WILLINGNESS TO PAY FOR IMPROVED IRRIGATION WATER SUPPLY IN ZAMBIA: A CASE OF KABWE CITY

BY

MILTON MALAMA

BSc. AGRICULTURAL ECONOMICS (UNZA)

REG. NO. 2013/HD02/1897X

A THESIS SUBMITTED TO THE SCHOOL OF POST GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE AWARD OF THE DEGREE OF MASTERS OF SCIENCE IN AGRICULTURE AND APPLIED ECONOMICS OF MAKERERE UNIVERSITY

SEPTEMBER 2015

DECLARATION

To the best of my knowledge, I declare that the contents of this draft report are original unless if stated otherwise and the draft report has never been submitted anywhere for any award

………………....... ……………..

MILTON MALAMA **DATE**

This draft thesis has been submitted with permission and satisfaction from university supervisors

FIRST SUPERVISOR

……………………… ………………

DR W. EKERE **DATE**

SECOND SUPERVISOR

………………………… ………………

DR G. ELEPU **DATE**

DEDICATION

This report is lovingly dedicated to:

The glory of my Lord Jesus Christ

Who has blessed me beyond anything I could ever have imagined and who has loved me beyond my comprehension

My late grandmother Martha Fundafunda Malama

Who invested so much in me by raising me up but never lived up to reap the fruits of her investments. You gave me an opportunity to life that changed my destiny. I convey my thanks and may her soul rest in eternal peace.

Mrs Netty Malama

My best friend and my wife! Whose support and love for me never fails to lift me above the clouds of defeat and mediocrity.

"Who can find a virtuous woman?" I DID!!

Thank you for always lifting up my life to the throne of HIS grace through prayer every morning.

"Many women have done excellently, but you surpass them all"

Proverbs 31

ACKNOWLEDGEMENTS

For an endeavour of this scale, there are numerous people who I credit my gratitude for helping make it a possibility. I would like to take this opportunity to thank them. Firstly I extend my sincere gratitude to God almighty for opening this door for me to advance my career. I thank Prof. J. Mugisha for initiating me into this programme. I count myself highly indebted to him for the confidence and trust he put in me and for recommending me to pursue my master’s degree. My heartfelt gratitude also goes to my supervisor Dr William Ekere for his priceless interest in my research and consistent supervision. I ‘am deeply indebted to him for being so instrumental in giving me direction as I wrote this thesis. I thank him for his invaluable support. I also convey my gratitude to Dr G. Elepu for his supportive role he played as my second supervisor. The African Economic Research Consortium (AERC) and the Regional Universities Forum (RUFORUM) deserve recognition for the financial support extended to me to pursue this programme.

Special thanks go to Prof. Binswanger, Dr Makaudze and Dr Babatunde of the University of Pretoria for their helpful insights in Quantitative analysis as well as their input in the appropriate models to use in analysis of non – market goods. I gratefully acknowledge Mr Norman for his helpful insights in econometrics analysis. I also thank all the five research assistants for the priceless help you rendered during the process of data collection. My sincere gratitude also goes to the rural households of Katondo, Kasanda, chowa and Makululu communities in Kabwe who volunteered to be interviewed and for their contribution during the Focus Group Discussions.

Special thanks go to all lecturers of both Makerere University and the University of Pretoria for the priceless information, knowledge and wisdom they imparted in me. Had it not been for them, I would not have reached this far. A special thanks to all my course mates as well.

To the Matingas May God always look on them with favour for opening their home in Uganda when I couldn’t find where to stay as I finalised my thesis. I am forever grateful.

I wish in a very special way to extend my gratitude to my wife Mrs Netty Malama for her prayers, support and strong encouragement during my difficult moments as I worked towards completing this thesis. May the Almighty God remember her with favour for always being there when I needed her (Nehemiah 5:19). I ascribe all the glory to the Almighty God who gave me the grace and strength to complete this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

CVM	Contingent Valuation Method
CBM	Contingent Behaviour Method
CSO	Central Statistic Office
WTP	Willingness To Pay
WTA	Willingness To Accept
KDHO	Kabwe District Health Office
dL	Decilitre
ZCCM-IH	Zambia Consolidated Copper mines – Investment Holding Plc
WHO	World Health Organisation
ECZ	Environmental Council of Zambia
NOAA	National Oceanic and Atmospheric Administration
AHVLA	Animal Health and Veterinary Laboratory Agency
Pb	Lead
EAP	Environmental Protection Agency
MLE	Maximum Likelihood Estimate
RUM	Random Utility Model
CEP	Copperbelt Environmental Project

ABSTRACT

According to report produced by the Blacksmith institute (2013), Lead poisoning contributes 0.9 per cent of developing countries' disease burden. The main purpose of the study was to estimate the WTP for the improved water supply and sanitation services in Kabwe lead polluted areas in order to determine if the improved irrigation water supply project was viable. This was done using a contingent valuation method with a double bounded dichotomous choice question format. The study surveyed 485 randomly selected households using structured questionnaire face to face interview schedule in high lead endemic residential townships of Makululu, Chowa, Katondo and Kasanda. The sample included respondents aged 17-72 years old. Quantitative data was analysed using STATA computer software package. Analytical tools used included descriptive statistics and econometric Logit regression model. The results revealed that 75.05% of the rural smallholder farm households in the high lead affected areas were willing to pay for the improved irrigation water supply. Data sources originated from primary and secondary sources.

The study findings have shown that the majority of the sample households were affected by lead water pollution problems. Furthermore, results reveal that there is a positive WTP for improved irrigation water supply in Kabwe city. The response obtained from hypothetical market scenario indicates that households convey their WTP with a mean value of 50.072 Kwacha/household/month (US$7.58 /household/month) (US$1= K6.60) and the total WTP in the Kabwe city command areas is estimated to be 14,958,970 Kwacha/month (US$2,266,420.) for the whole population (300,000). Moreover, the study identified household income, age, education level; household size, gender, pollution control training, pollution experience, water source distance, first bid, and irrigated garden space are the main factors having a substantial effect on households' WTP of improved water supply. The study underlines that more attention should be given by government and other stakeholders for the implementation of irrigation water management practices in order to supply reliable irrigation water to the farmers. Furthermore, policy makers should develop and provide proper irrigation water pricing system, strengthen the existing soil and water conservation efforts and ensuring better soil and water conservation practices to manage the lead pollution problems in the catchment. Lastly, government and policy makers should consider the significant variables which have an impact in determining households' WTP.

Keywords: Willingness to pay; Contingent valuation method; Dichotomous choice. Irrigation

CHAPTER ONE

INTRODUCTION

1.1 Background

Water is one of the environmental resources which is vital for sustaining both animal and plant life, achieving sustainable development and maintaining ecosystems services (UNESCO 2006). It has unique attributes that determine both its allocation and use as a resource in agriculture. Irrigation is a very important component of agricultural production in many developing countries (Chandrasekaran *et al.,* 2009). 2.5% of the global surface water is fresh water, and it is suitable for drinking, agriculture (Devi *et al.,* 2009), recreational and environmental activities. However, the fresh water has been treated as an almost public good (Sadeghi *et al.,* 2010). As a result, with rapid economic and population growth, many water sources have become depleted or contaminated by heavy metals, therefore, now water has become a scarce good (Ahmad *et al.,* 2010). Due to increasing scarcity of water resource competition and conflicts among uses and users arise. It is therefore necessary to make decisions about conservation and allocation of water that are compatible with economic efficiency, sustainability and equity (Agudelo 2001). Therefore, pricing of water can be considered as a tool to improve sustainable use of water resources (Chandrasekaran *et al.,* 2009). Economists' uses individual willingness to pay (WTP) to determine the amount of money that consumers are willing to pay to improve the irrigation water and other environmental resources.

Environmental pollution due to increased mineral resource mining has had serious adverse effects on fish, food animals, wild animals, and humans in African countries (Jumba *et al.,* 2007; Yabe *et al.,* 2010). Zambia is rich in mineral resources such as copper (Cu), cobalt (Co), zinc (Zn), and lead (Pb). In 2008, Zambia accounted for 3.7 % and 9.2 % of global annual Copper and Cobalt production, respectively, with major mining areas being the city of Kabwe and the Copperbelt Province. Recently, environmental pollution due to mining and smelting activity has become a major problem in these two areas. Kabwe City, the provincial capital of Zambia's Central Province, has a long history of extensive lead and Zinc mining. In the Kabwe mine, which operated from 1902 to 1994, cadmium (Cd), silver (Ag), copper (Cu), and vanadium (V) were produced as by-products in addition to the main products of lead and Zinc (Kamona and Friedrich 2007). Previous studies recorded high concentrations of Pb, Zn, Cd, Cu, and arsenic (As) in Kabwe soil (Tembo *et al.,* 2006; Nakayama *et al.,* 2011).

High blood Pb levels in children (60–120 μg/dL) were also reported (Copperbelt Environment Project 2006). Given these, Kabwe has been ranked among the top ten most polluted places in the world (Blacksmith Institute 2007). In the Copperbelt Province, Copper and Cobalt mines and smelter plants are extensive. Discharge of mining waste into the Kafue River, which flows through the centre of Zambia, causes significant contamination. High concentrations of lead and Cobalt have been reported in water, sediment, and fish from the Kafue River (Choongo *et al.*, 2005) as well as in soil (Ikenaka *et al.*, 2010) in the Copperbelt Province. High Copper concentrations have also been reported in sediment and fish in Lake Itezhi-tezhi, which is located in the Kafue National Park, approximately 450 km downstream of the Kafue River from the Copperbelt Province (Nakayama *et al.*, 2010).

Mines in Kabwe were built and operated without health and safety concerns or environmental regulation. As a result, Zambian people are now facing the consequences. Families in the area have been warned not to drink water from wells as well food crops produced in their gardens. Kabwe's lead mine was run without pollution controls by the government-owned Zambia Consolidated Copper Mines (ZCCM) for most of its life before it became financially unviable and the smelter closed down. The open canal that carried toxic waste from the lead mine pits and smelter whilst the mine was in operation passes through the four neighbouring townships of Makululu, Chowa, Kasanda and Katondo. During the 2002 rainy season the canal flooded, spilling “several years” of toxic waste, silt and rubbish into the neighbouring communities. The vegetation, dusty soils and waterways are severely contaminated with heavy metals ever since (Blacksmith 2013)

Studies by Raschid-Sally and Jayakody, (2008) reveal that waste water irrigated agriculture face several challenges and opportunities associated with contaminated water irrigation crop farming in peri-urban areas in towns in developing countries. The challenges include inadequate information on the temporal changes in the heavy metal concentration in irrigation wastewater, soils and food crops (Buechler *et al.*, 2002a, b). Despite the challenges associated with wastewater irrigation farming, it is a source of livelihood for a large number of the urban poor in towns in developing countries (Raschid-Sally &Jayakody, 2008). Despite the fact that previous studies identified benefits and risks of wastewater irrigated agriculture in developing countries, they are either under-reported or underestimated in some sub-Saharan Africa countries (Raschid-Sally & Jayakody, 2008; Obuobie *et al.*, 2006). There is inadequate information on the extent of heavy metal contaminated wastewater use in crop farming in sub-Sahara Africa countries (Hamilton *et al.*, 2007).

Estimated monetary values for ecosystem goods and services which do not normally have prices are important for resource (like water) management decisions (Pearce, 2002). It helps policy-makers to set standards related to environmental goods and service uses and to design incentives that encourage ecosystem service protection (Anderson *et al.*, 2010). It can be also employed in the assessment and implementation of policies that are used to monitor and manage water resource depletion and degradation (Molla, 2005; Gebreegziabher and Tadesse, 2011). Hence, this study was undertaken in Kabwe rural mine townships where water resource is a serious problem due to lead contamination. It is aimed at estimating the economic value of improved irrigation water supply resource and identifying the factors that determine households' willingness to pay, assessing households' perception of the existing irrigation water supply situation and water problems and generating baseline information for policy intervention.

Water is a fundamental part of the environment which is vital for the survival of biotic segment of the environment. Like other environmental public goods, water has its total economic value (TEV) which includes use values (direct use, indirect use and option values) and non-use values (bequest values and existence values). This study estimates willingness to pay for improved irrigation water and potable supply in Kabwe city. The study also probes into the quality of irrigation water in the study area and people's willingness to pay (WTP) behaviour.

1.2 Problem Statement

Kabwe once had the largest and richest lead mines in Africa, but it had few pollution controls. Since 1994, the town has endured not only economic hardship but also the risk of lead poisoning. Kabwe's vegetation, soil and waterways are heavily contaminated with the highly poisonous metal. High levels of lead poisoning affect the entire population, but are particularly high in the children of the area. Children in Kabwe have been found to have as much as 10 times the EPA's allowable limit of lead in their blood. Kabwe district has 13,952 households or 35 per cent of its 300,000 population residing in lead poisoning endemic areas (CSO, 2012). These residential areas have more than 500mg of soil lead concentration per kilogram of its topsoil (ZCCM-IH, 2006). Therefore, the people in these areas are exposed to high lead poisoning of which 22 per cent are women of child-bearing age (ZCCM-IH, 2005; KDHO, 2009). The endemic areas are Chowa, Makululu, Railways, Katondo, and Kasanda areas. Heavy metal pollution is one of the most important environmental issues in Zambia and causes serious effects on humans and animals (Syakalima *et al*., 2001). In Kabwe the threat from the collapsed lead mining venture is present and needs attention from all Zambians.

Whereas studies on peri urban arable farming have been conducted in Zambia, the issues pertaining to heavy metal contaminated wastewater use in crop farming in peri urban areas have been inadequately handled (Hampwaye *et al.*, 2007; Shitumbanuma & Tembo, 2006). Studies on wastewater irrigated agriculture identified several challenges and opportunities associated with wastewater irrigation crop farming in peri-urban areas in towns and in developing countries (Raschid-Sally & Jayakody, 2008). The challenges include inadequate information on the temporal changes in the heavy metal concentration in irrigation wastewater, soils and food crops (Buechler et al., 2002a, b). Despite the challenges associated with wastewater irrigation farming, it is a source of livelihood for a large number of the urban poor in towns in developing countries (Raschid-Sally & Jayakody, 2008; Marshall et al., 2004).

Heavy metals comprising lead (Pb), chromium (Cr), cobalt (Co), copper (Cu), and nickel (Ni) were investigated due to:

(i) Their presence in wastewater used to irrigate crops.
(ii) Their potential negative effects on human health when ingested in large quantities;
(iii) Their implications on the livelihoods of people.

Results indicated that lead was present in the water and food crops and exceeded limits as set by Zambian legislative limits, FAO/WHO guidelines, EC Standards, and UK guidelines (GRZ, FAO/WHO, 2002; EC, 2001)

The types of crops contaminated with heavy metals in Kabwe included pumpkin leaves, tomato fruits, Swiss chard leaves; okra fruits and sugarcane stalk stem whilst the Chinese cabbage leaves and bean leaves were not contaminated with heavy metals. Nevertheless, different plant species have different capacity and capability to accumulate the heavy metals (Gharbi et al., 2009). Despite the challenges associated with wastewater irrigation farming, it is a source of livelihood for a large number of the urban poor in towns in developing countries (Raschid-Sally & Jayakody, 2008). Hence this study highlighted the problem of heavy metal contaminated crops consumed by peri urban population especially mining areas.

The focus of this study was to determine the value Kabwe rural farm households place on improved irrigation and potable water supply under the lead pollution conditions and to determine the factors that characterise heterogeneity in valuations across respondents. The Contingent valuation method was employed to investigate the Kabwe rural farm households' willingness to pay (WTP) for improved irrigation water supply services using Kabwe city as a case study.

Against this backdrop, understanding of household WTP for improved irrigation water supply services amongst Kabwe rural farm households can provide important input to the improvement of the welfare of the population through production of healthy irrigated food crops.

1.3 Objectives

The main objective of this paper is to determine the value Kabwe rural farm households place on improved irrigation water supply services under the lead pollution conditions and to determine the factors that characterise heterogeneity in valuations across respondents.

The specific objectives were:

i. To characterise the heterogeneity in valuations of improved irrigation and potable water supply services in Kabwe across respondents

ii. To estimate the mean willingness to pay (WTP) for the safe irrigation and potable water supply in Kabwe city and the aggregate mean willingness to pay (WTP)

iii. To determine the factors that influence WTP for improved irrigation and potable water supply in Kabwe city in valuations across respondents.

1.4 Research Hypothesis

Based on the objectives above, the following are the hypothesis derived thus:

i. The communities that are adversely affected by the lead poisoning will have positive willingness to pay for improved irrigation water services in Kabwe

ii. The mean willingness to pay for improved irrigation water supply in Kabwe city is significantly different from zero

iii. Factors such as individuals' income, age household size, gender, Irrigated garden space, Pollution experience, Pollution training, number of animals owned, location of water source employment and education have an influence on the willingness to pay for improved irrigation water in Kabwe.

1.5 Justification of the Study

This study contributes to the improvement of the design and refinement of economic valuation tools which support changes in water management and planning in water pollution context. The effect of different farm household characteristics on WTP was evaluated to help policy makers better target their interventions by improving their knowledge about farmers' perceptions.

Non-market goods and services are difficult to place a value on, because there are no prices for them. Economists have developed a number of tools to overcome this problem, which all require more effort than simply observing a market price. Policy makers who wish to promote reliable water and improved sanitation would benefit from knowing how much, if at all, people value the non-market goods and services that municipal council provides. By estimating the premium people will pay for improved water and sanitation that, for instance, decreases contamination and improves livelihoods, it will provide information on the likelihood that they will adopt the project. If policy makers choose to implement improved water services or some other payment for environmental- services scheme, it will help to determine how high payment levels will need to be.

This study provides highlights on how to enhance' Kabwe communities' willingness to pay for improved irrigation water hence partnering with the Zambian government in improving the health of the Kabwe society as well as improving the sustainability of safe water supply in Kabwe.The information this study may also be used in the planning and development of safe agricultural farming systems in peri urban areas in Zambia

The relevant authorities in Zambia may use information from this study in developing measures for control and monitoring of heavy metals in wastewater irrigation farming systems and ensure that food crops consumed by peri urban population is safe.

1.6 Organisation of the thesis

This study is organized into five chapters. Chapter two provides background information about Kabwe in Zambia and a literature review of studies regarding CVM on water valuation and people's WTP, and prior choice experiment studies done to estimate people's preferences. Chapter three outlines survey development and data collection procedures and describes the econometric models used to estimate the data and a conclusion. Chapter four outlines survey results and discussion on the results. Finally chapter five outlines the summary, conclusions of the survey as well as recommendations.

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews the most important and recent work on improved irrigation and potable water supply problems as well as people's willingness to pay for improved irrigation and potable water supply and the factors affecting people's willingness to pay for improved water services. It provides context for the problem and explores related works and on-going debates in the field of environmental pollution and the effects of water pollution

2.1 Overview of heavy metal water pollution

Yoshmori *et al.*, (2010) reveals that heavy metal pollution is one of the most important problems in Zambia and causes serious effects to humans and animals. In their study that was aimed at evaluating the spatial distribution of heavy metals in main areas of Zambia and understand the characteristics of the pollution in each area. River and lake sediments and soil samples were collected from a large area of Zambia and analysed for ten heavy metals (Cr, Co, Ni, Cu, Zn, As, Cd, Pb, Sr and Hg). The results indicated that heavy metal pollution in Zambia has strong regional differences. Using cluster analysis, the patterns of heavy metal pollution were divided into three major clusters: Kabwe, Copperbelt and Lusaka and other areas.

2.2 Heavy metals and water

In his study, Kapungwe (2013) investigated heavy metal contamination of water, soils and crops at two study sites in Zambia. Study sites included were New Farm Extension in Mufulira (mining area) and Chilumba Gardens in Kafue. Heavy metals comprising chromium (Cr), cobalt (Co), copper (Cu), lead (Pb) and nickel (Ni) were investigated due to:

(i) their presence in wastewater used to irrigate crops which were found to be higher than acceptable limits;

(ii) their potential negative effects on human health when ingested in large quantities;

(iii) Their implications on the livelihoods of people.

Samples of water, soil and crops were collected and analysed for lead, copper, chromium, cobalt and nickel using the Atomic Absorption Spectrometer (AAS). The results indicated that heavy metals were present in the water, soil and crops at the two study sites and exceeded acceptable limits. It was further noted that wastewater, soil and crops were contaminated with heavy metals at the two peri-urban areas in Zambia. The study highlighted the problem of heavy metal contaminated crops consumed by peri urban population. . the study results indicated that heavy metal contaminated irrigation wastewater implies that the wastewater was not suitable for crop irrigation. He further noted that heavy metal contaminated soil implies that there is the likelihood of soil toxicity and transfer of heavy metal contaminations to crops. The implications of heavy metal contamination of food crops are two folds firstly it implies that that the crops which recorded heavy metal contamination can be key in verification of heavy metal contaminated cropping systems. Secondly consumers of heavy metal contaminated food crops are associated with potential health risks.

Kapungwe (2013) suggest that the probable reason for relatively high levels of heavy metals in water at New Farm in Mufulira was that domestic sewage was contaminated with heavy metals from copper processing at Mopani Copper Mines in Mufulira which were consistent with the findings of. Moreover, he went further to note that the probable reason for heavy metal contamination of wastewater at the Chilumba Gardens was that the main source of irrigation wastewater was untreated effluent from Lee Yeast Factory and Kafue Chemicals in Kafue Estate Industrial Area operated throughout the year. This study indicated heavy metal contamination of irrigation water at two study sites which was similar to the results from the study by Muchuweti et, al. (2006) at Firle Farm in Harare, Zimbabwe where heavy metal contaminated wastewater was used to irrigate vegetables. Furthermore, the results from this study were similar to findings by Simukanga et al., (2002) on the Mwambashi catchment area in the Copperbelt province, Zambia which indicated that mining activities have negatively affected the water quality along the Mwambashi river and its tributaries in both the dry and wet seasons. In his findings Kapungwe (2013) further recommended that the relevant authorities in Zambia could use information from this study in developing measures for control and monitoring of heavy metals in wastewater irrigation farming systems and ensure that food crops consumed by peri urban population is safe.

2.3 Heavy Metals and levels in Food Crops

Kapungwe (2013) in a recent study found that copper and lead were present in a number of food crops and exceeded limits as set by Zambian legislative limits, FAO/WHO guidelines, EC Standards, and UK guidelines (GRZ, FAO/WHO, 2002; EC, 2001; UK guideline, 1989) whilst chromium and nickel were present in the food crops and exceeded acceptable limits outlined by Lake (1987) (Table 2.1). The cobalt was present in the food crops and exceeded limits as set by Ministry of Environment Ontario Canada (MEO, 2011). He also noted that often, highest concentrations of heavy metals in food crops tend to be found at start of the wet season. His findings indicated that the types of crops contaminated with heavy metals at New Farm Extension, Mufulira included pumpkin leaves, tomato fruits, Swiss chard leaves; okra fruits and sugar cane stalk stem whilst the Chinese cabbage leaves and bean leaves were not contaminated with heavy metals (Table 2.1).

Earlier studies found that generally, it could be argued that there was heavy metal contamination of food crops at the mining area site (Chishimba, 2008; Mulenga, 2008; Kapungwe, 2011). The probable reasons for relatively high levels of lead and copper in most foodcrops and water at New Farm in Mufulira mining area included: domestic wastewater contaminated with copper from copper processing at Mopani Copper Mines in Mufulira and relatively higher natural copper background levels in the soils since the New Farm study site was it located in copper ore mining areas in Mufulira.

Table 2.1: Heavy metals (mg/kg) in commonly eaten food crops in Mufurila mining area in Zambia by Season

Crops and seasons	Copper (Cu)	Lead (Pb)	Cobalt (Co)	Chromium (Cr)	Nickel (Ni)
Chinese cabbage leaves					
Cool dry season :April/July	0.54 ± 0.54	0.75±0.05*	4,71± 4.69	ND	0.44± 0.20
Hot dry season Aug/Oct	ND	ND	ND	0.31± 0.18	0.01± 0.01
Tomato fruit					
Hot/wet season :Nov/Mar	91.0*	17.8*	10*	153.4*	31.1*
Cool dry season: April/July	0.54	0.4*	ND	ND	0.72
Hot dry season: Aug/Oct	3.57 ± 1.41	ND	ND	0.18±0.14	0.02±0.02
Swiss chard leaves					
Hot wet season: Nov to Mar	6.08±2.27	0.105±0.09	ND	0.29±0.15	0.29±0.17
Cool dry season: Apr to July	0.9±0.92	0.67±0.03*	3.83±3.77	ND	ND
Hot dry season: Aug to Oct	525.2*	17*	12	104.6*	20.6*
Pumpkin leaves					
Hot wet season: Nov to Mar	789*	24.5*	20.0	159.9*	31.6*
Hot dry season: Aug to Oct	11.12±4.17	0.31±0.31*	ND	0.12±0.12	0.06±0.06
Bean leaves					
Hot dry season: Aug to Oct	12.2	ND	ND	0.24	ND
Okra fruits					
Hot wet season: Nov to Mar	71.02±55.0*	5.5±4.50*	2.05±1.62	36.46±27.73*	10.82±8.73*
Sugarcane stem					
Cool dry season: Apr to July	29.45±2.03*	12.09±1.27*	1.91±0.51	4.21±1.20*	6.19±1.42*
Hot dry season: Aug to Oct	22.46±1.33*	36.1±3.42*	1.67±0.42	13.87±0.78*	ND
Heavy metal acceptable limits	20-50.0	0.3-2.0	50	1.0	2.0

Source : Kapungwe,.2013; ND= Not detected; *heavy metals above acceptable limits, ** missing values, GRZ,1995; MEO, 2011, Lake 1987 FAO/WHO, 2002, EC 2001, UK guideline, 1989.

2.4 Factors determining household/farmer Willingness to Pay for Water

So many factors and circumstances have an effect on an individual's willingness to pay for good especially non market goods. These factors are discussed differently by different authors. in the case of the Koga irrigation project in Ethiopia, the mean willingness to pay (WTP) of smallholder farmers for improved irrigation water was determined using a contingent valuation method with a double bounded dichotomous choice question format. Alemayehu (2014) estimated the mean and the total WTP of households as well as the major determinants of the WTP by applying seemingly unrelated bivariate Probit regression model. The study identifies education level, household size, gender; first bid, total family income and cultivated land size are the main factors having a substantial effect on households' WTP of improved irrigation water.

Similar results were obtained by Mezgebo and Ewunet (2014) in estimating households' willingness to pay for improved water services in urban areas: In Nebelet town, Ethiopia**.** Cross-sectional data was used that was collected from 181 households in 2011/2012, and the probit model was used to identify socio-economic factors that affect the willingness to pay (WTP) of households. In their study they noted that income, distance, water expense, bid, education, level of existing water satisfaction, marital status and sex were associated with households' willingness to pay for the provision of improved water services. They further recommended that, in designing water project/policy, socio-economic factors (such as age, monthly income, educational level) should be considered for successful water project/policy at household level.

Sserunkuma *et al.*, (2005) in their study on the Collective Action in the Management of Canal Irrigation Systems: The Doho Rice Scheme in Uganda indicated that factors such as perception, coupled with limited awareness and poor enforcement of the bylaw, partially explained why some farmers were not willing to pay the user fee even when it was meant for their own benefit. They further noted that challenge remains that, without enough farmers willing to pay the fees, the irrigation system could not be adequately de-silted, which in turn lowers the amount of irrigation water supplied to the rice plots, hampering rice yields and farmers' ability to pay the user fees in the following season.

Their results showed that households that depend on rice for a large part of their cash income were more likely to comply, supporting the theory that users' dependence on a resource increases the incentives for organization for collective management of that resource. It was also noted that agricultural training in soil and water conservation and access to credit increase compliance, which underscores the importance of providing support services (extension and credit) to increase farmers' awareness of the need and enhance their ability to contribute to the cost of supplying water. Influence and recognition were leadership attributes that could facilitate organization for successful collective action.

Their results were found to be consistent with the finding of Balana *et al*., (2013) in their study in which they assessed the willingness to pay for reliable domestic water supply via catchment management: in Nairobi, Kenya. A censored regression model was employed to estimate the WTP. They noted that the monthly mean WTP was about 275 Kenya shillings. Moreover, they further noted that income, education, and age were the key variables affecting WTP. They recommended that lack of an appropriate institutional regime was the major public concern that hindered implementation of market-based domestic water supply schemes

2.5 Review of Stated Against revealed willingness to pay Studies

Jonsson (2014) revealed that there exists an important distinction between stated willingness to pay and revealed willingness to pay. Their findings further concluded that revealed WTP is based on observed behaviour and thus uses transaction prices. The stated WTP are based on intended choices and based on hypothetical responses collected through survey or interviews.

In this study, the discussion and analysis is based on the stated WTP. There exists a different approach to investigating stated preferences, one of which is a contingent valuation survey and a choice experiment. In the contingent valuation method, respondents are asked to state their willingness to pay in a direct question (often a binary yes/no question), whereas in a choice experiment respondents are asked to select answers from multiple alternatives.

Contingent valuation (CV) is frequently used for assessing monetary values on environmental goods and services (Carson, 2000). CV is often used to obtain information when goods and services are not available on the market and therefore there is rarely actual data regarding cost and sales. The respondents are asked to state their preferences, which are contingent upon the hypothetical market presented in the survey (Carson, 2000). According to Kling et al., (2012) Contingent valuation (CV) may be used for assessing willingness to pay for private and public goods and services, and produced estimates might be included in market analysis and cost-benefit analysis.

In his study, Jonsson (2014) notes that the approaches used in the measurement of WTP have been the subject of a long and heated debate. He noted that critics have been pointing out problems with the underlying assumptions for contingent valuation, survey bias and the reliability of produced estimates. Firstly, opponents argue that the results from CV indicate respondents' hypothetical opinion rather than a measure of preferences for the specific project or product, questioning respondents' familiarity and understanding of the studied subject (Hausman, 2012). Proponents agree that CV studies place respondents in a simulated market position, but contend that this method is no different than requesting customers to purchase "unfamiliar or infrequent commodities" (Hanemann, 1994). Opponents have further argued that the quality of CV is dependent on the survey design. The opponents raise the issue of phrasing and wording, the order of questions and the problem of comparability of responses (Diamond & Hausman, 1994; Hausman, 2012). They have also pointed out the hypothetical response bias that leads to producing overstated values (Hausman, 2012; Murphy & Stevens, 2004). Hausman (2012) argues that the bias in answers is often related to the specific nature of contingent valuation surveys, as respondents are asked to indicate willingness to pay expressed in specific monetary value for a certain outcome, without the possibility of different alternatives or a discussion. Moreover, the respondents are often not informed about how their answers are going to be used and therefore might be more likely to choose to give responses that please the interviewer. In addition, the CV survey often faces what is known as the "embedding effect" or the "scope problem". Kahneman and Knetsch (1992) were the first to explore the problem and wrote that "the assessed value for public goods is demonstrably arbitrary, because willingness to pay for the same good can vary over a wide range depending on whether the good is accessed on its own or embedded as part of a more inclusive package".

Opponents of the CV method have also questioned the accuracy of responses indicating that respondents may not be answering the question that the interviewer had in mind (Diamond & Hausman, 1994; Hausman, 2012). Additionally, the CV may not be an accurate measurement because respondents may experience a "warm glow" and express support for the good cause rather than indicating their individual preference (Diamond & Hausman, 1994). The term "warm glow" describes the private value an individual may experience by contributing to a worthy cause (Kling et al., 2012).

Advocates of CV approach argue that by implementing CV guidelines (Carson, 2000; Portney, 1994), conducting a reliable survey (Hanemann, 1994), and applying best practice protocols (Kling et al., 2012), the results obtained via CV can be reliable and any potential bias can be reduced. The survey bias and over-estimation of stated WTP can be reduced: when the criterion of value are clearly stated, presenting respondents with information on how the results may influence policies or strategies (Kling *et al.*, 2012), when participants are warned of a tendency to increase the values (Cummings & Taylor, 1999) and when certainty statements are included in the questionnaire (Blumenschein, *et al.*, & Freeman, 2008).

Finally, the proponents consider the difference between stated willingness to pay and accepted willingness to pay to be the definitive and non-dismissible argument (Diamond & Hausman, 1994; Hausman, 2012). The proponents agree that a discrepancy exists between willingness to pay and to accept, but contrary to opponents, find results in line with neoclassical economic theory and behavioural economics, explaining that the predicted properties of welfare are often different (Carson, 2012). Hanemann, (1994) revealed that proponents of CV established the fact that hedonic models and other tests based on market data are unable to provide complete information on measures of value, particularly if the value of the commodity is at least partly unrelated to consumption of complementary goods. (Carson 2012; Hanemann, 1994) further established that Contingent valuation was able to capture this value, often referred to in the literature as “existence value”, “passive use value” or “non-use value”

2.6 Review on Previous CVM Studies

A number of studies have been conducted using CVM methodology. Utilising CVM as an analytical tool Kanayo *et al.* (2013) estimated WTP for improved domestic water services in South Western Nigeria using CVM and identified the determinants of people’s WTP. A Tobit (censored) regression mode was used and the results that WTP for water services was sensitive to the level of education and occupation of the household head, the price charged by water vendor and the average income of the household

Mesa-Jurado *et al.* (2012) assessed the value farmers placed on the guaranteed water supply for irrigation in Guadalbullon river sub-basin (South of Spain) using CVM. The study revealed that farmers were willing to increase their irrigator’s community annual payment. Moreover, they were willing to cut average monthly income for their administrative water allowance, to increase the guarantee of their water supply. The study results also confirmed that, farmers had been given values when water became scarce associated with an increased guarantee, in addition to direct use of supplied water.

Alhassan *et al.* (2013) estimated farmers’ WTP for irrigation water in Northern Ghana using the CVM and randomly selected farm households based on their location of farms. The study used payment card elicitation format to collect WTP information. The study results confirmed that farmers were willing to pay for the improved irrigation water services. The study identified land ownership, location of the farm and land lease price as the determinants that affected farmers' WTP for the irrigation water.

Using CVM, Chandrasekaran *et al.* (2009) estimated farmer WTP for the tank irrigation system in India during dry and wet seasons of paddy cultivation. The study found that farmers were willing to pay for the irrigation water. The study used a logit regression model and identified education level of the household head, family size, age of the respondent and family labor force as factors determining farmer willingness to pay.

In Turhal and Sulvova regions of Turkey, Basarir, *et al.* (2009) analysed producers’ WTP for improved irrigation water using a contingent valuation survey technique. The survey technique was implemented through face-to-face interview with 130 randomly selected producers to elicit the WTP as well as collect data for the factors responsible for WTP. The researchers used Tobit and Heckman sample selection model for data analysis since their data were censored at zero. Result has showed that, male producers from Turhal region, who had more vegetable land, and polluted water were WTP more for increased the quality of irrigation water.

UNDP, (2006) observed that although the provision of tap water may be gradually increasing worldwide, system reliability and water quality still remain primary concerns in many developing and less developed countries. Specifically, many urban areas in developing countries face acute imbalance between demand for and supply of safe reliable water, as demand (at current pricing) and requisite infrastructure often surpasses existing capacity (Bateman *et. al.,* 2006). System revenues and available program subsidies are often not enough to adequately maintain water infrastructure and treat water for drinking purposes. In such contexts, tap water is often unsafe to drink and the water supply system is commonly unreliable (Gadgil, 1998; UNDP, 2006). Thus, in many developing countries, safe and reliable water supply remains a serious concern even when basic water delivery systems are in place. In such settings, households often adapt by using alternative sources, such as privately investing in water infrastructure, and treating water at home. Generally, prices for collecting water from alternative sources are significantly higher, and less efficient than collectively provided tap water systems (Whittington *et al*., 1991). Ferrier (2001) reports that the price per unit of bottled water is typically 500 -1000 times more expensive than tap water. Water treatment at home is also not cost effective (Goodrich *et al*., 1992). Thus, in addition to the high cost of using bottled water, poor households are less able to afford and undertake adequate private investments in water infrastructure and storage facilities.

Lack of information on household preferences regarding potential improvements in water services is an important impediment to the implementation of public provision of safe and reliable drinking water supply systems (Whittington *et al.*, 1990; World Bank, 1993). Improved understanding of household preferences for instance, willingness to pay (WTP) for safe and reliable drinking water, can help identify the preferred level of services, and help design appropriate policies for recovering maintenance costs and setting the project sustainable (Gadgil, 1998).

Nakayama *et al.* (2010) noted that in addition to unreliable water supply, tap water in Zambian cities is often polluted and unsafe for drinking. Several recent studies raise concern about water quality, particularly in the Central province (Lacatusu *et al.*, 2009; Kodom *et al*., 2010) found that 50% of the sampled wells and 48% of the tap water samples (in a number of cities including Kabwe) exhibited lead (pb) concentration above the safe standard (11 Bq/L) set by United States Environmental Protection Agency (US EPA). More generally, the OECD (2006) has stressed the need for increasing current water related investments and management efforts in Zambia to ensure better treatment of drinking water and its supply.

Bui *et al.* (2012) in their study on valuing rural piped water services in the Mekong Delta in Vietnam employed the double-bounded CVM for the first time to value rural piped water supply services in the Vietnam context. Using a sample of 217 households the results underscored the need for policymakers, donors or private sectors in Vietnam pay attention to the factors that affect household's willingness to pay (WTP).Findings of this study suggest that when designing water supply projects; they further established that cost-benefit analysis based on CVM estimation could be used to design suitable program for water supply services.

According to William *et al.* (2009), a referendum-format contingent valuation (CV) survey was used to elicit household willingness to pay responses for safe and reliable drinking water in Parral, Mexico. Individuals were found to adopt a variety of averting and private investment choices for instance. bottled water consumption, home-based water treatment, and installation of water storage facilities to adapt to the existing water supply system. These revealed behaviours indicated the latent demand for safer and more reliable water services, which is corroborated by the CV survey evidence. Validity findings included significant scope sensitivity in WTP for water services. Further, results indicated that households were willing to pay from 1.8% to 7.55% of reported household income above their current water bill for safe and reliable drinking water services, depending upon the assumptions about response uncertainty.

In a nutshell, the preceding empirical review issues evidence that CVM is a powerful tool to elicit and quantify farm households' WTP for non-market goods not only in developed but also developing countries. Despite the difference in CVM studies in developing countries, the result of WTP using CVM is very context dependent based on farmers social, economic and biophysical environment. Moreover, this study also contributes to the scientific literature regarding the application of CVM to irrigation water.

2.7 Lead Concentration in various Food Crops and Food Animals.

Loutfy *et. al.* (2006) noted that food consumption has been identified as the major path way of human exposure, accounting for greater than 90% compared to other ways of exposure such as inhalation and dermal contact. Ina study by Yabe *et al.* (2010), it was noted that contamination of food animals, fish, soil, water, and vegetables with heavy metals has reached unprecedented levels over the past decade in some parts of Africa. As a result human exposure to toxic metals has become a major health risk. Chronic intake of heavy metals above their safe threshold in humans and animals have damaging effects and can cause non-carcinogenic hazards such as neurologic involvement, headache and liver disease(John and Andrew,2011; Lai *et al.,* 2010; Zheng *et al.,* 2007).

Table 2.2: Average Metal levels (mg/kg dw) in organs of different animal groups from different regions

Study/country	Pollution factor	Animal	Organ	Cr	Co	Ni	Cu	Zn	Cd	Pb
Yabe et. al.,(2013) Zambia	Mining	C (Broiler	**L**	0.06	0.05	0.03	56.80	28.60	0.00	0.06
		C(free-range	**L**	0.07	0.09	0.07	3.40	30.90	1.60	4.15
			K	0.08	0.16	0.08	2.12	24.70	3.50	7.62
			M	0.08	0.01	0.02	Nd	4.16	0.01	0.23
			G	0.10	0.04	0.03	0.13	30.50	0.02	0.23
Uluozlu et. al., (2009) Turkey	Markets		**L**	0.04	0.02	0.01	12.10	22.50	2.24	0.12
Okoye and Ugwu (2010) Nigeria	Industrial and Urban		**L**				134.02	120.44	0.33	0.65
Caggiano et. al., (2005) Italy	Urban		**L**						0.33	1.50
Hussein et al (1996) Kuwait	Wholesalers	Goat	**L**						0.05	0.13
			K						0.44	0.43
Hussein et al (1996) Kuwait	Wholesalers	Sheep	**L**						0.04	0.13
			K						0.30	0.15

C- Chickens, G- Goat, S- Sheep, L-Liver, K, Kidney, M- Muscle, G-Gizzard

In their study, Bortey-Sam *et. al.* (2015) on "Human health risks from metals and metalloid via consumption of food animals near gold mines in Tarkwa, Ghana: Estimation of the daily intakes and target hazard quotients (THQs)" found that lead was detectable in all samples of liver, kidney, 80% of chicken gizzard and 38% of muscle. The result of this study indicated that chicken gizzard (0.3971.17 mg/kg ww) contained the highest concentrations of Pb followed by chicken kidney (0.2670.31 mg/ kg ww) and liver (0.1370.14 mg/kg ww). Tukey's test was used to compare the levels of Pb in the three food animals, and results showed no statistical significance in liver and muscle when chicken was compared with goat and sheep ($p>0.05$). Bortey-Sam *et. al.* (2015) went far as to suggest that the levels of lead in organs of free-range chickens may emanate mainly from contamination of soil, feeds and water sources. This is because, to be toxic, lead must be in a form which will be retained in the gizzard, thus resulting in continuous absorption over a prolonged period (Salisbury et al., 1958).

Bortey-Sam *et al.* (2015) found that the concentration of lead in some organs of chicken exceeded the EC (2006); and USDA (2006) standard of 0.5 and 0.1 mg/kg ww for lead in offal and muscle respectively (Table 2.1). They further suggested that the low levels of lead in the offals and muscles of the mentioned food animals could be due to the fact that, lead accumulates in bone and the metal concentration increases with age (Caggiano *et al.* 2005).

The findings of Bortey-Sam *et al.,* (2015) were compared with similar studies in different countries (Table 2.1). Results from this study were found to be: comparable with study by Husain et al. (1996), in goat and sheep livers and kidneys, in Kuwait; comparable (except Cu, Zn and Cd) and higher than similar study by Uluozlu *et al.* (2009) in the liver of poultry from Turkey and Philippines respectively. Cd and Pb levels from this study were lower than study conducted by Okoye and Ugwu (2010), Nigeria and Caggiano *et al.* (2005), Italy; in the livers and kidneys of goat and sheep from industrial and urban areas.

Study done by Yabe *et al.* (2013) near a Lead and Zinc mine in Kabwe, Zambia indicated that the levels of Cd and Pb in the livers and kidneys of free-range chickens were higher compared to this study but levels in muscle were comparable. On the other hand, the levels of Pb and Cd in chicken gizzard from this study were higher than the study by Yabe *et al.* (2013).

2.8 Techniques to measure economic value of ecosystem services

According to Loomis *et al.* (1999), there are several techniques that can be used to value the benefits of improved water quality or stream restoration. If restoration of water quality or recreation occurs in an urban setting where there are residences nearby the river, either the travel cost method or the hedonic property method may be applied. They further noted that both hedonic and travel cost method fail to account for bequest or existence value of the environmental good. By ‘existence value’ they established that it was the amount an individual would pay to know that a particular native fish exists in its natural habitat. By ‘bequest value’ meaning the amount an individual would pay for preservation today, so that future generations will have native fish in their natural habitat. Collectively, existence and bequest values are sometimes called non-use or passive use values.

2.9 Approaches to Measuring Environmental Resource values of Non- Market goods

Mitchell and Carson (1989) offered a classification of methods for estimating values of non-market goods that is based on two characteristics or methods. The first characteristic is whether the data come from observations of people acting in real- world setting. The second characteristic is whether the method yields monetary values directly or whether monetary values must be inferred through some indirect technique based on a model of individual behaviour and choice.

Table 2.3: Methods for Estimating Values

	OBSERVED BEHAVIOUR	HYPOTHETICAL
DIRECT	**Direct observed**	**Direct hypothetical**
	Competitive market price	Bidding games
	Simulated markets	Willingness to pay questions
INDIRECT	**Indirect observed**	**Indirect hypothetical**
	Travel cost	Contingent ranking
	Hedonic property values	Contingent activity
	Referendum voting	Contingent referendum

Source: Adapted from Mitchell and Carson (1989)

Based on the two methodological characteristics, any method for estimating environmental and resource values can be placed in one of the four possible categories,

In conclusion, the above empirical studies offer confirm that CVM is an effective and reasonable tool to elicit and quantify farm households’ WTP for non-market goods both in developed and developing countries.

2.10 Potential Bias in CV studies and Potential solutions

Whittington *et al.* (2014) attempted to test for the existence and magnitude of three types of biases in contingent valuation surveys that have been of particular concern in the literature: strategic bias, starting point bias, and hypothetical bias.

2.10.1 Strategy Bias

They further noted that strategic bias may arise when an individual thinks he may influence an investment or policy decision by not answering the interviewer's questions truthfully. They concluded that such strategic behaviour may influence an respondent's answers in either of two ways. For instance in a situation where an individual is asked how much he would be willing to pay to have a public tap near his house. If he thinks the water agency or donor will provide the service if the responses of individuals in the village are positive, but that someone else will ultimately pay for the service, he will have an incentive to overstate his actual willingness to pay. On the other hand, if he believes the water agency has already made the decision to install public tap in the village, and the purpose of the survey is for the water agency to determine the amount people will pay for the service in order to assess charges, the individual will have an incentive to understate his true willingness to pay. Therefore many attempts to estimate strategic bias have been highly structured experiments in which one group of respondents is told one set of factors about a situation that minimizes their incentive for strategic behaviour, and another group receives a different set that maximizes their incentives for strategic behaviour. They therefore concluded that most of the available evidence from the United States and Western Europe fail to support the hypothesis that individuals will act strategically in answering contingent valuation questions, but there is no evidence with respect to developing countries.

2.10.2 Starting Point Bias

According to Whittington *et al.* (2014), starting point bias exists if this initial price affects the respondent final willingness to pay. In the bidding-game question format, the interviewer starts the questioning at an initial price. They noted that a respondent who is unsure of an appropriate answer and wants to please the interviewer may interpret this initial price as a clue as to the correct bid. To test for starting point bias in their study they decided to distribute three different versions of their questionnaire, each with different initial prices in the bidding game. The questionnaires were randomly distributed in the sample population. In their findings they discovered there was no hint of starting point bias.

2.10.3 Hypothetical Bias

Two major reasons were found to be the causes of hypothetical bias. First, the respondent may not understand the characteristics of the good being described by the interviewer. They noted that this has been a particular problem when the contingent valuation method has been used to measure individual willingness to pay for changes in environmental quality because it may be difficult for people to perceive what a change, for example, in sulfur dioxide or dissolved oxygen means in terms of air or water quality.

Second, it is often suspected, particularly in the context of developing countries, that individuals will not take contingent valuation questions seriously and will simply respond by giving whatever answer first comes to mind. To correct for this type of hypothetical bias where it was prevalent, bids were randomly distributed and not systematically related to household characteristics and other factors suggested by economic theory (Whittington *et. al.* 2014).

In their study on estimating the willingness to pay for water services in developing countries a case of study of use of contingent valuation surveys in southern Haiti, Whittington., *et. al.* (2014) noted that it was possible to do a contingent valuation survey among a very poor, illiterate population and obtain reasonable, consistent answers. They further noted that there appeared to be no major problem with either starting point or hypothetical bias. The evidence with regard to strategic bias was less conclusive, but neither the limited test for strategic bias nor the experience of the enumerators indicated that it was a problem.

Furthermore, Whittington, *et al.* (2014) concluded that the results of their research strongly suggested that contingent valuation surveys are a feasible method for estimating individuals' willingness to pay for improved water services in rural Haiti. They went on further to indicate that this had important policy implications for rural water supply projects; it revealed that simple household survey can yield reliable information on the population willingness to pay for improved water services. Their findings suggested that contingent valuation surveys may prove to be a viable method of collecting information on individual willingness to pay for a wide range of public infrastructure projects and public services in developing countries.

2.11 Elements of a CV survey

Balana *et al.* (2013) in their study on assessing the willingness to pay for reliable domestic water supply via catchment management in Kenya noted that as CV deals with goods and services with no functional markets, it should be designed in such a way that a satisfactory (hypothetical) transaction is established in which people are fully informed and able to identify their own best interests. This would result in valid and reliable WTP estimates and will only take place if the environmental good under consideration, the method of payment, and the hypothetical market situation are well defined and understood by the respondents (Hoevenagel 1994, Whitehead 2006). This is implied by the name of the method itself, which produces values 'contingent' upon the description of the good and on the method of payment. They further noted that generally, a CV questionnaire should consist of the following three key elements:

1) Description of the change: This refers to description of the environmental resource under current conditions, as well as the proposed conditions if the respondent pays.
2) Description of the constructed market: The organisations or agents that will be involved in the provision of the proposed environmental change, and descriptions of the details on how the market (demand and supply) for the specific environmental good will operate.
3) Payment vehicle: Respondents need to be told the means by which they would pay for the proposed changes, for instance. Through a higher water bill or a tax increase. The payment schedule (monthly or yearly) and its temporal limits must be specified. Finally, the respondents are asked whether they would pay a certain amount, which varies randomly across respondents.

2.11.1 Questions of payment vehicle

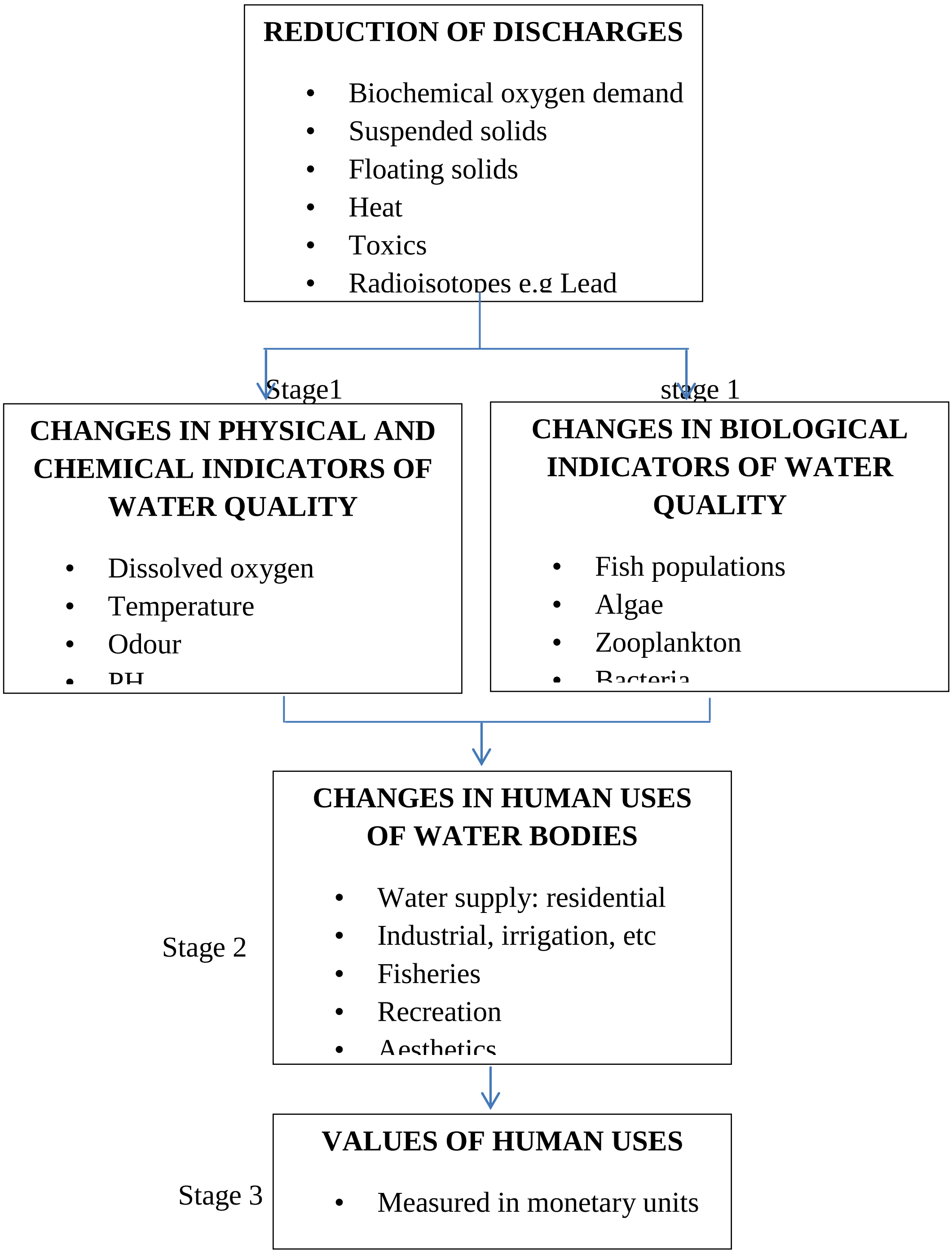
In their study, Kofi *et al.* (2014) investigated the effect of experience with monetary and labour payment vehicles on the relative acceptance of CV scenarios and protest bids in terms of these two payment vehicles. Their results indicated that there is an asymmetry in acceptance rates between the two payment vehicles (although not in the rate of protest bids, nor in the mean WTP) when respondents only have experience with one of the vehicles. However, they further noted that asymmetry disappears when respondents have experience with both payment vehicles. Kofi *et al.*, (2014) went far to suggest that being familiar with monetary and labour payment vehicles attenuates time/money response asymmetry in the CV method. They further concluded that in terms of the conduct of the CV method, their results suggest that the payment vehicles that are adopted in the CV method should not be of paramount concern. They also noted that, policies do not need to adopt a particular payment vehicle to promote participation.

2.11.2 Improving CV Surveys

In trying to improve the performance of contingent valuation studies in developing countries, Whittington (2002), discussed the three major reasons why so many of the contingent valuation studies conducted in developing countries are so unfruitful. Firstly, he noted that the contingent valuation surveys themselves are often poorly administered and executed. Secondly, he noted that the contingent valuation scenarios are often poorly stated. Thirdly, he noted that few CV studies conducted in developing countries are designed to test whether some of the key assumptions that the researcher made were the right ones, and whether the results were robust with respect to simple variations in research design and survey method. Whittington (2002), went further to suggest that research on stated preference methods in developing countries is critically important to the successful implementation of these methods because there is no empirical evidence to suggest that rapid streamlined CV surveys yield reliable, accurate results and there is a significant risk that the current push for cheaper, simpler CV studies could discredit the methodology itself. Moreover, he further noted that the policy debates to which CV researchers are asked to contribute are often of tremendous importance to the well-being of households in developing countries. He further suggested that because the cost of policy mistakes can prove tragic, it was critical that CV researchers push for excellence in the CV research enterprise.

2.12 Conceptual Framework

Figure 1: Overview of the production of benefits from improved ambient water quality



Source: Adapted from Air and Water Pollution control: Cost Benefit Assessment by Freeman *et al*. (1982)

2.13 Analytical Framework

2.13.1 CV modelling

Logit, probit and other binary response models are routinely fitted to CV survey data to obtain estimates of the unobserved latent WTP. For example, earlier analyses of closed-ended or single-bound CV data use logit models to derive fitted choice probabilities for 'yes' (yi =1) and 'no' (yi = 0) responses to the valuation questions (Bishop et al. 1983, Cameron and James 1986).

Hanemann *et al.* (1991) questioned the statistical efficiency of the single-bound dichotomous CV method and developed a more statistically efficient WTP estimation framework for 'double-bounded' dichotomous choice contingent valuation. Hanemann *et al.*, (1991) used a logit modelling framework and a maximum likelihood (ML) estimation technique on CV survey data obtained from Californians on their WTP for protection of wetlands and wildlife habitat in the San Joaquin Valley. They showed the gain in efficiency in the double-bounded model, and also found that the double-bounded data yielded a lower point estimate of median WTP than the single-bound data. Both the gain in efficiency and the direction of change in the estimate of median WTP were explained by the fact that the follow-up bid in the double-bounded approach improves a poor choice of initial bid.

Double-bounded models are based on the assumption that the distributional parameters for the underlying latent WTP values are identical for both the first and follow-up questions. However, Cameron and Quiggin (1994) challenged this assumption and explicitly assumed separate distributional parameters of WTP for the two CV questions, that is .they argued that respondents might form two WTP values, one for the initial bid and another for the follow-up bid, which are likely to be correlated, but need not be identical. Based on this assumption, they applied a bivariate binary response model (bivariate probit) to a 'dichotomous choice with follow-up' CV survey conducted in Australia, and obtained estimates of WTP that were significantly different from the double-bounded model estimates.

Marcella *et al.* (2014) in their study on "Climate change and the willingness to pay to reduce ecological and health risks from wastewater flooding in urban centres and the environment" , applied the mixed logit model (McFadden and Train, 2000; Train, 2003). This was done in an effort to address some limitations of the standard conditional logit model (McFadden, 1974) such as homogenous preferences and the assumption of the independence of irrelevant alternatives (IIA) (Hausman and McFadden, 1984). They noted that in the standard conditional logit model, it is assumed that the choice between the alternatives is driven by the respondent's underlying utility, which is denote as U. Respondents are assumed to choose the alternative j in the choice set that results in the highest utility. Formally, a respondent chooses alternative k from the choice set S of alternatives if and only if $U_k > U_j$, $\forall j \neq k \in S$. The respondent's utility U is broken down into two components: $U_{ij} = V_{ij}(X_{ij},\beta) + \varepsilon_{ij}$. The first component $V(X_{ij}, \beta)$ is deterministic, and it is assumed to be a function of the vector of parameters β and a vector X of the attributes of the alternatives including their cost and of the socio-demographic characteristics of the individual i. The second component ε is a random component, which captures individual and alternative-specific factors that influence utility but are not observable to the researcher

Alberini *et al.* (2006) went on to note that in the mixed logit model, unlike the standard conditional logit model, heterogeneity in preferences is accounted for by allowing the vector of parameters β to vary among individuals with values that depend on a underlying distribution f, which captures the respondents' random taste. They assume that the coefficients of the attributes are all normally distributed with the exception of the cost and event variables, which they specified as fixed. The coefficient of the cost variable is specified as fixed to ease the estimation of the WTP distribution, as it is done in common practice for instance (Hensher *et al.,* 2005; Revelt and Train, 1998). The coefficients of the variables corresponding to the different type of events are assumed fixed based on an initial analysis where respondents showed homogenous preferences for these variables. The model includes as socio-demographic variables gender, age, education (vocational school, high-school, technical university, and university; less than high-school is the omitted category and so the reference case), income, region of residence (Italian, French, and German part of Switzerland, where the latter is the reference case), risk preferences (risk loving, risk adverse, and risk neutral as the reference case).

In modelling their CV, Whittington *et al.,* (2014), used the ordered probit model to estimate household willingness to pay for improved water in Haiti. This ordered probit model was used to predict the number of households in a community which would use a new water supply source if various prices were charged. Since the interval for each category was known, y_h (the category into which household h fell). They further summed the number of households in each category in Laurent (Haiti) to yield the demand schedules. In conclusion they noted that such demand schedules are precisely the kind of information needed by planners and engineers to make sound investment decisions, hence they believed the ordered probit model, estimated with WTP bids obtained from a contingent valuation survey, was a promising approach to modelling village water demand relationships.

CHAPTER THREE

METHODOLOGY

This chapter outlines the methods that were used to achieve the stated objectives. It gives information on the data that was required for the study with emphasis on the study sites, data collection procedure and data analysis tools.

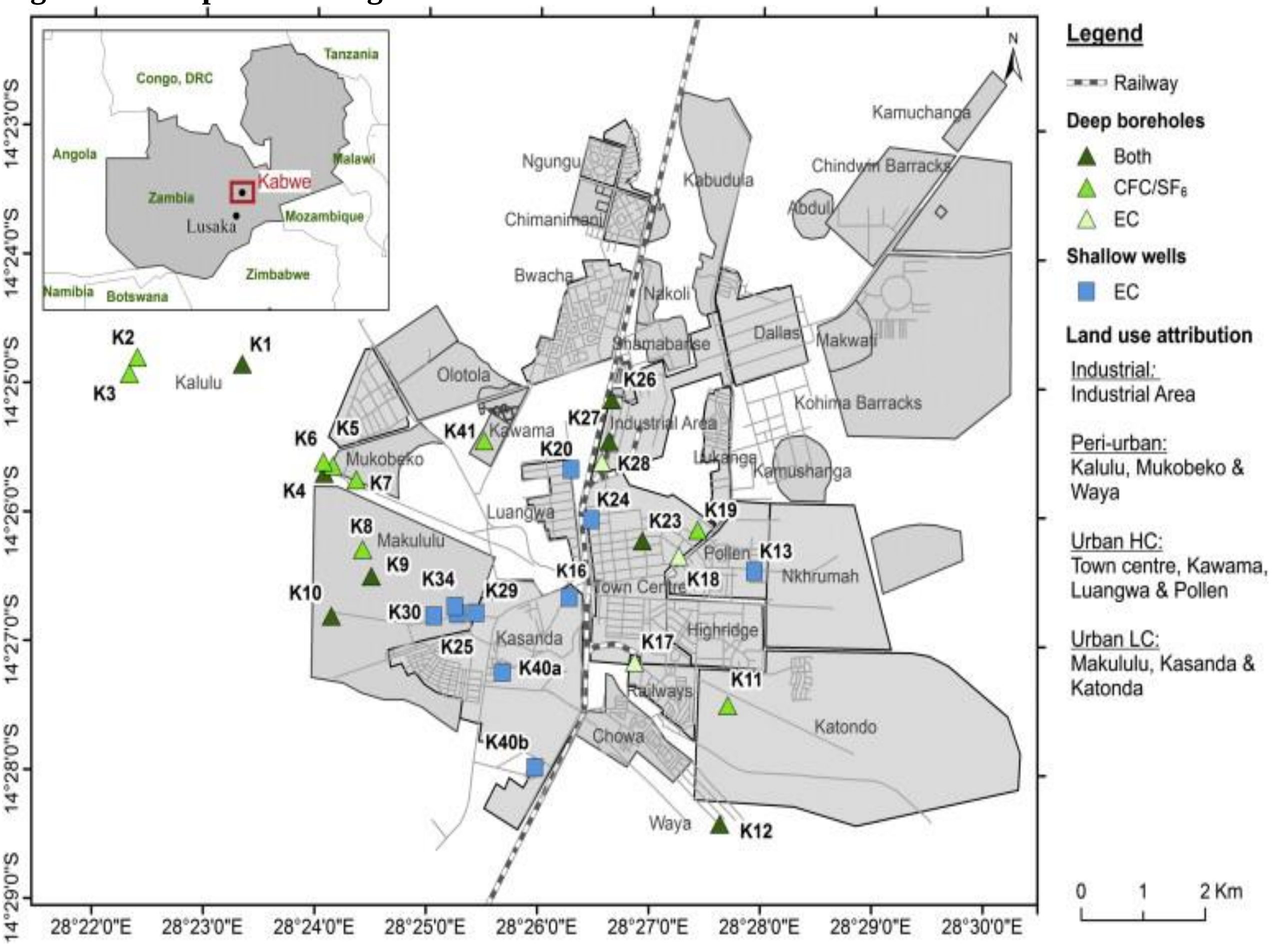
3.1 Description of the Study area

This study was conducted in Kabwe, which is the provincial capital Republic of Zambia's Central Province, is located at about 28^{0}26E and 14^{0}27S. the city has a population estimated at 300,000 as at the 2010 census (CSO 2012). Formerly named Broken Hill, it was founded when lead and zinc deposits were discovered in 1902 and located on an altitude of 1,158m. It is an important transportation and mining centre principally dealing in Pb–Zn mining. Despite closure of the mine, scavenging for metal scraps from the abandoned tailings and wastes stored on the mine has continued to serve as a source of metal pollution, especially dusts emanating from the mine dumps.

In the current study, data was collected from households located in Chowa, Kasanda and Makukulu and Katondo townships. Kasanda Township lies west to the mine and its center is about 2.2 km from the smelter (Fig. 1). However, some households in Kasanda are within 1 km of the mine. Makululu Township is a large squatter compound that lies adjacent and to the west of Kasanda Township. These two townships are affected by dust emanating from the mine as the prevailing winds most of the time blow from the east to the west. Makululu is the largest shanty compound in Zambia. It is located in the city of Kabwe, a town that once thrived. That was before the mining industry dried up, leaving Kabwe to look more like a 'ghost town'.

Moreover, lots of dust is emitted by vehicles as roads in the township are not tarred. Many households in the township use well water in addition to communal water taps and there are high levels of poverty in the community. Chowa Township is equally close to the mine as Kasanda but is least affected by dust as it lies on the windward side of the mine. In contrast to Makululu, houses in Kasanda and Chowa are made of concrete bricks. Households from these townships were selected because soil samples in these townships are highly polluted with lead (Pb) (9–51188 mg kg-1) and other metals (Nakayama *et al.* 2011).

Figure 2: Map of Kabwe ground water sources and distribution



Source: Sorensen *et al.*, (2015)

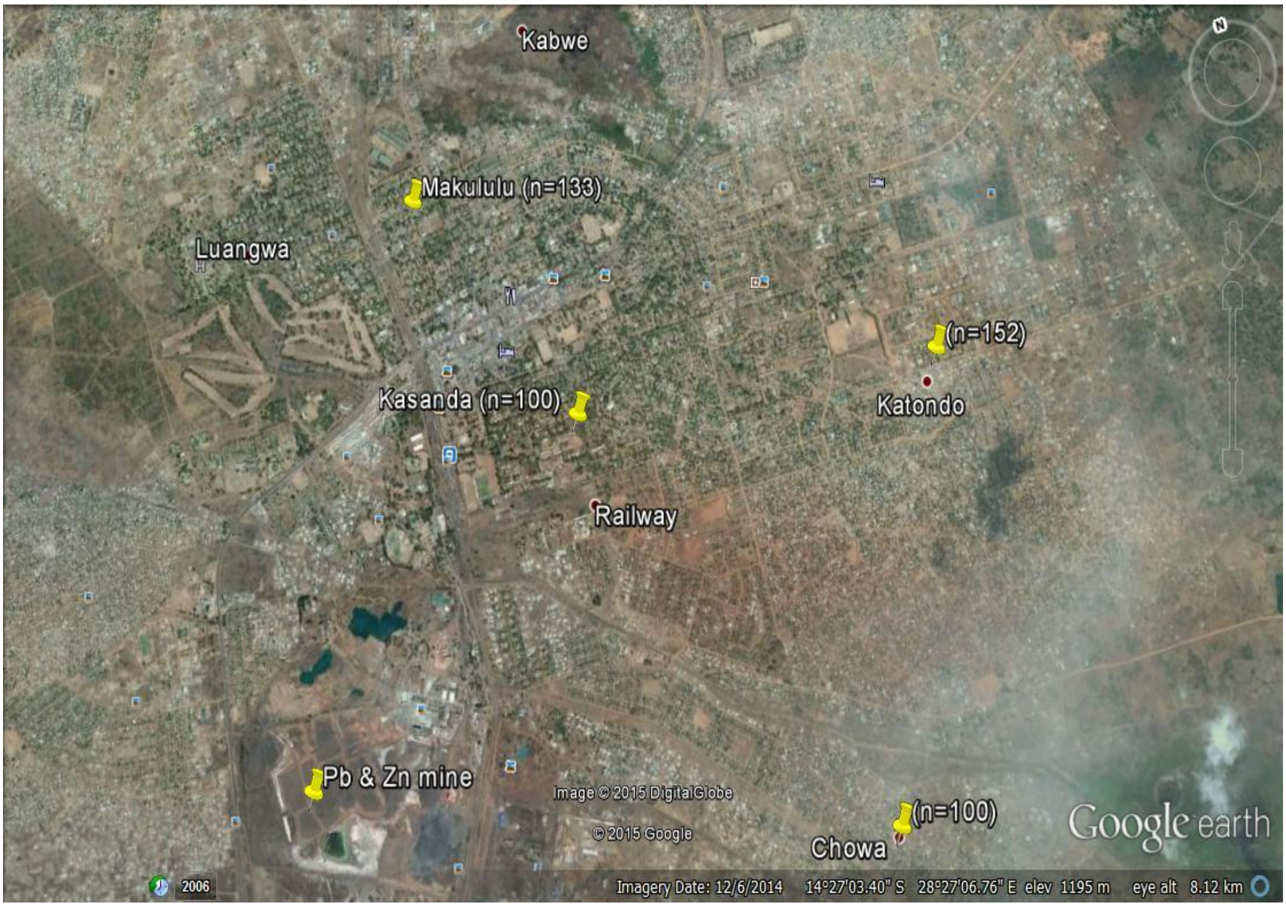


Figure 3: Map of Kabwe showing different geographical areas and sampling sites (Google maps)

3.2 Sampling and Sample Size.

A representative sample of households interviewed in this study was obtained using a simple random sampling technique. A list of potential beneficiary households was obtained from the Kabwe municipal council and respective peasant association administration. Out of which 485 sample respondents were selected from the four purposively lead affected townships using simple random sampling technique. The primary data was collected using a pre-tested questionnaire in a face-to-face interview survey method. To arrive at WTP estimates, a CVM study in the Double Bounded Dichotomous Choice elicitation format was used. This method is advantageous in many ways. Firstly, a given function is fitted with more data points because of the increased number of responses. Second, the yes-no and the noise responses sequential bid yields clear bounds on WTP. Finally, from the yes-yes and no-no combinations there is the efficiency gained in that they truncate the distributions where the respondent's WTP are expected to exist.

3.3 Data and Data collection methods

Both primary and secondary data were used. Primary data were collected through stakeholder consultations, Focus group discussions (FDGs) and the key informant interviews at the village level; and respondents survey at the household level. A questionnaire was designed to obtain information on the extent to which respondents to the survey thought that lead pollution affect their lives. This was supplemented by on-farm observations. The survey was carried out between March and May of 2015. Using pretested questionnaire (Apendix 1), heads of selected households were interviewed. In the absence of the household head, the spouse or any other responsible adult member of the household was interviewed. The main respondent would provide most of the information, but consulted with other household members where necessary. Qualitative and quantitative data were collected from the selected households. Information on the nature and perceptions of water pollution in the study sites; the vulnerability of the people, crops and the livestock to lead water pollution, adaptive or other types of responses to each pollution problem. Factors affecting these responses and impacts of the responses to people's livelihood, economic development, local natural resource and environmental conditions were captured using structured questionnaires.

The data collected included socio-demographic data, economic data, production constraints and service delivery and information on rural household's willingness to pay for improved irrigation water supply. Information on the rural household various characteristics including age, sex, marital status, incomes, number of animals owned, irrigated garden space, distance of water sources from the lead mines and experience of pollution was collected. In addition, information on the status of lead pollution and geographic characteristics of the study area was collected. To collect supplementary information, key informants interviews were also conducted with the district vertinary officers and district agricultural officers as well as local leaders. This information was used to validate what was collected from farmers. It comprised of information incidences of lead water pollution and outbreaks due to pollution, household's coping strategies in the event of lead water pollution and opinions on the lead pollution control methods.

Focus group discussions were conducted in order to gain a deeper understanding of the lead pollution in Kabwe city. These were arranged into two categories (community leaders, and smallholder farm leaders). In total eight focus group discussions were conducted; two in Katondo, two in Chowa, two in Makululu and two in Kasanda. For each township one group consisted of community leaders and the other one consisted of only smallholder farm leaders. Each group consisted of 6 people for easy conduct. There was one female or atmost two in each group. General questions about lead water pollution and how they can be controlled were asked to each group. The responses were recorded.

Literature was collected from various publications on clean water supply and pollution control measures as well as agriculture in the lead endemic areas. These publications included reports, newspapers, library sources, researches, ECZ reports, NGOs, documentaries, international and government publications such as ZCCM-H, Zambia Bureau of Standards, CSO, Ministry of Environments, internet, and Kabwe municipal council.

Interviewers were trained in data collection techniques including interviewing skills, consent procedures and other relevant information and skills. The data collection team was recruited based on the competence in the language of the area where the data collection was planned to be conducted.

3.3.1 CV design

Eliciting a respondent's preferences through the CV method requires careful survey design, choice of survey mode, and selection of the random sample (Bateman *et al.*, 2002; Whittington, 2002). Following guidelines in Bateman *et al.*, (2002) the focus group discussions and face to face interviews were used to aid in the development and validation of the questionnaire, including the wording of questions. The questionnaire used in the survey was organised into four main parts: (i) Respondents' demographic and socio-economic characteristics (ii) Respondents' perception and knowledge about the current state of water supplied in the study area for instance about the quality of the water they receive and the satisfaction with the water quality they receive. (iii) Respondents' preferences and values towards improved irrigation water as well as improved sanitation services in the Kabwe rural farm areas elicited through WTP questions.

3.3.2 The CV scenario

The CV scenario was defined in terms of the current environmental situation, i.e. lead pollution due to intensive human lead mining activities and the impact of this on the water supply into the four townships of Kabwe city; the hypothetical environmental change through improved water supply for irrigation; the potential increase in quantity and reliability of water to the peri urban and the suggested method of payments.

After the scenario description, the CV questionnaire captured how much a respondent was willing to pay for improve irrigation water supply through elimination of lead contamination in in Kabwe. To discover what an individual's WTP was, a respondent was not directly asked an open-ended question. Instead, a 'double-bounded' CV survey procedure was applied whereby each individual i was provided with a random initial bid (BIi) (see Table 3.1) and asked whether he/she would be willing to pay this amount. According to the 'double-bounded' CV procedure, each person was asked a 'follow-up bid' which was lower or higher depending on the response to the first bid, that is the follow-up bid was higher if the first bid was accepted and lower if the first bid was rejected. Hence, for each respondent an initial bid (BIDI) and one of the follow-up bids B_{Li} and B_{ui}, where $B_{Li} < B_{Ii} < B_{ui}$. Each respondent was asked a random initial bid and the follow-up bid according to the schemes presented in Table 3.1. These bid values were chosen based on the water tariff structure in Kabwe city. The four possible outcomes for the two WTP questions were:

1) both answers 'yes';
2) both answers 'no';
3) a 'yes' followed by a 'no'; and
4) a 'no' followed by a 'yes'

Table 3.1: Random bidding strategies used in the CV Survey (in Zambian Kwacha)

Bidding scheme	Initial BID (B^1)	Follow-up bid (decreased) (if 'NO' B^1)	Follow-up bid (Increased) (if 'YES' B^1)
Strategy 1	100	50	200
Strategy 2	200	100	400

Zambian Kwacha: during survey period K7.38 ≈ 1US$

3.4 Data Analysis

Data was analysed using STATA software. Descriptive statistics and Logit Models were used to address three objectives. In case of continuous variables, an exploratory data analysis was done to determine their distribution. For non-normality distributed variables, an appropriate transformation was done to remove skewness or heavy tails.

To achieve objective one (characterising affected townships), descriptive statistics were employed. These involved use of percentages, t-tests, standard deviations and mean comparisons. Percentages were used to determine and explain proportions while t-tests were used to test significant differences between socio-economic characteristics of individuals affected by lead pollution.

To achieve object two and three, willingness to pay for improved irrigation water supply was modelled in the Random utility framework where a respondent was assumed to have two choices; either to choose paying for the improved irrigation water supply or not.

This study tried to identify the key factors that determine the log odds of an individual's willingness to pay for the improvement of water quality and supply in Kabwe after the deadly incidence of Lead poisoning. A Logit regression model was used to determine this log odds of WTP. A Logit model is a probability model which gives specifications of binary response models. This model takes the form;

$Y_i = \beta X_{i+} u_i$

Y_i = 1 if $WTP_i^* >$ BID and 0 if $Y_i <$ BID

Where Y_i^* was a latent variable which takes on the values 1 if the individual is willing to pay and zero otherwise, X was a vector of variables that affect the probability of a household's willingness to pay for water improvement and β is a vector of unknown parameters to be estimated. More specifically, the X_i are individual's age, household size, education, income, gender of household head

3.4.1 Theoretical Framework

This study used a CV to determine Kabwe people's valuations of clean water availability and reliability of water supply. CV surveys are a type of discrete choice modelling. Discrete choice modelling is theoretically based upon Random Utility Theory (McFadden, 1974) and on Lancaster's theory of characteristics (Lancaster, 1966). According to Lancaster, it is not goods themselves but the attributes or characteristics of goods that provide consumers with utility.

The theoretical basis of most stated preference techniques is random utility theory (McFadden, 1974; Thurstone, 1927). This theory states that the probability of an individual making a choice from a range of goods depends on the utility provided by the good compared to the utility from other goods. Therefore, individual q will choose good I over j when $U_{iq} > U_{jq}$ $(i \neq j \in A)$ $(i \neq j\ A)$, where A is the set of choice (Hanemann, 1984; Hanemann and Kanninen, 1996).

All in all, WTP is the measure of pay or cash that makes the respondent indifferent between the present state of affairs (the current circumstances) and proposed unexpected valuation situation (Haab and McConnell 2002, Siyaranamual 2014). Then again, WTP is characterized as the measure of greatest pay (cash) an individual willing to spend in return for a change of circumstances or increase or decrease in the nature of the environmental circumstances. The ultimate goal of most practical dichotomous choice contingent valuation studies is to provide an empirical estimate of the WTP and the effects of covariates on the WTP (Haab and McConnell 2002). Different scholars employed the random utility model approach for dichotomous contingent valuation responses to estimate the WTP (Hanemann 1984, McFadden 1999, Haab and McConnell 2002). Moreover, Hanemann (1984), rationalized dichotomous CV questions putting them in a framework that allows how parameters to be estimated and interpreted. Hanemann (1984) has recommended deriving WTP from the indirect utility function. The indirect utility function of respondent j can be formulated as follows:

$$V_{ij} = v_i(y_i, \mathbf{q}_j \mathbf{M}, p, \varepsilon_{ij}) \ldots\ldots \quad (1)$$

Where, V (.) is the indirect utility function, y_i, is the respondent household income, q_j is the situation of the improved water supply project, *M is* the covariates or characteristics of households that might affect farm households' WTP and p is an exogenous price and ε_{ij} a component of preferences known to the individual respondent but not observed to the researcher. For the status quo, where there is not any improvement in the improved water supply and sanitation services (i=0), the indirect utility function of the smallholder farm household is given by:

$$V_{0j} = v\ (y_i, \mathbf{q}_0 \mathbf{M}, p, \varepsilon_{ij}) \ldots\ldots \quad (2)$$

Letting 0 subscripts denote the initial (status quo) conditions and 1 subscripts denote the new conditions, then q_0 is the improved water and sanitation services project current situation and q_1 is newer or improvement situations. If the household is willing to pay some money C(C>0) for the improved water program, because of quality and quantity changes (q_1>q_0), the indirect utility function of the individual farm household is given by:

$$V = V(y - WTP, p, q_1; M) \quad (3)$$

In a general market equilibrium, we need to consider the amount of income that an individual will give up to make the farmer indifferent between an initial situation (the current situation of the irrigation project where income is at yi and good at q_0, and revised or final situation (in this case the improved irrigation water situations, where income is at (y_i– WTP) and good is at q_1 – Economist call this amount of income the compensation variation or the WTP (Haab and McConnell 2002). Therefore, the compensation variation in the Kabwe improved irrigation water supply project case is given by a mathematical equation below:

$$V(y - WTP, p, q_1; M) = V(y, p, q_0; M) \quad (4)$$

Where v (.) is the indirect utility function, y is the income of a Kabwe city farm households, q_0 is the level of goods in the current situations of the improved water project, q_1 is the level of goods in the improved water project ($q_1 > q_0$ and increase in q is desirable), *M* is the covariates or characteristics of households that might affect farmers WTP and *p* is a vector of exogenous prices and, c is the compensation variation, that is the WTP bid of the Kabwe households smallholder farmer.

3.4.2 Compensation Variations/ Equivalent Variations

The goal of contingent valuation is to measure the compensation or equivalent variation for the good in question. Both compensation and equivalent variation can be elicited by asking a person to report a willingness to pay amount. For instance, the person may be asked to report his WTP to obtain the good, or to avoid the loss of the good. Formally, WTP is defined as the amount that must be taken away from the person's income while keeping his utility constant:

$$V(y - WTP, p, q_1; \mathbf{Z}) = V(y, p, q_0; M) \quad (5)$$

Where;

V denotes the indirect utility function, *y* is income, *p* is a vector of prices faced by the individual, and q_0 and q_1 are the alternative levels of the good or quality indexes (with $q_1 > q_0$, indicating that q_1 refers to improved environmental quality). M is a vector of individual characteristics.

Therefore, such type of binary choice problem can be best analysed or modelled by considering (WTP) as a binary response variable, where,

$Y_{i} = \{1, \text{ if } U^1 \geq U^0 = U^1(Y\text{– BID}, M, q^1) + \varepsilon_1 \geq U^0(Y, M, q^0) + \varepsilon_0$................................(6)

OR = 0, otherwise

This provides a fundamental structural model for estimating the probability of WTP and can be estimated either using a logit or Probit model, depending on the assumption on the distribution of the error term (ε) and computational convenience (Greene 2003, Gujarati 2003).

When the dependent variable in a regression model is binary (0, 1) the analysis could be conducted using either linear probability model or logit or Probit models. But, the linear probability model may generate predicted values less than 0 or greater than 1, which violate the basic principles of probability and the coefficient of determination (R^2) is likely to be much lower than one. For this reason, it is questionable to use R^2 as a measure of model fitness (Gujarati 2003, Gujarati 2004). The other problem with the linear probability model is that the partial effect of any explanatory variable is constant (Maddala 1983). Hence, in this study, the Logit model was used to identify the factors that affect WTP. Following Cameron and Quiggin (1994), the Logit model takes the following form;

$Y_i^* = \beta X_i + \varepsilon_i, Y_i = 1 \text{ if } Y_i^* \geq \text{BID}_i \text{ and } Y_i = 0 \text{ if } Y_i^* < \text{BID}_i$...(7)

Where:

Y_i^*	=	Unobservable households' actual WTP for irrigation water.
Y_i	=	Discrete response of the respondents for the WTP,
B	=	is a vector of unknown parameters of the model,
X_i	=	is a vector of explanatory variables (Land cultivated, total household income, age of the household head, education level of household, household family size, gender of the household, access to extension services, farm experience, access to credit, initial bid),

BID$_i$ = the offered initial bids assigned arbitrarily to the ith respondent random component

ε$_i$ = error term

3.4.4 Econometric Logit model specification

However, before the Logit model equation 4 was run to determine the effect of the explanatory variables on WTP, a test for multicollinearity was applied by computing the variance inflation factor (VIF). It was run using STATA computer software. Moreover it was computed as follows:

$$\text{VIF}\left(\dot{X} - \frac{1}{1-R2}\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (8)$$

Where, R_i^2 is the coefficient of determination in the regression of one explanatory variable (X) on the other explanatory variables (Xi). If there is no co-linearity between regressors, the value VIF is one (Gujarati, 2004). To see the degree of association between the dummy variables a contingency coefficient was also estimated by using Equation (2):

$$C - \sqrt{\frac{\chi 2}{N + \chi 2}} \dots.\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (9)$$

Where C = coefficient of contingency, χ^2 = Chi- square test and N = total sample size. The data was analysed using STATA version 11.0 econometric software.

Generic Logistic function is given as

$$L = \ln\left(\frac{P_1}{1-P}\right) = Z = \beta_0 + \beta_1 X_I$$

$$L_i = \ln\left(\frac{yP_{ayi}}{1-yPay}\right) = \beta_0 + \beta(BID)_I + \beta(\chi)2 + \beta(\chi)3 + \beta(\chi) + \varepsilon_i \dots\dots\dots (10)$$

Where:

The BID variable represents the hypothetical increase/decrease in the willingness to pay for the improved water and sanitation. yPay represents the probability that the survey respondent indicated that Yes, they would be willing to pay this increased amount for the improved irrigation water supply services.

3.4.5 Empirical LOGIT model estimation

Following Cameron and Quiggin (1994), the LOGIT model takes the following form:

$Y_i = 1$ if $Y_i^* \geq BID$ & $Y_i = 0$ 1 if $Y_i^* < BID$ .... (11)

From equation (11) above, Y_i^* can be explicitly written as:

$Y_i^* = \beta x + \varepsilon_i$ OR $WTP_i^* = \beta x + \varepsilon_i$.. (12)

Where:

β	=	is a vector of unknown parameters of the model;
X_i	=	is a vector of explanatory
Y_i^*	=	Unobservable households' actual WTP for improved water supply and sanitation services or Y_i^* is simply a latent variable.
Y_i	=	Discrete response of the respondents for the WTP for improved irrigation water supply; BID_i the offered initial bids assigned arbitrarily to the i[th] respondent;
ε_i	=	Unobservable random component assumed to be logistically distributed.

The respondents know their own willingness to pay Y_i^*, but to the researcher it is random variable with a given cumulative distribution function (cdf) denoted by G (Y_i^*, θ) where θ represents the parameters of this distribution, which are to be estimated based on the response to the CV survey.

To estimate these factors the following LOGIT regression model was estimated and was specified as follows:

Y^* = $\beta_0 + \beta_1 Hinco + \beta_2 Age + \beta_3 IrrG + \beta_4 Dist + \beta_5 BID + \beta_6 LivNo + \beta_7 OwnLa + Gen_1 + PolTr_2 + Edu_3 + Exper_4 + Mar_3 + \varepsilon_i$.. (13)

OR

WTP = $\beta_0 + \beta_1$Hinco + β_2Age + β_3IrrG + β_4Dist + β_5BID + β_6LivNo + β_7OwnLa + $Gen_1 + PolTr_2 + Edu_3 + Exper_4 + Mar_3 + \varepsilon_i$……………………………..….. (14)

Where:

Y^* = Willingness to Pay (WTP) for improved irrigation water services

$Hinco_1$ = Household monthly income

Age = Age of the household head;

IrrG = Irrigated Garden space.

Dist = Distance of water source from the mines

BID = BID variable represents the hypothetical increase/decrease in the willingness to pay for improved irrigation water

LivNo = number of livestock owned

OwnLa= Land endowment own by a farmer.

Gen = Gender of farm manager dummy, 1 if male, 0 otherwise;

PolTr = pollution control training dummy, 1 if good, 0 otherwise

Edu = Education level of household head dummy, 1 if is literate, 0 otherwise

ε_i = Random error which is normally distributed with zero variance.

3.4.6 Mean Willingness to Pay

Hanemann (1989) provides a formula to calculate the expected value of WTP if WTP must be greater than or equal to zero (as is logical for an improvement). The formula is:

$$\text{Mean WTP*} = \left(\frac{\ln(exp^{(\beta_0 + \beta(BID)_I + \beta(AGE) + \beta(INCO) + \beta(GEN) + \varepsilon_i)}}{\beta BID} \right) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . (15)$$

On simplifying Equation (15), equation (16) is derived

$$WTP = -\frac{\beta 0}{\beta 1} = WTP^* = \text{Mean WTP} \dots\dots\dots\dots\dots\dots\dots (16)$$

Equation (16) can be re- expressed as:

Mean WTP = $(1/\beta_1) * \ln(1-e^{\beta o})$……………………………………………………………..(17)

Where:

B_1 is the coefficient estimate on the bid amount and *Bo* is either the estimated constant (if no other independent variables are included) or the grand constant calculated as the sum of the estimated constant plus the product of the other independent variables times their respective means.

3.4.7 Maximum Likelihood function;

Logit model uses same Random Utility Model (RUM) framework as probit, but assume **ε_i** has a logistic distribution.

$$\prod_{i=1}^{N} F_i(Y_1) = \prod P_i^{y}(1-P_1)^{1-y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (18)$$

MLE chooses estimate for β which maximizes L(β_i)

$$L(\beta)_i = \prod_{i=1}^{N} \left(\frac{exp^{(X\beta)}}{1+exp^{(X\beta)}}\right) y \left(\frac{1}{1+exp^{(X\beta)}}\right) 1-y \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(19)$$

$\Pr(Y_i = 1) = \left(\frac{exp^{(X\beta)}}{1+exp^{(X\beta)}}\right)$ probability that respondent says YES to improved irrigation water supply services and $\Pr(Y_i = 0) = \left(\frac{1}{1+exp^{(X\beta)}}\right)$ probability that respondent says NO to improved irrigation water supply services.

Where the X_i are the explanatory variables and β is a vector of unknown parameters. In these studies, the threshold bid value was considered as the sole explanatory variable and the resulting choice probabilities were interpreted as the probability that a randomly selected respondent would agree to pay the stated fee as a function of the amount of money tendered. (Cameron and James, 1986)

Table 3.2: Variable description and their a priori expectations in estimating WTP

Variable	Description	Unit of measurement	Expected sign	Source
BID	How much respondents said they would pay	Kwacha	-	Alemayehu (2014)
Gen	Gender of respondent (0=female; 1= Male)	dummy	+/-	Alemayehu (2014)
Mar	Marital status of the respondent 0=Single 1=Married and staying with spouse	Dummy	+	Alemayehu (2014)
Child 18yrs	Number of Children who are under the age of 18years	Number	+	Mezgebo & Ewunet (2014)
H/H Size	Total number of people in a household	Number	+/-	Chandrasekaran (2009)
Employ	Employment status of the household head. (0=unemployed; 1= employed)	Dummy	+	Alemayehu (2014)
Hinco	Net household income [1 US$ is equivalent to K6.60 Zambian Kwacha as of March 2015]	Kwacha	+	Mesa –juran *et al.* (2012)
PolTr	If household received training on lead pollution control in Kabwe (1 for yes, 0-otherwise)	Dummy	+	Kapungwe (2013)
Farmer's exp	Years of experiencing pollution	Years	+	Basrir *et al.* (2009)
LivNo	Number of livestock animals owned by household/farmer	Number	+	Balana et al.
IrrG	Land size or garden size under irrigation	Hectares	+	Chandrasekaran (2009)
Edu	Education of the respondent (years of schooling)	years	+	Kanyao et al. (2013)
Sat	The household's level of satisfaction with existing water service, 1 if satisfied, 0 otherwise	dummy	-	Basrir *et al.*, (2009)
Dist	Distance of water source from the lead mines	kilometers	-	Alhassan *et al.* (2013)
Age	Age of the respond (in years)	years	-	Chandrasekaran (2009)

3.4.8 A priori Expectations

It was expected that household WTP for safe drinking water increases with individuals being male. This is because most income generating activities are are run and owned by males. Given that our split-sample treatment is designed in terms of valuing only an improvement in water quality or valuing an improvement in water quality and system reliability then this is a test of scope of a nested good (Carson and Mitchell, 1995).

As a measure of construct validity, in the theoretical framework it is assumed that improved irrigation water supply services is a normal good (a positive income effect on the WTP) (Whitehead, 1995). Hence, Income was expected to have a positive relationship with household willingness to pay. This is because the more money one has, the less budget constraints they face. Therefore, improved irrigation water supply services were viewed as a normal good implying that the respondent's willingness to pay for improved irrigation water supply rises with income.

It is expected that household level of satisfaction will be negatively related with household willingness to pay for improved irrigation water supply services in Kabwe rural. This is because households who are not satisfied with the present quality or quantity of water supplied will be more willing to pay for improved water than the their counterparts who are satisfied.

As a further measure of construct validity (and the substitution effect), households who are married were expected to report a higher WTP, given that the proposed improvement in the water system would be expected to provide a less expensive substitute for contaminated well water. Household with a good number of children under the age of 18 were expected to report a higher WTP, given that the proposed improvement in the water system would be expected to provide water 24hrs in a day.

WTP was expected to be lower the older the respondent was. Age was expected to negatively influence the activities one participates in as well as the perception of various issues. Young adults are assumed to have a relatively high socio economic status (Randela *et al*., 2000). These individuals are assumed to recognise the importance of maintaining a healthy agricultural society through adequate availability of improved irrigation water supply services.

Bidding price is included in this model to act as a measure of affordability, (Mugasi, 2009). It was a reflection of individual's willingness to pay for the improved water and sanitation (Frick *et. al*., 2003). The price is expected to negatively influence individual's willingness to pay for improved irrigation water supply services because theoretically demand is negatively related to price (Nicholson 2005).

Household size was expected to influence willingness to pay for improved irrigation water supply services either positively or negatively. This is because large household is expected to have a higher demand for improved irrigation water supply because it is assumed that the large the household size the large their irrigated garden space hence increasing demand for water supply, thus positively influencing the individual's willingness to pay for safe water. However, it is also expected to be negative because a large household usually is constrained on budget and that limits money available to meet other household demands. Literature reveals that larger households would have greater demand on available money hence would be less willing to pay money for improved irrigation water supply services (Pokou *et al.,* 2010)

The Location of the water source for both irrigation and drinking in relation to the location of the mines was expected to be negatively related to WTP. The closer the water source is to the mines the more willing to pay for improved irrigation water supply services. This is primarily because the closer the water source is to the mines the more vulnerable it is to lead contamination.

Education is an important explanatory variable because the level of education determines whether the respondent appreciates the danger of lead contamination. The level of education attained by the household heads was expected to have positive sign, which indicates that households whose heads have higher education indicated a higher willingness to pay than the less educated ones. Higher education shifts the demand for improved irrigation water services to the right, implying a higher level of welfare. A household with higher level of literacy has better chances of maximizing the utility and welfare from utilizing improved irrigation water services. The result is not unusual; the enlightened population has great impact on the demand for welfare facilities like water, health, education, sanitary conditions.. Similar results were found by Ogujiuba (2013), Herath and Masayuki (2014) in their study on estimating the Willingness to Pay for Water Services.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents and discusses the study findings. It begins with a presentation and discussion of the demographic characteristics. The aspects influencing farmers to participate in the sorghum contract farming such as age of the farmer, experience, availability of family labour, gender of the farmer and educational level of the farmer. Finally the chapter is concluded by discussion of the Logit regression estimates and marginal effects.

4.1 Characterisation of Sampled households

A number of socio-economic characteristics hypothesised to influence households' willingness to pay for improved irrigation water supply services in Kabwe are summarised and discussed in this section. These include age, gender, marital status, education, household size, land holdings under irrigation, number of livestock and income. Survey responses were obtained from 485 respondents. These respondents were from three major townships in Kabwe which were affected by the lead poisoning in Kabwe.

Households were classified as those "willing to pay for improved irrigation and potable water" and "not willing to pay" households basing on whether they gave yes/no response to WTP question in relation to their socio-demographic and socio-economic characteristics as indicated in the table above. "Willing to pay" households were those who gave a "YES" response when asked if they would pay for the improved irrigation water supply services in case there was an incidence of lead water pollution in the area while " Not willing to pay" households were those who gave a "NO" response. The majority (75%) of the households expressed positive willingness to pay for improved water compared to 25% of the households who were not willing to pay.

Comparing Bid covariate for households willing to pay for improved irrigation water supply services with those not willing to pay, those not willing to pay had a lower mean bid than those who were willing to pay for improved irrigation water supply services (Table 4.1). This was significant at 5%. This was expected based on theory of demand as price is always negatively related to demand.

Age of the respondent was also an important covariate to consider in willingness to pay for improved irrigation water supply services because it had an implication on the understanding of clean water supply to the health of human life. The household heads who were interviewed were found to be in the age range of 19 to 72 years, with a mean of 37.91 years (Table 4.1). there was a significant difference at 10% level in age between the household heads who were willing to pay compared to those not willing to pay. The mean age of those willing to pay for improved irrigation water supply services (38 years) was greater than that of those not willing to pay (36 years).

The household size for households willing to pay for improved irrigation water supply services were slightly bigger (3.95 persons) than those not willing to pay (3.34 persons). (Table 4.1) shows that there was significant difference at 5% level between the two categories of households. This was expected because a large household exhibits a higher demand for improved irrigation water supply services than those of smaller households.

Some socio-economic parameters such as marital status, education, training and or number of livestock animals were not significantly different among households willing to pay for improved irrigation water supply services and those not willing to pay. Results show that the average number of livestock owned was 4 livestock per household (Table 4.1). Those not willing to pay for improved irrigation water supply services had less livestock as compared to those who were willing to pay.

There was a significant difference at 5% level in household monthly income between the two categories of respondents. Household who were willing to pay for improved irrigation water supply services earned more income than those not willing to pay (Table 4.1). This is probably the more money one has, the less the budget constraints they face. Therefore, payment for improved irrigation water supply services is viewed as a normal good implying that the respondent’s willingness to pay for improved irrigation water supply services increases with income. This is consistent with the findings of that individual’s income level increases their demand for good attributes such as environmental friendliness, safety, hygiene and ethics involved in the production and marketing processes (Regmi and Gehlhar 2005; Ngigi *et al.,* 2010).

The sampled farmers reared livestock and grew crops on land ranging from 0.25 to 2 hectares (Table 4.1). The average land size under irrigation owned by Kabwe households was 0.604 ha (Table 4.1). There was a significant difference (5%) in land holdings between those willing to pay for improved irrigation water supply services and those not willing to pay.

Comparing household land size under irrigation for households willing to pay for improved irrigation water supply services with those not willing to pay, those willing to pay for improved water and sanitation services were found to have more land space under irrigation than those who were not willing to pay. This was found to be significant at 5%.

Table 4.1: Socio-demographic and Socio-economic characteristics of the sample of respondents in Kabwe City

Variable	Unit	Total (n=485)		WTP (n=364)		Not-WTP (n=121)		p-Value
		mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Bid	Kwacha	73.03	67.94	96.93	61.69	1.157	12.73	0.0321
Age of respondent	Number	37.91	9.192	38.437	9.056	36.397	9.452	0.0595
Household size	Number	3.794	2.131	3.95	2.23	3.34	1.74	0.0237
Households monthly income (‘000’Kwach)	Kwacha	1123.28	829.36	1188.27	852.162	927.77	725.42	0.0165
Irrigated land	hectares	0.604	0.29	0.47	0.21	0.22	0.11	0.0211
Livestock	Number	4.21	2.03	3.01	2.01	1.16	2.05	0.4321

Source: Own survey, 2015

Gender of the household head for respondents willing to pay for improved irrigation water supply services had more male household heads as compared to those not willing to pay for improved irrigation water supply services in Kabwe city. Table 4.2 shows that differences (5%) existed between gender of those willing to pay improved irrigation water supply services in Kabwe and those not willing to pay. There were more male as household heads in Kabwe rural farm households willing to pay for improved water supply (74.7%) than those not willing to pay (67.2%) (Table 4.2). This could be explained by the fact that most men were more able to pay for improved irrigation water supply services in Kabwe because men were noted to run most income generating activities like business than women. Moreover, there were more men in employment than women. Furthermore, most of households were headed by men.

Though not significant, marital status there were more married kabwe rural farm households not willing to pay for improved irrigation water supply services (77.7%) than those willing to pay (73.6) (Table 4.2). This could be because married people had a greater demand on the available resources hence, less willingness to pay for improved irrigation water supply services. This also consistent with the findings of (Bayiyana, 2013) who when determining willingness to pay (WTP) for Trans-boundary Animal Disease control also reported that those who were married had a lower willingness to pay for Trans-boundary Animal Disease controls because they had greater demand on the limited available resources.

Households in Kabwe have experienced the of lead pollution differently. Table 4.2 shows that the majority of those that experienced the adverse effects of lead pollution were more willing to pay for improved irrigation water supply services (72.1%) than those who did not experience (35.6%). Table 4.2 shows that significant differences (5%) also existed between lead pollution experience of those willing to pay for improved irrigation water supply services and those not willing to pay. There were more lead pollution victims among those willing to pay for improved water supply and sanitation services (72.1%) than those not willing to pay for improved irrigation water supply services (35.6%).

Education levels in the study areas were quite low. Moreover, education was not significantly different among the Kabwe rural farm households willing to pay for improved water supply and sanitation services and those not willing to pay. The average number of years of education was 7 years, which corresponds to primary education. Hence the Kabwe rural farm households were categorised into two groups that is literate and illiterates. The majority of those literate were found to be more willing to pay for improved water and sanitation services (42.3%) than those who were illiterate (37.2%)

Another factor that was looked at was employment status of the Kabwe rural farm households. Results of the study show that majority (70.3%) of the people who were interviewed were into farming this was as a result of the mines closing down in 1994, most former miners resorted to farming. Moreover, the majority of those willing to pay for improved irrigation water supply services were into farming as the form of employment as compared to those who were not willing to pay for improved irrigation water supply who mainly were into business rather than farming that's dependant on the water.

Employment status of the respondent was found to be significant at 10% level. Table 4.2 shows that among those not willing to pay for improved irrigation water supply services, there was a higher proportion of those not willing to pay who were in business as compared to those who were willing to pay. This was expected in that most of the people in Kabwe area were in less rewarding business hence are more constrained in finances such that the money available to meet household needs is never enough.

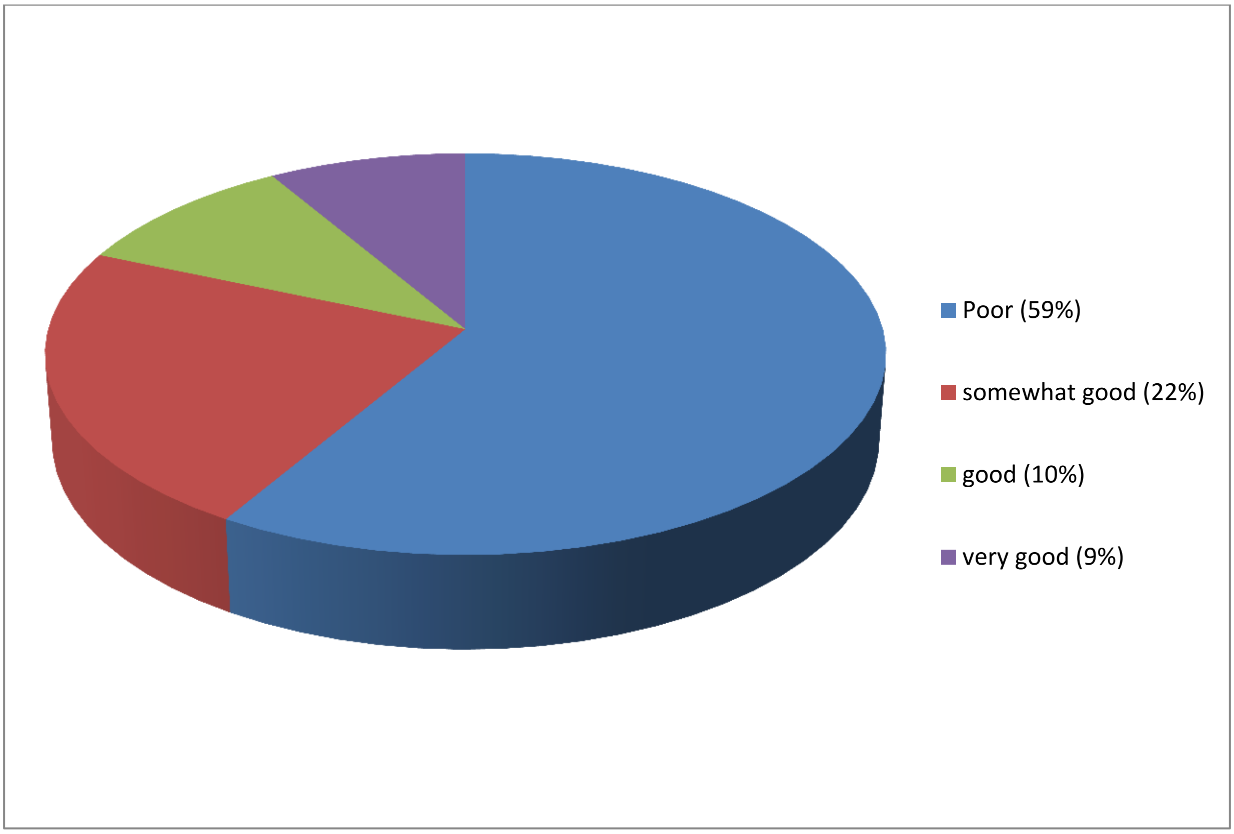
Table 4.2: Categorical Socio-demographic and socio-economic characteristics of the sample of respondents in Kabwe City

Variable		**Total (n=485) (%)**	**WTP (n=364) (%)**	**Not-WTP (n=121) (%)**	**Chi-Square**	**p-Value**
Gender of respondent	Male	0.729	0.747	0.672	9.02	0.045
	Woman	0.271	0.253	0.328		
Respondent's education	Literate	0.410	0.423	0.372	0.56	0.322
	Illiterate	0.59	0.577	0.628		
Marital Status	Married	0.746	0.736	0.777	0.47	0.588
	Divorce	0.027	0.027	0.00		
	Single	0.103	0.026	0.141		
	Widowed	0.124	0.211	0.082		
Employment status of respondent	Miner	0.202	0.198	0.215	8.04	0.058
	Farming	0.703	0.510	0.110		
	Business	0.080	0.212	0.530		
	Employed	0.015	0.080	0.145		
Pollution Experience	Experienced	0.803	0.721	0.356	9.12	0.032
	Not experienced	0.197	0.279	0.644		
Training (pollution control)	Trained	0.407	0.40	0.12	0.46	0.51
	Not trained	0.593	0.60	0.88		

Source: Own survey, 2015

Very few chemical data are available for groundwater in Zambia on which to base an assessment of the quality of available resources and reconnaissance testing programmes are urgently needed to establish the irrigation-water quality. However, from the figure 4 below the majority (59%) of the respondents perceived the water quality to be poor while only 9% perceived it to be very good. Given the geology of the region, the principal ground water quality problems are likely to be pollution problems associated with metal mining in Kabwe region.

Figure 4: Perception of Respondents on the Quality of irrigation Water in Kabwe



Further survey results obtained in included respondent awareness of the existence of the water regulation policies. Results of the study show that majority (72.4%) of those willing to pay for improved irrigation water supply in Kabwe were aware of the water regulation policy and they understood that the policy demanded them to pay for water through water bills hence they assumed a sense of responsibility. However, very few of those not willing to pay (13.6%) were aware of the policy that should regulate water in the area hence they perceived water supply as a government responsibility and that it should be free.

Disease outbreaks and in some worse instances death incidences due to lead water contamination was reportedly a common threat to the Kabwe residents particularly those that are situated closer to the mines. Hence majority of those willing to pay for improved water supply (Table 4.3) reported to have experienced disease outbreaks such as diarrhoea that was reportedly due to water contamination and children were reported to be the most vulnerable. Moreover, they also reported their awareness of other disease outbreaks that are due to lead contamination such as infertility in women and brain damage in children.

Normal blood levels are less than 10 μg/dl, and levels above are considered unhealthy according to the World Health Organization. In Kabwe as high concentrations as 300 μg/dl has been recorded in children, and investigations show average blood levels of children between 60 and 120 μg/dl.17 Children are particularly vulnerable to toxic effects of lead and can suffer severe and permanent health effects which influence the development of the brain and nervous system.

Another characteristic that was looked at was to establish whether households had alternative water sources apart from the regular source they had. Results of the study show that 50.2% of those not willing to pay for the improved water supply had alternative water sources. Moreover, contamination of irrigation water in the Kabwe mining areas made headlines. It was further reported that a similar contamination incident occurred in Chingola in 2006. During a second incident in January 2008, at least 13 people in Mufulira in northern Zambia were admitted to hospital after drinking water alleged to have been contaminated by the nearby Mopani Copper Mines. Residents were afraid to irrigate their gardens using tap water and collected water from shallow wells or nearby streams as their alternative.

Table 4.3: Household Perception and Awareness of various water issues

Survey Results	Percentage of H/Hs (n = 485)		Total
	WTP (n=364)	Not WTP(n=121)	
Water regulation policy awareness	72.4	13.6	86
Disease/Death incidences due to food crop contamination	51.2	23.2	74.4
Awareness of the negative health effects of lead contaminated water and food crop consumption	44. 4	12.2	56.6
Alternative irrigation water source	10.1	50.2	63.3
Preferred water source			
Regular water source	71.6	22	93.6
Alternative water source	10.2	54.2	84.4

Source: own survey

Majority (71.6) (Table 4.3) of those willing to pay for improved water supply preferred water from the regular source. This explains why they exhibited a positive willingness to pay for the restoration of the contaminated water source. However, majority (54.2) of those not willing to pay for improved water supply preferred the alternative source in that they were not required to pay any money for it.

Table 4.4: Water sources in Kabwe Rural Farm Households

	% of HOUSEHOLDS		
Source	**WTP(n =364)**	**Not WTP (n=121)**	**Total**
Deep borehole	28.4	43.2	71.6
Shallow wells	56.8	36.9	93.7
In- house Tap water source	16.5	26.1	42.6
Unlined shallow wells	54.6	35.8	90.4
River/stream	1.9	0.0	1.9
Fully sealed public water supply	0.0	12.5	12.5

Another factor to be considered was the water sources for different Kabwe rural households. Table 4.4 shows that the majority of the households sourced their water from either shallow wells (93.7%) or unlined shallow wells (90.4%) rendering the majority to be vulnerable to pollution problems. During the Focus Group Discussions (FDG) it was further noted that the majority of the households who were willing to pay sourced water from shallow wells as opposed to those that sourced their water from in house tap water sources and fully sealed public water supply. This explains why the majority were receptive to the suggested water improvement scenario. From the findings of this study it could be noted that the major source of water in the study area was the groundwater particularly the shallow wells which explained why the communities were vulnerable to lead pollution. The FDG reports are also supported by the findings of MacDonald *et al.,* (2012) who also noted that there were growing demands for freshwater sources in Africa, with groundwater continuing to form a critical component across the continent. It was further reported that shallow groundwater sources are particularly important as local sources of drinking water, but are also potentially very vulnerable to anthropogenic contamination (Hunter *et al.,* 2010).

Furthermore results were obtained following the qualitative analysis of major issues raised during the focus group discussions held with the communities in the study areas in Kabwe was done. (Balana *et. al.,* 2010, 2011) established that Focus group discussion involves a way of learning about opinions, views, attitudes and experiences from a selected group of individuals about a particular topic. To keep the discussion focused, open-ended discussion guides were identified (Appendix 2). Community members highlighted lead contamination of water for both irrigation and domestic use as the major problem in the study areas. They identified that flooding of lead waste from the canals that ran through the study areas straight from the old lead smelter were the main reasons for the decline of clean water supply.

Following results from the FDGs, it was reported that contaminants were most prevalent in shallow wells sited in low cost housing areas. This is attributed to localised vulnerability associated with inadequate well protection from lead, sanitation, and household waste disposal. These results were found to be consistent with the findings in the study by Sorensene *et al.,* (2015) in Kabwe City on “Emerging contaminants in urban groundwater sources in Africa” where groundwater samples were obtained during both the dry and wet seasons from a selection of deep boreholes and shallow wells completed within the bedrock and overlying superficial aquifers, respectively. Groundwater sources were distributed across the city to encompass peri-urban, lower cost housing, higher cost housing, and industrial land uses. They concluded that emerging contaminants were most prevalent in shallow wells sited in low cost housing areas. They also attributed to localised vulnerability associated with inadequate well protection, sanitation, and household waste disposal.

Farming in Kabwe

Table 4.5: Commonly grown crops/ livestock in Kabwe city

Crop/livestock	Percentage of farmers (n = 485)		Total
	WTP (n=364)	Not WTP(n=121)	
Livestock			
Cattle	52.4	23.6	76
Goat	41.2	33.2	74.2
Sheep	14. 4	12.2	26.6
Piggery	3.1	0.2	3.3
poultry	36.1	14.2	50.3
Duck	2.0	0.0	2.0
Crops			
Maize	71.4	22.2	93.6
Sorghum	60.2	24.2	84.4
Beans	58.4	36.7	95.1
Sweet potato	27.3	12.4	39.7
groundnuts	26.4	14.2	40.6
cassava	46.8	28.4	75.2
vegetables	10.4	2.3	12.7
Tomatoes	8.8	2.0	10.8
Irish potatoes	10.4	4.0	14.4

One of the major characteristics that were looked at was the type of crops grown that was in the study area and the type livestock reared. Results of the study show majority of the people who were interviewed ventured into practicing agro-pastoralism after the lead zinc mine got closed down in 1994. Very few were into scrap metal scavenging in the old mine tailings. The agro- pastoralists had a wide range of enterprises including livestock such as cattle, goats, sheep and poultry, and crops. Crops which represented the highest percentage of production included maize (93%) sorghum (84.4%), beans (95.1%) and cassava (75%) (Table 4.5). Moreover, because of high dependence of farming enterprises on water, the majority of those willing to pay for improved irrigation water supply services were those households whose major income source was farming.

However, it was reported in the Focus Group Discussion that the most important challenge to human health in as far as farming is concerned was the lead (Pb) contamination of the environment. It was reported that lead is widespread, especially in areas like Makululu that are in close proximity to the mines. Lead was reported to be present in the atmosphere, soil, water, and in food crops. It was reported that lead is present in the soil as a result of weathering and other pathogenic processes acting on soils parent material; or from pollution arising from anthropogenic activities; such as mining, smelting and disposal; or adoption of the unsafe and unethical agricultural practices such as using of sewage sludge, and waste water in the production of vegetables crops or cultivation of vegetables near the mining areas.

The FDG results were consistent with the findings of Feleafel and Mirdad (2012) who went on to note that lead (Pb) concentration is generally high in leafy vegetables than other vegetables. They further noted that the factors affecting lead uptakes in crops include its concentration in the soil, soil PH, soil type, organic matter content, plant species, water and unsafe agricultural practices. Consequentially as lead concentration increases; dry matter yield of roots, stems and leaves as well as total yield is decreased. The mechanism for growth inhibition by lead involve: a decrease in number of dividing cells, a reduction in chlorophyll synthesis, induced water stress to plants and decreased nitrate uptake, reduced nitrate and nitrite reductase activity, a direct effect of lead on protein synthesis, a decrease in the uptake of concentration of nutrients in plants (Feleafel and Mirdad, 2012).

Table 4.6: Reported adverse effects of lead poisoning in Kabwe

	Major health problems due to lead (Pb)	**Mode of transmission**
Adults	Nervous breakdown	Drinking water
	miscarriages	dust
	Kidney damage	soil
	Muscle spasm	
	Premature birth	
	Low birth weight	
Children (age 7years)	Memory loss	Drinking water
	Brain damage	dust
	diarrhoea	soil
	vomiting	Crop foods
	Mental retardation	
Food Crops	Reduced-chlorophyll synthesis	Mainly water
	Reduced plant-nutrient uptake	Soils through nutrient uptake
	Induced water stress	
	Decreased yield	
	Stunted plant growth	
Domesticated animals		
Cattle	Liver ,kidney infection	water
Goats	Liver, kidney infection	soil
Sheep	Liver, kidney infection	vegetable
Pigs	Liver, kidney infection	
Free-range chickens	Liver, gizzard, muscle heart Kidney infection	grass

Source: survey Focus Group Discussion with Agro-Vets specialists (FDGs)

4.1.1. Food animals and Lead contamination

Following to the FDG held with agro- vet specialists, it was reported in FDGs that most endangered livestock to lead contamination were free range chickens which are left to fend for food themselves. It was reported that these free range chickens are usually seen scouting for food in the most contaminated areas which poses a health risk to people that feed on them. These reports were found to be consistent with the findings of Yabe *et. al.*, (2012) in their study on " metal distribution in tissues of free-range chickens near a lead–zinc mine in kabwe, Zambia" who noted that free-range chickens reared in Makululu Chowa, Kasanda, and Katondo townships near the Pb–Zn mine in Kabwe accumulate large quantities of Pb and Cd compared to commercial broiler chickens. They further noted that the source of metal pollution is most likely the now closed mine site. They went on to further conclude that prolonged consumption of high concentrations of Pb and Cd in chicken offal may lead to accumulation of these metals in the human body and cause metal toxicity.

From Table 4.5 it is evident that almost every farm enterprises as well as humans were at risk of diseases that are due to lead pollution in Kabwe rural farm communities. Based on the Focus group Discussions (FDGs) with the Kabwe agro-vet specilists, they each reported atleast one outbreak of animal or crop disease due to lead in the communities in the past. Moreover, they reported that the situation has been growing worse but might soon get better with different projects that are coming in such as the Blacksmith Institute projects of cleaning up lead infested areas. The animal and plant attacks with economic significance to farmers were decreased yields on crops and liver, kidneys infection on cattle and other ruminant animals such as goats and sheep. It was further suggested in the FDGs that the levels of lead in organs of cattle, sheep, goat, free-range chickens may emanate mainly from contamination of soil, feeds and water sources. The claims received through Focus Group Discussions (FDGs) were found to be consistent with findings of Yabe *et. al.,* (2010), who noted that contamination of food animals, fish, soil, water, and vegetables with heavy metals has reached unprecedented levels over the past decade in some parts of Africa. They further noted that as a result, human exposure to toxic metals has become a major health risk.

The Blacksmith institute project completion report of 2014 further revealed that in the U.S normal blood levels of lead are less than 10 g/dl (micrograms per deciliter). They however noted that in Kabwe, blood concentrations of 300 g/dl have been recorded in children and records show average blood levels of children were between 60 and 120 g/dl. This was confirmed by Bortey-Sam *et al.,* (2015) in a study on the dietary intakes of As, Cd, Hg, Pb and Mn from the offal and muscle of free- range chicken, goat and sheep in Tarkwa, Ghana where they found that intake of these heavy metals were low when compared to the FAO/WHO (2010) tolerable daily intakes. They also noted that children are especially vulnerable to acute, sub-acute and chronic effects of ingestion of chemical pollutants, since they (children) consume more (twice of the amount) of food per unit of body weight as adults (ENHIS, 2007). As a result, intakes of these four toxic metals through food could be higher for children in Tarkwa. THQ of As, Cd and Hg showed that there could be potential health risk to inhabitants through consumption of larger quantities of contaminated offal of free-range chicken

4.1.2. Food Crops and Lead contamination

The most serious lead pollution effects reported in Focus Group Discussions (FDGs) by the kabwe rural farm households and agro- vet specialists was its effect on decreasing yield and stunting the growth of crops especially vegetables as revealed in (Table 4.5). Their report was found to be consistent with the findings of to Seregin and Ivanov (2001), who noted that lead phytotoxicity leads to inhibition of enzyme activities, disturbed mineral nutrition, water imbalance, change in hormonal status and alteration in membrane permeability. They further noted that these disorders upset the normal physiological activities of the plant and would result in loss of biomass yield as noted in this Focus Group Discussion. The claim of effects of lead on crops was further approved by the findings of Hamvumba, (2014), who noted that Chinese cabbage, sunflower and sorghum all showed a poor growth pattern as the concentration of Lead in the soil increased among treatments.

They further noted that the observed inverse relationship between plant growth and soil lead concentration could be attributed to the direct negative effects of lead on plants. (Hamvumba, 2014) further noted symptoms of lead toxicity at higher lead levels included stunted growth and chlorosis. Previously, Sharma and Dubey (2005) noted that excess lead causes a number of toxicity symptoms in plants such as stunted growth, chlorosis and blackening of the root system, this agrees with the results of the FDGs. Alternatively, lead in the soil has been shown to be able to complex other plant nutrients such as phosphorus, thereby rendering them both unavailable for uptake (Xie, Wang, Sun, & Li, 2006). It was also noted that it is possible that plants suffered phosphorus deficiencies contributing to poor plant growth that is stunting, even if the classic purple discoloration of leaves was not observed.

4.2 Determinants influencing Households' WTP for Improved Irrigation Water Services in Kabwe.

Household size, age, income, sex, distance between source of water and the lead/zinc mines, Pollution experience, Pollution control training, education level, marital status, irrigated Garden space, Level of satisfaction and initial bid were some of the variables identified to affect households' willingness to pay for improved irrigation. Before the Logit regression was estimated, the explanatory variables were checked for multi-co-linearity using the variance inflation factor and simple pair wise correlation matrix and serious multicolinearity problem was detected between the variables household size and number of children below 18 years old,.

Table 4.7: Logit model estimates of determinants for households' WTP for improved Irrigation and Potable water services in Kabwe.

VARIBLES	**WTP**			
	Coefficient	**Standard Errors**	**P-Value**	**Marginal Effects**
GEN	0.862	0.434	0.010	0.000239
MAR	0.293	0.460	0.657	0.0000702
AGE	-0.035	0.021	0.021	-0.0000781
H/H SIZE	0.179	0.088	0.001	0.0000397
EMPLOY	-1.437	0.635	0.224	-0.000527
EDUC	0.739	0.442	0.042	0.000157
POLTR	0.239	0.105	0.024	0.0003
EXP	0.072	0.037	0.053	0.00215
DIST	-0.311	0.000	0.027	-0.011
HINCO	0.0010	0.0003	0.008	0.0000163
IRRG	-1.322	0.486	0.013	-0.04489
SAT	-2.996	1.138	0.008	-0.00312
LIVNO	-0.039	0.099	0.451	-0.01005
BID	-0.110	0.021	0.000	-0.00307
CONSTANT	5.541	1.744	0.002	
Observations	467			
LR Chi2 (8)	332.45			
Log likelihood	-98.830847			
Pseudo R^2	0.5071			
Prob> Chi2	0.0000			

The variable number of children below the 18 years old was dropped from the regression. Standard errors were checked for the presence of heteroskedascity. A test to avoid dummy variable trap was conducted and no dummy variable trap was found. The Shapiro w tests for normal data were conducted for the normal distribution of the explanatory variables and variables were found normally distributed. In addition, Breusch-pagan/cook-Wisberg test was used to to confirm if the robusted standard errors were clear the problem of heteroskedasticity. The result of the contingency coefficient and variance inflation factor confirmed the non-existence of multicollinearity between the variables. The Breusch-pagan test also indicates no problem of heteroskedasticity in the Logit model.

The results show that out of 9 explanatory variables included in the model, five were significant and these included education level (EDU), family size (H/HSize), Age (AGE) of the respondent, gender (GEN), Level of satisfaction (SAT) and household income (HINCOME) have a significant and positive effect on the households' willingness to pay for the offered initial bid for the improved irrigation water supply services.

Two of the independent variables, namely the initial bid offered (BID) and total cultivated land under irrigation (IRRG) had a negative and significant effect on the willingness to pay for the offered initial bid for improved irrigation water supply services amongst Kabwe rural farm households. However, the rest of the explanatory variables included in the model were not significant at ($p < 0.05$) probability level.

In table 4.6, there are two basic outputs. The first output includes the coefficient and standard errors of the Logit model and the second output is the output of the marginal effects of the Logit model. The coefficient of the Logit model does not show the marginal effects of the independent variable on the variation of the dependent variable willingness to pay; rather it tells us only the sign of each independent variable. On the other hand, in order to infer the effects of each explanatory variable on the likelihood that households reject or are willing to pay the initial bid, the marginal effect of each independent variable was taken.

This study investigated the effects of socio-economic characteristics of respondents and some farm characteristics on WTP for the improved irrigation water supply services in in the four lead affected communities in Kabwe city using a Logit model. In addition to the socio-economic characteristics, such as household monthly income, age, gender, marital status, employment, household size and pollution training, education, variables concerned with farm description, such as Irrigated garden size and number of domesticated animals and water source location or distance of source from the mine area were considered. Other variables such as marital status, employment, livestock number were found to be non-significant determinants of WTP for improved irrigation water supply services. However, it should be noted that non-significant variables do not necessarily contradict expectations, simply that their influence in WTP was not observed in this dataset (Mesa-Jurado, 2012). The results of the Logit model are reported in the table 4.6. As the pseudo R^2 is above 0.2, the overall model fit is considered good (Hensher and Johnson, 1981)

A significant difference was observed during the survey between households willing to pay for the provision of improved irrigation water supply services in Kabwe. Based on the results, the INCOME variable has the expected significant positive sign, implying that respondents with higher income were willing to pay more for the improved irrigation water supply than those with a lower income. These results agree with the findings of Jurado *et al.,* (2012) in their study on "economic value of guaranteed water supply for irrigation under scarcity conditions". The total income of the respondents (HINCOME) had a positive and significant effect at ($\rho < 0.01$) probability level. This relationship indicates that higher income households are more willing to pay a pre-specified initial bid than lower income households. This result also is consistent with the general demand theory which states the positive relationship between income and demand for normal goods. The marginal effect underlined that keeping other variable constant at their mean value, a one kwacha increase in income of the household increases probability of the willingness to pay by 0.0000163%. Similar results have been obtained by (Balana, *et. al.* 2013); who assessed WTP for reliable domestic water supply via catchment management: using contingent valuation methodology in Nairobi City, Kenya. This is also consistent with the results obtained by (Arounaand 2012; Mezgebo, et. *al.* 2013) In their CVM study on irrigation water. This tells us the realities that as the income of households increase their demand to improved services increased. This is also in line with the studies done by Fujita et al. (2005), Hensher *et al.,* (2005), and Fanta (2007), who found that when income increases the probability of the household saying yes to contribute for the improved irrigation service increases.

Pollution training implies a better understanding of the adverse effects of lead poisoning both to food crops and to humans leading to decreased labour productivity due to health problems due to lead water contamination. Both agriculture and pollution training leads to higher productivity of labour and more innovative behaviour, hence this explains the positive significant ($\rho < 0.05$) relationship between this variable and the WTP value. The marginal effect underlined that keeping other variable constant at their mean value, implying a farmer attending training in pollution training increased probability of the willingness to pay by 0.03%. These results agree with the recommendations made by the Blacksmith Institute, (2013) that training individuals on pollution control creates awareness and hence helps curb the problem.

The coefficient for total cultivated garden size under irrigation of the respondent (IRRG) was negative and significant at ($p < 0.05$) probability level. This implies that, there was a greater WTP for households with small irrigated garden space as opposed to those with medium-large irrigated garden space. This because larger farm garden space under irrigation tend to be costly for resource poor farm household. The farm households owning large size of cultivated land that require irrigation were less willing to pay the offered bid value than respondent with small cultivated land size. Large cultivated garden sizes generally require huge amounts of irrigation water which may be too costly for these resource poor Kabwe households. A related study by Chandrasekaran, *et al.,* (2009) found similar results on Farmers' willingness to pay for irrigation water: a case of tank irrigation systems in South India. Moreover the marginal effect on (IRRG) indicates that a unit increase in the family irrigated garden space decreases the probability of willingness to pay by 4.49%, keeping other variables constant.

Age of the respondent variable was found to be negatively correlated with WTP for improved irrigation water supply, this implies that the younger farmers were willing to pay more than older individuals, which is consistent with the a priori expectation and also agrees with the findings of Mesa-Jurado *et al.,* (2012). It can be reasoned that farmers close to retirement age tend to be less forward looking and do not see investment in water resources as strategic move for their farm business enterprise considering lead (Pb) pollution has adverse effects on the farm business as it negatively affects crop yield. Moreover, variation in willingness to pay for improved irrigation water supply services that was observed on households in as far as age is concerned was due to the fact that old aged households were less likely to pay for the provision of the improved water service because of income related issues. As people age, the more they fear to invest on projects on which their return is expected after long term. Studies by Fujita *et. al.,* (2005) and Mezgebo and Ewnetu (2015) support this assertion when they asserted that the younger the age of the respondent, the higher is the monthly income and the higher is the willingness to pay for the improved water service.

The coefficient associated with variable level of households' satisfaction with the existing water quality (SAT) had the expected sign and was statistically significant at 5% level of significance. Households had showed a significance difference on willing to pay to the provision of improved irrigation water supply services. Individuals who were satisfied with the existing water supply were less likely to pay for provision of improved water supply and sanitation services over those unsatisfied. One possible reason could be those households who were unsatisfied with the current water standard due to contamination poor quality, and absence of own private pipe are likely to pay for improved water services than those households who were satisfied with the existing services. The fact that, it is significant showed that the level of households' satisfaction with the existing water supply was a major determinant of the willingness to pay the amount for the proposed water supply services. An earlier study by Gebreegziabher and Berhanu (2007) equally found a negative relationship between willingness to pay and households' level of satisfaction. In terms of the marginal effect, it implies that a unit increase in the farm household water quality satisfaction decreases the probability of willingness to pay by 0.312.%, keeping other variables constant

Households are also willing to pay more, when there are a greater number of victims who have experienced the lead pollution over the years. From this evidence it can interpreted that farmers who had experienced the pollution over the years and how it led to reduced yields resulting into reduced household income, were more willing to pay for improved irrigation water supply services. Hence this explains variable experience's (POL/EXP) significant relationship with the WTP value. Moreover the marginal effect on POL, EXPERIENCE indicates that having experienced pollution increases the probability of willingness to pay by 0.22%, keeping other variables constant.

The Gender variable (GEN) was positive and significant at 5% level. A significant difference was recorded between male and female in their willingness to pay for the improved irrigation water supply services among the Kabwe rural farm households. Female repondents were more willing to pay for the improved irrigation water supply services than their male counterparts. This may be because females are usually responsible for collecting water for irrigating household gardens and are directly influenced by water related problems. This is similar to the research done on rural household affordability and willingness to pay for improved water services in urban areas. The results confirms a recent study by Mezgebo and Ewnetu (2015) who observed a difference on willingness to pay between male and female respondents in Neblet, Ethiopia for water. An earlier study by Bayru (2004) equally observed a difference on willingness to pay between male and female headed households in their study on affordability and willingness to pay of water supply in Nazrath town, Ethiopia,

.

The distance variable or water source location (DIST) shows the distance between the water source and the lead/zinc mines. Significant difference was observed among the households' in willing to pay for the provision of improved irrigation water service. The further the household was from the lead/zinc mines, the less likely they would be willing to pay for improved irrigation water supply services. The variable has a priori positive sign, indicating that households whose source of water is far away from the mines would be less willing to pay for improved irrigation water supply services. This could be because households whose water source is near to the lead/zinc mine would be more susceptible to lead contamination than those located further away from it. This is in line with the previous studies that recognized a positive relationship between households' willingness to pay and distance of source of water (, Olajuyigbe and Fasakin (2010), Coster and Otufale (2014),)

The regression result analysis showed that marital status (MAR) was affecting respondent WTP for improved irrigation water supply services ($p > 0.05$). However, it was expected that married respondents would be more likely willing to pay for improved irrigation water supply services as compared to their unmarried counter parts. This is because married people are more cautious of the health and other risk involved in contaminated improved irrigation water supply services due to family responsibility in the future than their single counterparts. This is has been noted in an earlier studies done by Coster and Otufale (2014).

The Bid variable (BID) was negative and significant at 1% level of significance and therefore consistent with a priori expectation. As the bid offered to the respondent increased the probability of household WTP for the improved water service decreased. These results are in agreement with the studies done on improved water service in Harare town by Coster and Otufale (2014) who recognized a negative relationship between willingness to pay and initial bid. The implication of this indicated that as the value of the initial bid increases the likelihood that a respondent would say yes as the bid value decreases and vice versa that is also consistent with the economic theory of the negative relationship that exists between price and demand. The marginal effects of BID1 indicated that a one kwacha increase in the BID price of improved irrigation water supply services in Kabwe would decrease the probability of willingness to pay for the proposed initial bid by 0.307%, keeping other variables in the model constant.

4.3 Households Mean WTP for Improved Irrigation Water Services

The mean WTP from the logit model was calculated using the formula specified by Haab and McConnell 92002) as follows:

$$\text{WTP} = -\frac{\beta constant}{\beta BID}$$

$$\text{WTP} = -\frac{\alpha}{\beta} = \text{WTP*} = \text{Mean WTP}$$

Where α = a coefficient for the constant term or the intercept of the model and β= slope coefficient of bid values that will be offered to the respondents.

$$\text{WTP} = -\frac{5.541332}{-0.1107446} = 50.03$$

$$\text{WTP}^{+} = \text{Truncatd mean WTP} = \beta^{-1}\ln(1 + e^{\alpha})$$

$$\text{WTP}^{+} = \text{Truncatd mean WTP} = 0.1107446^{-1}\ln(1 + e^{5.541332}) = 50.072$$

The mean WTP for the double bounded dichotomous contingent valuation was analysed using the Logit regression model. The logit output in table 4.6 revealed that the coefficient of the initial BID had a negative sign and significant at less than 1% significant probability level, respectively. The implication of this negative relationship indicated that, as the value of the initial and second price increased, households' WTP for improved irrigation water supply services decreased. The mean WTP for the improved irrigation water supply services from the double bounded Logit was estimated to be 50.03 Kwacha /household/month which was equivalent to (US$7. 58 /household/month). Consistent with this, earlier empirical studies also document that consumers are sensitive to their residential demand for water with respect to price changes (Gaudin, 2006). In both the models WTP ranges from 50.03 to 50.072 and the difference between the median WTP* and the truncated mean WTP^{+} is modest. The calculations above show the median WTP for safe drinking water with corresponding 95% confidence intervals calculated using Krinsky and Robb's (1986) boot-strapping procedure.

Both methods indicate that the median sampled households would pay K50.03 Zambian kwacha more in their monthly water bill for improved water provision.

Table 4.8: Reason for protest zero and not willing to pay households,

Reasons	Frequency	Percent
I cannot afford to pay	30	75%
I do not trust the improvement	5	12.5
The government is responsible	5	12.5
Protest zero	10	25

A panel of prominent social scientists convened by The National Oceanic and Atmospheric Administration (NOAA) which was established in 1992, to assess the reliability of contingent valuation (CV) studies. The result of the panel's discussions was a report that laid out a set of recommended guidelines for CV survey design, administration, and data analysis. The invalid responses are calculated by multiplying the sum total percentage of the protest responses in the sample by the total population in the command area. Expected invalid response = 0.021 * 300,000 = 6300 households. Thus, the valid number of responses = 300,000 - 6300 = 293,700 households.

4.4 Analysis of Aggregate WTP for the Improved Irrigation

One of the ultimate objectives of WTP contingent valuation study is to estimate the aggregate WTP of the goods valued or the analysis of welfare measures using the value of total WTP obtained from the sample households to the total population in the water pollution command area. For valid analysis of aggregation of benefits, the different bias of the sample design during contingent valuation study has to be minimized, and protest zero responses should be excluded from the data (Mitchell & Carson, 1989). Hence, attention has been paid to minimize all the biases in this study. An appropriate sampling technique to select sample households lists were obtained from corresponding Kabwe municipal council administrations. Moreover, the questionnaire was administered through a face-to-face interview that helped get a high-response rate. Lastly, as indicated in table 4.7, based on the NOAA panel guide following Arrow & Solow (1993), protests zero households are excluded from the aggregation, and hence expected none of the different biases in the analysis. Consequently, the total WTP for the project area was calculated by multiplying the mean WTP value obtained from the Logit regression model for the double bounded by the valid number of households in the project area. The valid number of households was obtained after deducting the expected protest zero responses (6300) from the total population. Therefore, the entire aggregate values of the improved irrigation water supply services in the Kabwe from the double bounded formats are 14,693,811 Kwacha/month (US$2,226,246.)

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

Being able to access improved irrigation water supply services for Kabwe rural households and smallholder farmers where the challenges of environmental pollution has an adverse effect can have many positive effects. It may help to satisfy the household demand for food, reduce poverty and improve employment opportunities. Understanding the relevance of employment opportunities and the rich deposits of Lead in Kabwe area, the government of Zambia launched the Lead mining project in the Kabwe district, in the central province region. However, due to environmentally unregulated mining activities and lack of maintenance and rehabilitation of canals that transport lead mining waste, as well as lack of proper implementation of the lead mining project and as a consequence, there was massive water contamination by the lead waste that came from the smelter in Kabwe rural areas situated near the mines which has endangered the Kabwe rural households and smallholder farmers in the area. Thus, there is a need to improve the irrigation water supply services for both consumption and irrigation purposes in the area. In order to improve the irrigation water, the government considered applying a mechanism that rural households and smallholder farmers contribute recovering the cost burden for management, maintenance and operation of the improved water and sanitation service system. Implementing such a mechanism requires information about; whether Both rural household and smallholder farmers are willing to contribute to the improved water project, and How much or how large is the total WTP for the improved water going to be.

Therefore, methodologically this study utilised the CVM study with dichotomous double bounded choice format to estimate the mean WTP and then the total WTP for the improved water. The contingent valuation study used survey data collected from 485 randomly selected sample households from four affected townships in Kabwe city lead pollution command area and administered questionnaire through face-to- face interviews by enumerators. Households were selected using a simple random sampling technique and numbers of sample households was determined from each township using probability proportional to size sampling technique and simple random sampling techniques.

The result of the survey shows that, 81.29% of the sample Kabwe rural farm households described that the existing irrigation water was unsatisfactory for agricultural animal and crop productions, which are caused by lead pollution. Moreover, the descriptive statistics confirmed that 75.05 % (364) of the sample farm households were willing to pay for the improved irrigation water services and 24.95% (121) were not willing to pay the initial offered bid. This shows that most of the sample rural households as well as farm households understood the existing lead water pollution problems in the area and were willing to pay and assist the government for the improvement of water supply. Moreover, this result tells us that, if smallholder farmer households in Kabwe once realize the benefits obtained from improved water supply for irrigation in terms of better productivity and increased income, they are willing to pay more than the above stated WTP value. The mean WTP for the improved irrigation water (the hypothetical market scenario) from the double bounded dichotomous elicitation response using the empirical result obtained from the Logit econometric model was estimated to be 50.13 Kwacha/month (US$7.58 /Month).

The aggregate value of the improved irrigation water supply in Kabwe rural farm households improved water project from the double bounded formats per month for the entire population was 14,658,811 Kwacha/month (US$2,226,246.). Moreover, the empirical findings identified education level, family size, gender, Age household income, level of satisfaction, pollution experience the size of the initial bid and irrigated garden size have a significant effect on the households WTP for improved irrigation water supply in Kabwe**.**

The analysis presented in this study provides evidence that Kabwe rural farm households are willing to pay for improved irrigation water supply services guarantee, motivated by the perceived improvement in the welfare. Regarding demand heterogeneity, the relevant factors that significantly affect the value of WTP are socio-economic characteristics: age, gender, marital status, monthly household income, pollution training, pollution experience, employment status, household size and education. This information could help policy makers to better target their interventions for improving their knowledge about the likely support among different types of Kabwe rural households especially farmers for specific policy actions.

5.2 Conclusions

In conclusion, it can be argued that water, soil and crops were contaminated with heavy metals at the two peri urban areas in Kabwe. Heavy metal contaminated irrigation water implies that the water was not suitable for crop irrigation. Heavy metal contaminated soil implies that there is the likelihood of soil toxicity and transfer of heavy metal contaminations to crops. The implications of heavy metal contamination of food crops was that consumers of heavy metal contaminated food crops are associated with potential health risks. The results confirm that, in the incidence of water contamination, households have non- market values associated with improved irrigation water supply services in addition to direct use and irrigation of the supplied water. This means that households perceive benefits in this change as their welfare increases, providing evidence of the support to measures or strategies that permit such improvement

This study presented results of a contingent valuations (CV) study conducted in a heavy metal polluted region, namely, the Kabwe rural in Zambia, which elicited Kabwe rural households' preferences and their WTP value for improved irrigation water supply services. The results show that farmers predict a significant increase in agricultural benefits due to additional improved water for both use and irrigation and they are willing to pay to secure these benefits. It implies that improved water supply increases not only the farmers' benefits but could potentially increase the government's revenue.

5.3 Recommendations

Based on the results of the study, the economic effects of lead contamination control measures could be mitigated through measures aimed at control, containment and eradication. This has clear private benefits that accrue to Kabwe rural farm households. However, the challenge would be how to make sure sufficiently large numbers of farmers pay for the improved irrigation water supply services. This can be achieved with government involvement in the following ways.

Farmers' monthly income plays a major role in willingness to pay because it determines the ease with which farmers gain access to improved irrigation water supply services both for farming and domestic use. Farmers should therefore be sensitized on paying for improved irrigation water supply services because it is from the healthy animals and crops as well as family labour force that reasonable monthly income is realised. Government can improve farmers' income by beginning to provide credit to Kabwe rural farm households at reasonable interest rates.

Results showed farm households who had attained pollution control training had a positive willingness to pay for improved irrigation water supply services. Therefore in order to promote this, Government through the Environmental Council of Zambia should create more platforms for pollution control trainings for the Kabwe rural households for awareness purposes. This will help in sensitizing agro-pastoralists on the sustainable agricultural practices in the face of lead pollution

Government should put in place measures that would enhance the availability and affordability of improved irrigation water supply services in rural areas. For instance, some of the money allocated to agricultural programmes such as irrigation schemes should specifically target farm rural households in heavy metal polluted areas. Government should promote private – public partnerships for example by working with the relevant stakeholders and non-governmental organisations (NGOs) in the respective locations to extend improved water supply and sanitation services to remote rural areas especially those vulnerable to heavy metal pollution due to mining activities. The role of government should be to provide an enabling environment through provision of appropriate incentives for the private providers of improved irrigation water supply services to operate in rural areas specifically Kabwe rural areas. For instance by waiving of local taxes for private providers of improved water supply and provision of affordable loans to the private sector players involved. Government should also put in place a regulatory framework to ensure quality control.

Results indicated that the larger the garden space under irrigation is the less probability of the willingness to pay for improved irrigation water supply services because it would be costly especially for those with larger garden sizes. Therefore, Kabwe municipal council services particularly improved irrigation water supply should be subsidized to encourage households' willingness to pay. There is also need to encourage households to establish sizes of gardens which are within their management capacity thus able to manage in case lead pollution occurs. Households should also be sensitized about the importance of their payment towards improved water supply and sanitation services as this boosts their outputs and thus their profits.

The government should implement irrigation water management practices to supply reliable irrigation water to the farmers and government should set up proper irrigation water pricing an amount close to the mean WTP that households were willing to pay considering the mean willingness to pay was way 50% below the initial bid. Moreover, the government should establish and strengthen administrative and institutional set up of the project.

Environmental pollution information relating to adverse effects of lead water contamination has some elements of a public good. In order to encourage willingness to pay for improved water supply, the government should develop systematic information dissemination systems relating to disease incidence, the types of control measures available, where to obtain them and how to obtain it. This would help solve problems of information asymmetry and bounded rationality thereby increasing adoption of lead pollution measures. Information dissemination can be in form of regular radio programmes in different languages and simplified reading materials to accommodate the less educated Kabwe rural people.

From the results, there seemed to be a negative relationship between number of animals owned and the willingness to pay for improved water supply, there is need to encourage farmer to rear a reasonable and quality number of animals which they are able to provide improved water supply for and hence able to manage in case of water contamination as it has been confirmed medically that food animals are also susceptible to contamination. Farm households should not merely keep large herds of animals which they cannot take care of in cases of pollution.

The findings of the analysis underlined that environmental pollution due to lead pollution is the main reason for the scarcity of the improved irrigation water supply services in the area.

Therefore, government through the Environmental Council of Zambia should innovate and adapt soil and water conservation technologies that fit the current lead pollution situation to protect the water sources from degradation, and to minimize the accumulation of heavy metals such as lead in the different water sources. Furthermore, sustainable land management practices and anthropogenic activities such as mining should consider the biophysical and socioeconomic contexts of the community at village level.

The results of the analysis reveal that lead wastes flooding in the canals is the main reason for the pollution of the water sources in the Kabwe rural farm areas. Therefore, government should institute environmentally friendly mining regulation and conservation technologies to protect other mining areas from massive environmental contamination as was the case with Kabwe city.

From the results obtained in the FDGs, Other possible mitigation options for reducing lead consumption directly through food can be divided into two categories: Changes in agricultural practices. Government and other stakeholders to reduce lead in the agricultural produce by decreasing the availability of lead in the production environment by changing the water and soil management practices and by introducing new crops that have low lead or lead resistance such as sorghum, and cabbage.

Choosing of a suitable method to supply water with low lead content depends on several factors and is complicated as the majority of the lead exposed Kabwe population lives in rural areas lacking infrastructure and with decentralised water supplies from a large number of shallow wells extracting water from contaminated shallow aquifers. It is therefore recommended that government's mitigation strategies need therefore to address both the technological and the socioeconomic considerations.

Results showed that water sources that are in close proximity with the form lead/zinc mines were more contaminated as compared to those situated far from the mines. Therefore the Ministry of Mines and Energy in partnership with Kabwe Municipal Council should discourage giving out land for agricultural production in high lead exposed areas.

References

Ahmed, F., Rahman, M. (2003) Low-cost water supply technologies. In: Ahmed, F.,Rahman, M. (Eds.), Water Supply & Sanitation. Rural and Low Income Urban Communities. ITN-Bangladesh, Dhaka, pp. 407–441.

Ahmed, M.F., Shamsuddin, S.A.J., Mahmud, S.G., Rashid, H., Deere, D., Howard, G. (2005) Risk Assessment of Arsenic Mitigation Options (RAAMO). APSU, Dhaka, ISBN-2675-5,984-984.

AHVLA, (2014) Livestock and food Farming" Gov. UK, Dept. for Environment, food and Rural Affairs. Corporate report.

Alhassan, M., *et. al.,* (2013). "Estimating Farmers' Willingness to Pay for Improved Irrigation: An Economic American journal of agricultural economics 66(3): 332-341. Application of Contingent Valuation method." Journal of Economics and Sustainable Development

Agnieszka Zalejska-Jonsson, (2014) Stated WTP and rational WTP: Willingness to pay for green apartments in Sweden. KTH, Royal Institute of Technology, School of Architecture and Built Environment, Brinellvägen 1, 100 44 Stockholm, Sweden

Blumenschein, K., Blomquist, G. C., Johannesson, M., Horn, N., & Freeman, P. (2008).Eliciting willingness to pay without bias: Evidence from a field experiment. The Economic Journal, 118(525), 114–137.

Basarir, A., et al., (2009). "Analyzing producers' willingness to pay for high quality irrigation water." Bulgarian

Bateman, I., Carson, R.T., Day, B., Hanemann, W.M., Hanley, N., Hett, T (2002). *Economic Valuation with Stated Preferences*: A Manual. Edward Elgar, Cheltenham.

Bayiyana Irene (2013) Economic Analysis of Trans-boundary Animal Disease Control in Ntungamo and Rakai Districts of Uganda. A Case of Food and Mouth Disease and East Coast Fever. Agric and Applied Economics. Makerere University.

Bayru A (2004). Affordability and willingness to pay for improved water supply in urban areas of Ethiopia.

Behailu S, Kume A, Desalegn D (2012). Household's willingness to pay for improved water service: A Case Study in Shebedino District, Southern Ethiopia. Water Environ. J. 26(3):429 434.

Bedru, Babulo, Balana , Delia Catacutan & Miika Mäkelä (2013) Assessing the willingness to pay for reliable domestic water supply via catchment management: results from a contingent valuation survey in Nairobi City, Kenya, Journal of Environmental Planning and Management, 56:10, 1511-1531, DOI: 10.1080/09640568.2012.732934

Berkeley Mineral Resources PLC: The Kabwe Mine; (2013) Available at: http://www.bmrplc.com/lead-and-zinc/kabwe-mine/

Berrens, R., Bohara, A., Jenkins-Smith, H., Silva, C., Weimer, D., (2004) *Information and effort in contingent valuation surveys: application to global climate change using national Internet samples.* Journal of Environmental Economics and Management 47, 331–363.

Blacksmith Institute (2007). The World's Worst Polluted Places, The top ten of the dirty thirty. pp. 1-69.

Blacksmith Institute (2013). The World's Worst Polluted Places, The top ten of the dirty thirty. pp. 1-69.

Boyle, K.J., (2003) *Contingent valuation in practice*. In: Champ, P.A., Boyle, K.J., Brown, T.C. (Eds.), A Primer on Nonmarket Good Valuation. Kluwer Academic Publishers, Netherlands.

Bradl HB (2005). Heavy metals in the environment: Origin, interaction and remediation. London: Elsevier Academic Press

Briscoe, J., Furtado de Castro, P., Griffen, C., North, J., Olsen, O., (1990) Toward equitable and sustainable rural water supplies: a

Buechler, S., Hertog, W., & Van Veenhuizen, R. (2002a). Wastewater use for urban agriculture. *Urban Agriculture Magazine, 8*, 1-4.

Buechler, S., Devi, G., & Raschid, L. (2002b). Livelihoods and wastewater irrigated agriculture: Musi River in Hyderabad City, Andhra Pradesh, India. *Urban Agriculture*

Magazine, *8*, 14-17.

Bui D. KinhKasusja Thanaka, & Shunj Mtsanoka (2012) Valuing Rural Piped Water Services in the Mekong Delta, Vietnam: Case Study at PhuocVinh Dong Commune Cambridge, Englandby local people." Journal of environmental economics and management 31(2): 129-144.

Caggiano, R., Sabia, S., D'Emilio, M., Macchiato, M., Anastasio, A., Ragosta, M., Paino, S., (2005) Metal levels in fodder, milk, dairy products, and tissues sampled in ovine farms of Southern Italy. Environ. Res. 99, 48–57.

Cameron TA, Quiggin J (1994). Estimation Using Contingent Valuation Data From A 'Dichotomous Choice With Follow-Up' Questionnaire: J. Environ. Econ. Manage. 27(3):218-234.

Carson, R. T. (2000). Contingent valuation: A user's guide. Environmental Science &Technology, 34(8), 1413–1418.

Carson, R. T. (2012). Contingent valuation: A practical alternative when prices aren't available. Journal of Economic Perspectives, 26(4), 27–42.

Cummings, R. G., & Taylor, L. (1999). Unbiased value estimates for environmental goods: A cheap talk design for the contingent valuation method. The American Economic Review, 89(3), 649–665.

Coster AS, Otufale GA (2014). Households' Water-Use Demand and Willingness to Pay for Improved Water Services in Ijebu Ode Local Government Area, Ogun State, Nigeria. J. Environ. Earth Sci. 4(17):2225-0948

Cameron, T. A. and J. Quiggin (1994). "Estimation using contingent valuation data from a" dichotomous choice

Cameron, T.A., (1988) A new paradigm for valuing non-market goods using referendum data: maximum likelihood estimation by censored logistic regression. Journal of Environmental Economics and Management 15, 355–379.

Carson, R.T., Groves, T., (2007) Incentive and informational properties of preference questions. Environmental and Resource Economics 37, 181–210.

Carson, R.T., Hanemann, W.M., (2006) Contingent valuation. In: Ma¨ ler, K.G., Vincent, J.R. (Eds.), Handbook of Environmental Economics, vol. 2, pp. 821–936

Central Statistical Office, 2004. Zambia 2000 Census of Population and Housing Central Province Analytical Report Volume One, Lusaka. .CSO.

Central Statistical Office, (2009). *Zambia Demographic and Health Survey 2007: Key Findings***.** Calverton, Maryland, USA. CSO and Macro International Inc.

Central Statistics Office, 2012. *2010 Census of Population and Housing Report.* Lusaka. Calverton, Maryland, USA. CSO and Macro International Inc.

Chandrasekaran, K., et al., (2009). "Farmers' willingness to pay for irrigation water: a case of tank irrigation conditions." Agricultural Water Management **113**: 10-18.

Chishimba, C. (2008, Thursday, January, 30). Mufulira Water Contaminated. Times of Zambia Food and Agricultural Organisation/World Health Organisation (FAO/WHO). (2002). Joint FAO/WHO expert committee on food additives (JECFA) Rome: FAO. Consultants Ltd. Shrewsbury, UK.

Dale Whittington, John Briscoe, Xinming Mu and William Barron., (2014) Estimating the Willingness to Pay for Water Services in Developing Countries: A Case Study of the Use of Contingent Valuation Surveys in Southern Haiti .Economic Development and Cultural Change, Vol. 38, No. 2 (Jan., 1990), pp. 293-311Published by: The University of Chicago Press Stable URL: http://www.jstor.org/stable/1154028

Dale Whittington, (2002) Improving the Performance of Contingent Valuation Studies in Developing Countries. Environmental and Resource Economics 22:323-367, 2002.© 2002 Kluwer Academic Publishers. Printed in Netherlands

Deressa, T., *et al.*, (2008). Measuring Ethiopian farmers' vulnerability to climate change across regional states, Development." J Hum Ecol**41**(2): 93-106. Disease Control-Priorities Project, "Public Health Significance of Diarrheal Illnesses," http://www.dcp2.org/pubs/DCP/19/Section/2531.

Devi, J.S., B. Joseph, K. Karunakaran, B. Anurdha and K. R. Devi (2009) People's attitudes towards paying for water: India Review Article, *Current Science*, 97(9)

Diamond, P., & Hausman, J. (1994). Contingent valuation: Is some number better than no number? Journal of Economic Perspectives, 8(4), 45–64.

DPHE, (2008) Union Wise Water Technology Mapping [Dhaka Circle]. DPHE Publication #1, November 2008, Dhaka. ISBN: 984-300-002672-1. Eastern Nigeria Using Contingent Valuation Method (CVM): Implications for Sustainable Environmental Planning and Management 56(10): 1511-1531.

Environment and Health Information System (ENHIS). http://www.euro.who.int/en/data-and-evidence/environment-and-health-information-system-enhis/publications/pre-2009/archived-enhis-fact-sheets-2007/ levels-of-lead-in-childrens-blood-enhis-2007-fact-sheet-4.5

Environmental Protection and Pollution Control Act No.12, 1990. Cap.204. *Laws of Zambia*. Lusaka. Government Printers. Essays in honour of John S. Chipman**15**: 253.

European Commission (EC). (2001). Commission Regulation (EC) 466/2001. Setting maximum levels for certain contaminants in foodstuffs. Official Journal of the European Communities.

Evaristo Mwaba Kapungwe,. (2013) Heavy Metal Contaminated Water, Soils and Crops in Peri Urban Wastewater Irrigation Farming in Mufulira and Kafue Towns in Zambia. Journal of Geography and Geology; Vol. 5, No. 2; 2013 ISSN 1916-9779 E-ISSN 1916-9787 Published by Canadian Center of Science and Education

Food and Agricultural Organisation/World Health Organisation (FAO/WHO). (2002). Joint FAO/WHO expert committee on food additives (JECFA) Rome: FAO.

FAO. Review of world water resource by country. Water report, 23. Rome: Food and Agriculture Organization of the United Nations; 2003. Free downloads from IFPRI.

FAO/WHO, (2010). Summary Report of the Seventy-third Meeting of JECFA. Joint FAO/

Freeman A (1993) The measurement of environmental and resource values: theory and methods. Resources for the Future, Washington DC

Freeman, A. Myrick, III. 1982. Air and Water Pollution Control: A Benefit- Cost Assessment. New York: John Wiley.

Frick, K.D., Lynch, M., West., S., Munoz, B. and Mkocha, H.A. (2003). Household Willingness to Pay for for azithromycin treatment for trachoma control in the United Republic of Tanzania. Bulletin of the WHO, 81(2):101-107

Gebre, A., et al., (2007). "Stakeholder analysis of the Koga Irrigation and Watershed Management Project." Geneva. WHO.

Gebreegziabher K, Berhanu A (2007). Valuing water supply service improvements in Addis Ababa: Ethiopian economic association, proceedings of the fifth international conference on the Ethiopian Economy 5(3):978-999 44-54-07-5.

Gebreegziabher K, Tadesse T (2011). Household Demand for Improved Water Supply Services in Mekelle City, Northern Ethiopia. Water Policy 13(1):125–142.

Molla TY (2005). Farmers' response and willingness to participate in water harvesting practices: A Case Study in Dejen District, East Gojam Zone. A Thesis, Submitted to the Department of Agricultural Economics, Alemaya University.

Gidey Kidu Mezgebo and Zeleke Ewnetu (2015) Households willingness to pay for improved water services in urban areas: A case study from Nebelet town, Ethiopia. Vol.7(1), pp. 12-19 , January 2015DOI: 10.5897/JDAE2014.0604 ISSN: 2006-9774

Godwin Kofi Vondolia, HåkanEggert, Ståle Navrud & Jesper Stage (2014) What do respondents bring to contingent valuation? A comparison of monetary and labour payment vehicles, Journal of Environmental Economics and Policy, 3:3, 253-267, DOI: 10.1080/21606544.2014.892034

Goodrich, J., Adams, J., Lykins, B., Clark, R., (1992). *Safe drinking water from small systems*. Journal of the American Water Works Association 84, 49–55.

Greene, W. H. (2003). Econometric Analysis, 5/e, Pearson Education India.

Griffin, C., Briscoe, J., Singh, B., Ramasubban, R., Bhatia, R., (1995) Contingent valuation and actual behavior: predicting connections

Griffin, R.C., Mjelde, J.W., 2000. Valuing water supply reliability. American Journal of Agricultural Economics 82, 414–426.

Guha S (2011). Valuation of clean water supply by willingness to pay method in a developing nation: A Case Study in Calcutta, India. J. Young Investig. 21:6.

Gujarati, D. N. (2003). "Basic Econometrics fourth edition McGraw-Hill." New York.

Gujarati, D. N. (2004). Economics–basic econometrics, McGraw-Hill Companies.

Haab TC, McConnell KE (2002). Valuing Environmental and Natural Resource: The Economics of Non Market Valuation. New Horizon in Environmental Economics, Printed and Bounded in Great Briton by MPG Books Ltd, Bodmin, Cornwall. P. 352.

Hampwaye, G., Nel, E., & Rogerson, C. M. (2007). Urban agriculture as local initiative in Lusaka, Zambia. *Environment and Planning C: Government and Policy*, *23*, 553-572. http://dx.doi.org/10.1068/c7p

Hanemann, M, (1984). Welfare evaluations in contingent valuation experiments with discrete responses. Am. J. Agric. Econ. 67 (3), 332–341.

Hanemann, M, (1989). Welfare evaluations in contingent valuation experiments with discrete response data: reply. Am. J. Agric. Econom. 71 (4), 1057–1061.

Hanemann, M., Loomis, J., Kanninen, B., (1991) Statistical efficiency of double-bounded dichotomous choice contingent valuation. Am. J. Agric. Econom. 73 (5), 1255–1263.

Hanemann, W. M. (1994) Valuing the environment through contingent valuation. Journal of Economic Perspectives, 8(4), 19–43.

Hausman, J. (2012) Contingent Valuation: From Dubious to Hopeless. Journal of Economic Perspectives, 26(4), 43–56.

Hausman, J. and McFadden, D. (1984) Specification tests for multinomial logit model', Econometrica, Vol. 52 pp. 1555-1559

Hensher, D., Johnson, L. (1981) Applied Discrete Choice Modelling. Wiley, New york.

Hensher, D., Shore, N., Train, K., (2005) Household's Willingness to Pay for water service attributes. Environmental and Resource Economics 32, 509-2630

Herath G, Masayuki T (2014). Willingness to pay and inclusive tariff designs for improved water supply services in urban Bangladesh. J. Sustain. Dev. 7(5):1913-9071

http://dx.doi.org/10.1111/j.1467-9493.2011.00422.x

Hunter, P.R., MacDonald, A.M., Carter, R.C., (2010). Water supply and health. PLoS Med. 7 (11), e1000361.

Husain, A., Al-Rashdan, A., Al-Awadhi, A., Mahgoub, B., Al-Amiri, H., (1996). Toxic metals in food products originating from locally reared animals in Kuwait. Bull. Environ. Contam. Toxicol. 57, 549–555. Indirect Valuation Approaches as a Measure of Sustainable Resource Use."

Institute, B, (2013). The Worlds Worst 2013 Report: the Top Ten Toxic Threats, p. 34.

IRIN: Kabwe, Africa's Most Toxic City; (2006) Available at: http://www.irinnews.org/report/61521/zambia-kabwe-africa-s-most-toxic-city

Ishizuka M. (2010). Heavy Metal Accumulation in Lake Sediments, Fish (Oreochromis niloticus and Serranochromisthumbergi), and Crayfish (Cheraxquadricarinatus) in Lake Itezhitezhi and Lake Kariba, Zambia. Arch. Environ. Contaminat. Toxicol., 59(2):291-30

Islam, M.A., Sakakibara, H., Karim, M.R., Sekine, M., Mahmud, Z.H., (2011) Bacteriological assessment of drinking water supply options in coastal areas of Bangladesh. J. Water Health 9, 415–428. Journal of Agricultural Science **15**(6): 566-573.

J.P.R. Sorensen, D.J. Lapworth , D.C.W. Nkhuwa , M.E. Stuart , D.C. Gooddy , R.A. Bell, M. Chirwa , J. Kabika , M. Liemisa , M. Chibesa , S. Pedley , (2014) Emerging contaminants in urban groundwater sources in Africa. Journal homepage. Robens Centre for Public and Environmental Health, University of Surrey, Guildford GU2 7XH, UK. www.elsevier.com/locate/watres

John Loomis, Paula Kent, Liz Strange, Kurt Fausch, Alan Covich (1999), Measuring the total economic value of restoring ecosystem services in an impaired river basin: results from a contingent valuation surveya*Department of Agricultural and Resource Economics*, *Colorado State University*, *Fort Collins*, *CO* 80523 -1172, *USA*

Kabwe District Health Office (KDHO), Kabwe District Health Management Team Report on ICM, 2009

Kabwe District Health Office (KDHO), Number of households for each health centre Catchment area report 03/07/09.

Kanayo, O., et al. (2013). "Estimating the Willingness to Pay for Water Services in Nsukka Area of South-

Kapungwe, E. M. (2011). Industrial land use and heavy metal contaminated waste water used for irrigation in peri-urban Zambia. Singapore Journal of Tropical Geography, 32(1), 71-84.

Kahneman, D., &Knetsch, J. L. (1992). Valuing public goods: The purchase of moral satisfaction. Journal of Environmental Economics and Management, 22(1),57–70.

Kling, C., Phaneuf, L., &Jinhua Zhao, D. J. (2012). From Exxon to BP: Has some number become better than no number? Journal of Economic Perspectives, 26(4),3–26.

Kapungwe, E. M. (2011). Industrial land use and heavy metal contaminated wastewater used for irrigation in peri-urban Zambia. *Singapore Journal of Tropical Geography*, *32*(1), 71-84. http://dx.doi.org/10.1111/j.1467-9493.2011.00422.x

Lacatusu R, Citu G, Aston J, Lungu M, Lacatusu AR (2009) *Heavy metals soil pollution state in relation to potential future mining activities in the Rosia Montana area.* Carpathian J.Earth Environ. Sci., 4: 39-50.

Lancaster, K. 'A new approach to consumer theory', journal of Political Economy, Vol. 74, (1966)pp. 132- 157

M.N. Faleafel and Z.M. Mirdad., 2012. Hazard and Effects of Pollution by Lead on Vegetable Crops. Journal of Environmental Economics. Department of Arid Agriculture. Faculty of Meteorology, Environment and Arid Agriculture, King Abdulaziz University, Jeddah 80208, Saudi Arabia.

MacDonald, A., Bonsor, H., Dochartaigh, B.E. O., Taylor, R., 2012. Quantitative maps of groundwater resources in Africa. Environ. Res. Lett. 7 (2), 024009.

Maddala, G. S. (1983). Limited-dependent and qualitative variables in econometrics, Cambridge University management: results from a contingent valuation survey in Nairobi City, Kenya." Journal of

Marshall, B., Bowyer-Bower, T., Chishala, B. H., Kapungwe, E. M., Agrawal, M., Agrawal, R., Sharma, R. (2004). *Contaminated irrigation water and food safety for the urban and peri-urban poor: Appropriate measures for monitoring and control from field research in India and Zambia. Main Inception Report*: *Department for International Development (DFID) project No.R8160.* London: Department for International Development (DFID-UK).

Marcella Veronesi ,Fabienne Chawla , Max Maurer , Judit Lienert (2014) Climate change and the willingness to pay to reduce ecological and health risks from wastewater flooding in urban centers and the environment. Institute for Environmental Decisions, ETH Zurich, Switzerland Eawag: Swiss Federal Institute of Aquatic Science and Technology, P.O. Box 611, Ueberlandstrasse 133, CH-8600 Duebendorf, Switzerland

McFadden, D. (1999). "TO-PAY IN RANDOM UTILITY MODELS." Trade, Theory, and Econometrics:

McFadden, D. 'Conditional Logit analysis of qualitative choice behaviour', in P. Zarembka (ed) (1973), Frontier in Econometrics (New York: Academic press, , pp. 105-142)

McFadden, D. and Train, K. Mixed MNL models of Discrete response', (2000) Journal of Applied Econometrics, Vol. 15, pp. 447-470

Mesa-Jurado, M. A., et al. (2012). "The economic value of guaranteed water supply for irrigation under scarcity

Mesa-Jurado, M.A., et al., (2012), The economic value of guaranteed water supply for irrigation under scarcity conditions. Agric. Water.Mgt htt://dx.doi.org/10.1016/j.agwat,2012.06.009

Mezgebo, A., *et al.*, (2013). "Economic Values of Irrigation Water in Wondo Genet District, Ethiopia: An

Millennium Development Goals Progress Report /Zambia/2013, 2013. Lusaka: UNDP.

Ministry of Environment (Ontario Canada). (2011). *Green facts: Cobalt in the Environment*. Retrieved December 30, 2011, from http:/www.archive.org/greenfactscobalt

Mitchell, R. and Carson, R. (1989) Using Surveys to Value Public Goods: The Contingent valuation Methods, Resources for the Future (Baltimore: John Hopkins University press,

Muchuweti, M., Birkett, J. W., Chinyanga, E., Zvauya, R., Scrimshaw, M. D. & Lester, J. N. (2006). Heavy metal content of vegetables irrigated with mixtures of wastewater and sewage sludge in Zimbabwe: Implications for human health. *Agriculture, Ecosystems & Environment, 112*(1), 41-48. http://dx.doi.org/10.1016/j.agee.2005.04.028

Mugasi, S.K. (2009). Economic Analysis of tsetse control technology in south-Eastern Uganda Unpublished PhD Thesis, Makerere University

Mulenga, N. (2008, Friday, January, 11). Mine water pollution cases need decisive measures. Times of Zambia.

Nakayama MMS, Ikenaka Y, Muzandu K, Choongo K, Oroszlany B, Teraoka H, Mizuno N,

NestaBortey-Sam, Shouta M.M. Nakayama, Yoshinori Ikenaka, OseiAkoto, Elvis Baidoo, YaredBeyeneYohannes, HazukiMizukawa, Mayumi Ishizuka (2015) Human health risks from metals and metalloid via consumption of food animals near gold mines in Tarkwa, Ghana: Estimation of the daily intakes and target hazard quotients (THQs).Ecotoxicology and EnvironmentalSafety111160–167

Nicholson, W. (2005). Microeconomic Theory: Basic principles and extensions. International student Editon, Thomson Learning, 9th Edition.

Nweke, Onyemaechi C., and William H. III Sanders. (2009) "Modern Environmental Health Hazards: A Public Health Issue of Increasing Significance in Africa." *Environmental Health Perspectives*.

OECD (2006), " Willingness to Pay Vs. Willingness to Accept", in Cost Benefit Analysis and the Environment: Recent Developments, OEC Publishing

OECD, (2003). *Social Issues in the Provision and Pricing ofWater Services*. Organization for Economic Co-operation and Development (OECD) Publishing, Paris, France.

OECD, (2006). Water management policy brief for the Mexican project. Policy Note, Environment Directorate, Office of Economic Co-operation and Development (OECD), Mexico

Oelofse S (2008). Mine water pollution–acid mine decant, effluent and treatment: a consideration of key emerging issues that may impact the state of the environment. Emerging Issues Paper: Mine Water Pollut., 2008

Ogujiuba K, Ukwueze E, Ogbonnaya M (2013). Estimating the willingness to pay for water services in Nsukka area of south-eastern Nigeria using contingent valuation method (CVM): Implications for Sustainable Development. J. Hum. Ecol. 41(2):93-106

Olajuyigbe AE, Fasakin JO (2010). Citizens' willingness to pay for improved sustainable water supply in a medium sized city in south western, Nigeria: Curr. Res. J. Soc. Sci. 2(2):41-50.

Pearce D (2002). Economic valuation with stated preference techniques: Queen's Printer and

Controller of Her Majesty's Stationery Office.

Portney, P. R. (1994). The contingent valuation debate: Why economists should care.Journal of Economic Perspectives, 8(4), 3–17.

Gujarati DN (2004). Basic Econometrics. 4th Edition. McGraw-Hill, Inc.

Okoye, C.O.B., Ugwu, J.N., 2010. Impact of environmental cadmium, lead, copper and zinc on quality of goat meat in Nigeria. Bull. Chem. Soc. Ethiop 24 (1), 133–138.

Rahmana,b, Md. Asaduzzamana,b, Ravi Naidua,b, (2011), "Consumption of arsenic and other elements from vegetables and drinking water from an arsenic-contaminated area of Bangladesh", Research Centre for Contamination Assessment and Remediation of the Environment (CRC-CARE), P.O. Box 486, Salisbury South, SA 5106, Australiah Journal of Hazardous Materials 262 (2013) 1056– 1063

Randela, R., C.F. Liebenberg, F.Kirsten, and R.F. Townsend(2000) demand for livestock tick control

Rashad S, Barsoum MD (2006). Chronic kidney disease in the developing world.New Engl. J. Med., 354: 997-999. Report for the International Water Management Institute.

Sadeghi, A., M. G. Mohayidin, Md A. Hussein and A. Baheiraei (2010) Determining the economic value of the irrigation water in production of wheat in Iran**.** University Putra Malaysia. *Australian Journal of Basic and Applied Sciences,* 4(6): 1391-1402p

Sserunkuuma, D. 2003. The adoption and impact of improved maize and land management technologies in Uganda. Paper presented at the Workshop on Green Revolution in Asia and Its Transferability to Africa, Durban, South Africa, August.

Dick Sserunkuuma, Nicholas Ochom, and John H. Ainembabazi. 2005. Collective Action in the Management of Canal Irrigation Systems: The Doho Rice Scheme in Uganda

Shitumbanuma, V., &Tembo, J. M. (2006). Characterization of soils at No.1 Nkana Cobalt Plant, OBD 53 and the Mwekera area in Kitwe, Zambia: A report for ZCCM Investment Holding Plc, Lusaka: University of Zambia.

Shyamsundar, P. and R. A. Kramer (1996). "Tropical forest protection: An empirical analysis of the costs borne

Simukanga, S, Shitumbanuma, V., &Kalinda, T. (2002).Impacts of mining effluents on the water quality, sediments, soils and crops in the Mwambashi Catchment area of the Copperbelt of Zambia.Lusaka:Ministry of Tourism, Environment and Natural Resources Pilot Environmental Fund.

Siyaranamual, M. D. (2014). "Essays on the non-monetary aspects of cooperative behaviours."

Keyworth, Nottingham. British Geological Survey, (2001) Study of the Bontanga Irrigation Scheme in Northern Ghana." Journal of Agricultural Science (1916-

Syakalima M, Choongo K, Nakazato Y, Onuma M, Sugimoto C, Tsubota T, Fukushi H, systems in South India." Water **1**(1): 5-18. Tembo DB, Sichilongo K, Cernak J (2006).Distribution of copper, lead, cadmium and zinc concentrations in soils around Kabwe Town in Zambia. Chemosphere, 63: 497-501

Tesfahun Alemayehu, (2014). Smallholder Farmer's Willingness to Pay for Improved Irrigation Water: A Contingent Valuation Study in Koga Irrigation Project, Ethiopia Journal of Economics and Sustainable Development www.iiste.org ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online) Vol.5, No.19, 2014

The World Bank: Copperbelt Environment Project Tackles the Lead and Uranium Danger in Zambia. Available at: http://go.worldbank.org/NQ5GAPHMA0

Tiwari, D. N. (1998)."Determining Economic Value of Irrigation Water: Comparison of Willingness to Pay and to new water systems in the State of Kerala, India. The World Bank Economic Review 9 (3), 373– 393

Train, K. (2003) Discrete choice methods with simulation. Cambridge University Press,

Turner, K., S. Georgiou, R. Clark, R. Brouwer, and J. Burke (2004) Economic valuation of water resources in agriculture: from the sectoral to a functional perspective of natural resource management, FAO 2004, Rome, Italy

Uluozlu, O.D., Tuzen, M., Mendil, D., Soylak, M., (2009) Assessment of trace element contents of chicken products from turkey. J. Hazard. Mater. 163, 982–987

UNDP, (2006) Human Development Report 2006. United Nations Development Program, New York.

UNDP, (2006) .*Human Development Report 2006*.United Nations Development Program, New York University of California; 1996.

UNESCO (2006) Water: a shared responsibility. United Nations second world water development report, United Nations Education: New York.

United States EPA, (1994) “Revised Interim Soil Lead Guidance for CERCLA Sites and

Whittington, D., (2002) Improving the performance of contingent valuation studies in developing countries. Environmental and Resource Economics 22, 323–367.

Whittington, D., Lauria, D., Mu, X., (1991) .*A study of water vending and willingness to pay for water in Onitsha, Nigeria*. World Development 19, 179–198.

Whittington, Dale, (2002). Municipal water pricing and tariff design: a reform agenda for cities in developing countries. Issue brief 02-29, Resources for the Future, Washington, D.C.

Whittington, Dale, Pattanayak, S.K., Yang, J., Bal Kumar, K.C., (2002). Household demand for improved piped water services: evidence from Kathmandu, Nepal. Water Policy 4, 531– 556.WHO Expert Committee on Food Additives, Geneva.

WHO, (2011).Guidelines for Drinking-water Quality, vol. 4.World Health Organisation, pp. 315–318.Wilkie, J.A., Hering, J.G., 1996 with follow-up" questionnaire." Journal of environmental economics and management **27**(3): 218-234.

WHO, (2010) Water Related Diseases. Arsenicosis.<http://www.who.int/ water_sanitation_health/diseases/arsenicosis/en/print.html> (21.07.10).

World Bank, (1993).*The demand for water in rural areas: determinants and policy implications*. The World Bank Research Observer 8, 47–70.

World Health Organisation, (1995).*Lead, Inorganic*.Environmental Health Criteria 165.

World Health Organisation, 2002.*World Health Report 2002*.Geneva: WHO.

Yabe, J., Ishizuka, M., Umemura, T., (2010) Current levels of heavy metal pollution in Africa. J. Vet. Med. Sci. 72, 1257–1263.

Yabe, J., Nakayama, M.M.S., Ikenaka, Y., Muzandu, K., Choongo, K., Mainda, G., Mabeta, M., Ishizuka, M., Umemura, T., (2013). Metal distribution in tissues of free-range chickens near a lead–zinc mine in Kabwe, Zambia. Environ. Toxicol. Chem. 32 (1), 189–192.

Yabe,J.,Ishizuka,M.,Umemura,T.,(2010).Currentlevelsofheavymetalpollutionin Africa. J.Vet.Med.Sci.72,1257–1263.

Yabe,J.,Nakayama,M.M.S.,Ikenaka,Y.,Muzandu,K., Choongo,K., Mainda,G.,Mabeta, M.,Ishizuka,M.,Umemura,T.,(2013).Metaldistributionintissuesof free-range chickens near a lead–zinc mine in Kabwe, Zambia. Environ. Toxicol. Chem. 32(1),189–192.

Yoshida M, Itagaki T, Yasuda J (2001). An investigation of heavy metal exposure and risks to wildlife in the Kafue flats of Zambia. J. Vet. Med. Sci., 63: 315-318.

Yoshinori Ikenaka1, Shouta M. M. Nakayama *et al* (2010), *Heavy metal contamination of soil and sediment in Zambia*,Department of Pharmacology, School of Veterinary Medicine RakunoGakuen University, Ebetsu 069-8501, Japan

Zambia Consolidated Copper mines Investment Holdings (2006) .*Copperbelt Environmental Project 2003* "Kabwe lead mines" www.cepzambia.org.zm accessed on 23 /10/2009

Zambia Consolidated Copper mines Investment Holdings, (2005). *Copper belt Environment Project* 'Kabwe Scoping and Design Study (KSDS) Phase 2 Report: Geochemical Hazard Screening and Human Risk Analysis 2005' ZCCM –IH, Water Management

Zambia Consolidated Copper mines Investment Holdings, (2006) .Copperbelt *Environment Project* ‘Kabwe Scoping and Design Study (KSDS) Phase 3 Report 2006’ ZCCM – IH, Water Consultants Ltd. Shrewsbury, UK.

Zambia Consolidated Copper mines Investment Holdings, (2006).Copperbelt *Environment Project* Kabwe Scoping and Design Study (KSDS) Project Synthesis 2006’ ZCCM – IH, Water Consultants Ltd. Shrewsbury, UK.

Zheng, N.,Wang,Q.C.,Zheng,D.M., (2007) Health risk of Hg,Pb,Cd,Zn,and Cu to the inhabitants around Huludao zinc plant in China via consumption of vegetables. Sci. Tot.Environ.383(1–3), 81–89

APPENDICES

Appendix 1: QUESTIONAIRE

Questionnaire

Questionnaire serial number: |__|__|__|

WILLINGNESS TO PAY FOR IMPROVED IRRIGATION WATER SERVICES IN ZAMBIA:

A CASE OF KABWE

Department of Agribusiness and Natural Resource Economics, Makerere University (UGANDA).

Survey Instrument

This questionnaire is for academic purposes only. Be rest assured that all the information you provide will be treated as private and confidential as possible. Feel free to answer all the questions honestly. Your cooperation in this regard will be highly appreciated.

Instructions: Please write some answers or tick in the table, blank spaces or boxes provided

---

Response status (1=Complete; 2=Did not benefit; 2=Refusal; 3=Non-contact)	**status**	|__|
Date of enumeration (dd/mm/yy)	**daten**	|__|__/__|__/__|
Name of enumerator ______________________ Enumerator code	**enum**	|__|__|
Date checked (dd/mm/yy)	**datec**	|__|__/__|__/__|

Name of field supervisor____________________	Supervisor code **sup**

Interview code: ________________________________

Interview date: ________________________________

Start time: ________________________________

Finish time: ________________________________

Place of interview: ________________________________

Participant'sgender: ________________________________

Record 1: Background profiling:

Indicate Household type:

- **Urban formal settlement**
- **Urban informal settlement**
- **Rural formal settlement**
- **Rural informal settlement**

1.1 What is your marital status?

- **Single**
- **Married and staying with spouse**
- **Married but spouse working in city/mine/farm**
- **Divorced**
- **Widowed**
- **Living with a life partner**
- **Other (specify)** __________________________

1.2 What is your age? _____________(*OK if respondent states month/year or year only*)

1.3 Are you the HEAD of this household?

- **Yes**
- **No**

1.4 If NO to Q1.2 how are you related to the head of this household?

- **Spouse**
- **Son**
- **Daughter**
- **Other (specify)** _________________________

1.5 Let's look at the size of household:

- **How many children are under <10: _______________**
- **How many children are between 11-17 ____________**
- **How many adults between 18-29 ______________**
- **How many adults between 30-50 _____________**
- **How many adults greater than >50 _______________**

Record 2: Education and Employment history

2.1 **What is the highest education you attained? (indicate)**

- **Never attended school**
- **Primary: <Grade 4**
- **Primary: Grade 5-7**
- **High School: Grade 8 -10**
- **High school: Grade 11-12**
- **College: (specify)__________________**
- **Other (specify) ____________________**

2.2 Did you receive any formal/professional training?

- **YES**
- **NO**

2.3 If YES to Q2.2 what training did you receive?

Type of training received_____________________________

2.4 **If YES to Q2.2 when did you receive training? When: ______________**

2.5 From the following select one that describes your <u>current</u> **employment status?**

- **1st I'm** formally **employed and report for work**
- **2nd I'm** informally **employed and report for work**
- **3rd I'm** casually **employment and report for work**
- **4th I'm unemployed** due **to illness**
- **5th I have** never **been employed**
- **6th I'm fulltime peasant farmer**

2.5 Summary of Income sources

Below let's summarize ALL **your income sources and amounts you earn per month including** SPOUSE/PARTNER **or** ANY **family member staying with you and contributing to the household. First we discuss your primary sources (**own effort/resources**) and second your secondary sources (**govt grant orremittances or other relief sources**).**

Source	Place	Amount earned

	a tick	(R/month)
(a) Primary Sources (own effort)		
Salary from formal employment		
Salary from informal employment		
Salary from casual/contract employment		
Earning from self-income generating project		
Earning from own farm activities		
Earning from own business		
Other *(specify)*		
(b) Secondary sources (from others)		
Income contribution from your spouse/partner		
Income contribution from family member *(staying in household)*		
Income received from Govt pension grant		
Income received from Govt disability grant		
Income received from Child support grant		
Income received from any other Govt support *(specify)*		
Income received as Remittances *(from relatives/non-relatives not staying in household)*		
Other *(specify)*		

Basic Asset Ownership

2.6 **Do you own any of the following assets and if YES indicate number or amount?**

a. Immovable assets

	YES	NO	What is the size? Or How many?
▪ Farmland ▪ Urban brick-house ▪ Rural brick-house ▪ Urban shack-house ▪ Rural shack-house ▪ Other (specify)			

b. Financial assets

	YES	NO	Indicate the amount range (Rs)?
▪ Current account ▪ Savings account ▪ Finance clubs ▪ shares ▪ Other (specify)			
c. Livestock assets	**YES**	**NO**	**What is the herd-size?**
▪ Cattle ▪ Goats ▪ Sheep ▪ Pigs ▪ Other			

Record 3: Water policies

a. Water Policy/legislation

3.1 Is there any government policy/rule/regulation concerning water use or water provision that you are aware of?

- ○ **YES**
- ○ **NO**

3.2 If YES to Q 6.1 what does this policy/rule/regulation say?

List of policies:

- **1. Free basic water**
- **2. Save water**

- **3. Pay for water**
- **4. Save and Pay for water**
- **5. Other (specify)**

3.3 If YES to Q6.1 how would you assess/rate the effectiveness of this policy/rule/regulation in achieving its intended goal?*(explain to the respondent the 5 rating options and ensure he/she understands)*

	1	2	3	4	5
	Very effective	**Effective**	**Somewhat effective**	**Not effective**	**Not sure**
Assess the policy/rule/regulation					

3.4 If response to Q 6.3 "column 4", suggest how you think this policy/rule/regulation should be improved?
Suggestion(s): ________________________________

____

b. Water Sources

3.5 **What is your** source **of water in this household?** *(don't read out the options below just mark appropriate response)*

- **In-house piped tap water**
- **On-yard piped tap water**
- **On-yard bole-hole water**
- **Outside-yard common piped tap water**
- **Out-side yard common bole-hole water**
- **River/stream water**
- **Dam water**
- **Shallow well**
- **Other**

3.6 Let me seek your opinion regarding the quality **of water you consume in this household. In your opinion what do you regard as** quality **water?** *(don't read out options below just mark the appropriate response)*

Water Quality means	**Place a tick**
▪ **Tap water**	
▪ **Clear water**	

▪ **Water without odour/smell**	
▪ **Tasteless water**	
▪ **Water without sediments**	
▪ **Shallow well**	
▪ **Other (specify)**	
▪	

3.7 How do you rate the <u>quality</u> of water you consume in this household? *(explain to the respondent the 5 rating options and ensure he/she understands)*

	1	2	3	4	5
	Very good	**Good**	**Somewhat good**	**Poor**	**Not sure**
Water quality					

3.8 If response to Q6.7 is "column 4", why do you think so?

Reasons: *(encircle)*

- **1. Public good and Govt's responsibility**
- **2. Unemployed and too poor**
- **3. Unemployed and too sick**
- **4. Staying in informal house**
- **5. Other (specify)**

3.9 How would you rate the availability of water for its various uses/purposes in this household? *(explain the 5 rating options to the respondent until he/she understands, <u>then</u> read out the use category for which respondent answers accordingly)*

Use category ↓	1	2	3	4	5
	Always	**Available**	**Somewhat**	**Not**	**Not sure**

	available		**available**	**available**	
Drinking					
Cooking					
Hand-washing					
Baby-milk prep					
Dish-washing					
Body-washing					
Laundry					
House cleaning					
Other					

c. Water Price and affordability

3.10 **Are you making any payments for the provision of water?**

- **YES**
- **NO**

3.11 If YES **to Q6.10, how much are you paying per month? Payment per month:_____**

3.12 If YES **to Q6.10 how would you rate price of water you are paying***? (explain the 5 rating options to the respondent and ensure he/she understands)*

Water charges ↓	**1**	**2**	**3**	**4**	**5**
	Very affordable	**Affordable**	**Somewhat affordable**	**Not affordable**	**Not sure**
Price of Water					

3.13 If NO **to Q6.10, why are you not paying for water?**
Reason(s):

- **1. A public good and Govt's responsibility**
- **2. Unemployed and too poor/sick**
- **3. Staying in informal house**
- **4. Never told/asked to pay**
- **5. Other (specify)**

3.14 In opinion do you think you should pay for water?
- **YES**
- **NO**

3.15 If YES to Q6.14, why should you pay for water?
Reason(s):

- **1. It's a service and hence obliged to pay**
- **2. Only if I own a proper house**
- **3. Only if water tap is in-house or on my yard**
- **4. Never told/asked to pay**
- **4. Other (specify)**

3.16 If NO to Q6.14, why should you NOT pay for water?
Reason(s):

- **1. A public good and Govt's responsibility**
- **2. Unemployed and too poor/sick**
- **3. Staying in informal house**
- **4. Never told/asked to pay**
- **5. Other (specify)**

d. Incidences of Water-borne diseases (WBD) due to lead poisoning

3.17 **Have you or any member of your household suffered or died from any water-borne disease due to lead poisoning within the past 2 years?**
- **YES**
- **NO**

3.18 If YES to Q6.17, when did this incident happen? When: _________________
3.19 Where was the diagnosis carried out? Place of diagnosis:__________________
3.20 What was the disease? Disease was identified as: ______________________
3.21 How did you know the ailment is water-borne disease due to lead poisoning?
3.22 How you knew its WBD due to lead poisoning: ____________
3.23 What steps have your household/community/local authority taken to prevent any future outbreaks?
Control measures taken: ____________________________________

____

Record 4. Water and Impact on livelihoods of Kabwe

4.1 **Do you think the water you are consuming in this household does have an effect on your health?**

- **YES**
- **NO**

4.2 If YES to Q7.1, what effect does the water have on your health?

Effects of water on my health:

- **1. Causes bodily rash/irritation**
- **2. Causes diarrhoea**
- **3. Fear Cholera and other water-borne diseases**
- **4. Kidney damage**
- **5.brain damage**
- **6. infertility**
- **5.Other (specify)**

4.3 Do have alternative water source if regular water services are not available to you?

- **YES**
- **NO**

4.4 If YES to Q7.3, what do you think about the water quality of this alternative source compared to regular source?

- **1. Good**
- **2. Bad**
- **3. No difference**
- **4. Not sure**

4.5 Which water source do you prefer to use? *NB: Please give a reason for this answer.*

- **Prefer regular source**
- **Prefer alternative source**

Reason(s): __________________________________

4.6 What aspects of your livelihood would be most positively impacted by improvement in the provision of water/water services as a kabwe resident? *(Use codes below to assist you make the list)*

List below livelihood aspects impacted by improvement in water services	**Place a tick**	**Select ONE aspect MOST impacted**

1	2	3	4	5	6	7	8
Improve my health	**Reduce opportunistic lead infection**	**Reduce risk to diarrhoeal infection**	**Reduce risk to cholera infection**	**Reduce risk to water borne diseases**	**Likely to live longer**	**Enhance my dignity as rural resident**	**Other (specify)**

Record 5. WTP for provision of IMPROVED water services by kabwe municipal

5.1 **Let's consider the following hypothetical scenario: For years residents in this community have raised serious concerns regarding the quality of water due to lead poisoning, water provision or the lack of both. As a result the local authority is considering passing a bill/legislation/rule/regulation that calls for the introduction of mandatory water levy to be charged to ALL local residents regardless (employed or not; sick or not). But before passing/enacting/enforcing this bill/legislation/rule/regulation the local authority is to hold a referendum where you are required to vote freely either for or against the bill. Voting for the bill/rule/regulation will result in an improvement in water quality and/or provision of water services but at a cost; Voting against the bill/legislation/rule/regulation will see you not scarifying any payment but maintain the status quo. Do you understand the scenario so far?**

- **YES** *(if so proceed to Q 8.2)*
- **NO** *(if so repeat Q 8.1 until respondent understands)*

5.2 How would you vote?

- **Vote YES for the bill** *(proceed to Q8.3)*
- **Vote NO for the bill (***proceed to Q8.4***)**

5.3 If you vote YES in Q8.2, the local council/authority charges a monthly water fee/levy of:

- **K100_______**
- **Would you be willing to pay this amount?**
  - **YES**
  - **NO**
- **In the Table below iterate the amount upwards/downwards** *(by small amounts)* **depending on initial response**

Initial Price bid	**Iterate upwards if YES until response is NO**	**Iterate downwards if NO until response is YES**
K		

5.4 **If you vote** NO **to Q8.2, what are the reasons?** *(encircle)*

- **1. Government's responsibility**
- **2. Unemployed and too poor**
- **3. Too sick to participate**
- **4. Don't trust the government**
- **5. Other (specify)**

Record 5: Toilet/Sanitation system

5.1 **What type of toilet do you use or have access to in this household**

- **1. Flush toilet**
- **2. Pit latrine**
- **3. Bucket system**
- **4. Chemical toilet**
- **5. Bush toilet**
- **6. Other**

How would you rate your level of satisfaction with this type of sanitation? *(explain the 5 rating options to the respondent and ensure he/she understands)*

	1	2	3	4	5
	Very satisfied	**Satisfied**	**Somewhat satisfied**	**Not satisfied**	**Not sure/NA**
Toilet system					

5.2 If response in Q9.1 is "Column 4", ask why?

Reasons:

- **1. Too degrading and dehumanizing**
- **2. Too dirty, smells and stinks**

- 3. Makes me Vulnerable to opportunistic infection
- 4. Other

5.3 Are you paying for sanitation services?

- **YES**
- **NO**

5.4 If YES to Q9.3 how much are you paying per month? Payment per month: ________
If YES to Q9.3 how do you rate the price you are paying for sanitary services? *(explain the 5 rating options to the respondent and ensure he/she understands)*

	1	2	3	4	5
	Very affordable	**Affordable**	**Somewhat affordable**	**Not affordable**	**Not sure**
Price charges					

5.5 In your opinion, do you think you should pay for sanitation services?

- **YES**
- **NO**

5.6 If YES to Q9.5, why should you pay?
Reasons:

- 1. It's a service and hence obliged to pay
- 2. Only if I own a proper house
- 3. Only if it's in-house services
- 4. Never told/asked to pay
- 4. Other (specify)

5.7 If NO to Q9.5, why should you NOT pay?
Reasons:

- 1. It's Govt's responsibility
- 2. Unemployed and too poor/sick
- 3. Staying in informal house
- 4. Never told/asked to pay
- 5. Other (specify)

5.8 **As we did with water, let's discuss how improvement in sanitation/toilet system will impact you as a Kabwe resident. Indicate to me what aspects of your livelihood would be most positively impacted by improvement in sanitation as a Kabwe resident?** *(Use codes below to assist you make the list)*

Livelihood aspects impacted by improvement in sanitation	Place a tick	Select ONE aspect MOST impacted

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Improve my health	**Reduce opportunistic lead infection**	**Reduce risk to diarrhoeal infection**	**Reduce risk to cholera infection**	**Reduce risk to water borne diseases**	**Likely to live longer**	**Enhance my dignity as Kabwe resident**	**Other (specify)**

WTP for provision of IMPROVED sanitation by kabwe municipal

5.9 **Let's consider the following hypothetical scenario: For years residents in this community have raised serious concerns regarding the general lack of sanitation due to lead poisoning. As a result the local authority is considering passing a bill/law/rule that calls for mandatory charges for sanitation services that ALL local residents should pay regardless (whether employed or not; sick or not). But before**

passing/enforcing this bill/law/rule the local authority holds a referendum where the local community (you included) is required to vote. Voting for the bill//law/rule will see an improvement in the provision of sanitation services but at a cost. Voting against the bill/law/rule will mean no monthly charges or payments to you but this maintains the status quo. Do you understand the scenario so far?

- **YES** *(if so proceed to Q 9.10)*
- **NO** *(if so repeat Q 9.9 until respondent understands)*

5.10 How would you vote under such a referendum?

- **Vote YES for the bill (***proceed to Q9.11***)**
- **Vote NO for the bill** (*proceed to Q9.12*)

5.11 If you vote YES in Q9.10, the local council/authority charges a monthly fee/levy of:

- **RX_______**
- **Would you be willing to pay this amount?**
  - **YES**
  - **NO**

In the Table below iterate or repeatedly increase the amount upwards/downwards *(by small amounts ranging 10-15)* depending on respondent's initial response

Initial Price bid	**Iterate upwards if YES until response is NO**	**Iterate downwards if NO until response is YES**
K		

5.12 If you vote NO to Q9.10, what are the reasons the bill? *(encircle)*

1. Government's responsibility

2. Unemployed and too poor

3. Too sick to participate

4. Don't trust the government

5. Other (specify)

Record 6: Hygiene Practices and assessment

6.1 **What do you understand by hygienic living?**

Hygienic living includes:

____

____

6.2 With your understanding of hygienic living, how do you rate the following livelihood aspects as they apply to you. *(explain the rating options to the respondent until he/she understands, then read out the impact for which respondent answers accordingly)*

Hygienic living	1	2	3	4	5	6
	Excellent	**Good**	**Somewhat good**	**Bad**	**Not sure**	**Rank**
Food hygiene						
Body hygiene						
Dishes/utensils hygiene						
Clothes/linen hygiene						
Toilet hygiene						
Other						

6.3 Are there any hygienic campaigns in this community to do with water, sanitation and hygiene that you aware of?

- **YES**
- **NO**

6.4 If YES to Q10.3 what organization(s) is/are involved in these campaigns?

Name of organizations: _____________________

6.5 If YES to Q10.3 what is the campaign about?

Nature/type of campaign: ____________________________

If YES to Q10.3 do you think these campaigns are effective is achieving the intended goal. In Table below rate the effectiveness of these campaigns. *(explain the 5 rating options to the respondent and ensure he/she understands)*

	1	2	3	4	5
	Very effective	**Effective**	**Somewhat effective**	**Not effective**	**Not sure**
Hygiene campaigns					

6.6 In your opinion do you think there should be hygiene campaigns specifically targeting Kabwe residents?

- **YES**
- **NO**

6.7 If YES to Q10.7 what specific hygiene campaigns do you think would be necessary for PLWHA?

Specific campaigns:

6.8 If NO to Q10.7 why do you think hygiene campaigns are not necessary for Kabwe residents?

Reasons:

6.9 As we did with water and sanitation, let's discuss how improvement in hygienic conditions will impact you as a Kabwe resident. Indicate in the table below aspects of your life that would be most impacted by improvement in hygiene. *(Use codes below to assist you make the list)*

List below livelihood aspects impacted by improvement in water services	**Place a tick**	**Select ONE aspect MOST impacted**

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Improve my health	**Reduce opportunistic infection**	**Reduce risk to diarrhoeal**	**Reduce risk to cholera**	**Reduce risk to water borne**	**Likely to live longer**	**Enhance my dignity**	**Other (specify)**

		infection	**infection**	**diseases**		**as rural resident**	

Record 7. Farm level data on livelihoods of Kabwe

7.1 **Do you do farming/gardening?**

- **YES**
- **NO**

7.2 If YES to Q7.1, what crops do you grow?

- **1. Maize**
- **2. sorghum**
- **3. Cassava**
- **4. Beans**
- **5. vegetables**
- **6. Sunflower**
- **5.Other (specify)**

7.3 Do you do irrigation on you farm/garden?

- **YES**
- **NO**

7.4 If YES to Q7.3, what do you think about the water quality of your source for irrigation?

- **1. Good**
- **2. Bad**
- **3. No difference**
- **4. Not sure**

7.5 How much garden/ farm is under irrigation

: ___________________________________

7.6 What is the distance between your source of water for irrigation and the former lead/zinc mines?.

: ___________________________________

End of Questionnaire

Thank you!

Appendix 2: Focus group discussion guide

Why this focus group?

The aim of the focus group was to learn and understand local water user's perception, attitudes, experiences and views on:

1) Problems related to the lead water contamination in some parts of Kabwe city;
2) Potential solutions to the problem through Government intervention; and
3) Possibility of compensating mine owners for adopting pollution control management practice.

Questions/issues:

1) In your opinion, is heavy metal pollution of water supply a serious problem in your area? (Why or why not?)
2) In your view, what is (are) the main cause(s) of this problem?
3) What effects of lead pollution on humans have you observed?
4) What effects of lead pollution on food crops have you observed?
5) What effects of lead pollution on food animals have you observed?
6) What effects of lead pollution on children have you observed?
7) What should be done to increase the improved water supply in your area?
8) Many people argue that to improve the quality and reliability of water supply sustainably, water should be increased at the very source through water purification infrastructure or water enhancing conservation measures; for instance, in the Kabwe. Do you agree on this? Why or why not?
9) If lead mining is the underlying cause of water pollution, how can we motivate landowners in the mine areas to adopt water conservation measures? What can mine area beneficiaries do?
10) As a water user and resident in Kabwe, what can you do to improve the quality and quantity of water? If you are asked to contribute to pay for farmers in affected townships for adopting water enhancing community water management, are you willing to pay a certain amount of money for such a project? Why or why not?

Appendix 3 Figures of income and age distributions

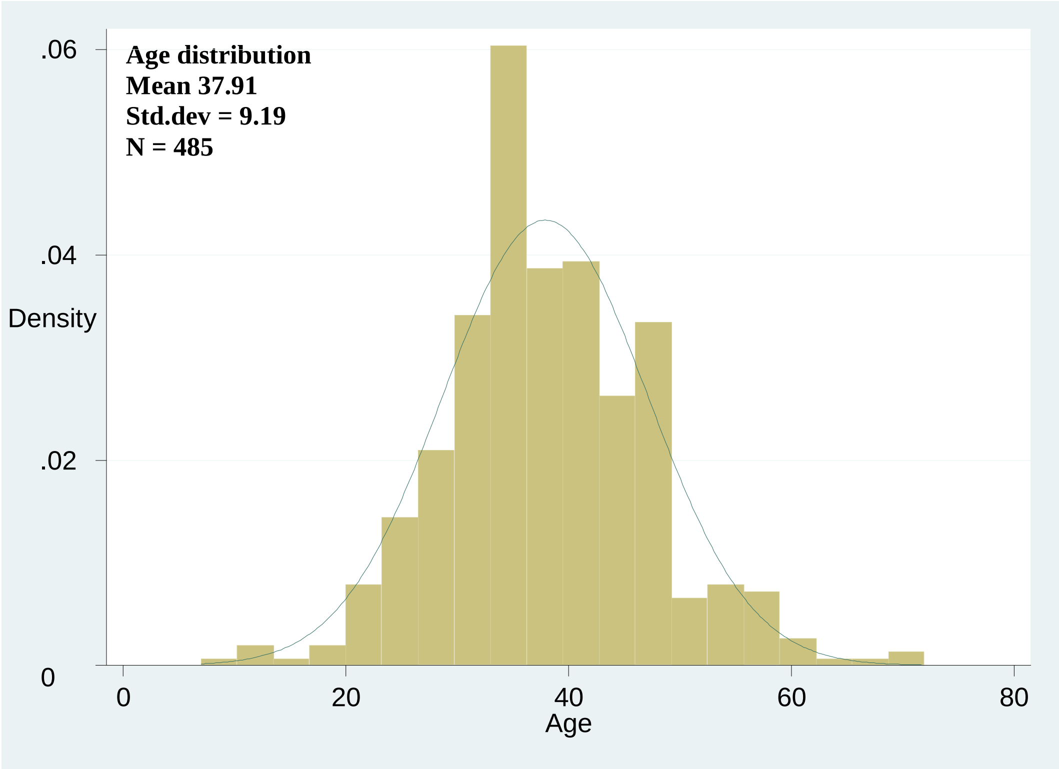


Figure 4.2