas;

$$\mathrm{N} = \frac{1.96 * 1.96 * 0.5(1-0.5)}{0.08 * 0.08} = 150 \text{ households}$$

For rural areas,

$$\mathrm{N} = \frac{1.96 * 1.96 * 0.5(1-0.5)}{0.08 * 0.08} = 150 \text{ household}$$

In summery 300 households were used as the sample size; half in urban areas and the remaining half in rural areas.

3.3.3 Sampling method

Household interviews were done in two locations; one rural (having surface water source users') and the other urban (having use tap water users'). To get information from different economic categories of people, three different urban areas were randomly selected from each of the economic categories represented in table 3.3. After random selection, Kaptembwa represented low income areas, Shabab represented mid-income areas and section 58 represented high income areas (see table 3.3). The three areas in urban areas were pooled together to form a single sampling area.

Economic categories of residential areas	Low income	Mid income	High income
Areas	Lungalunga Kaptembwa Free area Baruti Kapkures Mwariki Ponda Mali	Shabab Manyan Viwandani Nakuru national park Lanet	Section 58 Milimani Kiamunyi

Table 3.3: Economic classification of residential areas in Nakuru municipality: source: Focus group discussions with NAWASCO.

In rural areas, the first selection was based on the drinking water source. Areas that have exclusive use of surface water were selected. Although surface water is used in areas like Kihingo, Mau Narok and Njokerio, it was only in Nessuit where a substantial population of surface water users could be found. Nessuit was therefore selected as the other survey site to represent rural areas.

3.4 Design for CE and CV

3.4.1 Design for CV

To elicit a response on the WTP for GDM, a hypothetical market was created. According to Bateman (2001), for effective creation of a hypothetical market for public or private good in a CV, several elements should be considered key among them;

- Technical and political feasibility of the change - it's important to assure the respondents that whatever they being asked to value is both beneficial to them and is working technically. With a solid knowledge of the working of a good or service being valued, a correct WTP value can easily be elicited. In this study, the working of the GDM was described to the respondents and advantages of using GDM explained in detail. Basic facts of GDM including its durability, effectiveness in removing bacteria, viruses, protozoa and reducing turbidity, water sources that can be treated, flow rate among other characteristics were explained to the respondents in the simplest terms poosible.
- Who is expected to pay for the change - Some policies involve state actors, financial institutions NGO's or public - private partnership (PPP) as implementers. For such policies, often the public will inflate the WTP values especially if they have to invest little but are sure of the benefits of such ventures (free rider problem). Respondents are forced to assess their WTP value and may give a realistic value if they are responsible for implementation. In this study, respondents were specifically told to consider their income when stating the maximum WTP for GDM. This left no doubt as to their financial involvement in acquiring a GDM filter.

Other important aspects to consider are institutional structure involved in the implementation of the policy that is being valued and the time of implementation. Because most of the POUs in Kenya are sold on the market, this study was done on the assumption that respondents understood that these GDM will be implemented through the normal market institution with only a-one-time payment system. Time of implementation was not considered at all as this is a private good whose costs are not very big and whose implementation only requires a decision by the household head.

The design of CV had two parts. The first part asked for the maximum[12] WTP for GDM for a standard filter. The question was framed thus:

"if you would be given the opportunity to purchase a standard outfit of a filter with storage capacity of 10 litres, a filter that takes 15 Minutes to filter one litre of water and reduces the number of cases of diarrhoea in your household on average from, four times per child per

[12] Results are presented as WTP values but not as maximum WTP values to avoid ambiguity and repetition.

year to once per child per year, would you be interested to buy this filter[13]? And if so, what would be the maximum amount of money you would be willing to pay for this filter? Ksh................... "

Before the respondent answered, a payment card was shown from which he/she was asked to make choice. The payment card had 35 bids with options of don't know, zero and more than Ksh 15000, included. The payment card bids were designed exponentially. Initial bid ranges were Ksh 250 then it goes to Ksh1000 and finally Ksh 6000 (see annex 13). The second part was a follow up to distinguish between the types of zeros in the study. The question was framed thus:

"If you are not willing to pay anything, can you explain why not..?"

3.4.2 Design for the Choice experiment

Among HWTS, filters have similar basic attributes that define their functionality. For instance, most of them store water, have a flow rate, are effective in reducing water related diseases, last for a period of time and have a purchase price among other attributes. The utility that consumers get from these POUs is not therefore defined by these functionalities but rather by the different levels of these attributes[14]. Ceramic filters for instance only remove bacteria and protozoa from drinking water. This reduces diarrhoea prevalence to some degree but GDM removes viruses which reduce diarrhoea prevalence further. We can in this context say that ceramic filters are 'moderately' effective while GDM is 'highly' effective. CE is an effective way of distinguishing the effect of these different levels of attributes has in decision making as consumers make choices based on the levels of attributes that maximize their utility and also assign the WTP for each of the attributes.

In this research, the attributes and their corresponding levels (see annex 1) used in CE were generated by fractional factorial design that came up with 150 cards. This attributes of GDM used in the study include;

a) **Purchase price**

This is the amount of investment that a household needs to make to acquire GDM filter. This GDM characteristic is important because it helps evaluate the significance end users of GDM attach to the pricing mechanism of the GDM in relation to the other characteristics of GDM. Do people want free GDM or does price matter? Some POUs in Kenya (for instance life straw) are distributed for free but the effect of this free circulation on their use is yet to be determined. The capital expenses for

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[13] The first aspect of the first CV question asked people whether they would be interested to buy the filter. This means that only those people who were interested in buying the filter gave answers; thus all the WTP values were valid and usable responses.

[14] Attributes and characteristics of GDM has been used in this report interchangeably

GDM had five variations i.e. Ksh 2'000, 2'500, 3'000, 3'500 and 4'000. These variations were reached based on the expected GDM filter price of Ksh 3'000 which in this case is the median cost.

b) **Effectiveness**

This is the ability to remove pathogenic organisms from drinking water. Practically, this characteristic of GDM filters cannot be changed by design. However, this attribute is important because it helps assess the health risks prevention users attach to water treatment. Although all POUs remove pathogenic contaminants from drinking water by design, GDM removes all the pathogens making water safer than most POUs. The researcher found it difficult to communicate this information to end users. For this reason, diarrhoea prevalence as an indicator of water contamination was chosen because it has been established that contaminated water causes diarrheal diseases (Albert et al, 2010, Campbell and Campbell, 2007, Kiruki, et al, 2011, Mirza, et al, 1997)

Currently, there is a diarrhoea prevalence of 3.5 per child per year in Kenya relative to the world diarrhea prevalence of 3.2 per child per year (Morage and Ndingu, 2007). To make this characteristic easy to assess and to explain to respondents, the Kenyan diarrhoea prevalence value was averaged to 4 per child per year. Hypothetically, very effective POUs like GDM filters will reduce these incidences by 80% (Johnston R, personal communication). The prevalence will therefore be 0.8 per child per year which was averaged to 1 per child per year. Effective POUs will reduce diarrhoea incidences by 40 %. The prevalence will therefore be 1.6 per child per year which was averaged to 2 per child per year. Ineffective POUs will reduce diarrhoea by only 10%. The prevalence will be 3.6 per child per year which was averaged to 4 per child per year.

Based on this values, the effect of effectiveness of GDM on the choices the end users make was evaluated by having three levels of diarrhoea prevalence on the choice cards that the respondents were given i.e. four times per child per year, twice per child per year and once per child per year (table 3.4) .

c) **Storage capacity**

This is the amount of clean safe drinking water GDM system can store. This GDM characteristic was used to evaluate the significance users attach to storage of drinking water and the risk of recontamination. Some POUs like life straw have no storage and users have to filter the water every time they need to drink. The variations of this characteristic were 1 liters storage capacity, 5 liters storage capacity and 10 liters storage capacity (table 3.4).

d) **Treatment time**

This is how fast GDM filters water. It was used a measure of how long respondents are willing to wait before they can get safe drinking water if they have a filter. Practically, treatment time of GDM can be changed by varying the number of filters in the GDM housing case. This attribute was used to determine the significance end-users attach to the promptness of the filters to give safe drinking water. The levels of this characteristic are 1.3lh^{-1}, 2lh^{-1} and 4lh^{-1}. It was made clear in the introductory description of the GDM that the treatment time and storage capacity are independent of each other. During the pre-surveys, however, there was confusion between two attributes i.e. storage capacity and treatment time[15]. The levels therefore were 15 minutes, 30 minutes and 45 minutes (table 3.4).

Attributes	Diarrhoea prevalence	Flow rate (time taken to treat one litre of water)	Storage capacity	Price (in Ksh)
Levels of attributes	Once per child per year	15 minutes = (4 lh^{-1})	1 litre	2,000
	Twice per child per year	30 minutes = (2lh^{-1})	5 litres	2,500
	Four times per child per year	45 minutes = (1.3lh^{-1})	10 litres	3,000
				3,500
				4,000

Table 3.4: Different attributes of GDM and their corresponding levels used in the CE experiment

In each payment card, respondents were given two choices (options) of GDM each having different levels of attributes (See annex 12). Respondents had also the option of declining to choose any of the two options. This effectively means that the respondent likes the status quo without GDM filter in which price is zero, diarrhoea is four times per child per year, storage capacity is zero and flow rate zero.

3.5 Focus group discussions (FDGs)

In using the FDGs , this study aimed at getting a deeper understanding of the drinking water situation in parts of Kenya (specifically in Nakuru and Njoro), identifying the current methods of water treatment that people use and the characteristics of POUs that people value in the field. The FGDs were done between October 2011 and December 2011. There were four groups involved in the FGDs.

Nakuru water and sanitation (NAWASCO) staff – this group was engaged in November 2011. The discussion was focused on identifying the water service and sanitation provision in Nakuru municipality district. From the discussions, water services coverage in Nakuru is about 98% while

[15] During pilot surveys, it was apparent that flow rate and storage capacity was being mixed which prompted to change flow rate to treatment time as the appropriate indicator for flow rate.

sanitation services coverage is only at 30% (Njenga, personal communication). The discussion was also focused on the quality of water provided in the area. Further, from the discussions, the researcher was able to delineate the economic areas of Nakuru municipality district.

EAWAG/KWAHO staff - the discussion was done in October with staffs who are involved with SODIS and GDM in Kenya. Information gathered from these discussions helped identify important GDM characteristics to be used during the CE exercise. They also gave important information about the working of GDM, the POUs found in the market presently and where they are used in Kenya. From these discussions, the design of the study was discussed.

Local administration- this group included planning officers in the office of District commissioner of Njoro, the district officer, the chief and assistant chiefs of several sub-locations including Njoro, Njokerio, Nessuit and Shabab. This group gave information about the number of people in the administrative units to help define the sample frame, the water sources of their residents and the methods of treatment that exists.

Egerton university staff - these included researchers in Egerton University and a PhD student from University of Amsterdam (Netherlands). This group helped shed light on the demarcations of the area of study, the population sizes, sanitation situation, water quality and drinking water sources.

3.6 Questionnaire

3.6.1 Questionnaire administration

Face to face administration of interviews is probably the best method of administering questionnaires in LIC especially in rural areas where mail and phone services are probably non-existent or not working. Face to face administration is also relatively cheaper. These reasons formed the basis for choosing face to face as the most appropriate method of administering questionnaire in this study.

3.6.2 Questionnaire structure

The survey questionnaire had four sections. The first sections had a small introduction that sought to give direction to the interviewers and assure the respondent of the confidentiality of the information being collected. The introduction also sought the willing participation of the respondent in the survey. This section also sought general information from the respondent including demographic data, their sources of drinking water and its safety, sanitation, water treatment methods used and knowledge of the threat of drinking unsafe water. This section had both open ended questions where a respondent was allowed to give any answer and structured questions that restricted the respondents' answers. Annex 9 shows the whole questionnaire used in the study.

The second section of the questionnaire had the choice experiment exercise where the working and important characteristics of GDM that are distinguishable from other POUs were described in details to the respondents with the help of filter designs graphic (see annex 10). Further the variable characteristics of GDM (storage capacity, time it takes to treat one litre of water, diarrhoea prevalence and the purchase price were also described by the interviewers to the respondent using the filter description card as shown in annex 12. Using example card (annex 11), the interviewers described to the respondents how choices are made. This exercise was repeated until respondents were confident to make the choices on their own. This was followed by a test of the respondents' understanding using an example card. Respondents were then allowed make choices on five cards (making one block).

The results of section three was recorded on in a table as one shown in table 3.5

BLOCK	CARD NUMBER	FILTER OPTION		
		(A)	(B)	NONE OF THE TWO
	1			
	2			
	3			
	4			
	5			

Table 3.5: for recording of results from the choice experiment.

Section three had the CV part. Respondents were asked if they would be willing to buy a standard filter and how much they will be WTP for the standard filter (a filter which reduces diarrhoea in children from currently four times per year to once per time per year, takes 15 minutes to treat one litre of water, and has a storage capacity of 10 litres) as explained in section 3.4.1. Another follow up question was also asked for those who did not want to pay anything.

In section four respondents were asked to give their income. This included breakdown of family income sources to help elicit more reliable income figures. The number of household members earning income was recorded with their corresponding monthly income. Income from primary occupation, secondary occupation and other occupations were simultaneously recorded. Income from remittances, from borrowings, and agricultural activities were aggregated. Months of unemployment was also recorded to help calculate annual income.

The last part of the household survey was an informed consent form which assured respondents of voluntary participation and confidentiality of the information given. It also had space for the respondent sign so as to verify participation.

3.7 Pre-test, pilot study and survey implementation

This study included several pre-test[16] of the questionnaire. During these pre-tests, the questions were shown to decision makers (GDM group, supervisor, interviewers and some respondents in the field) to improve the quality of the questions. Questions that were not well formulated (grammatically or logically) were reviewed and improved.

A total of three pilot surveys were carried out in December 2011 (table 3.6). This was to test the pictograms (choice cards, filter design, example cards, filter description design); peripheral materials including the payment cards and the responses were analyzed to check the effectiveness of the survey materials. It was also meant to familiarise and test performance of interviewers in the actual field.

		Number of households interviewed		
Survey	Date	Town (Nakuru)	Rural areas (Njoro)	Total
1st Pilot-survey	17th -19th December 2011	45	45	90
2nd Pilot-survey	23th and 24th December 2011	30	30	60
3rd Pilot survey	14th and 15th January 2012	30	30	30
Final survey	3rd - 13th February 2012	150	150	300
Totals		255	255	510

Table 3.6: Summery of surveys done in Nakuru county (November 2011-February2012)

Results of the pilot study indicated that flow rate was only significant at $\alpha=0.1$ while storage capacity was not significant at all. This was interpreted to mean that either people did not care about the storage capacity when making their decisions or that the two characteristics were being mixed up by the respondents. This prompted changing the flow rate into time taken to clean one litre of water (after which the pictograms were also changed to represent the time). Flow rate of the filter was changed into 15 minutes (for 4 lh^{-1}) , 30 minutes (for 2 lh^{-1}) and 45 minutes (for 1.3lh^{-1}) Further, The pictograms of storage capacity changed from tanks to jerry cans which are the most widely used vessels of water storage of water form most households.

3.8 Study implementation

Implementation of this study was done from 20th -31st of January. Five enumerators were involved. Several random field visits and telephone contact were maintained to monitor the work of the enumerators as one way of quality control. Figure 3.2 presents a summary of the framework of methods and processes used during this research.

[16] A small number of people were shown the questionnaire for validity of the structure and questions

3.9 Summary

To summarize this chapter, the study was done in Nakuru Kenya, a county that has a better sanitation compared to the national average but whose access to safe drinking water is below the national average. The sampling frame included households in rural areas using surface water and urban areas using tap water. The study involved 300 households drawn from both rural and urban areas by multistage sampling procedure. In designing the CV, two important considerations (technical and political feasibility of GDM use) were used. Institutional setup for implementation of GDM was assumed. Payment card was used as the elicitation technique for CV which had a follow up question to determine the type of zeros. CE design was based on the different levels of GDM attributes. Two options and an option to choose the status quo were included for the respondents. During the study, focused group discussions were held to identify suitable attributes for GDM and to identify suitable sampling sites. Face to face administration of semi-structured questionnaires was done. The questionnaire had four parts with "warm up" questions preceding CE and CV questions. Financial questions were the last. There were several pre-tests and three pilot surveys done whose focus was to sharpen the survey instruments.

Having examined the approaches and procedures observed during this research in this chapter, the next chapter examines in detail the results of the research.

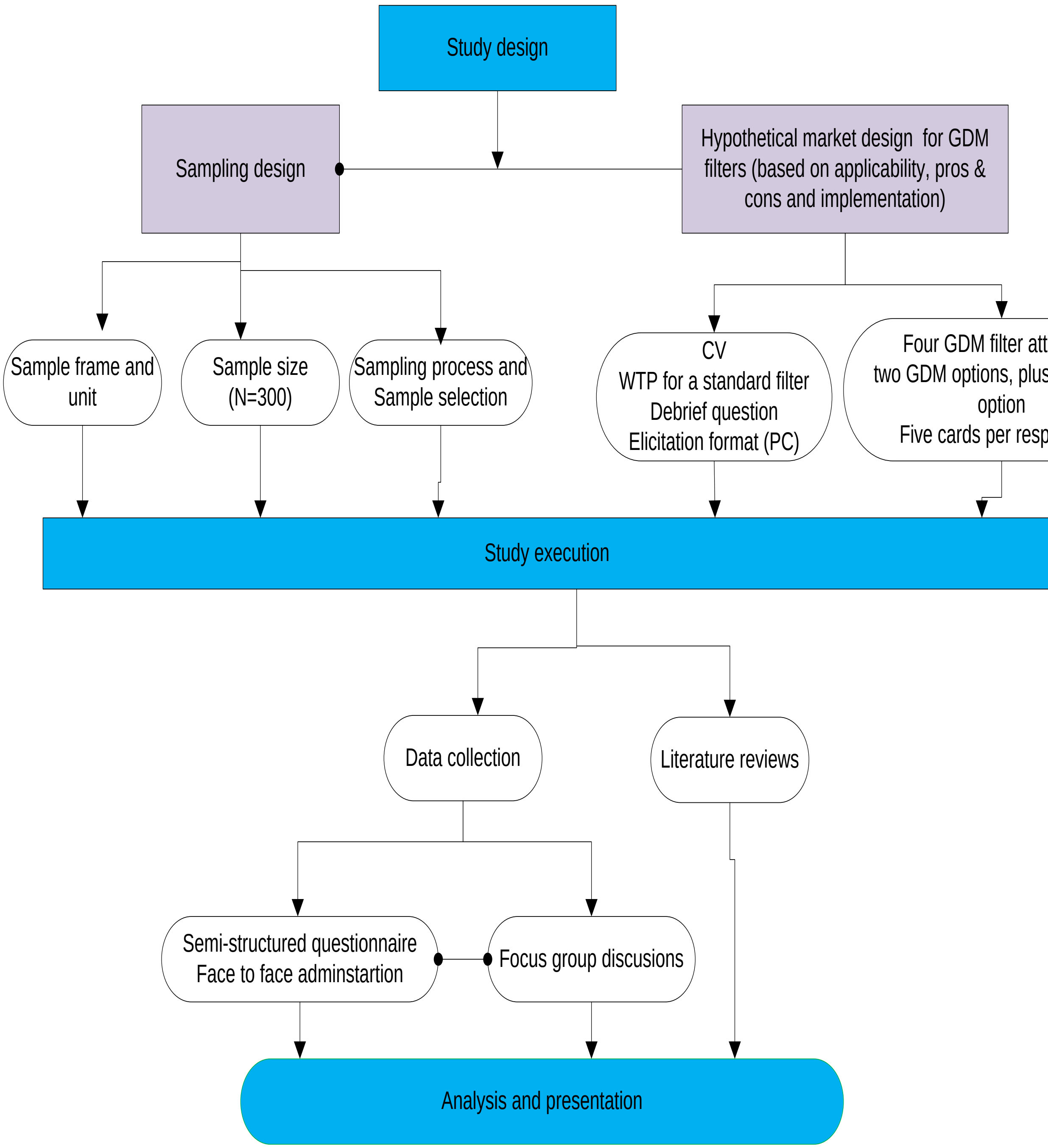

Figure 3.2: Schematic representation of the research methodology

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4.0 RESULTS

4.1 Introduction

Having presented the approaches and activities of the research process in the previous chapter, this chapter aims to present the data of the research exercise. This research exercise involved three pilot-surveys and a final survey based on the continuous changes of the household questionnaire, choice cards, filter description cards, example cards to make the survey tools more suited to get accurate results, only results of the final survey will be presented.

The second part of this chapter presents the summarized raw data of socio-demographic features of the study population including gender, education, sanitation and household sizes. This has been presented in a comparative manner between the urban and rural populations. Section 4.3 and 4.4 describes drinking water sources and treatment situation in Nakuru County. Section 4.5 and 4.6 describes the income and WTP in deciles for both the rural and urban populations. The last sections describe the relationship between income and WTP, demographic factors that affect WTP, and the characteristics of GDM important to decision makers.

4.2 Summary of demographic characteristics of the sample population

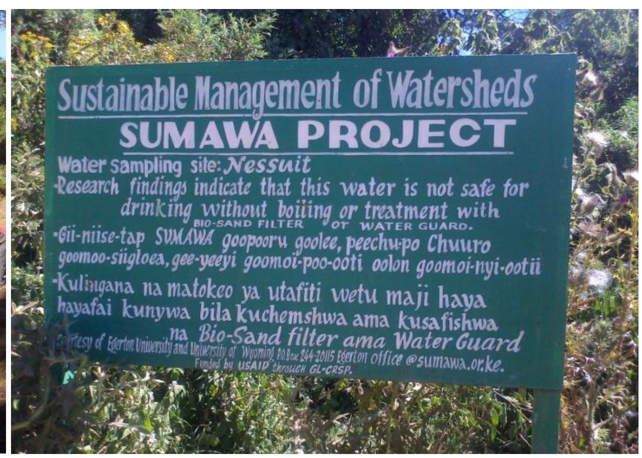
The research conducted in Nakuru County involved more females (56.3%) than males (43.7%) respondents. About 78% of the people interviewed were the household heads, 20% were spouses of the household heads and the remaining 2% were children of the household heads. Seventy-five percent of the respondents were below the age of 40 and the mean age of all the respondents was 30.9 years. More than 80% of the households are headed by men (annex 4). The mean number of years of education for adults is significantly higher in urban (13.4yr) than in rural areas (9.9yr); (P>0.001). The mean household size is significantly large in rural (5.7 members) areas as compared to the urban areas (4.3 members); (P<0.001)

Toilets (either connected to the sewerage or to the septic tanks) are only found in urban areas. The number of people in rural areas who defecate openly (without access to any form of sanitation) is high (12.7%). More than half (52.7%) of the population in Nakuru County use uncovered pit latrines (annex 4) as their sanitation facilities. For households who have children, respondents in rural areas reported a higher diarrhoea prevalence rate (23.3%) than in urban areas (6.9%) in a recall period of two weeks.

4.3 Water sources

Fifty two percent of people in Nakuru County use separate storage for drinking water. The rate is however high in urban areas (59%) than in rural areas (49.6%). Of importance to note is that in the study areas, there is no piped water system in rural areas and people rely mostly on surface water sources (streams, springs) and ground water for drinking and other household uses (annex 5). In urban areas there are only piped water sources (systems found in dwellings, in compounds and public taps) on which people rely for drinking water. About 10% of urban respondents rely on bottled water for drinking. But even among this group some still mix bottled water and piped water as a source of drinking water.

The mean amount of water households consume for (drinking purposes only) is similar for both rural and urban areas (4.0 liters per day) despite the significant difference in the family sizes (5.7 in rural areas and 4.2 in urban areas). In urban areas, a slight majority of people (52%) consider their drinking water source safe, not so for the rural population where 55.7 % consider their drinking water source unsafe. Reasons given for unsafe of drinking water varied by location: in urban areas people are mostly concerned about contamination of water (76.9%), whereas people in rural areas are concerned with contamination (50.6%), turbidity (38.9%) and both factors combined (3.9%) (Annex 5). Njoro River [17] normally contains highly turbid water. Also research findings by Sustainable Management of rural Watersheds (SUMAWA) project in the area indicate that the water is contaminated as it contains up to 3.6 and 244 MPN/ml of fecal and total coliform at the river source. This figure can be as high as 1880 and >2700MPN/Ml for fecal and total coliform respectively downstream of the river (Kiruki, et al., 2011) and should not therefore be consumed without treating it (figure 4.1b).



4.1 a) *4.1 b)*

Figure 4.1 (a) a man fetches water from river Njoro (b) public sign board warning people to not use the water without treating it first: source survey 2011.

The time take by people in rural areas to fetch water and come back is significantly higher in rural areas (29.1 minutes) compared to urban areas (4.5 minutes) (P<0.001).

[17] Njoro River and its tributaries is the main river where people get water for drinking in the study area. Nessuit is located in the upper catchments of the river

4.4 Drinking Water treatment

Even though a slight majority of the rural population believes the water they drink is not safe (52.3%), only 43.3% treat drinking water. On the other hand, the number of people treating water in urban areas is large (79.4%) among the urban population. Boiling and chlorination is by far the most popular methods of water treatment in the study area (74.7%). In rural areas few treatment methods are known. Treatment methods such as ceramic filters, ceramic candle filters and SODIS are totally unknown to the rural community (table 4.1)

Treatment method	Known			Used		
	Rural	Urban	Total	Rural	Urban	Total
Boiling	86	68.7	77.4	27.2	37.8	32.6
Chlorination	49.6	58.7	54.0	13.7	26.5	20.1
PUR	1.3	-	0.7	2.7	-	1.3
Decantation	-	5.3	2.7	-	-	-
Ceramic filters	-		-	-	-	-
Bottled water	-	-	-	-	10.0	5.0
Ceramic candle filters	0.7	9.5	5.2	0.7	9.1	4.9
Other combinations	-	6.5	3.7	-	2.1	1.1
Don't know	4.0	-	2.0	N/A	N/A	N/A
Don't treat	N/A	N/A	N/A	56.7	20.0	38.3
Percentage Total	100	100	100	100	100	100

Table 4.1 water treatment behavior in Nakuru County in percentages[18]

Even though bottled water is not considered a method of water treatment, five percent of people still use it as a safe drinking water source. Up to four percent of people in rural areas do not know any treatment method at all. Of those people who don't treat drinking water in rural areas, about half (41.8%) said it's because there is no need and no one has suffered because of drinking untreated water. For those people who don't treat drinking water in urban areas, about sixty percent think the water is already clean and therefore there is no need treating the water again.

4.5 Income and WTP of the study population

4.5.1 Income

The income indices used are monthly income, percapita monthly income and annual income. Calculation of percapita monthly income involved division of monthly income by the number of household members. Calculating percapita annual income involved dividing annual income by

[18] The totals are more than 100% because many people stated boiling and chlorination together and this had to be added on separate boiling and chlorination figures.

number of household members. To arrive at the household annual income the following formula was used

$$percapita\ annual\ income = \frac{total\ monthly\ income\ (regular) + total\ irregula\ income}{number\ of\ household\ members}$$

Note - The total irregular income included loans, grants, money from agricultural harvests that were irregular.

The income levels in Nakuru County are diverse. The mean monthly income of rural areas ($ 190) is significantly lower than the mean monthly income of urban areas ($ 950); ($P<0.001$, $\alpha=0.05$, d.f=298). Also the gap between the rich and the poor is much higher in urban areas (standard deviation of monthly income is $ 1,081) compared to Njoro district ($143). The lowest monthly income recorded in Nakuru municipality was $ 25 and the maximum recorded was $ 7,500. Table 4.2 shows the income of both the rural and urban households in Nakuru County in deciles. The richest ten percent of the urban population earns $ 1,125 monthly in the rural areas while in urban areas it was $ 7,500. The difference in income (monthly and percapita income) increases with the income deciles (table 4.2 and figure 4.3). The poorest ten percent in rural areas earn $ 50 in rural while their counterparts earn almost double the amount ($ 100). The median monthly income for rural population is $ 150 while in urban areas its $ 612

To give a little bit of insight into the spending capability of this population, percapita monthly income among the ten percent poorest urban population is double that of the rural population which the same as the monthly income is. Among middle income earners urban population has five times higher percapita income in rural although they have only three times higher monthly income than the rural middle income. Also the ten percent richest population in urban areas has ten times more percapita income than the rural area although their monthly income is only six times higher. Figure 4.2 indicates the percapita income deciles in Nakuru County. This means that although there may be money in the rural areas, the spending power is relatively low because of the family size.

Economic Deciles	Monthly income ($)		percapita monthly income ($)		percapita annual income($)		WTP ($)	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
10	51	100	13	25	126	289	6.3	6.3
20	78	138	16	48	180	570	9.4	12.5
30	113	188	21	66	239	871	12.5	18.8
40	125	375	25	112	310	1,500	12.5	25.0
50	150	594	31	156	375	1,994	18.8	31.3
60	188	863	38	188	450	2,495	18.8	37.5
70	229	1,231	43	250	526	3,484	25.0	37.5
80	275	1,613	59	328	780	4,852	25.0	43.8
90	338	2,350	78	543	1,033	7,310	31.3	56.3
100	1125	7,500	141	1,250	7,463	15,000	50.0	62.5

Table 4.2: Income and WTP[19] for GDM filters in Nakuru County

Further differences in monthly income exist in Nakuru municipality. A one way ANOVA analysis followed by a Bonferon analysis indicate that one neighborhood surveyed in Nakuru municipality (Section 58) has a mean annual income significantly higher than three other locations in Nakuru including Shabab (P<0.05), Lungalunga (P<0.001) and Manyani (P<0.05) but not significantly different from Kiamunyi (P=0.056)

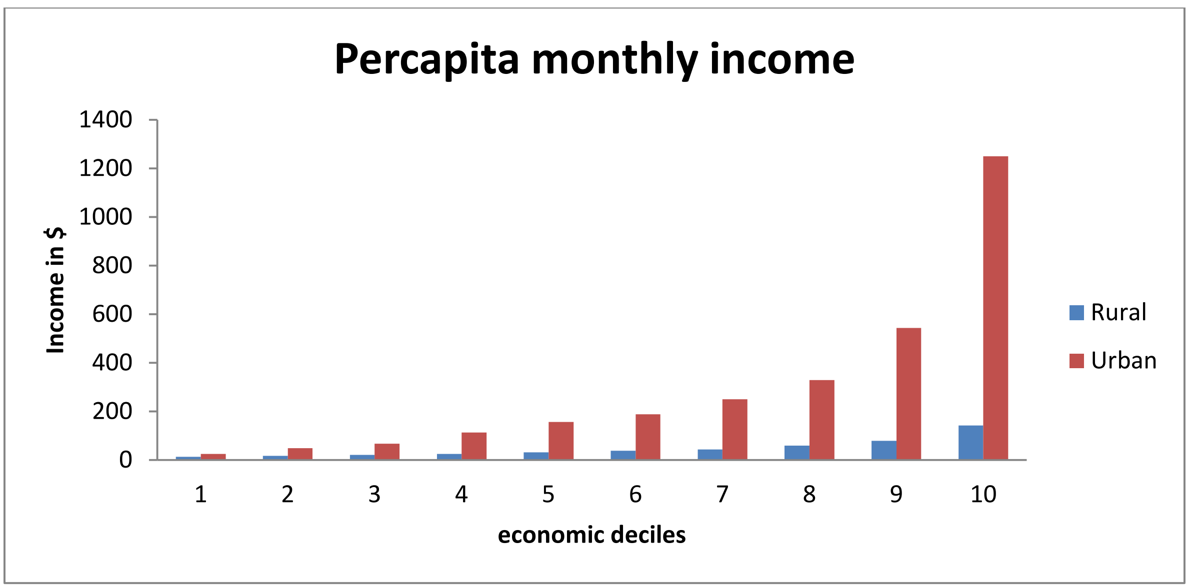


Figure 4.2: Percapita income for rural and urban population in Nakuru County. Source: survey (2012)

[19] 1$=80Ksh

4.5.2 WTP

The lowest WTP value reported for both rural and urban areas was $ 0 while the highest WTP values were $50 and 460 for rural and urban households respectively (see annex 8). The mean WTP reported for the urban areas ($ 30) was significantly higher compared to that reported in rural areas ($ 18; P<0.001; CI=95%) and the median WTP reported $ 19 and $ 31 for the rural population and urban population respectively (figure 4.3).

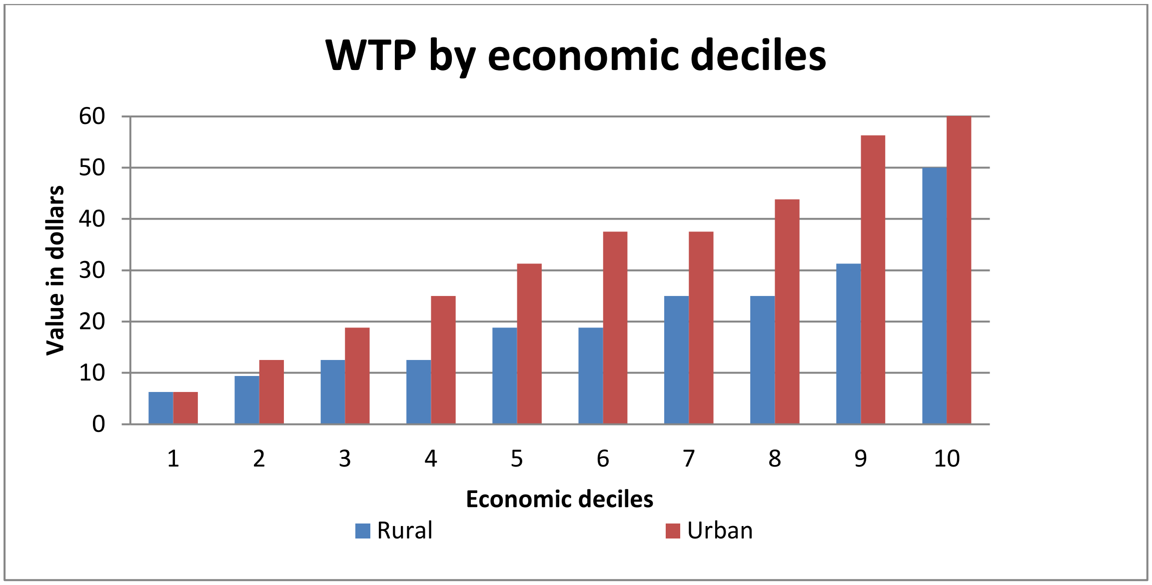


Figure 4.3: Willingness to pay for GDM in rural and urban areas in Nakuru County.

The first deciles of both rural and urban populations have similar WTP ($ 6) although the latter has double monthly percapita income of the former (table 4.2). In rural areas, the richest decile earns almost double the second richest decile and their WTP is almost double the second richest deciles group. In urban areas however, the richest decile earns triple the second richest deciles, but difference in their WTP is only $ 6 (table 4.2).

4.6 Relationship between WTP and demographic characteristics

4.6.1 Association between WTP and income and education

Pearson's chi-square test for maximum WTP and monthly income indicates that the two variables are indeed related strongly ($P<0.001$). Chi-square tests also indicate that education is strongly related to the income and by association to the WTP ($P<0.001$). This makes it difficult to say with certainty if variation in the WTP is as a result of income change or education changes. A three way cross table was used to determine whether income is related to the WTP with education used as a control. The Pearson chi-square test indicate that for people who did not go to school, had only adult education or had limited education up to primary level, there is no significant association between their income and their WTP ($P=0.617$, $P=0.86$ and $P=0.124$ respectively). However, among people who have finished secondary school, diploma colleges and university education, there is a strong association between the family income and the WTP for GDM filters ($P<0.001$, $P<0.001$ and $P<0.05$ respectively)

4.6.2 Regression analysis:

The linear dependency of two variables can be expressed by a regression equation thus;

$Y=\alpha+\beta X+\varepsilon$ eqn 4.1

Where; y is the dependent variable;

α is the point of intersection of the regression line at Y=0 (constant);

β is the slope of the linear regression;

X is independent variable;

ε is the standard error of estimates.

The null hypothesis in this case is

$H0:\beta=0$

$HA: \beta\neq0$

This means that if the slope β is significantly non-zero, we cannot reject the null hypothesis that WTP is not related to income. The closer β value is close to 1, the more the linear dependency and the close it is to 0, the less the dependency. A negative β value would indicate negative dependency.

Results indicate that the linear regression between WTP and monthly income for the entire population is highly significant (figure 4.6, equation 4.1)

$$Y=18.06+0.011X+0.84;\ F_{1,\ 298}=168;\ R^2=0.361\ P<0.001; \qquad \text{eqn 4.1}$$

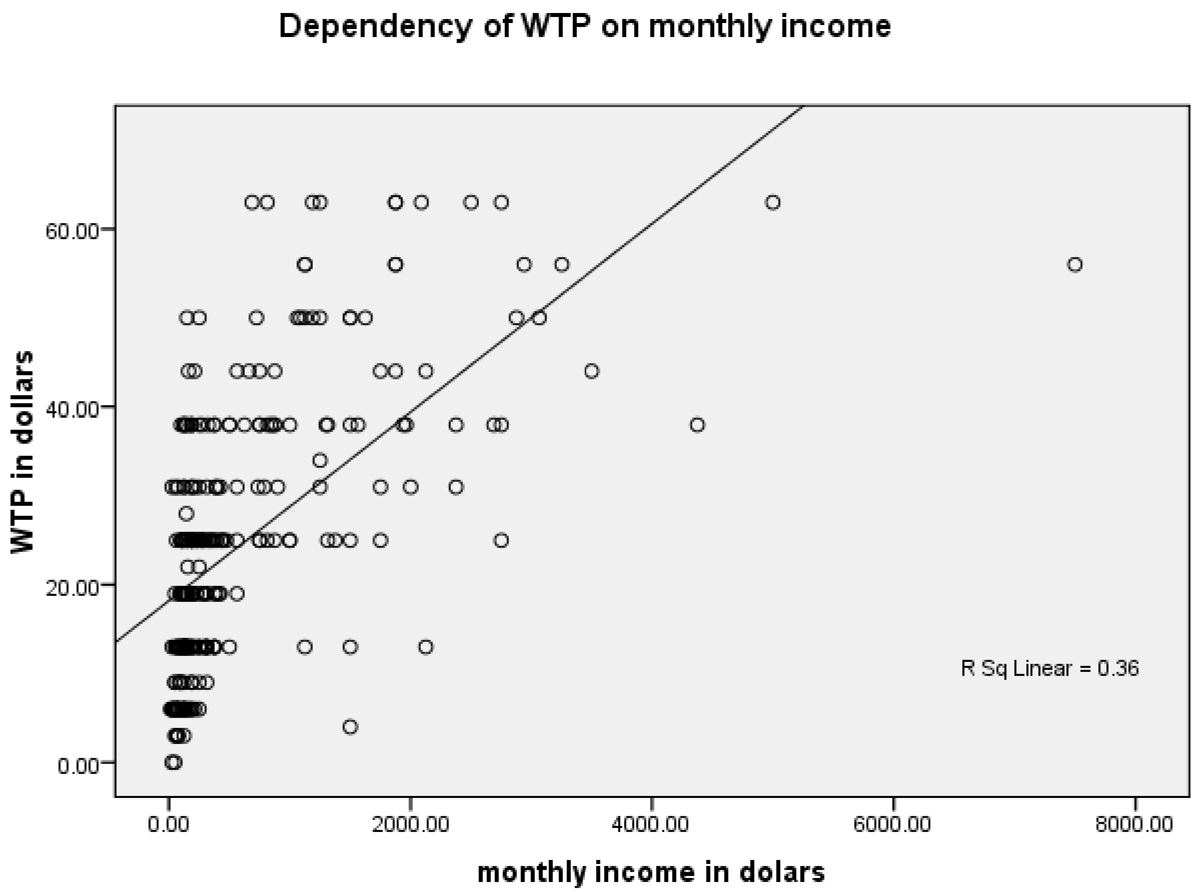


Figure4.4: Linear dependency of WTP on income

Results also indicate that the linear regression between WTP and percapita income is highly significant (figure 4.7 and equation 4.2). The relationship of percapita income and WTP is not so different if it's calculated using monthly income or percapita monthly income (Indicated by β in eqn 4.1 and 4.2).

$Y=18.10+0.47X+0.84; F_{1, 298}=166; R^2=0.358; P<0.001$ equation 4.2[20]

[20] Equation for the linear dependency of WTP on percapita monthly income

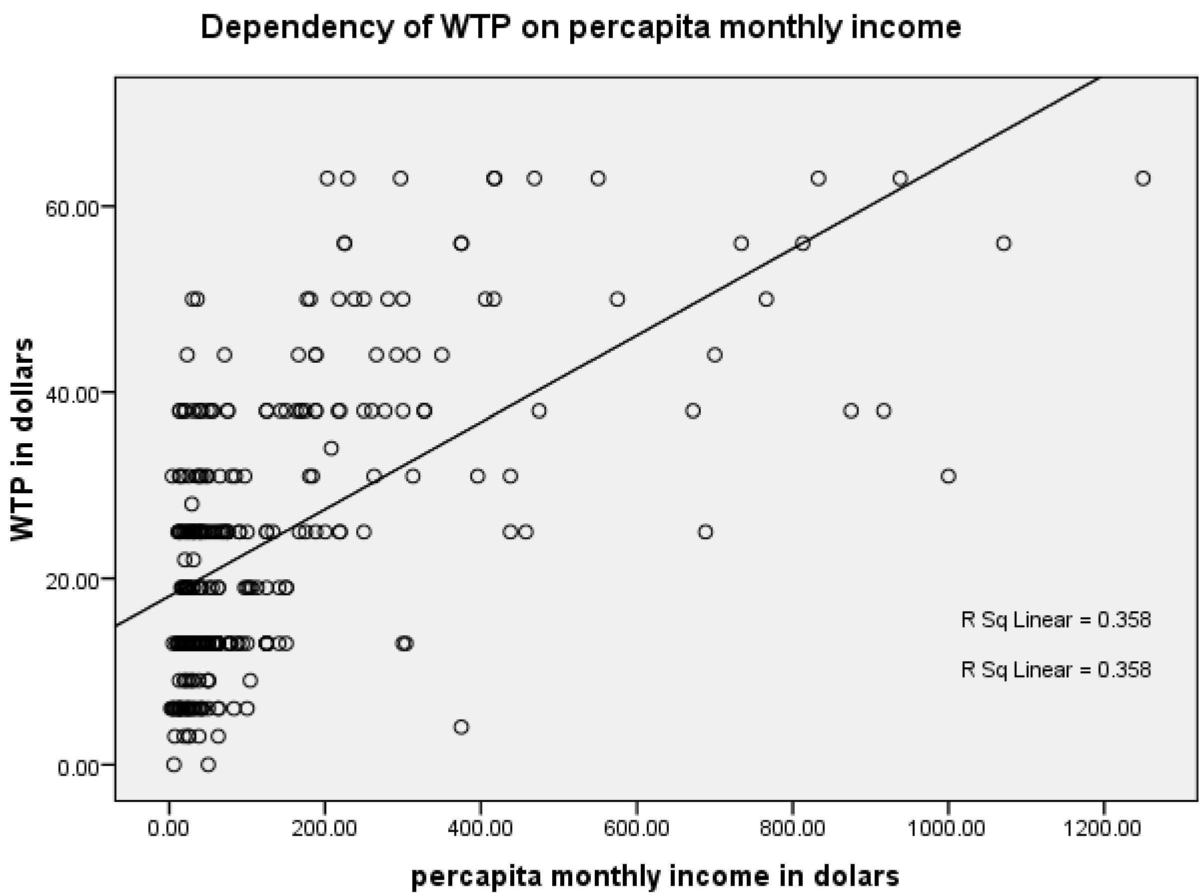


Figure 4.5: Linear dependency of willingness to pay on percapita monthly income

Results furthermore indicate that the linear regression between WTP and annual family income is highly significant

$Y=17.76+0.001X+0.83$; $F_{1, 2898}=186$; $R^2=0.385$; $P<0.001$ eqn 4.3

There is also direct dependency of WTP on the percapita annual income as indicated by equation 4.5

$Y=17.78+0.004X+0.83$; $F_{1, 298}=182$; $R^2=0.379$; $P<0.001$ eqn 4.4

Table 4.4 indicates the summarised coefficients for simple linear dependency regression of WTP on different income indicators.

Indicator	α	β	ε	R^2	F	P
Monthly income	18.06	0.011	0.84	0.361	168	0.000
Percapita monthly income	18.10	0.047	0.84	0.358	166	0.000
Annual income	17.76	0.001	0.83	0.385	186	0.000
Percapita annual income	17.78	0.004	0.83	0.379	182	0.000

Dependent variable is WTP

Table 4.4: Coefficients of bivariate linear regression between WTP and income indicator

4.6.3 WTP in different areas and among different population groups

4.6.3.1 Differences in rural and urban areas

Since the WTP is not a normal distribution it was transformed into a log WTP.

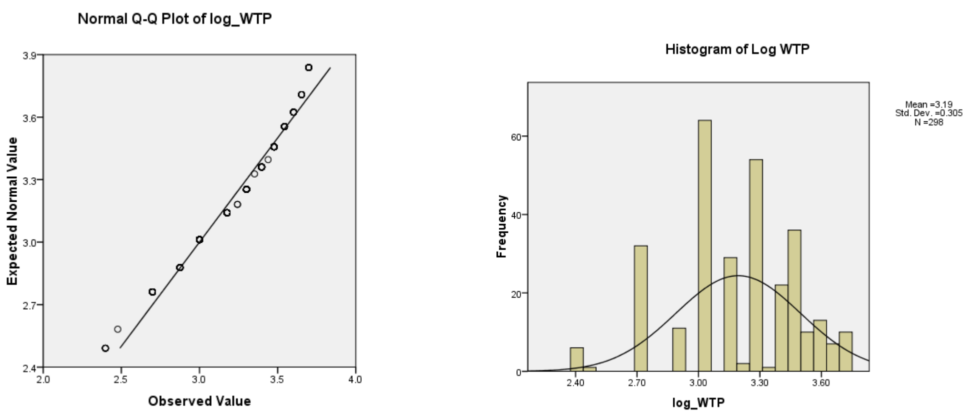


Figure 4.6: Normal Q-Q plots and Histogram of WTP indicating normality in distribution

To test if the sample means of WTP in Nakuru (urban area) is significantly different from that of Njoro (rural), a t-test was used. The hypothesis therefore becomes

H0: $\mu_{nj}=\mu_{na}$

HA; $\mu_{nj}\neq\mu_{na}$, where μ_{na} is the parametric mean for Nakuru and μ_{nj} the parametric mean for Njoro. The mean WTP for Njoro district ($ 18.13) is significantly lower than the mean WTP for Nakuru municipality ($ 30.09); (t-test, t=-7.4, d.f. =298 and P<0.001)

A regression analysis indicates that there is a linear dependency of WTP on income for both rural and urban areas (figure 4.7). The linear dependency of WTP values on income is different between urban and rural areas as indicted by the value of β in equation 4.5 than in urban area (equation 4.5 and eqn 4.6). Althouth linear dependency may not be significantly different, the linear dependency is however more for urban than rural areas at the same confidence interval.

Y=14.63+0.001 X+1.25); r^2=0.26; $F_{1,263}$ =89.9; P<0.001; CI=95% for rural areas[21]. eqn 4.5

Y=19.68+0.42X+1.43); r^2=0.29; $F_{1,239}$ =99.0; P<0.001; CI=95% for urba areas . eqn 4.6

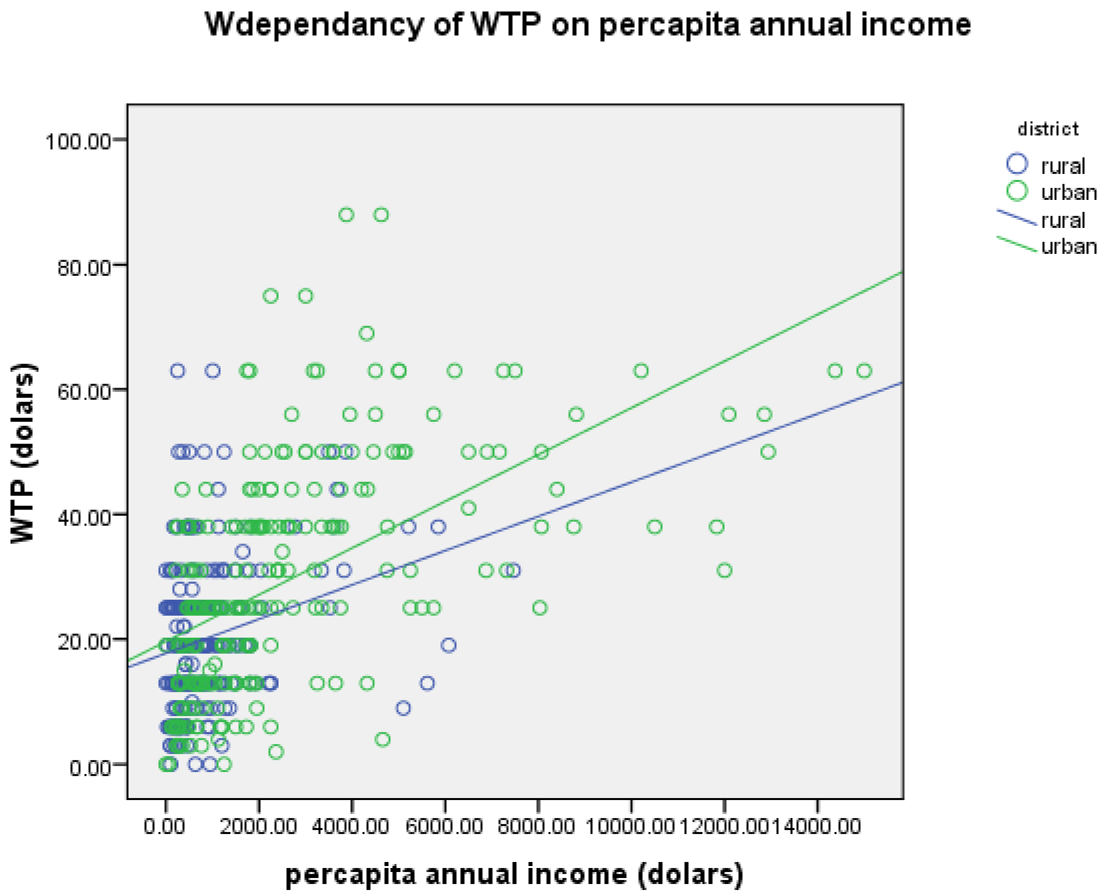


Figure 4.7: Linear dependency of WTP on income for urban Nakuru) and rural (Njoro) populations

4.6.3.2 Difference of WTP among different water users

Figure 4.8 shows a comparison of the linear dependency of WTP on percapita income between surface water (rivers and springs) and tap water (piped water in dwellings, piped water inside compound and public taps) users. There is a significant linear dependency of WTP on percapita monthly income among surface water users (eqn 4.8)

[21] Areas sampled in Njoro district were rural and those in Nakuru were urban. Njoro and Nakuru have been used interchangeably to mean urban and rural areas respectively.

$Y=16.75+2.447X+9.8; r^2=0.36; F_{1,148}=6.3; P=0.001$ eqn 4.8

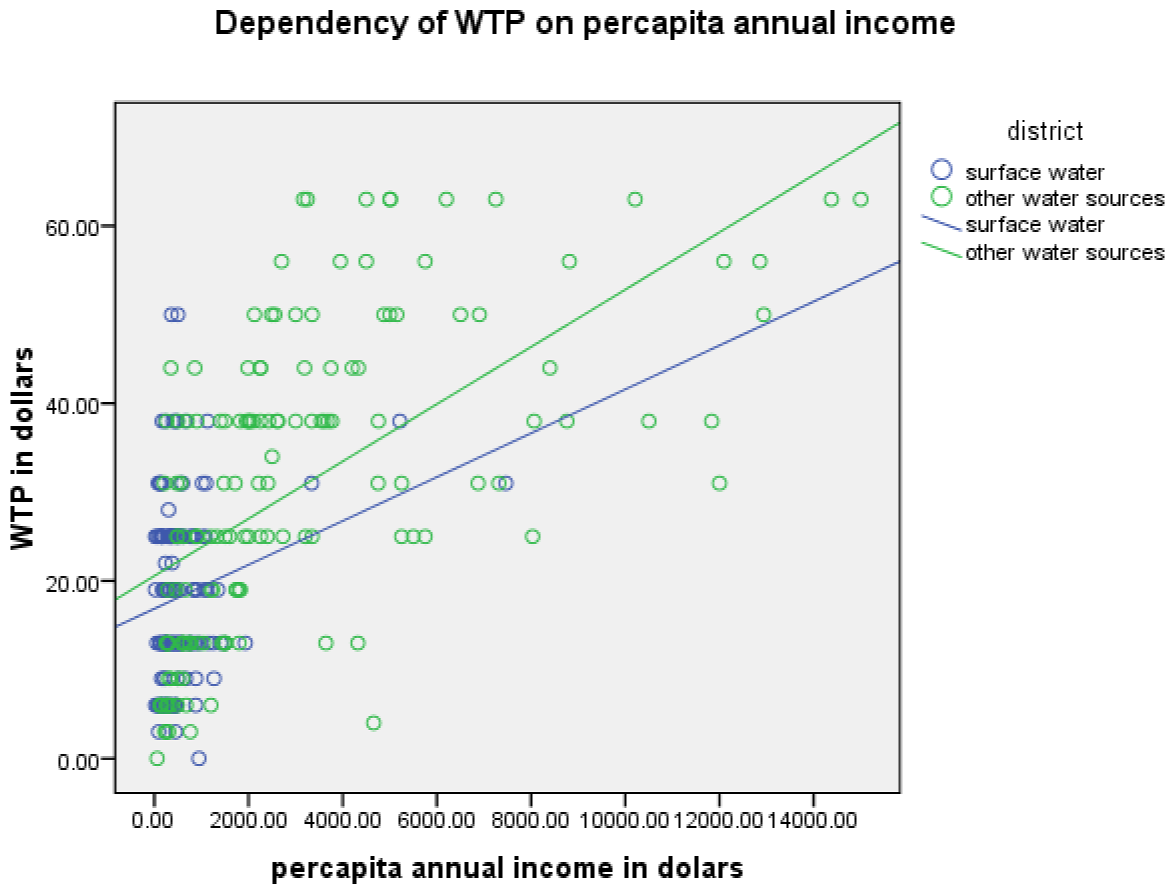


Figure 4.8: Difference in the linear dependency between WTP and income for surface and tap water users.

Also, there is a significant linear dependency of WTP on income for other water users as indicated by the regression equation (eqn 4.9). However, the linear dependency of WTP on income for surface water users is less strong compared to tap water as indicated by the β in eqn 4.8 and 4.9 at the same confidence interval of 0.95.

$Y=20.04+3.243X+1.6; r^2=0.41; F_{1,148}=83.8; P<0.001;$ eqn 4.9

4.7 Demographic factors affecting WTP

To determine which socio-demographic factors that affect WTP among those included in the study (see annex 9 - questionnaire for these factors) a backward multiple linear regression model was built in which several independent variables were included. Among these variables were; amount of money used on bottled water, age of respondent and other sources of income other than the ones discussed below. These variables were removed from the final model even though they are significant if a bivariate model is run. On the other hand, variables like diarrhoea prevalence and source of drinking water (surface or 'other') were removed from the final model although they had a strong bivariate relationship with the WTP.

The effect of different independent variables on the WTP for GDM has been summarized in table 4.5. The final regression model had gender, highest education of household adult member, sanitation, amount of drinking water used in a day and percapita annual income. The overall model is statistically significant (P<0.001). R^2=0.54 meaning that about 54% of all variability of WTP is accounted for by the variables in the model. Diarrhoea and water source has been included because they were significant in the bivariate but not in the multivariate linear regression model.

Variable	Multivariate		Bivariate	
	Coefficient ($)	P-value	Coefficient ($)	P -value
Gender	-4.3	0.002	-5.2	0.000
Education in yrs	0.5	0.040	2.0	0.000
Sanitation	8.7	0.000	17.7	0.001
Drinking water used in a day	0.8	0.001	1.34	0.000
Percapita annual income ('000 $)	2.6	0.000	3.6	0.000
Diarrhoea prevalence	2.0	0.299	3.9	0.038
Surface or other water source	-1.2	0.544	-11.6	0.000

Dependent variable is the WTP

Table 4.5: coefficients of the various independent variables in multiple regression analysis

Women respondents are more likely to give a lower WTP value ($ 4.3 less) than the men Also the mean WTP for women was significantly lower ($21.6) than that of men ($ 27.4; P=0.001). People who had unimproved sanitation including open defecation and uncovered pit latrines were likely to pay $ 6.7 less than those who had access to improved sanitation facilities like toilets and VIP. Increasing the amount of water people use in the house by 1 litre was likely to lead to an increase of WTP by $ 0.8. Increasing the annual percapita income by $ 1, 000 was likely to lead to increased WTP by $ 2.6

4.8 User perceptions

Based on the results of the pre-survey, decision making in the choice experiments were basically based on three most important factors; GDM effectiveness, price and the flow rate. Changing the price of GDM across all the different attribute levels (Ksh 2'000, Ksh 2'500, Ksh 3'000, Ksh 3'500, Ksh 4'000) made significant difference in the choice made by the respondent (P<0.001 CI=0.95).

Also, the choice was significantly different when the highest and the lowest price levels were interchanged. Most low income earners

Changing the difference in effectiveness of GDM i.e. changing the number of diarrhoea incidences from once per child per year to twice per child per year or four times per child per year made significant change in the choices that the respondents made (P<0.001 CI=0.95). Flow rate was only significant at 10% confidence interval while storage capacity was not significant at all.

Characteristics	Between highest and lowest level	Between subsequent levels	Overall
Price	Highly significant	Highly significant	Highly significant
Effectiveness	Highly significant	Highly significant	Highly significant
Flow rate	Significant[22]	Not significant	Significant [23]
Storage capacity	Not significant	Not significant	Not significant

Table 4.6: summary of the significance changing GDM characteristics changes the choices of respondents

4.9 Chapter Summary

About half the population use uncovered pit latrines. Rural populations still use open defecation. Compounded with poor water quality, the levels of diarrhoea is high especially in rural areas. Rural households are as expected larger than urban households, but this reduces significantly their spending power as it lowers the percapita monthly income. Majority of rural population consider drinking water to be unsafe although most of them don't treat. Boiling and chlorination are the popular methods of water treatment. The use of bottled water though not a treatment method is significantly high in urban areas.

Rural populations are poor with up to 60% in absolute poverty. Income disparity is more prevalent in urban areas. There is a high direct dependency of maximum WTP on income. Best income indicator on which to base the WTP is the percapita annual income. The relationship between income and WTP is high in rural areas than in urban areas. Also there relationship between WTP and income is high among tap water uses than surface water users. The relationship between WTP and income is not significant among surface water users. WTP is affected by gender, sanitation, income, perceived safety of drinking water, diarrhoea prevalence and the amount of water people drink in a day.

Having presented results of the research in this chapter, the next gives interpretation of the results and tries to link it to the current scientific work going on.

[22] Was significant at 90% confidence interval but was insignificant at 95 % confidence interval.
[23] Was significant at 90% confidence interval but was insignificant at 95 % confidence interval.

Chapter five

5.0 DISCUSION

5.1 Introduction

In most low income (LIC) Kenya included, the numbers of people moving into urban areas is increasing. The continuous movement of people into urban areas is to access social amenities including, education, medical, electricity, water among other others (Abdullah and Wilner, 2011). This chapter tries to discuss this situation by interpreting results of the research presented in chapter 4. In this chapter, the drinking water and treatment situation is explained. The chapter goes ahead to describe the WTP patterns in both the rural and urban areas, differences in the WTP patterns and the factors that affect the maximum WTP for GDM.

5.2 Drinking water treatment and the effects

As indicated in chapter four, everyone among the surveyed population in urban areas (Nakuru municipality) had access to piped water systems which they use for drinking and other household activities. This could collaborate with the information NAWASCO staff say that about 98% of the town is covered by drinking water services (Ngugi, personal communication). However, occasional 'dry taps' and concerns of quality make people to use bottled water for drinking especially among the high income households (Kiruki, et al, 2011). In rural areas (specifically in Nessuit) there is total lack of piped water system. There are a few boreholes and most people rely on surface water sources for drinking water (streams and springs).

Compared to urban areas, most respondents in rural area are concerned about the water quality. In river Njoro, poor water quality results from high contamination (Yillia, et al., 2008) and turbidity caused by poor watershed management (Shivoga, et al., 2007). Indeed when respondents in the rural population, when asked why their drinking water source is unsafe, 50.6% cited contamination and 38.9% cited turbidity of the water source. Still a significant percentage of the respondents think both factors are responsible for the unsafe of their drinking water sources.

The result of drinking highly contaminated water is high diarrhoea prevalence (23.3% in rural areas and 6.9% in urban areas). Minority of the rural population treat drinking water (43.3% compared to 79.4% of urban population). This is in line with a study in Nairobi Kenya which indicated that users of POUs had less disease attacks than non-users (Mosler, et al., 2008). For those households that treat drinking water in rural areas, only a fifth treats every time while the rest just treat incidentally. Further, half of them boil the drinking water; a method that is highly vulnerable for recontamination and irregularity in use. Other than boiling and to some extend chlorination, other methods of water treatment have not been sustained in Kenya just as suggested in a study done in kenya in a Bondo- another part of rural Kenya (Luotto, et al, 2011b).

High diarrheal prevalence in rural areas of Nakuru County is therefore an expected outcome because there are studies that link water contamination with diarrhoeal prevalence (Arnold and Colford Jr, 2007, Ashbolt, 2004, Mara, 2003, Montgomery and Menechem, 2007, Murage and Ndingu, 2007, Schouten and Mathenge, 2010). For river Njoro from which rural households draw water for drinking, the total and faecal coliform was 35MNP/ml and 4.5MPN/lm respectively (Kiruki et al, 2011).

Generally microbiological water quality in most of the of Nakuru municipality (except for Bondeni and Ronda) is satisfactory for drinking as the water has total and faecal coliform is less than 0.003 MPN/ml. Diarrhoea prevalence in urban areas was mostly (60% of all reported cases in urban areas) reported in low income areas of urban areas (Kaptembwa). This is attributable to recontamination of drinking water and the poor sanitation prevalent in the area (Murage and Ndingu, 2007) and hygiene. Overall low levels of diarrhoea in urban areas (6.9% see annex 6) can be attributed to treatment of water both by water Service Company and the large treatment level by individual household water users, better sanitation and hygiene.

The low rate of treatment in rural areas can be attributed to the low education and awareness levels, inaccessibility of affordable treatment systems and the low disposable income that people have. The education levels are low (the mean years of education in the rural areas were 9.8 years as compared 13. 2 years for the urban areas) which hinders the understanding of the impacts of water people in rural areas drink has on their health. Also, religious believes are deep rooted in the rural areas and some of the respondents think drinking water should not be treated because God's water is already clean and safe.

5.3 Income and WTP

5.3.1 Income

A household spending power can be measured either by using its income, expenditures or the wealth index. In this study, family income was used with different indicators of family income calculated, including monthly income, percapita monthly income, annual income and annual percapita income. This was necessitated by two factors i.e. differences in the frequency families get income and the differences in family sizes. Most families in rural areas are farmers and therefore get income during the harvesting season (which in the case of Nakuru is once for maize per year and twice for most other products) making it difficult to calculate their monthly income. In urban areas on the other hand most households have salaried members but have access to loans, grants and other financial facilities that changes their income patterns.

Based onnthese reasons, percapita annual income is the best indicator for measuring families' wealth. The differences in household sizes made it necessary to calculate the percapita income, which measures the amount each individual in the household has to dispose. Though people in rural areas may have substantial monthly income, the percapita monthly income in rural areas is significantly low as compared to the households having similar family income in urban areas. For instance, the average household income for rural areas is 5.7 persons which is one-third higher than 4.3 persons recorded in urban areas. This reduces the spending capacity of rural households.

5.3.2 WTP for GDM

Only two respondents (0.67%) expressed zero WTP. One of them indicated financial constraints as the reason for zero payment; this would imply that if the respondent had financial security, WTP would be a positive figure as there is appreciation of the value of GDM. The other respondent cited government as the responsible party in ensuring that water is safe for all citizens. Thus more than 99% of respondents appreciate the positive value of GDM filters and expresses at least some WTP for the filters. The highest WTP values given for the rural households were $ 50 and for urban households were $ 63.

The range of WTP values given during the household surveys ($ 63) is an expression of a variety of factors discussed in the next section. Table 4.3 gives a summary of the different amounts users are WTP for GDM filters by percapita annual income deciles.

Even though the poorest urban deciles earn double the rural decile (in terms of percapita monthly income), the two groups expressed the same WTP ($ 6.3) for GDM filters. If GDM would be taken to the market, half of the rural population will be WTP as much as $ 18.9 while in the urban areas, half the population will be WTP as much as $ 31.3.

Since income is lower in rural areas, the proportion of income that households are WTP towards purchasing a GDM filter is substantial with some reportedly willing to spend even more than fifty percent of their monthly income (figure 5.1). Although 47.3% of the rural respondents were willing to spend more than ten percent of their monthly income purchasing a GDM filter, only 14% of the urban population were willing to spend more than 10% of their monthly income to purchase a GDM filter. This is consistent with the finding that rural people see drinking untreated water as a threat to their livelihood more than do people in urban areas. This is backed by the large percentage of the population who think that the water they drink is unsafe as compared to a small proportion of urban dwellers who think that the water they drink is safe and does not therefore need treatment.

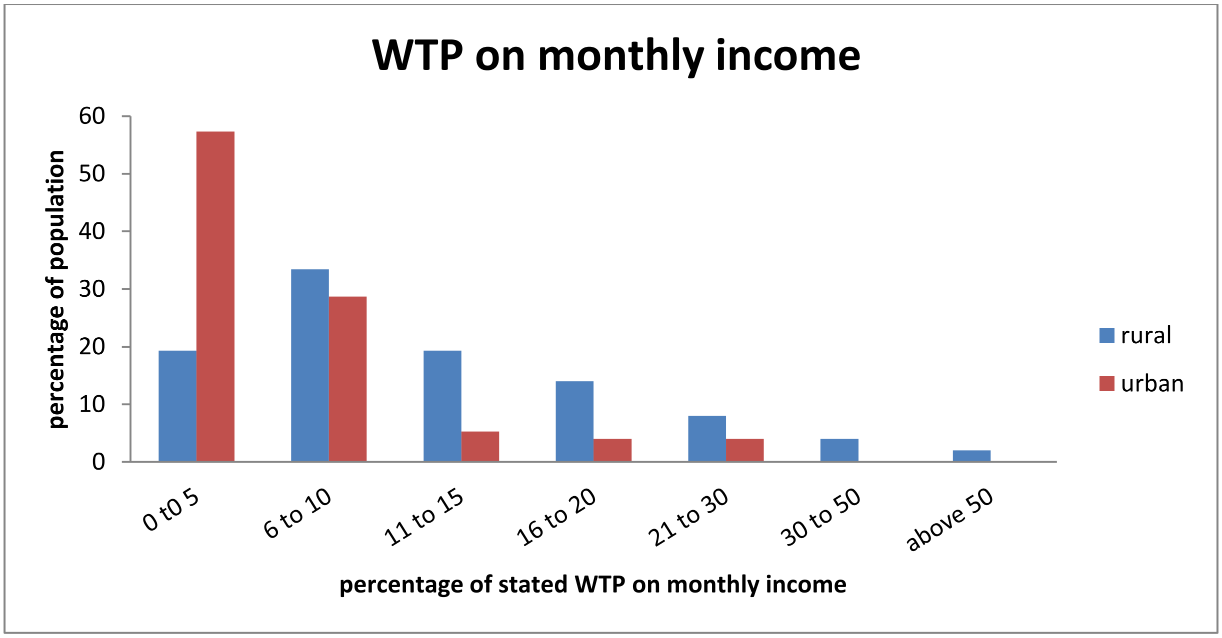


Figure 5.1: Maximum willingness to pay as a percent of monthly income. Source: survey 2012.

Especially in rural areas, people would need to accumulate income over several months in order to purchase a GDM filter. This means people value GDM and see the technology as a durable investment, similar to other durable goods like cooker, television and refrigerator.

5.3.3 Relationship between income and WTP

There is a direct dependency of WTP on income regardless of the income indicator used. However, depending on the indicator used, the relationship is more direct than the other for instance; WTP is more directly dependent on percapita monthly income than the monthly income. This is because of the differences in family sizes. The higher the family size, the lower the percapita income available for those families having same income. This means that percapita income is a realistic measure of a family's spending freedom than just the monthly or annual income.

Also, WTP is more dependent on the annual income than on the monthly income. This is because most the people do not have regular income but their spending decisions are based on the annual income.

WTP in rural areas has less direct dependency on income than in urban areas (figure 4.6 and 4.7). In rural areas, there is less information on available water treatment methodologies and even less on available POUs for such treatment. Though people in rural areas need a water treatment system probably more than the urban areas (based on the water quality issues and diarrhoea prevalence), the limited available income in rural areas has more needs to meet and therefore are willing to commit less money for the purchase of GDM.

Although, the mean WTP in urban areas is significantly higher than in rural areas, there exist many different water treatment options including consumables (chlorination, PUR, ceramic filters, bottled[24] water etc.) in urban areas. WTP for GDM filters in urban areas therefore reflects a complex decision making process in which several issues are considered i.e.

- The utility provided by the attributes on GDM filters (effectiveness, storage capacity, flow rate of GDM filters as described to the respondent by the interviewer) in relation to the attributes of other POUs present in the market as known by the respondent.
- The availability and ease of use of GDM filters as explained by the interviewer to the respondent.
- The reality and danger posed by water related diseases especially given the fact that the water provided by NAWASCO is generally good for consumption and the strong assurance from the company that the water is indeed clean.

5.4 Difference in WTP between surface water and tap water

WTP for Tap water users (urban households) is directly dependent on the income (equation 4.7). Also, there is a direct linear dependency of WTP on income for surface water users. However the dependency of WTP on income is less prominent among surface water users than among the tap water users. Reasons for this include;

- The religious and cultural practise in the area - rural populations have strong religious believes. Asked about why the household didn't treat water one respondent asked :

  "*Why do you want to do God's work of cleaning water? Just as rain from heavens is clean so is spring water coming from underground*"

  About third of the people (who don't treat drinking water in rural areas) don't believe the water needs treatment because they have been using the water for long and no one has suffered yet. Investing in a treatment technology is therefore not necessary.

- Income -the sources of income in rural areas are not so regular. As indicated earlier most of the people are farmer, some keep livestock and a few are salaried. Farmers may have their crop yield for months until they find the market for their produce. This may take short or long depending on the type of produce and the available market. The amount of money people get from these produce sometimes is not even enough to meet their needs. With string tight budgets, their WTP for a water treatment system is expected to be low.

- Educational levels - (As indicated in annex 4) rural areas have low education levels compared to urban areas. People with low education may not appreciate the relationship

[24] Bottled water is not considered an improved source of drinking water by WHO/UNICEF although people use it as a means of getting clean water

between the high diarrhoea prevalence reported and quality of water they consume. The perceived health risk is therefore low in rural areas as compared to urban areas. The costs associated with the having GDM filter (price of GDM expressed as the WTP) is perceived to be much higher than the benefits of having GDM (the reduced diarrhoea at family level, the social status associated with having GDM and comparative benefits of using GDM to other POUs). This explains why WTP for GDM is significantly higher in urban areas than in rural areas. Also, people are relatively poor in rural areas than in urban areas. This means that the budgets of rural population are tight and there is not so much left for buying water treatment systems.

5.5 Demographic factors affecting WTP for GDM

During data collection, respondents were asked what is their maximum WTP for a standard filter (reducing diarrhoea prevalence from four times per child per to once per child per year, having a storage capacity of 10litres and takes 30 minutes). The differences in WTP stated by different respondents could not be based on the different characteristics of GDM because a standard filter had already been described. The differences in the WTP values indicated can be attributable to the differences in socio-demographic and psychological factors in the population. Such factors are described below.

5.5.1 Gender

Gender in household setting affects the decisions people make in the house. From table 4.5, gender of the respondent significantly affects the WTP if all other variables are kept constant (P=0.002). Even though in most parts of Kenya it is women who bear the biggest responsibility of collecting water for the family (Whittington, et al., 1990), women have for long been victims of educational and economic marginalization making their role in decision making concerning drinking water and sanitation limited. Although the difference in income between houses headed by females were not significantly different from the income of those households headed by men, difference in WTP between households headed by men or women was significant in this study. Female respondents reported WTP were $ 4.3 less than the male respondents. The mean WTP for female respondents was significantly lower than the male respondents. Most of the women in the rural setting are also subjected to physical abuse when they make decisions on behalf of the family. This means that even when such women participate in surveys, it's a challenge to make decisions that require consultations with the head of the household and may commit less financial resources to GDM even when they think it is worth more than that.

5.5.2 Education and awareness of the target population

Education and awareness is one factor that improves ones understanding of the relationship between water and sanitation and the prevalence of water related diseases. Formal education curricula have subjects that teach people about environmental health and hygiene. People who have formal education in Kenya are therefore better equipped to make informed decisions concerning the water quality they take based on the health risks and the possible solutions. The level of understanding of these environmental and health issues are higher with increasing number of years of formal education.

Education levels are higher in urban areas than in rural areas (See section 5.2 and annex 5). All factors kept constant, increasing education by a year will increase the WTP for GDM by $ 0.5 in both rural and urban areas (P=0.017; table 4.5). People who have higher education value the safety of the water they drink and will additionally be WTP more for GDM to ensure this is achieved. Also increasing the level of awareness on the available POUs and their work increases their usability (Mosler, et al 2008).

Further, increasing the level of awareness among water users on the quality of water may increase their WTP and their water treatment behaviour. A study done by Luotto, et al (2011) concluded that;

> *".......Sharing information about local water quality increases water treatment by 7-10 percentage points (11-24%) above that achieved by providing free products. Persuasive social marketing messages that harness findings from behavioural economics increase water treatment by additional 9-11 percentage points......"*

Even though several studies have been done on the quality of water on river Njoro (Kiruki, et al, 2011, Shivoga, et al., 2007, Yillia, et al 2009, Yillia, et al., 2009), Communication of this information has so far had little impact on the people it is supposed to help. This was clearly evident during this survey when only 43% of the people treat water and an equally large number claim there is no need to treat drinking water. Figure 4.1 indicates a surface water source which is very turbid and a public sign board advising water users to treat the water before drinking. In his study, Luotto et al (2011) argues that by measuring the contamination level of water that is stored in households awaiting use and communicating this results to individual household heads, the method of communication increases drinking water treatment behaviour. This effectively increases the expenditure on the available POUs. Even though this method could prove expensive and laborious; it may be effective in increasing adoption and scale up of POUs effectively reducing diarrheal diseases. On the other hand, this conclusion was reached without conclusive evidence was presented especially for microbiological water contamination.(Lucas, et al., 2011). This could however be a good area to explore to increase water treatment behaviour

5.5.3 Sanitation

The population in Kenya that has access to improved sanitation was only 24.3 % (USAID and KNBS, 2009). Building of Sanitation facilities is costly in Kenya. People who have considerable amount of money have access to such facilities unless the sanitation facilities are public. It's expected that such people will have enough money to invest in safe drinking water. On this basis, in this study, people with access to improved sanitation are willing to pay $8.7 (all factors kept constant) more than people who don't have access to improved sanitation. Also, people who invest in sanitation with the knowledge that it reduces their medical bills (by reducing their water related diseases), will invest in drinking water treatment technologies with the knowledge that drinking untreated water may jeopardise the dream of reducing medical bills. On the other hand, poor people especially in villages do not have access to such facilities, are poor and thus do not have enough to invest in drinking water technology especially if they know that even with clean drinking water, water born diseases will be still rampart because of poor sanitation.

5.5.4 Amount of water consumed in a day in households

From table 4.4, all factors kept constant, the WTP will directly depend on the amount of drinking water household need in a day. Increasing the water a household drinks by 1 litre, increases the WTP by $ 0.725 (P=0.001). Some people don't spend significant amount of time in their house (Green, 2005) and drink water out (especially families that don't have children). Also for small families, buying an expensive treatment technology which stays in the house when a lot of drinking water is not required in the household presents a difficult option. Paying for a water treatment technology which will be used in the house makes no sense.

5.5.5 Percapita annual income

Increasing the annual percapita income by $ 1,000 increasing the WTP by $ 2.6 (P<0.001). If people became more economically stable then their WTP for GDM will increase because of they have more money to spend. In LIC, people are not so much concerned with the quality of water they consume and if they have to make a decision to buy a water filter, most will consider more pressing needs like food and shelter before spending money on water filtration.

5.5.6 Other important variables

Variables that were removed from the model but are considered important are discussed below.

5.5.6.1 Diarrhoea prevalence

As indicated in section 5.2, diarrhoea prevalence is high in rural areas than in urban areas. It's therefore expected that families that reported diarrhoea in children in a recall time of two weeks will be WTP more for a GDM filter than families that did not report diarrhoea in the recall period. With the threat of diarrhoea real, rational family decision making will be geared towards reducing the hospital bill on such preventable water born disease by investing in a water treatment system. From table 4.4, diarrhoea reported in two weeks will increase the WTP by $ 3.91. The direct linear dependency of WTP on diarrhoea (P=0.038for bivariate linear regression) is an indication of the families health risk value.

On the other hand, diarrhoea is closely related to poor sanitation (Martella, et al., 2011, Montgomery and Menechem, 2007). Most people therefore associate diarrhoea with poor sanitation and fail in a way to realise the importance of contaminated drinking water plays in the spread of diarrheal diseases. This is more prevalent among people with less education. This could explain why a high diarrhoea prevalence was reported in rural areas (23%) but only 43% treat water in rural areas.

further about ten percent of people think drinking untreated water is safe in an areas where 12% of people practise open defecation.

5.5.6.2 Perceived safety of drinking water source

In this survey, perceived safety of drinking water was dictated by factors that were reported to cause unsafe water i.e. contamination, turbidity, bad smell and bad taste of the water. The perceived "safety of drinking water" is also a factor in the WTP. If respondents feel that water has contaminants, is turbid, smells or had bad taste, they express a higher WTP. If the perceived water quality drives demand for a water technology like GDM, the highest demand will be in rural areas of Nakuru than in urban areas.

People who think that drinking water is safe have less compulsion to invest in treatment technology while those who think that their health is threatened by the drinking water source will invest in a drinking water treatment technology to reduce chances of getting sick and their health costs. Even though, Kiruki et al (2011) established that in some places in Nakuru municipality the total and faecal coli form levels in water was above the standards for drinking water, about half of people in Nakuru municipality (urban areas) are convinced that the water they take (supplied by NAWASCO) is safe. Such people may not see an immediate need for the filter.

A study done on determinants of household-level use of chlorination products in rural areas of Kenya concluded that initial use of chlorinated products is high for turbid water sources although this did not translate into continuous usage (DuBois, et al., 2010). With the high level of turbidity in the surface water of Njoro River, turbidity may be major driving force the use of GDM or any other technology that reduces this turbidity levels.

5.6 Important characteristics considered when choices are made

5.6.1 Effectiveness

From the results, the effectiveness of POUs determines whether the POUs will be chosen or not. In urban areas, there are so many POUs available with different effective level. For an individual household to choose POUs, they need to be sure that it is going to reduce diarrheal prevalence in the households. In a survey done in Ghana evaluate factors that affects people's choice of HWTS, major health improvement was the most important motivation factor in adoption of a HWTS (Green, 2005).

Having a filter that can Change the diarrhoea prevalence from four times per child per year to two times per child per year means a health risk that parents are not willing to take. Likewise, having a filter that can change the prevalence of diarrhoea from two times per child per year to one time per child per year means a considerable health benefits. Most parents are willing to sacrifice significantly to get a water treatment system that will secure the health of their children.

5.6.2 Price

Poverty is a dominant factor both in rural and urban areas although much more in the former than in the later. Many people struggle to obtain basic necessities. Buying a household filter presents an additional strain on household income. Although people see the need to own a treatment filter, their income cannot support these decisions. Many people were therefore going for the cheapest filter on the choice cards. Some people especially in rural areas were only considering the prices. This does not imply that the filter is useless to them but rather the affordability was the main issue.

Changing the price of a filter from Ksh 2000 to 2500 for instance means that a household decision maker will have to fore gore Ksh 500 which can be saved for other purposes. Changing the price from one bid level to the next therefore significantly affected the choices people made.

5.6.3 Treatment time

The importance of treatment time in making choices cannot be understated. Most people want a filter that can filter the water very fast. This researcher visited homesteads in western Kenya where life straw was distributed free but were not being used because of the low flow rate associated with it.

Interestingly, having a filter that takes 15 minutes or one that takes 30 minutes does not make a significant difference on the choices that end user makes. Also, having a filter that treats water for 30 minutes or one that takes 45 minutes to treat one litre of water is not so important for the decision maker. However, when faced with the option of whether to choose a filter that takes 15 minutes or one that takes 45 minutes to filter one litre of water, end users significantly choose filters that take 15 minutes. This means that even though the difference between individual levels of treatment time attribute were not significant in shaping the choices, a difference between the highest and lowest levels made a significant difference in shaping end-users choices.

5.6.4 Storage capacity

This factor was neither significant between individual attribute levels nor between the highest and lowest attribute levels. Knowing that the filter will have a storage capacity, most people did not care to choose storage capacity that is high or low. Given that the daily average amount of drinking water consumed by households is 4.0 litres, and the levels of storage capacity were 1 litre, 10 litres and 20 litres, people don't make choice of POUS on the storage capacity.

5.7 The subsidy debate

The Maximum WTP values take up about on average 13.6 % of the total household income in rural areas as compared to an average 6% in urban areas. Figure 5.1 indicates that some families in rural areas are willing to sacrifice more than fifty percent of their monthly income so as to acquire GDM. Although, most of the rural households are farmers and therefore WTP could be based on seasonal income not monthly income, this will mean that in rural areas, there is a lot of strain on the family resources if the family has to purchase a single GDM as compared to urban areas.

This therefore calls for means of easing this strain according to DuBois et al (2010). This could come inform of a microcredit finance systems in which people are either given money to buy GDM or GDM filters are bought and distributed to users who then pay it in instalments. Given the opportunity to pay for the filter slowly may increase the uptake of GDM and make scaling up easier. Although this is a viable option for increasing adoption of GDM, the fact that GDM does not have direct financial benefits that could facilitate repayment of the money borrowed may undermine sustained production and utilization of GDM.

The other option is having a system that allows poor people to pay less than the mid-income or high income earners. This could be achieved by designing two or more different GDM prototypes with different housing units that costs differently. Money got from the expensive GDM filter (used by the mid and high income customers) could be used to compensate the production and distribution of GDM prototypes used by the low income customers. The problem with this model is that even the high or mid income earners will have access to the GDM prototype meant for the low income earners. Also, GDM prototypes that are meant for the low income earners could be stigmatized as the GDM of poor quality even when only the housing casing is different. This could undermine its utilization.

5.8 Limitation of the study

During the implementation of this study, several biases limitations, and assumptions were involved that could limit the application of the results

- Sampling bias or exclusion bias - The areas selected for this study did not represent the entire Nakuru county population. The choice of the rural area was specifically based on the areas' use of surface water sources for drinking. Many other rural areas in Njoro were left out because with random sampling in such areas, the researcher was not sure to get the right number of respondents using surface water. This limits the degree with which the results can be generalized. Also, as discussed in section 3.1.2 the margin of error for the results 8 %.
- Design bias - some of the factors of interest are correlated. For instance, water sources and urban/ rural are collinear. It's therefore very difficult to say with certainty how much of the WTP is due to urbanization and how much is due to water sources. To make this possible one needs to include in urban areas people using surface water and in rural areas people using tap water. This was not possible in the study area.
- Owing to lack of Willingness to pay studies on household drinking water filters, the researcher could not compare this results with the results of previous studies.
- The number of households in each cluster was difficult to establish especially in Nakuru municipality because of the constant rural-urban migrations and the unplanned housing exercise that continues to characterize most Kenyan towns. In rural areas, the total lack of demographic statistics meant that the researcher had to rely on outdated data which limited the robustness of the sampling procedure. It was difficult to identify an accurate sampling frame

- Also socio-cultural differences between clusters have been assumed to have no effect on the water treatment method, the user choices made and the WTP for GDM. Further, the study assumes the effect of temporal variation on the demand for GDM filters or the need for water treatment.
- Further the study limits the variable characteristics of GDM filters included into the study only to price, storage capacity, flow rate and effectiveness. This list is not conclusive because there are other inherent characteristics that affect the choice of POUs including the brand name, the type of water one can use the operational requirements, and the beauty of the design of the POUs can affect the choices people make. This study therefore assumes these other characteristics to be constant during the entire survey.

5.9 Summary

Rural populations in Nakuru County largely drink contaminated surface water thereby suffering high diarrhoea prevalence rates as compared to urban populations. Urban populations have a relatively higher awareness, education and resources to treat the water. As a result many households in urban areas treat their drinking water. Urban populations have a higher WTP than the rural areas. Consequently WTP is higher among tap water users than surface water users. There is a direct relationship between the WTP for GDM and income. Percapita annual income is the best income indicator on whose WTP is dependent. A households' WTP is based on other factors including gender, amount of water household's use for drinking, sanitation facilities, diarrhoea prevalence, awareness and education levels of household decision makers and whether water is perceived to be safe for drinking. The lower WTP among sections of the society which take up to 50% of their income is an indication of the need to find an ingenious mechanism of funding GDM implementation in terms of subsidies or a financial system which reduces the burden of paying for GDM once.

Chapter six

6.0 **POLICY IMPLICATIONS AND CONCLUSION**

6.1 Purpose

The purpose of this chapter is to review in a summarised form the problem of the research as discussed in chapter one and link it to the results and discussions in chapter four and five respectively. Drawing from the conclusions in section 6.3, section 6.4 discusses what the results mean for policy makers concerning safe drinking water provision in Nakuru County specifically and the country in general. The last part of this chapter (section 6.5) explores the research direction for GDM and drinking water policy makers.

6.2 Review of the Problem

There is a high number of POUs in Kenya developed by different actors with the aim of improving accessibility of potable water and reduce diarrheal diseases. The acceptance and adoption of these technologies by the target population is low because of; the high investment costs involved, the ineffectiveness in improving water quality to expected levels, attributes of POUs that make usage difficult, the change of water quality (smell and taste) after treatment and the recontamination of the water after treatment. Owing to these problems associated with the present POUs in the market, diarrheal diseases are still a real threat to many Kenyans especially in rural areas.

A another (GDM); POUs that is very effective in removing even viruses from water, that is durable and therefore cost effective in the long run and that is easy to use was created. To assess its acceptability and its impact in society, this research set out to seek information on the Maximum WTP by target population and how changing levels of the basic attributes of GDM can shape the choices made by end users. The information will be used in the design of GDM for easy scale up.

6.3 Conclusions

Boiling and chlorination are still by far the most popular water treatment methods in Nakuru County. Although not a treatment practise, most people in urban areas are buying bottled water as a means of ensuring access to safe water. Filtration is still minimally used but only in urban areas. Even though there is sufficient information about the different water quality and POUs available to make drinking water safe, most people in rural areas do not treat water and those who treat just boil the water. The low treatment practises have led to high diarrhoea prevalence.

WTP among the surface water users is significant low than that of users of other sources of drinking water. The poorest 10% of people in both rural and urban areas are willing to pay $ 6.3 although the later has double percapita annual income than the former. The second economic deciles' willingness to pay is $ 9.4 and $12.5 for rural and urban areas respectively. The third and fourth economic deciles' for rural areas WTP is the same i.e. $ 12.5. Similarly, the fifth & sixth and the seventh & eighth economic deciles in rural areas are willing to pay same amounts i.e. $ 18.75 and $ 25 respectively. For Urban areas, the sixth and seventh economic deciles' WTP is also similar i.e. $ 37.5. The richest 10% of rural areas have WTP significantly lower ($ 50) than that of its urban counterpart ($ 63).

WTP is linearly dependent on income. WTP has a linearly dependency on all income indicators (monthly income, percapita monthly income, annual income and percapita annual income) with P values less than 0.001. The mean WTP is significantly higher among users of "other sources of water" users than surface water users. Also Mean WTP is significantly higher in urban areas than in rural areas.

WTP for GDM is a factor of different demographic characteristics including household income, the amount of water consumed in the household, diarrhoea prevalence, education and awareness levels, sanitation and gender of the respondent. In summary, WTP is high when 1) the respondent is male; 2) the household has access to improved sanitation, 3) when adult members have a higher education level, 4) when household income is high, 5) when the amount of water consumed in the household is high and 6) when household reported diarrhoea in children in a recall period of two weeks.

Filter choices made by of end-users' choices on appropriate GDM filter are affected by the purchase price, the effectiveness of the filter and the treatment time of the filter. Households do not only, prefer effective filters that reduce diarrhoea prevalence among children but also filters that are affordable and which take less time treating water. Storage capacity is not a very important factor in determining the choice of GDM filter end users.

In relation to the research hypotheses,

- There is evidence to support the hypothesis that WTP for GDM is linearly dependent on income of the household.
- There is no evidence to support the hypothesis that WTP is high among surface water users than among tap water users. Actually there is evidence to the contrary.
- There is no enough evidence that storage capacity and income significantly affects end users choices of GDM filter than effectiveness and time taken for filtration. Rather, evidence suggests that filter price, and time used for filtration significantly affects users' choices than storage capacity.

6.4 Drinking water policy recommendations

Based on the wide divide of income and WTP given, different GDM models would be appropriate. The high awareness level that already exists in urban areas can be tapped by developing different GDM models costing different amounts for the low income and high income groups. This needs careful review of the housing units of GDM and their costs. The quality of GDM filtration should not however be compromised in the process. Money generated by high and middle income GDM users can be used to subsidise the cost for the low income.

Without a careful look on the effectiveness, flow rate, and pricing of any POUs and GDM in particular, implementation will be difficult. This is because most people are interested in filters that are low cost, effective and that can give more water for a short period of time. In urban areas where there are so many water treatment options, effectiveness becomes critical. Even if GDM is distributed free of charge without careful consideration of the said factors, its use cannot be guaranteed. High poverty prevalence rates demands an increased assessment of the pricing systems of POUs introduced in the market.

There needs to be a shift in the means of communication of the research findings to the affected communities consuming untreated water. Even though there were warnings of drinking untreated water at the points where people took water from the rivers, still people did not treat water. Communicating the results of bio-chemical drinking water quality may be more useful than just general conclusions. However, the method of communication should directly target decision makers. As Luotto (2011) suggests, communicating directly to house hold decision makers about the quality of water present in the household increases treatment behaviour than the generalised methods of information sharing used presently.

Effective reduction of diarrheal diseases in rural areas among low income earners needs cross-sectoral multidisciplinary planning and implementation. Planning exercise should address the drinking water need, sanitation needs, and more important the awareness needs. Although provision of clean drinking water is a good start, sanitation is very poor and the level of recontamination is may be high even among households that have a good POUs system like GDM because there is not so much awareness concerning spread of water related diseases. This planning exercise should include local government, community based organizations, NGO's and the private sector.

Continuous monitoring the bio-chemical quality of drinking water and sharing this information to the affected users is a good means of creating demand for POUs and GDM. Further information flow on the benefits of treating water and the methods of doing so should be continuously communicated to the people. Marketing strategies that focus on the benefits of GDM would be more beneficial than focusing on the health risks associated with drinking untreated water.

6.5 Research Recommendations

The focus of this research was how effectiveness of the filter, purchase price, treatment time, and storage capacity affects choices of the filter by end users. It was assumed that these are the basic attributes that affect adoption of HWTS. It will be of great interest to include other factors including the brand name, durability; colour, the design and the supply channel of thee filter and investigate how these also affects the choices of the user.

Also, WTP on GDM or any HWTS should include different financing options under the design of the hypothetical markets. Options like monthly payments, one-time payment, or annual payment could be included in the research to see what effect this has on the WTP values. Most people in rural may not be able to afford the filter on a one payment basis thus giving a different WTP value than when the payment option is changed.

More research needs to be done to determine to what extend poor sanitation leads to diarrheal infections and differentiate this from the levels of diarrheal disease directly caused by drinking untreated water. This is because there is a strong relationship between sanitation facilities used by households and the maximum WTP for GDM filters. When people are not sure about their sanitation situation, they could be reluctant buying POUs because they will still be vulnerable to diarrheal infections.

A study that addresses that can successfully lead to positive water treatment behaviour needs to e carried out. So far, many POUs are in the market, there is an information warning person about the danger of drinking untreated water but water treatment behaviour is still low especially in rural areas.

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8.0 **ANNEXES**

Annex 1: Design of GDM filter attributes

Block	Card	filter options	Storage	Flow rate	Diarrhea	Price	Storage	Flow rate	Diarrhea	Price
1	1	1	1	1	1	1	1=1 liter	1=1 liter/hour	1=1 time per child per year	1=2000
1	1	2	2	2	3	2	2=10 liter	2=5 liter/hour	2=two times per child per year	2=2500
1	1	3	0	0	0	0	3=20 liter	3=10 liter/hour	3=four times per child per year	3=3000
1	2	1	3	3	2	5				4=3500
1	2	2	1	2	1	3				5=4000
1	2	3	0	0	0	0				
1	3	1	3	3	3	3				
1	3	2	2	1	2	4				
1	3	3	0	0	0	0				
1	4	1	2	3	1	1				
1	4	2	1	1	3	5				
1	4	3	0	0	0	0				
1	5	1	1	3	3	2				
1	5	2	3	2	2	4				
1	5	3	0	0	0	0				
2	1	1	2	2	2	3				
2	1	2	3	1	1	2				
2	1	3	0	0	0	0				
2	2	1	3	2	3	1				
2	2	2	1	3	1	4				
2	2	3	0	0	0	0				
2	3	1	2	1	2	5				
2	3	2	3	2	1	4				
2	3	3	0	0	0	0				
2	4	1	2	1	3	3				
2	4	2	1	3	2	1				
2	4	3	0	0	0	0				

Number of blocks: 30
Number of cards per block: 5
Number of cards: 30 x 5 = 150

Annex 2: Biological water quality of Njoro surface water drawing points and Nakuru municipal water

Table 1. Bacteriological assessment of water quality from Nakuru Municipal water.

Water source	Total coliforms (MPN ml^{-1}) Wet	Total coliforms (MPN ml^{-1}) Dry	P value	Faecal coliforms (MPN ml^{-1}) Wet	Faecal coliforms (MPN ml^{-1}) Dry	P value
Shabab						
Mean± SD	1.63±0.61	2.50± 0.31	0.006	0.10 ±0.12	0.091 ±0.12	**0.940**
Range	0.93-2.40	2.10-2.90		0.03- 0.30	0.03- 0.30	
Bondeni						
Mean± SD	7.30±1.07	4.72±0.96	0.044	2.00±0.58	0.09 ±0.12	**0.001**
Range	5.70-8.70	4.00-6.40		1.20-2.60	0.03-0.30	
Town centre	<0.03	<0.03		<0.03	<0.03	
Kiti	<0.03	<0.03		<0.03	<0.03	
Milimani	<0.03	<0.03		<0.03	<0.03	
Ronda						
Mean± SD	9.60±1.87	4.52 ±1.10	0.010	7.36±2.00	4.14 ±1.33	**0.023**
Range	7.40- 12.00	3.70-6.40		4.50- 9.40	3.00- 6.40	

Results are expressed as mean ± SD for five replicates. P values in bold represent significant difference in the total and faecal coliforms between the wet and dry season (Student's t-test).

Table 2. Bacteriological assessment of water quality from River Njoro.

Water source	Total coliforms (MPNml^{-1}) Wet	Total coliforms (MPNml^{-1}) Dry	P value	Faecal coliforms (MPN ml^{-1}) Wet	Faecal coliforms (MPN ml^{-1}) Dry	P value
Nessuit						
Mean± SD	35.00 ±7.54	30.00 ±5.87	0.110	3.66 ±0.78	4.54±2.78	**0.586**
Range	27.00-43.00	25.00-40.00		2.90-4.60	2.30- 9.40	
Beeston						
Mean±SD	47.60± 6.67	24.40± 3.90	0.084	4.42± 1.02	4.32±3.16	**0.960**
Range	29.00-64.00	17.00- 38.00		3.60-6.10	0.72-9.40	
Njokerio						
Mean±SD	148.00±35.64	110.00±18.61	0.163	101.60±12.84	101.80±12.70	**0.970**
Range	110.00-200.00	93.00-140.00		90.00-120.00	90.00-120.00	
Njoro canning						
Mean±SD	1780.00^{a}±507.00	1066.00^{a}±542.00	0.145	1440.00^{a}±798.70	414.00^{a}±24.80	**0.045**
Range	1100.00-2400.00	640.00-2000.00		400.00-2300.00	380.00-440.00	
Njoro Bridge						
Mean±SD	2700.00^{a}±1177.00	1388.00^{a}±536.00	0.083	1880.00^{b}±486.80	520.00^{a}±165.40	**0.002**
Range	1500.00-4600.00	900.00-2100.00		1100.00-2400.00	380.00-750.00	

Source Kiruki, et al, (2011).

Annex 3: Non parametric tests- Chi-Square Tests

education of a another adult member		**Value**	**df**	**Asymp. Sig. (2-sided)**
primary	Pearson Chi-Square	705.629[a]	590	.001
	Likelihood Ratio	277.298	590	1.000
	Linear-by-Linear Association	2.361	1	.124
	N of Valid Cases	96		
secondary	Pearson Chi-Square	1814.618[b]	1653	.003
	Likelihood Ratio	519.075	1653	1.000
	Linear-by-Linear Association	23.645	1	.000
	N of Valid Cases	154		
diploma college	Pearson Chi-Square	995.015[c]	994	.485
	Likelihood Ratio	383.403	994	1.000
	Linear-by-Linear Association	13.325	1	.000
	N of Valid Cases	89		
university	Pearson Chi-Square	965.586[d]	910	.098
	Likelihood Ratio	348.826	910	1.000
	Linear-by-Linear Association	9.763	1	.002
	N of Valid Cases	84		
other	Pearson Chi-Square	8.000[e]	6	.238
	Likelihood Ratio	8.318	6	.216
	Linear-by-Linear Association	2.947	1	.086
	N of Valid Cases	4		
none	Pearson Chi-Square	4.000[f]	3	.261
	Likelihood Ratio	4.499	3	.212
	Linear-by-Linear Association	.250	1	.617
	N of Valid Cases	4		
Total	Pearson Chi-Square	7451.400[h]	6102	.000
	Likelihood Ratio	1599.944	6102	1.000
	Linear-by-Linear Association	138.171	1	.000
	N of Valid Cases	496		

Annex 4: socio-demographic characteristics of the respondents

	Characteristics of the variable	Njoro (rural)	Nakuru (urban)	Totals
Mean age of respondent (year)		34.7	27	30.9
Gender of respondent	% Male/female	40.7/59.3	46.7/53.3	43.7/56.3
Gender of Household head	% Male/female	82.7/17.3	83.3/16.7	83.0/17.o
Education levels of adult HH members	None	3	0	1.5
	Primary	48.1	9	28.1
	Secondary	42.1	23.9	33.1
	Diploma	5.1	26.9	16.0
	university	1.3	36.9	19.0
	"Other"	0.3	2.7	1.5
Mean education in years		9.8	13.2	11.5
Mean household size		5.7	4.3	5.0
Sanitation	Toilet	-	60.7	32.3
	VIP	2.7	10.0	6.3
	Covered pit	3.3	1.3	2.7
	Uncovered pit	81.3	24.0	52.7
	Bush/open space	12.7	-	6.3
Diarrhea prevalence		23.3	6.9	13.7

Annex 5: Drinking water sources in Nakuru County

Water variable	Characteristic		Rural (Njoro)	urban (Nakuru)	Total
Drinking water sources	Piped water	dwelling	-	*38*	*19.1*
		compounds	-	*28.7*	*14.3*
		public	-	*20.7*	*10.3*
	Boreholes		*2.0*	-	*1.0*
	Stream		*39.3*	-	*19.7*
	Protected dug wells		*1.3*	-	*0.7*
	Protected springs		*24*	-	*12.0*
	Unprotected springs		*32*	-	*16.0*
	Rain water		*0.7*	-	*0.3*
	Bottled water		*0.7*	*6.7*	*3.3*
	Bottled water and piped water		-	*6*	*0.6*
Mean amount of drinking water consumed in a day (liters)			*4.0*	*4.0*	*4.0*
Is drinking water safe	Yes		*45.3*	*52*	*48.7*
	No		*51.3*	*46.7*	*49.0*
	Don't know		*3.3*	*1.3*	*2.3*
Why is drinking water unsafe	Contaminated		*50.6*	*76.9*	*63.6*
	Turbid		*38.9*	*8.1*	*23.9*
	Smells		*1.4*	*2.6*	*2.0*
	Tastes bad		-	*1.4*	*0.6*
	Contaminated and turbid		*3.9*	*1.4*	*2.6*
	Other reasons		*5.3*	*9.5*	*7.4*
Time used in collection of water (minutes)			*21.9*	*4.5*	*13.2*
Water source for other uses	Piped water	dwellings	-	*46*	*23*
		Compounds	-	*32.7*	*16.3*
		public	-	*16.7*	*8.3*

	Boreholes	*2*	-	*1.7*
	Stream	*58*	*3.3*	*30.7*
	Protected dug wells	*0.7*	-	*0.3*
	Protected springs	*14.7*	-	*7.3*
	Unprotected springs	*24.7*	-	*12.3*
Safe to drink untreated water	Yes	10	0.7	*5.3*
	No	88	98.7	*93.3*
	don't know	2	0.7	*1.3*
Why not	Causes diseases	*46*	*51.8*	*49.7*
	Turbid	*4*	*0.7*	*2.4*
	Bad smell	-	*1.5*	*0.7*
	Contaminated by fecal matter	*24*	*37.2*	*30.9*
	Bad taste	-	*3.6*	*3.2*
	Water quality is bound to vary	*0.7*	*0.7*	*0.7*
	Common sense	*2.7*	*3.4*	*3.0*
	Combination of reasons	*22.7*	*3.6*	*12*

Annex 6: Water treatment situations in the study area

Variable	Characteristic	Rural (Njoro) (%)	Urban (Nakuru) (%)	Total (%)
Methods of water treatment known	Boiling	45.3	20	32.7
	Chlorination	8.9	10	9.3
	PUR	1.3	-	0.7
	Decantation	-	5.3	2.7
	Ceramic filter	-	9.5	0.3
	Boiling & chlorination	40.7	48.7	42.0
	Other combinations	-	6.5	10.3
	None	4.0	-	2.0
Do households treat drinking water		43.3	79.4	61.0
Why not	No need	41.8	25.2	33.4
	Water is already safe	38.1	59.3	48.7
	It's expensive	8.4	6.1	7.2
	Religious reasons	1.9	-	0.9
	No time	1.9	3.2	2.5
	Mix of reasons	3.8	6.1	4.9
How often households treat water	Every time	19.3	66.0	42.7
	When I find it turbid	8.0	0.7	4.3
	When it's convenient	16.0	13.3	14.7
	Don't treat	56.7	20.0	38.3
Method of treatment used	Boiling	26.7	33.3	30.0
	Chlorination	13.3	22.0	17.7
	PUR	2.7	-	1.3
	Don't treat	56.7	20.0	38.3
	Boiling &chlorination	0.7	0.7	0.7
	Ceramic filters	-	2.7	1.3
	Bottled water	-	10.0	5.0
	Other combinations	-	2.1	1.6
	Ceramic candle filters	-	9.1	4.7
Amount used in consumption of bottled water (median)		6.25	9.37	8.75

Annex 7: Income and WTP of the respondents

Variable	Characteristic	Rural (Njoro)	urban(Nakuru)	average
Monthly income	Mean	190	950	570
	Median	150	594	213
	Mode	188	125	13
	Maximum	1125	7500	7500
	Minimum	14	25	14
	25 percentile	100	150	125
	50 percentile	150	594	213
	75 percentile	250	1406	681
	Standard deviation	143	1081	859
Percapita monthly income ($)	Mean	39	225	132
	Median	31	156	50
	Mode	31	125	63
	Maximum	141	1250	1250
	Minimum	2	6	2
	25 percentile	19	55	25
	50 percentile	31	156	50
	75 percentile	50	298	159
	Standard deviation	28	240	194
Percapita annual income	Mean	558	3002	1780
	Median	375	1994	638
	Mode	450	600	450
	Maximum	7463	15000	15000
	Minimum	21	59	21
	25 percentiles	217	665	300
	50 percentiles	375	1994	638
	75 percentiles	603	4230	2025
	Standard déviation	802	3187	2623
WTP	Mean	18	30	24
	Median	19	31	25
	Mode	13	38	13
	Maximum	50	63	63
	Minimum	0	0	0
	Variance	7624	23331	18297
	Standard déviation	10	17	15
	25 percentiles	13	13	13
	50 percentiles	19	31	25
	75 percentiles	25	44	37

Annex 8: Drinking water sources and treatment methods in Kenya

Table 2.6 Household drinking water

Percent distribution of households and de jure population by source, time to collect, and person who usually collects drinking water; and percentage of households and the de jure population by treatment of drinking water, according to residence, Kenya 2008-09

	Households			Population		
Characteristic	Urban	Rural	Total	Urban	Rural	Total
Source of drinking water						
Improved source	89.3	53.8	63.0	89.7	53.1	60.2
Piped water into dwelling	22.8	4.7	9.4	24.4	3.5	7.5
Piped water into plot	33.1	9.0	15.2	30.7	7.5	12.0
Public tap/standpipe	19.8	6.1	9.7	21.3	6.2	9.1
Tube well or borehole	6.7	9.5	8.8	5.6	9.7	8.9
Protected dug well	4.7	11.6	9.8	5.1	12.9	11.4
Protected spring	1.6	10.2	8.0	1.9	11.0	9.2
Rainwater	0.6	2.7	2.2	0.7	2.4	2.1
Non-improved source	6.3	45.8	35.5	6.2	46.5	38.7
Unprotected dug well	1.3	6.2	4.9	1.5	6.4	5.5
Unprotected spring	0.9	7.2	5.6	1.0	7.7	6.4
Tanker truck/cart with small tank	2.1	1.1	1.3	1.8	1.1	1.2
Surface water	1.9	31.3	23.7	2.0	31.3	25.6
Bottled water, improved source for cooking/washing[1]	1.4	0.0	0.4	1.2	0.0	0.2
Bottled water, non-improved source for cooking/washing[1]	0.1	0.0	0.1	0.1	0.1	0.1
Other	2.8	0.4	1.0	2.7	0.3	0.8
Total	100.0	100.0	100.0	100.0	100.0	100.0
Percentage using any improved source of drinking water	90.8	53.8	63.4	91.0	53.1	60.4
Treatment of water[2]						
Boiled	38.0	25.4	28.6	37.6	24.0	26.6
Bleach/chlorine	21.5	16.3	17.6	22.9	17.0	18.2
Strained through cloth	0.3	1.5	1.2	0.4	1.7	1.4
Ceramic, sand, or other filter	1.7	0.5	0.8	1.6	0.6	0.8
Solar disinfection	0.0	0.2	0.1	0.0	0.2	0.1
Allowed to settle	0.2	0.5	0.4	0.1	0.4	0.4
Other	0.3	0.1	0.1	0.3	0.1	0.1
No treatment	42.5	59.1	54.8	42.1	59.7	56.3
Percentage using an appropriate treatment method[3]	57.1	40.2	44.6	57.5	39.8	43.2
Number	2,350	6,707	9,057	7,365	30,704	38,069

[1] Because the quality of bottled water is not known, households using bottled water for drinking are classified as using an improved or non-improved source according to their water source for cooking and washing.
[2] Respondents may report multiple treatment methods, so the sum of treatment may exceed 100 percent.
[3] Appropriate water treatment methods include boiling, bleaching, straining, filtering, and solar disinfecting.

Annex 9: Household Survey Questionnaire

Name of the interviewer...............................Block...

Questionnaire No.............. Cluster number ....cluster name.....................Date.......................

INTERVIEWER INSTRUCTIONS

INTERVIEW ONLY HOUSEHOLD MEMBERS WHO LIVE IN THE HOUSE
INTERVIEW ONLY ADULT HOUSEHOLD MEMBERS (18 YEARS AND OLDER)
INTERVIEW AN EQUAL NUMBER OF MEN AND WOMEN IF POSSIBLE
INTERVIEW AN EQUAL NUMBER OF YOUNG AND OLD PEOPLE IF POSSIBLE
INTRODUCE YOURSELF
THIS IS AN INDEPENDENT RESEARCH PROJECT
THE INTERVIEW WILL LAST ABOUT 30 MINUTES
PLEASE ANSWER AS TRUTHFULLY AS POSSIBLE
YOUR ANSWERS WILL BE TREATED COMPLETELY CONFIDENTIAL
YOU WILL NOT BE CONTACTED AFTERWARDS BY ANYONE ELSE ABOUT THE ANSWERS

Section one: demographic data

I a). Gender of the respondent (0) Male (1) Female

1b). Can you state your age ....years

2. What is your role in this household, are you the head of the household? (0) No (1) Yes

3. If No, what is your relationship to the head of the household? I am:
(0) Husband/wife of the head of the household (1) Son/daughter of the head of the household
(2) Brother/sister of the head of the household (3) father/mother of the head of the household
(4) Other, namely ………………………………..

4. How many people live in your household, including yourself?

children under 18		adults over 18	
…........ boys	…........ girls	…....... men	…......women

5. Did you go to school (0) No (1) Yes
6. If yes, what is the highest level of education you reached?
(0) Primary school (1) Secondary school
(2) Diploma colleges
(3) University degree (4) other, name grade ….................................

7. Can you tell me the highest level of education of any other adult household member?
(0) Primary school (2) Diploma (4) Others (specify)..................................
(1) Secondary school (3) University degree

8. What is the **Main** type of sanitation facility that members of your household use?

(0) Flush toilet connected to sewerage (3) Flush toilet connected to septic tank
(1) In the bush/open space (4) Covered Pit latrine
(2) Ventilated improved pit (VIP) (5) uncovered pit latrine
(6) Other, namely …………….

9. Do you separate drinking water from water for other uses? (0) Yes (1) No

10. What is the **Main** source of drinking water for members of your household?
(0) Piped water inside dwelling (4) Piped water inside compound (8) public taps
(1) Borehole (5) protected spring (9) Unprotected spring
(2) River/stream (10) Rain water
(3) Protected Dug well (7) Unprotected dug well (11) other, namely.............

11. Do you think the water you use for drinking is safe? (0) Yes (1) No (2) I don't know

12. If no why not?
(0) Contaminated by germs (1) It is muddy
(2) It smells (3) its taste is bad (4) other, namely............................

13. Has any of your children suffered from diarrhoea in the last two weeks? (0) Yes (1) No

(For households whose drinking water source is not found in the house or in the yard)

14). Approximately how long does it take get to the nearest water source, fetch water and come back?.........................minutes

15. Why does it take that long
....
....

16. What is the amount of water your household uses for **drinking** on average in a day? .... litres?

17. What is the **Main** source of water for members of your household for other purposes like cooking and washing?
(0) Piped water inside dwelling (4) Piped water inside compound (8) public taps
(1) Borehole (5) protected spring (9) Unprotected spring
(2) River/stream (10) Rain water
(3) Protected Dug well (7) Unprotected dug well (11) other, namely.............

18. Do you think untreated water is safe for drinking? (0) Yes (1) No (2) I don't know

19. Why or why not?..
....

20. Do you know any method of making drinking water safe? (0) No (1) Yes

21.If yes which ones...

22a) . Do you treat/do anything to make water safe to drink? (0) No (1) Yes

22b) If no why not...

(**JUMP TO SECTION TWO IF THE ANSWER IS NO**)

23. How often do you treat drinking water?

(0) Every time (2) when there is a disease outbreak (4) when it's convenient
(1) When there is a public campaign (3) When I find it dirty (5) other (specify).....................

24. What method of drinking water treatment do you use?

(0) Boiling (3) Water guard/Aqua tab (6) solar disinfection (SODIS)
(1) Ceramic candle filter (4) Ceramic filter (chujio) (7) PUR
(2) Bottled water (5) others (specify)....................................

JUMP TO SECTION 2 IF THE ANSWER IS NOT BOTTLED WATER

25. How much in a month do you use for consuming bottled water? Ksh ....

Section two: Choice experiment

I'm now going to describe to you an example of a new water filter (**show filter design**). To fill the tank, wwater collected from a river, spring, well, tap or rainwater can be used without any pre-treatment. The filter removes all possible sources of diseases and mud from the water, making the water clear, clean and safe to drink (**indicate on the filter design**). The filter does not change the taste or the smell of the water. The time the filter takes to clean water depends on the treatment speed. This can vary from 15 minutes, to 45 minutes. So, the shortest time period the filter takes to clean water for direct use in the house is 15 minutes and the longest time period is 45 minutes.

The filter comes in different sizes. The storage capacity varies from 1 to 10 litres (**indicate storage tank on the filter design)**. So, the smallest tank is able to store a bottle of one litre, while the biggest tank is able to store 10 bottles of one litre. Note that the time it takes to treat 1 litre of water by the filters is independent of the storage capacity. So, a larger storage tank does not necessarily result in to a shorter treatment time. As a result of the new filter, the number of cases of diarrhoea in every household is expected to be reduced from currently, on average, four times per child per year to one time per child per year. The filter does not require any cleaning or maintenance and has a lifetime of 5 years.

We are interested in finding out which combinations of filter characteristics households in this area prefer most. To this end, I will now show you a number of possibilities on cards. Each card shows two filters with different characteristics. Each filter is described based on the time taken to treat one litre of water, storage capacity, ability to reduce the prevalence of diarrhoea cases of children per year and the purchase price. Remember that the time to treat 1 litre of water varies from 15 minutes, 30 minutes and 45 minutes, the storage capacity can vary from 1 to 5 and 10 litres and the occurrence of diarrhoea with children from 4 to 2 and 1 time per child per year I will show you first an example card to briefly explain the idea behind the cards. All you have to do is tell me which filter you prefer.

SHOW THE EXAMPLE CARD

In this example card, the first filter need 45 minutes to clean 1 litre of water and has a storage capacity of 1 litre. With this filter, the number of diarrhoea cases per child per year will stay the same, namely on average 4 times per year. The price of this filter is 2000 Kenyan shillings. The second filter needs 15 minutes to clean 1 litre of water a higher storage capacity of 10 litres. This filter is able to reduce the frequency of diarrhoea in children from currently 4 times per year to once a year. Obviously, because of the larger storage capacity and shorter treatment time, the price is also higher compared to the first filter, namely 4000 Kenyan shillings. Which filter do you prefer, the first one or the second? If neither is to your liking, you can also choose none of the two.

Is this example clear? If not, what is not clear exactly?

(Continue until the choice task is 100% clear)

If so, I will now show you five new cards. Again each card shows 2 different filters. All I ask you to do is to look carefully at each card and the 2 filters described on each card and tell me which filter you prefer. Note that every card should be evaluated separately from the previous one. The cards are not related to each other and should be considered independently. On every card you are asked to make a new choice. When you consider the filters in the next 5 cards, please take into account your household's disposable income and existing alternative filters on the market

26**. SHOW THE CHOICE CARDS FROM ONLY ONE BLOCK TO THE RESPONDENT AND INDICATE THE ANSWERS IN THE TABLE BELOW**

INSTRUCTION: DO NOT FORGET TO INDICATE WHICH BLOCK NUMBER YOU USE!!

INSTRUCTION: TICK WHICH FILTER THE RESPONDENT PREFERS IN EACH CHOICE CARD

BLOCK	CARD NUMBER	FILTER OPTION		
		(B)	(B)	NONE OF THE TWO
	1			
	2			
	3			
	4			
	5			

Section Three: CV

27. If you would be given the opportunity to purchase a standard outfit of the filter with a storage capacity of 10 litres, takes 30 minutes to treat 1 litre, and a filter which would reduce the number of cases of diarrhoea in your household from, on average, four times per child per year to one time per child per year, would you be interested to buy this filter? And if so what would be the maximum amount of money you would be willing to pay for this filter..?

If the answer is not ZERO jump to section 4

28. If you are not willing to pay anything, can you briefly explain why not?

....

Section four: income and household items inventory

29. How many household members work and generate income?

(0) IF ALL MEMBERS ARE UNEMPLOYED, TICK HERE AND SKIP THE TABLE

USE TABLE

a) Please specify what they do,

b) Indicate to the best of your ability how much income your household earned last year in 2011 with these occupational activities, and

c) If not all household members are currently employed all year round, indicate how many months per year they are unemployed.

Please note that all the information you give me will be treated completely confidential!

IF NECESSARY USE THIS TABLE TO HELP PEOPLE STATE THEIR MONTHLY INCOME LEVEL

(A)	<Ksh 5,000 per month	(G)	Ksh 30,001-35,001
(B)	Ksh 5001-10,000	(H)	Ksh 35,001-40,000
(C)	Ksh 10,001-15,000	(I)	Ksh 40,001 -45,000
(D)	Ksh 15,001-20,001	(J)	Ksh 45,001-50,000
(E)	Ksh 20,001-25,000	(K)	Ksh 50,001-550000
(F)	Ksh 25,001-30,000	(L)	Ksh 55, 001-60, 000
		(M)	>60,001

Person	Primary occupation			Secondary occupation			Other occupations		
	Occupation	Income 2011	Number of months/year unemployed	Occupation	Income 2011	Number of months/year unemployed	Occupation	Income 2011	Number of months/year unemployed
Woman 1		Ksh ……..			Ksh ……..			Ksh ……..	
Woman 2		Ksh ……..			Ksh ……..			Ksh ……..	
Woman 3		Ksh ……..			Ksh ……..			Ksh ……..	
Man 1		Ksh ……..			Ksh ……..			Ksh ……..	
Man 2		Ksh ……..			Ksh ……..			Ksh ……..	
Man 3		Ksh ……..			Ksh ……..			Ksh ……..	

Note 2: if the respondent is not sure or does not know the income generated by other household members, please ask him/her to consult other available family members

30. Does your household have other sources of income not mentioned before such as government grants or remittances? (0) No (1) Yes

31. If yes, can you indicate how much other income your household received in 2011?

Source...…………… Income in 2011: Ksh …………

Source...……………… Income in 2011: Ksh …………

Source…........................ Income in 2011: Ksh…………

32. Does your household borrow money from other people in your community? (0) No (1) yes

33. If yes what is the approximate amount you borrowed in 2011? Ksh..

34. If yes, can you tell me from whom? (0) Relatives (1) Non-related friends (2) Non-related neighbours (3) Others,(specify)……….

35 Can you tell me if your household owns any of the following?

Again, please note that all the information you give me will be treated completely confidentially!

Asset	Number	Livestock	Number
Houses		Milk /beef cow	
Kitchen stove (LPG gas cooker or electricity stove)		Local cattle breeds	
Refrigerator		Horses	
Freezer		Donkeys	
Car		Sheep	
Motorcycle		Goats	
Television		Chickens	
Radio			
Cell phone			
Bicycle			
electricity			
Solar panel			

36 If you are a (part-time) farmer, can you specify which crops you grow on your land?

Crop	**Crop yield 2011**	**Used for own consumption**		**Sold to neighbours/friend** Ksh		**Sold on market**	
	kg	kg	Value (Ksh)	kg	value (Ksh)	kg	value (Ksh)
Maize/							
Sorghum/							
Potatoes							
Fruits							
Vegetables							
Other, namely ……………………. …………………….							

INFORMED CONSENT FORM FOR CROSS-SECTIONAL SURVEY

Principle Investigator: Fumbi Cresent Job

Research title: **User perceptions and willingness to pay for gravity driven membrane technology in Nakuru- Kenya**

Introduction

I am working for Egerton /Eawag in Collaboration with UNESCO-IHE institute for water education (Delft, Netherlands). We are conducting a research study on our new household GDM water filters. We would like to learn what do people think about the filter and what their willingness to pay (WTP) for new filter is. We are trying to understand the user perceptions so as to optimize the design of the so that people can use it and reduce diarrheal diseases in Kenya.

Procedures

If you agree to take part, I will ask you some questions about your household, water consumption and treatment. I will take some notes on paper. It will take about 30 minutes. Based on that information, I will ask you more questions and ask you to make choices using cards.

BENEFITS: The information you give us, may help to improve the water quality and health conditions in the future.

COSTS and COMPENSATION: There is no cost to you for being in this study. You will not receive anything for being in the study.

RISKS: There is no risk from being in this study. We will only collect information.

CONFIDENTIALITY: We will keep all information that we collect locked. Only people working on the project will have access. Your name will not be used in reporting the findings. We expect the steps we take will keep all of your information confidential.

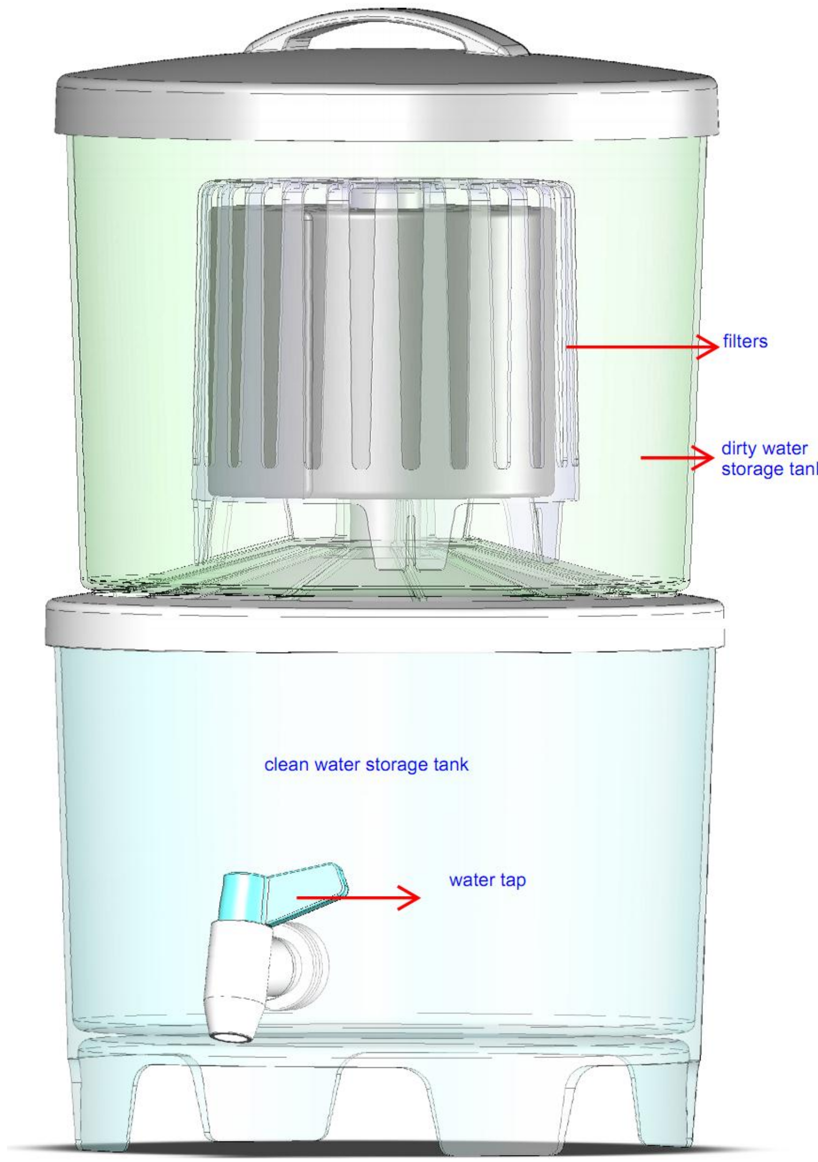
We are not interested in any particular answers, just in the answers that really represent your opinion. We would like to know why people are doing what they are doing so that we can improve the drinking water situation depending on this information. It helps us most if you answer as honest and properly as possible.

VOLUNTARY PARTICIPATION: You are free to decide whether or not to be in the study. If you start to participate in the study, you can stop at anytime. If you decide not to be in the study you will not lose any benefits.

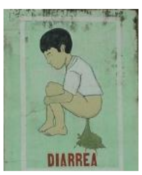
If you have any question about this research study you may contact Egerton University, department of environmental sciences, P.O Box 536 Egerton, e-mail- moturi33@yahoo.com. Tel +25405102217781 EXT 3412 or cresent.fumbi@eawag.ch

Interviewer..Date...........................Respondent ....Date...............................

Annex 10: Filter design


filters
dirty water
storage tank
clean water storage tank
water tap

Annex 11 example of a choice card

1-1		**Filter A**	**Filter B**	
	**Time to treat 1 litre**	 **45 minutes**	 **30 minutes**	
	**Storage capacity**	 **1 litre**	 **5 litres**	
	**Diarrhoea prevalence**	**One time per child per year**	**Four times per child per year**	
	**Price (Ksh)**	**Ksh 2000**	**Ksh 2500**	
Which option do you prefer?		☐	☐	☐ **None of the two**

Annex 12: Filter description

GDM filter attributes		**Levels of**	**attributes**			
	**Time o treat 1 litre**	 **45 minutes**	 **30 minutes**	 **15 minutes**		
	**Storage capacity**	 1 litre	 5 litres	 **10 litres**		
	**Diarrhoea prevalence**	**Four times per child per year**	**Two times per child per year**	**One time per child per year**		
	**Price**	**Ksh 2000**	**Ksh 2500**	**Ksh 3000**	**Ksh 3500**	**KSh 4000**

Annex 13: Payment card

☐ Ksh 0	☐ Ksh 1250	☐ Ksh 2500	☐ Ksh 3750	☐ Ksh 5000	☐ Ksh 6500	☐ Ksh 15,000
☐ Ksh 250	☐ Ksh 1500	☐ Ksh 2750	☐ Ksh 4000	☐ Ksh 5250	☐ Ksh7000	☐ More than Ksh 15,000
☐ Ksh 500	☐ Ksh 1750	☐ Ksh 3000	☐ Ksh 4250	☐ Ksh 5500	☐ Ksh 8000	☐ Don't know
☐ Ksh 750	☐ Ksh 2000	☐ Ksh 3250	☐ Ksh 4500	☐ Ksh 5750	☐ Ksh9000	☐
☐ Ksh 1000	☐ Ksh 2250	☐ Ksh 3500	☐ Ksh 4750	☐ Ksh 6000	☐ Ksh 10,000	☐ Other amount, namely Ksh ………….