PERCEPTIONS AND SOCIO-ECONOMIC IMPLICATIONS OF TREATED WASTEWATER IRRIGATION OF VEGETABLES IN URBAN AREAS:

A CASE STUDY OF GARDEN COMPOUND IN LUSAKA

By

Milimo J Mudenda

A dissertation submitted to the University of Zambia in partial fulfilment of the requirements for the award of the Post Graduate Diploma in Integrated Water Resources Management

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Declaration

I, Milimo Mudenda do hereby declare that this dissertation is based on my work and that the works of other scholars and researchers cited in the study have been duly acknowledged. I also declare that the dissertation has not been previously submitted for any other Post Graduate Diploma Programme at this University.

Signature:.....**Date:** .....

Approval

This dissertation of Milimo Mudenda has been approved as partial fulfilment of the requirements for the award of the Post Graduate Diploma in Integrated Water Resources Management by the University of Zambia.

Supervisor: Prof. Imasiku A. Nyambe

Signature: ..... **Date**: 21/7/10

Abstract

The study focused on the perceptions and socioeconomic repercussions of irrigating vegetables using treated wastewater in Garden Compound in Lusaka. This qualitative study was based on stratified sample population of forty (40) comprising wastewater vegetable irrigators and non wastewater vegetable irrigators, household consumers, restaurant patrons and restaurant operators. Questionnaires were used to obtain the primary data.

The results of the study revealed that 95% of the sample population understood the meaning of wastewater including identification of its sources. Wastewater irrigation was considered a safe and acceptable practice to 75% of the respondents while over 80% did not approve reuse of wastewater for purposes other than irrigation. The study also revealed that 90% of the respondents would be willing to consume the wastewater irrigated vegetables on condition that one or more measures to reduce contamination were applied on the vegetables or the wastewater itself. It was observed that the reuse of wastewater for irrigation by farmers in Garden Compound was motivated by the availability and nutrient value and costless nature of wastewater and the main deterrents included public health concerns vis-à-vis diarrheal diseases and the bad odour; and social stigma attached to wastewater.

The study revealed that the socioeconomic status of wastewater using farmers in Garden Compound was generally lower than that of non wastewater using farmers. This was against the assumption that the use of wastewater lowered the cost of producing vegetables in the Compound.

The study recommends that more research in wastewater should be done to provide information on the social and economic costs and benefits of wastewater irrigation. It is also recommended that government recognises wastewater as resource which can be beneficial to society.

Key words

Wastewater, Perceptions, Irrigation and Socio-economic

Dedication

To my dear good friend and wife, Chimuka

Acknowledgements

I would like to thank my family and friends (IWRM PG-Diploma class of 2009) for their consistent support and encouragement throughout the IWRM programme. I would also like to thank the Market Chairman of Garden Main Market in Garden Compound and all the respondents in Garden Compound for taking part in the study. Special thanks go Dr John Mudenda for his interest and encouragement throughout my studies.

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CHAPTER ONE: INTRODUCTION

1.1 Introduction

The dissertation is a presentation of the perceptions and socio-economic repercussions associated with the use of treated municipal wastewater for irrigation of vegetables in Garden Compound in the City of Lusaka.

The use of treated wastewater for irrigation is a common phenomenon in many communities around and near wastewater treatment plants in many parts of the world. Increase in urban poverty compounded by limited opportunities to sustain livelihoods causes many poor resource urban farmers to use wastewater to irrigate their crops. Scott et al (2006) and IWMI (2006) note that water scarcity, availability of wastewater, lack of alternative water sources, livelihood and economic dependence, proximity to markets, and nutrient value all play an important role in driving urban farmers to use wastewater for irrigation. Despite the overwhelming significance of wastewater irrigation in urban areas, concern is usually raised about the potential public health and environmental problems associated with wastewater (Scott et.al, 2004).

1.2 Economy and poverty

Since independence, the wealth of Zambia has largely been based on mining in the rich copper areas of the Copperbelt Province and now the North-Western Province also. However, downturns in copper prices have had severely damaging economic consequences on the economy of the country. The processing and manufacturing industry has also continued to grow gradually although the agricultural sector has remained underdeveloped and vulnerable to weather fluctuations, and food shortages have occurred. Since the 1970s Government has been making attempts to diversify to agriculture and to make the country self-sufficient in food. In the *Vision 2030*, the Zambian government recognised agriculture, tourism, environment, mining, manufacturing and energy as priority areas upon which economic development will be

based and where intervention and investment will be prioritized (Nyambe and Feilberg, 2009)

Zambia is among the least developed countries in the world ranking number 165 out of 177 countries on the UNDP Human Development Index. Approximately 63.8 % of the population are living on less than 1 US dollar a day with an overall unemployment rate for 2006 of 14 % (Nyambe and Feilberg, 2009). These statistics pose a serious challenge to government and society in general.

1.3 Water resources

Zambia is endowed with abundant water resources-both surface and groundwater despite the appalling poverty levels. The main water bodies are within the watersheds of the Zambezi and Congo rivers with their tributaries of Kafue, Luangwa, Luapula and Chambeshi and lakes Tanganyika, Bangweulu, Mweru and Mweru Wantipa. Others are the man-made lakes of Kariba and Itezhi-tezhi.

1.4 Characteristics of the study area

Zambia has a population of 11.7 million inhabitants (CSO, 2008) with an average population density of 15.5 persons per square kilometre. The annual population growth rate is estimated at 1.6 % and around 40 % of the population live in urban areas with the capital Lusaka having a population of 1,533,739 people. Lusaka is the most urbanised city in the country with an estimated 82% of the inhabitants living in the urban areas (CSO, 2005).

Garden Compound is a high density settlement located approximately 3 kilometres from the Central Business District of Lusaka City (Figure 1.1). The Compound has a population of approximately 65,718 and inhabitants and 14,153 households (CSO, 2000). The majority of the community members are not in formal employment and are mainly engaged in informal sector activities such as small scale trading and agriculture.

Within the vicinity of Garden Compound, there is a wastewater treatment plant operated by the Lusaka Water and Sewerage Company (LWSC) called Machinchi Wastewater Treatment Plant. It treats effluent for a larger part of Lusaka Central which includes among other townships Woodlands, Kabulonga, Rhodespark, Longacres, Roma and Northmead and the Central Business District of Lusaka including the industrial areas which are connected to the sewer network. The treated effluent is temporarily discharged and stored into stabilisation ponds located in the peripherals of the compound before it is finally discharged into the nearby Ngwerere stream in the northern part of Garden Compound. It is here that wastewater irrigation is thriving in Garden Compound.

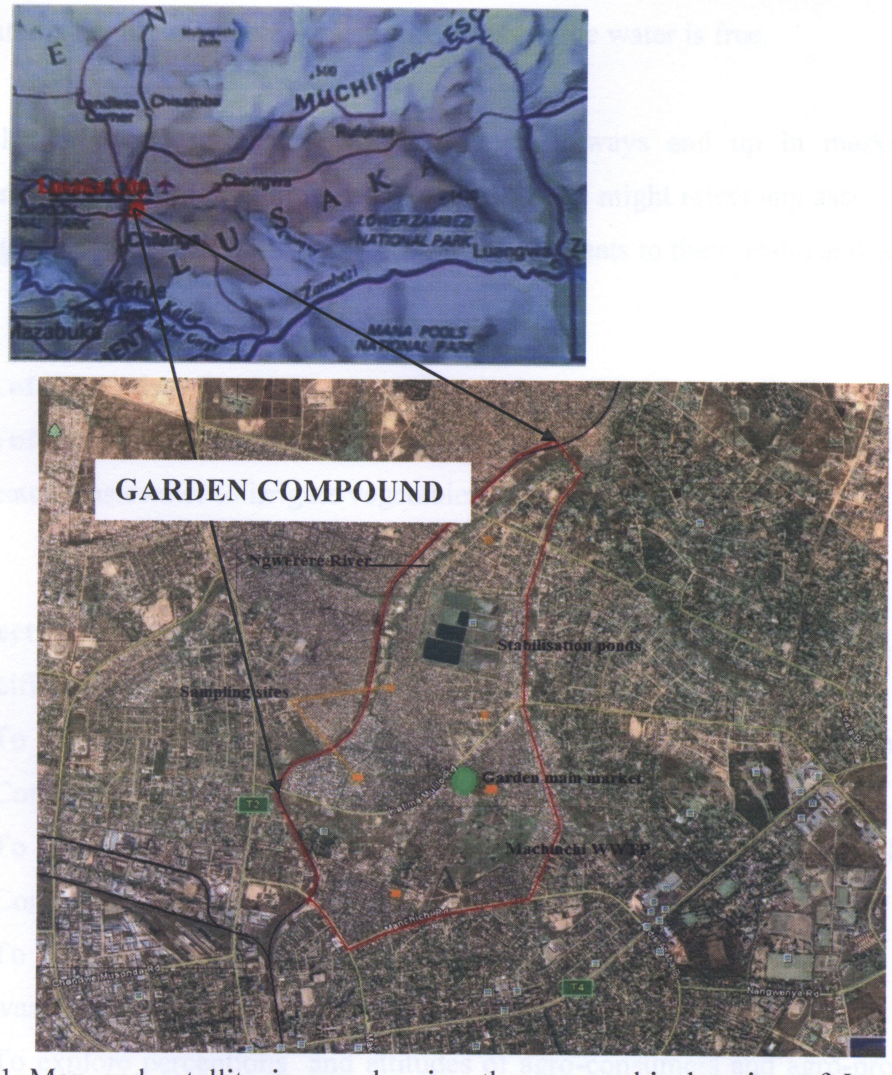


Figure 1.1 Map and satellite image showing the geographic location of Lusaka and Garden Compound and the Machinchi Wastewater Treatment Plant

Sources: *New Education Resource Atlas for Zambia and Europa Technologies (Googleearth.com)*

1.5 Statement of the problem

The use of treated wastewater to irrigate vegetables in urban areas is often viewed as an opportunity and a threat to communities. It is an opportunity in the sense that it allows farmers to produce vegetables for their food and income at a relatively low cost and satisfy the available demand for the vegatebles; and a threat because of the public health implications associated with it. The former is a typical scenario in urban areas where production is often constrained by the high cost, and sometimes the availability of water and artificial fertilisers. It is for this reason that wastewater, which is considered rich in nutrients is used by farmers in Garden Compound to irrigate their vegetables. The wastewater is readily available for use and access to the water is free.

Vegetables produced using the wastewater will always end up in markets where consumer perceptions determine their fate. Consumers might reject any association with these vegetables because of the perceived potential threats to their health and wellbeing.

1.6 Aim of the study

The aim of the study is to determine the perceptions and socio-economic implications of using treated wastewater to irrigate vegetables in urban areas.

1.7 Objectives of the study

The specific objectives of the study were:

1. To explore understandings and perceptions of the community of Garden Compound about wastewater
2. To identify the type of crops that are irrigated using wastewater in Garden Compound
3. To compare the socio-economic position of wastewater irrigators and none wastewater irrigators
4. To explore perceptions and attitudes of agro-consumers and agro-producers on the use of wastewater for irrigation
5. To determine the socio-economic implications of using wastewater for irrigation

1.8 Research questions

1. Is the use of wastewater for irrigation a socially acceptable practice among farmers and consumers?
2. Why do farmers use wastewater to irrigate vegetables?
3. Does use of wastewater for irrigation lower cost of production?

1.9 Significance of the study

The use of wastewater to irrigate vegetables is a reality not only in Garden Compound of Lusaka City but many other places. It contributes to the general wellbeing of farmers who use it as well as consumers who eat the vegetables produced. As a consequence of these contributions, it becomes necessary to understand the perceptions and attitudes about wastewater and wastewater irrigation; and the extent of reuse of wastewater for irrigation in Garden Compound.

The information obtained from the will reveal the importance, if any that is attached to wastewater and irrigation. The knowledge gathered will be essential in raising public awareness about wastewater irrigation; its costs and benefits to the community of Garden Compound and society in general. The information might also provide a premise for policy makers on decisions about wastewater and wastewater irrigation; whether to outlaw wastewater irrigation or to recognize wastewater as a renewable water resource which can complement urban agriculture and contribute to household income and food security of society. Streaming from the latter, wastewater irrigation could be integrated into the National Agricultural Policy, Irrigation Policy and Strategy and National Water Policy where appropriate regulatory and monitoring standards of wastewater for irrigation would be developed. Possible future commercialization of the treated wastewater is another development that can be realized from the same.

CHAPTER TWO: LITERATURE REVIEW

The chapter present a review of literature giving a historical background of wastewater reuse and wastewater irrigation and a global inventory of wastewater irrigation globally. It also reviews the position of other scholars, researches and government on wastewater irrigation.

2.1 History of wastewater reuse

The concept of using sewage effluent for agricultural production started more than 2000 years ago when crops in Greece were irrigated with such effluent (Pesco and Arar, 1988) while in China the practice has been prevalent for centuries. However, according to Mtonga (2000), the practice in Zambia started as soon as conventional sewage works became operational. The effluent discharged was then used to irrigate gardens established around the outflows.

2.2 Inventory of wastewater irrigation

In rural and peri-urban areas of most developing countries, the use of sewage and wastewater for irrigation is a common practice. Wastewater is often the only source of water for irrigation in these areas. Even in areas where other water sources exist, small scale farmers often prefer wastewater because its high nutrient content reduces or even eliminates the need for expensive chemical fertilizers (IWMI, undated).

The International Water Management Institute (IWMI) (2006) reports that recent surveys across 50 cities in Asia, Africa and Latin America that wastewater irrigation is a common reality in three-fourths of the cities in these places. In Vietnam and Pakistan alone, between 10,000 and 30,000 hectares are cultivated with undiluted wastewater. However, this does not reflect large areas using diluted wastewater or polluted water. IWMI further reports that in Ghana, in the city of Kumasi alone, farmers use polluted

water sources on about 12,000 hectares—more than twice the area covered by the country's formal irrigation schemes.

2.3 Importance of wastewater irrigation

The Food and Agricultural Organisation recognises the reuse of treated wastewater under water scarcity conditions as a resource that can be captured for irrigated agriculture. The availability of this additional water near population centres will increase the choice of crops which farmers can grow (Pescod M.B, 1992). The nitrogen and phosphorus content of sewage might reduce or eliminate the requirements for commercial fertilizers.

The use of suitably-treated wastewater for food crops, non-food crops and golf course irrigation is considered an acceptable and sometimes desirable practice, provided the operation is designed and operated to avoid public health and other environmental problems and is agriculturally beneficial (*Saskatchewan Environment,* 2004). Drechsel et.al, 2010 suggests that despite official restrictions and potential health implications, farmers in many developing countries use diluted, untreated or partly treated wastewater because:

- wastewater is a reliable and often the only water source available for irrigation throughout the year
- wastewater irrigation often reduces the need for fertilizer application as it is a source of nutrients

Gane et al. (undated) also observes that the use of wastewater for irrigation is a major source of livelihood for 78% of the urban and peri-urban communities in the vegetable production and distribution chain in the city of Kumasi in Ghana.

At the global scale, reuse of wastewater for irrigation is now coming under the spotlight as something which must be addressed, and not ignored given the water scarcity issues and the potential impacts of climate change. During the 2008 World Water Week in Stockholm, key players from the health, water and agricultural sectors acknowledged the importance of wastewater reuse to the *New Agriculturist* magazine where Vahid Alavian

(2008) a World Bank water advisor, feared that climate change might cause the available water resources to become less and less. He stressed the need for countries to begin to look at unconventional sources and uses of water; among them was treatment and utilisation of wastewater. The agricultural sector can benefit immensely from the wastewaters considering the fact that agriculture is the major consumer (approximately 70%) of available fresh water resources.

2.4 Benefits of wastewater irrigation

According to *Saskatchewan Environment* (2004), treated wastewaters are an inexpensive water source, containing useful plant nutrients such as nitrogen and phosphorus, which will normally increase crop yields and promote good grass growth on golf courses. It further reports that treated wastewater irrigation is generally considered to avoid wastewater discharge across privately-owned lands or into intermittent watercourses.

It is widely acknowledged that farms irrigating their crop with wastewater provide direct and indirect employment for several thousand people, and that managed wastewater reuse provides a valuable service to society, reducing health risks from unregulated discharges and protecting downstream environments (FAO, 1992).

2.5 Wastewater irrigation and policy in Zambia

In Zambia, the Fifth National Development Plan (FNDP) (2006), National Agricultural Policy (NAP) (2004) and Irrigation Policy and Strategy (IPS) (2004) recognize the significance of irrigation in agricultural development. These initiatives by government aim at promoting increased and sustainable agricultural production, productivity and competitiveness. It is expected that food security; income generation; creation of employment opportunities; and a reduction in poverty levels in the country will be achieved through these objectives.

However, following the recognition of irrigation as key in mitigating the challenges highlighted, wastewater irrigation seldom mentioned in the NAP let alone the IPS. This

is despite the opportunity wastewater provides to urban vegetable farmers considering the high cost and availability of fresh water.

CHAPTER THREE: METHODOLOGY

The methodology involved four main stages which included S*ampling, Questionnaire design, Data collection and Data analysis*

3.1 Sampling and classification of sample

The stratified sample of 40 respondents consisting 3 main groups was selected based on the interaction with vegetable production and vegetable consumption. The sample was stratified in such a manner so as to ensure exhaustive representation of the population of Garden Compound in Lusaka City. The sample constituents were captured from residential areas, the market (including restaurants) and vegetable fields or gardens.

3.2 Sample classification

The stratified sample of 40 respondents was broken down as follows;

1) Ten (10) Vegetable Farmers or Gardeners

- Five (5) Wastewater users
- Five (5) Non wastewater users

2) Fifteen Vegetable Consumers:

- Ten (10) Consumers at home
- Five (5) Consumers in restaurants

3) Fifteen Vegetable Retailers:

- Five (5) Restaurant operators
- Five (10) Vegetable sellers

3.3 Reasons for classification criteria

The reasons for the above classification of groups were as follows:

1. Farmers were categorised as *wastewater users* and *non wastewater users.* The choice of this criterion is related to the *3rd Research question* and the *3rd Research*

objective which relate production costs to wastewater use and socio-economic position of farmers respectively.

2. *Vegetable Retailers and Consumers* are both consumers essentially but interact at different levels with the farmers or vegetable producers. Restaurant operators *(these sell to restaurant clientele)* may get the vegetables directly from the farmers at the farm or from the Vegetable sellers (*Vegetable retailers*) at the market. These groups are likely to be aware of the sources of the vegetables and the type of water that is used. This criterion will in achieving *Research objectives 1, 2, 4 and 5* and *Research question 1.*

3.4 Questionnaire Design

The designed questionnaire was subjected to a pre-test in the field with 5 respondents taking part before the final revision and actual data collection (Appendix 1)

3.5 Primary Data Collection

The questionnaire was the principle tool for data collection and contained open and closed ended questions. The survey was conducted in selected parts of Garden Compound as shown on the map. This was to ensure a spatially representative sample of the population. English was the main language of communication although some local languages were used to clarify issues where necessary.

3.6 Secondary data

Supplementing secondary data came from governmental and non-governmental statistics, studies and reports. The documents consulted included among others the National Agricultural Policy and the Irrigation Policy and Strategy.

3.7 Data Analysis

The responses to open ended questions were tabulated (Appendix 2A) and responses to closed ended questions were coded and organized in tables (Appendices 2B and 2C).

SPSS 15.0 and Microsoft Office Excel 2007 statistical computer programmes were used for statistical analysis.

3.8 Limitations of the study

The study had the following limitations:

1. Literature on Zambia concerning wastewater reuse, especially agricultural is limited both in extent and quantity. It was therefore difficult to understand and document some the challenges and opportunities of wastewater irrigation in Zambia;
2. Land use changes in Garden Compound where land previously used for growing crops had been converted to housing. This means that there are fewer people growing vegetables in the compound and therefore the bulk of vegetables at Garden Compound main market are not sourced locally; and
3. It was not possible to interview all the irrigators (wastewater users and non-wastewater users) from their fields and observe the practice at the time of the study because this was the peak period of the rainy season. Irrigation was at its minimum and tends to be higher during winter and early summer when there is no rain.

CHAPTER FOUR: RESEARCH FINDINGS

This chapter presents findings based on forty (40) community members living in Garden Compound of Lusaka. The community members were selected based on their interaction with vegetable production and consumption. The first section of the chapter deals with *general social economic information* of the respondents whereas the second section addresses the *research objectives* concurrently. However, *research objectives 3 and 5* have been addressed last and together because of their similarity.

This approach was necessary in order to provide a logical flow and correlation of information collected.

4.1 Socio-economic information of respondents

The results on the educational levels of respondents (Figure 4.1) show that 25% of the males attained up to Secondary School education (i.e. 10% Grade 9 and 15% Grade 12) which is more than their female counterparts of 20% (i.e. 7.5% Grade 9 and 12.5% Grade 12). The percentage for males attaining the tertiary levels of education is higher for males (32.5%) than for females (15%).

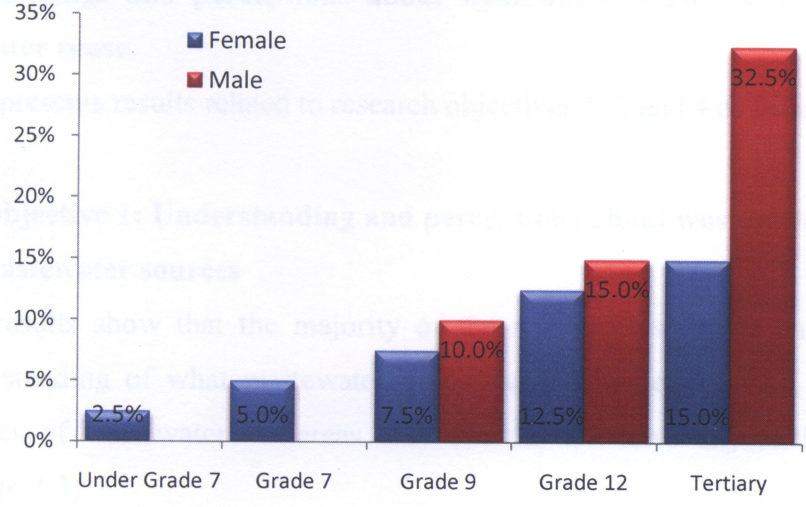


Figure 4.1: Gender and educational levels of the respondents in Garden Compound, Lusaka City

The general income distribution of the respondents (Figure 4.2) reveals that there are more members of the community (48 %) who earn a monthly income less than K500, 000 compared to any other income group. Those earning above K1, 250, 000 constituted 20% of the respondents.

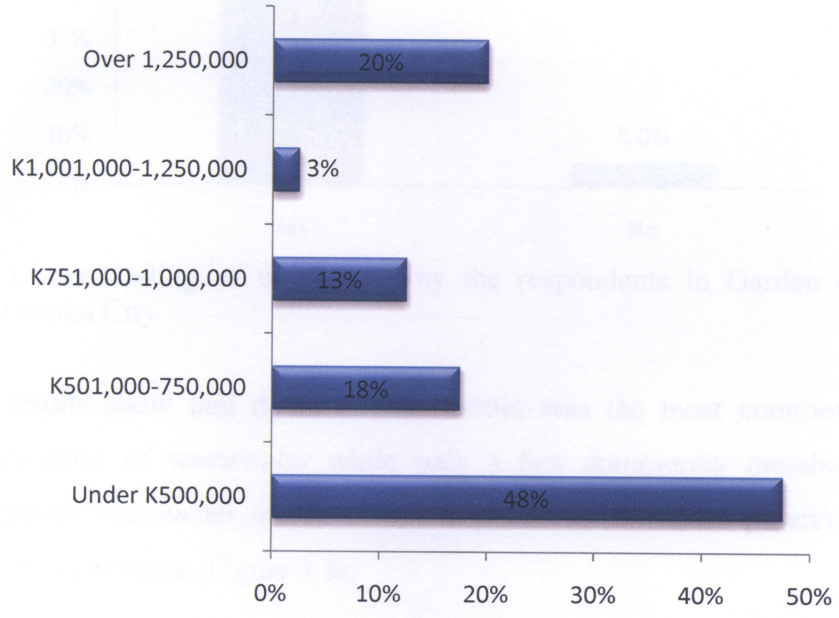


Figure 4.2: General income distribution of respondents Garden Compound, Lusaka City

4.2 Understandings and perceptions about wastewater, wastewater sources and wastewater reuse

This section presents results related to research objectives 1, 2 and 4 as follows:

- **Objective 1: Understanding and perceptions about wastewater and wastewater sources**

  The results show that the majority of the respondents (95%) have a general understanding of what wastewater is and have knowledge about some of the sources of wastewater whereas only 5% did not have any such knowledge (Figure 4.3).

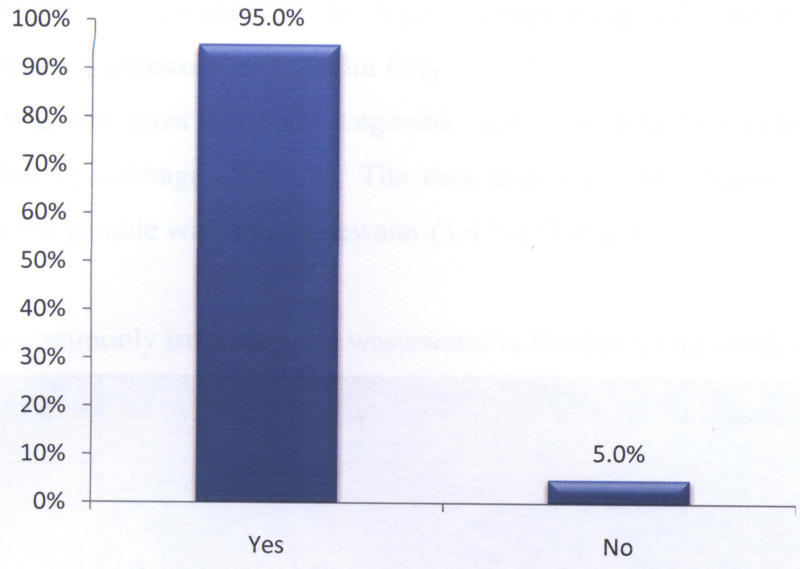


Figure 4.3: Understanding of wastewater by the respondents in Garden Compound, Lusaka City

The results show that domestic wastewater was the most common (39.6 %) known form of wastewater while only a few community members (6.3 %) recognised wastewater stored in sewer ponds (stabilisation ponds) as another form of wastewater (Figure 4.4).

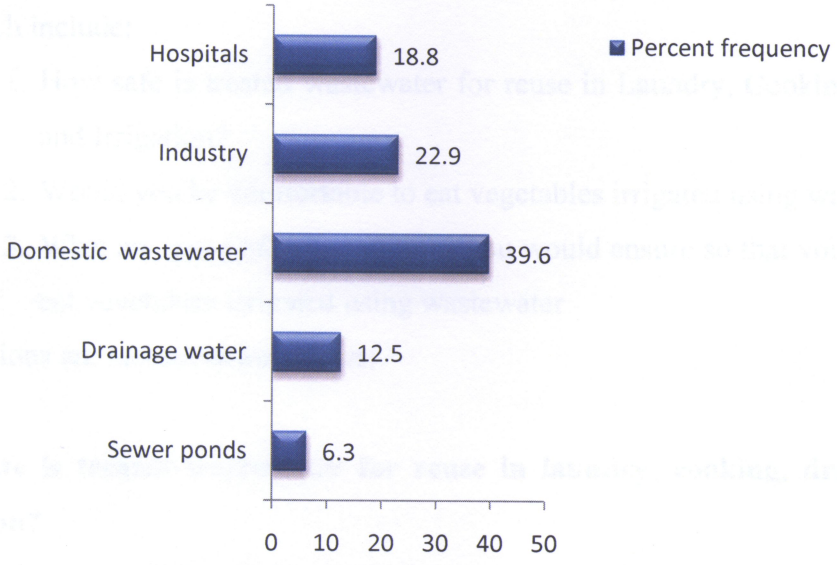


Figure 4.4: Identified sources of wastewater by respondents in Garden Compound, Lusaka City

- **Objective 2: To identify the type of crops irrigated with wastewater in Garden Compound of Lusaka City**

Rape was the most common vegetable (28.6 %) irrigated with wastewater seconded by cabbage (22.7 %). The data also show that beans was the least irrigated vegetable with the wastewater (3.4 %) (Table 1).

Table 1: Crops commonly irrigated with wastewater in Garden Compound, Lusaka City

	Crop	Frequency	%
1	Rape	34	28.6%
2	Cabbage	27	22.7%
3	Onion	9	7.6%
4	Tomatoes	17	14.3%
5	Sugarcane	15	12.6%
6	Beans	4	3.4%

- **Objective 4: To explore perceptions and attitudes of agro-consumers and agro-producers on the use of wastewater for irrigation**

Three questions asked to assess the respondents' perception and attitude towards wastewater reuse and consumption of vegetables irrigated using wastewaters which include:

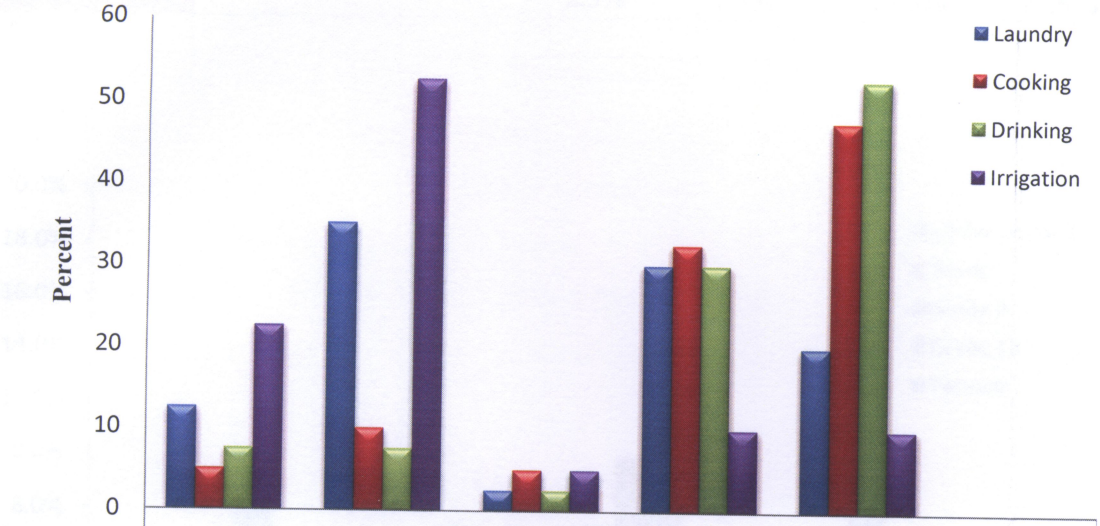
1. How safe is treated wastewater for reuse in Laundry, Cooking, Drinking and Irrigation?
2. Would you be comfortable to eat vegetables irrigated using wastewater?
3. What are some of the conditions you would ensure so that you are able to eat vegetables irrigated using wastewater

These questions are measured as follows:

1) How safe is treated wastewater for reuse in laundry, cooking, drinking and irrigation?

The results show that 75% of the respondents generally felt reuse of wastewater for irrigation was safe (i.e. 22.5% said it was safe and 52.5% said it was very safe) while 10% apiece felt that such water was unsafe, and safe for irrigation only (Figure 4.5). The

data also shows that 32.5% and 47.5% of the respondents felt that such kind of water was unsafe and very unsafe respectively for cooking. For reuse of wastewater for laundry 30% and 20% of the respondents felt it was unsafe and very unsafe respectively and for drinking, 30% and 52.5% of the respondents felt it was unsafe and very unsafe respectively.



	Very Safe	Safe	Dont Know	Unsafe	Very Unsafe
Laundry	12.5	35	2.5	30	20
Cooking	5	10	5	32.5	47.5
Drinking	7.5	7.5	2.5	30	52.5
Irrigation	22.5	52.5	5	10	10

Percent

Figure 4.5: Attitude of respondents towards reuse of wastewater for Laundry, Cooking, Drinking and Irrigation in Garden Compound, Lusaka City

2) Would you be comfortable to eat vegetables irrigated using wastewater?

The willingness to eat wastewater irrigated vegetables was studied together with the education levels of the respondents. The results (Table 2 and Figure 4.6) show that the willingness to consume these vegetables was independent on the education levels of the respondents. For example, among the 25% of the respondents willing to consume wastewater irrigated vegetables, 10 % had attained tertiary education and 5% attained apiece had attained up to grade 12 and grade 9 respectively. Two and half percent (2.5%) apiece had gone up to grade 7 and below grade 7 respectively.

Table 2: Perceptions of the respondents by education level about consuming wastewater irrigated vegetables in Garden Compound, Lusaka City

Education level	Under Grade 7	Grade 7	Grade 9	Grade 12	Tertiary	Total
Response						
Agree	2.5%	2.5%	5.0%	5.0%	10.0%	**25%**
Strongly Agree			2.5%	5.0%	7.5%	**15%**
Disagree		2.5%	7.5%	10.0%	12.5%	**32.5%**
Strongly Disagree			2.5%	7.5%	17.5%	**27.5%**

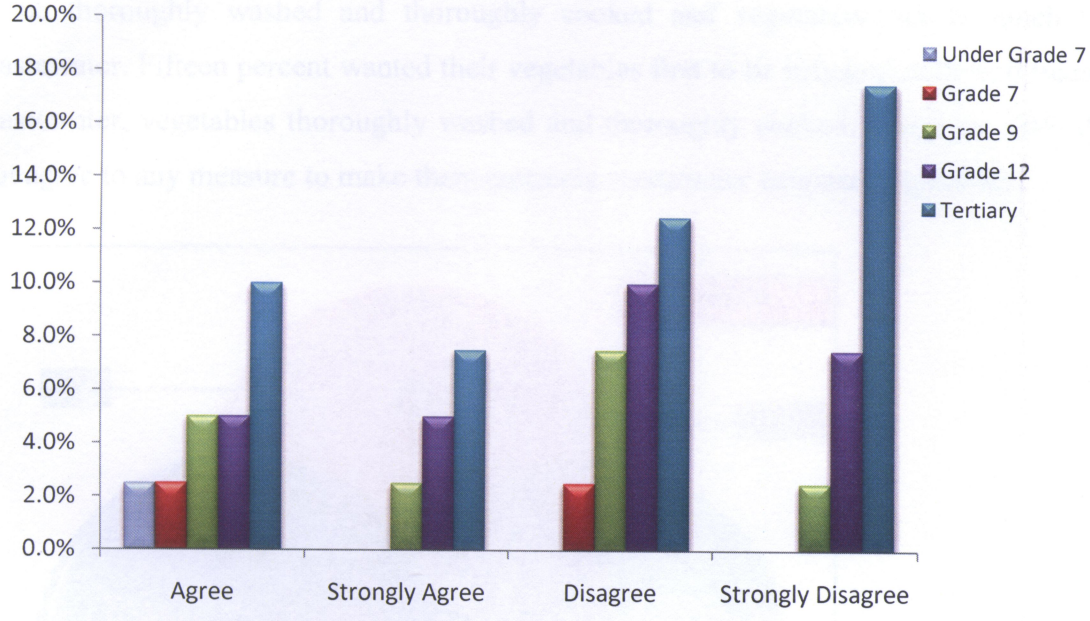


Figure 4.6: Perceptions of the respondents by education level about consuming wastewater irrigated vegetables in Garden Compound, Lusaka City

3) What are some of the conditions you would ensure so that you are able to eat vegetables irrigated using wastewater?

On the measures to be taken on consuming wastewater irrigated vegetables by the respondents (Figure 4.7), 15% felt they needed their vegetables to not be in contact with the wastewater, thoroughly washed and thoroughly cooked as well as the wastewater to be well treated. Ten percent (10%) felt the vegetables did not need to be in contact with the wastewater only and another 10% felt the wastewater needed to be well treated only. Seven and half five percent (7.5%) felt secure with their vegetables thoroughly washed

only whereas another 7.5% felt secure with the vegetables only thoroughly cooked before eating them. Five percent wanted their vegetables both thoroughly cooked and irrigated with well treated wastewater and 2.5% wanted their vegetables to be both thoroughly cooked and thoroughly washed. Other respondents (7.5%) wanted their vegetables not to be in contact with the wastewater and the wastewater to be well treated and 2.5% wanted their vegetables both thoroughly washed and not in contact with the wastewater. The results also show that 2.5% felt secure only when vegetables were irrigated with well treated wastewater, wastewater not coming into contact with the vegetables and vegetables thoroughly washed. Five percent (5%) felt vegetables needed to be thoroughly washed and thoroughly cooked and vegetables not to touch the wastewater. Fifteen percent wanted their vegetables first to be irrigated with well treated wastewater, vegetables thoroughly washed and thoroughly cooked. However, 10% did not agree to any measure to make them consume wastewater irrigated vegetables.

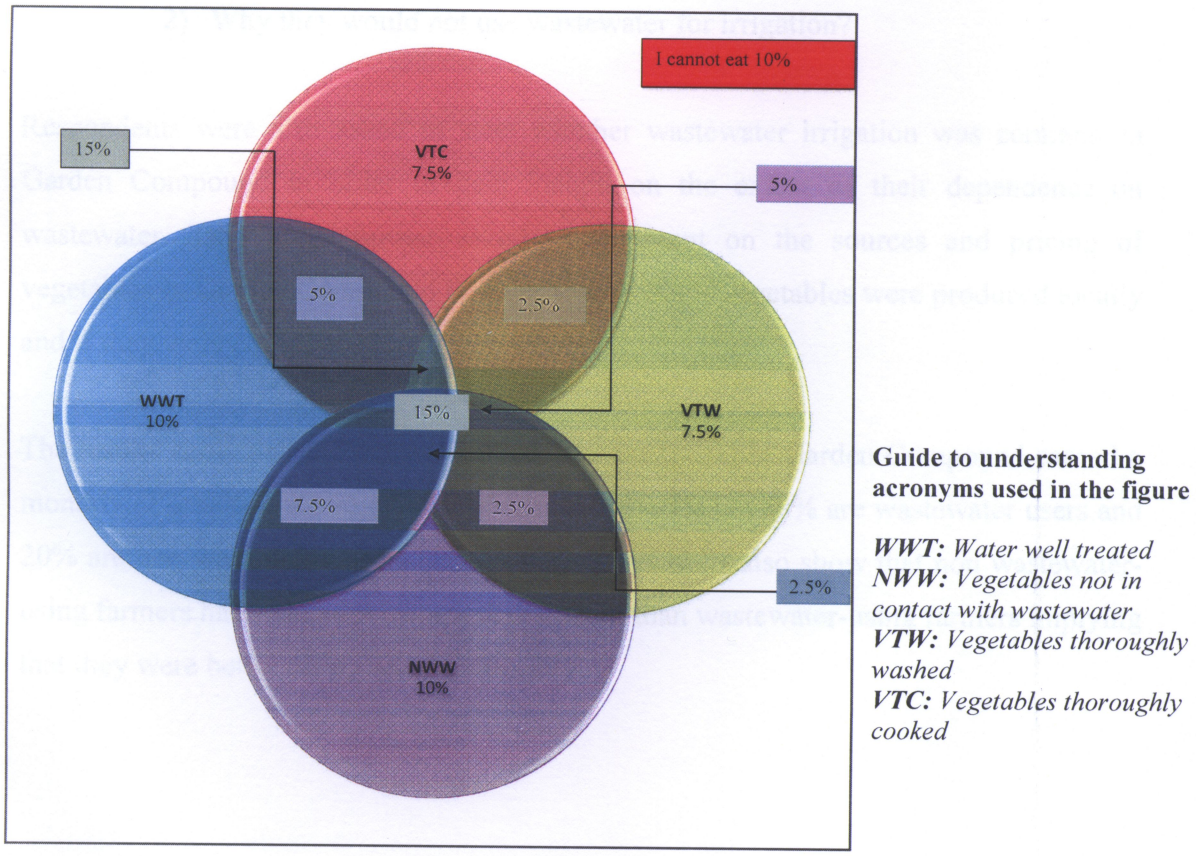


Figure 4.7: Conditions required to be met for respondents to eat vegetables irrigated with wastewater in Garden Compound of Lusaka City

4.3 Socio-economic implications of wastewater irrigation

This section presents results related to objectives 3 and 5 which address the socio-economic implications of wastewater irrigation.

- **Objectives 3 and 5: To compare the socio-economic position of farmers and determine socio-economic implications of wastewater irrigation**

In order to understand which type of farmers i.e. wastewater users and non wastewater users earned a higher monthly income and therefore better off, monthly incomes of these farmers were compared and to assess the socio-economic implications of using wastewater irrigation of vegetables in Garden Compound, the respondents were asked to state:

1) Why they felt wastewater irrigation was beneficial to them; and
2) Why they would not use wastewater for irrigation?

Respondents were also asked to state whether wastewater irrigation was common in Garden Compound in order to gain insight on the extent of their dependence on wastewater. They were further asked to comment on the sources and pricing of vegetables in Garden Compound in order to find out if vegetables were produced locally and if they were cheap.

The results show that the majority of the farmers (60%) in Garden Compound earned a monthly of less than K500, 000.of which the majority i.e. 40% are wastewater users and 20% are non wastewater users (Figure 4.8). The results also show that non wastewater-using farmers had a broader income distribution than wastewater-using farmers implying that they were better off socio-economically.

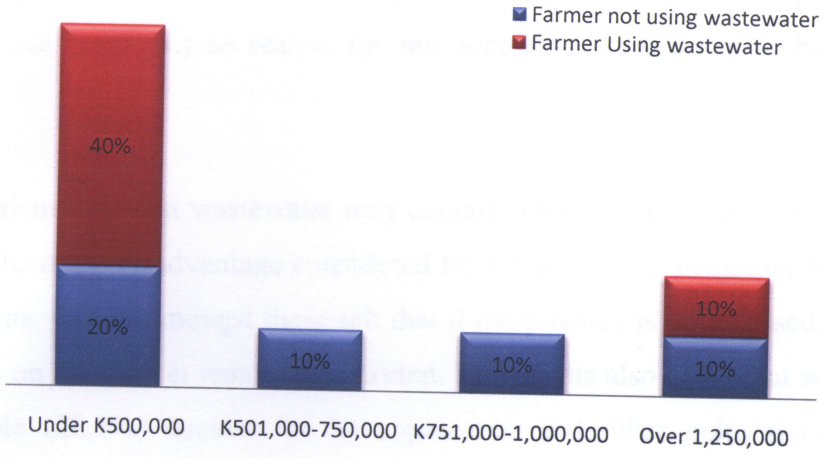


Figure 4.8: Income distribution among farmers interviewed in Garden Compound Lusaka City

The majority of respondents (47.5%) preferred wastewater to irrigate vegetables because of its intrinsic agricultural value (Table 3). Here 31.7% felt wastewater contained essential nutrients for plant growth. Under economic reasons (27.8 %), most of the respondents (13.1 %) felt water was too expensive compared to wastewater which is free (9.8 %). Unlike fresh water which is not readily available (13.1 %), wastewater was preferred for its availability and proximity to gardens (11.5%).

Table 3: Perceived benefits of wastewater irrigation in Garden Compound, Lusaka City

S/n	Response	Frequency	Percent (%)
1	**Economic reasons**		
A	Water is too expensive	8	13.1
B	Wastewater lowers the cost of production	3	4.9
C	Wastewater is free	6	9.8
			27.8
2	**Water Availability**		
A	Fresh water is not readily available	8	13.1
B	Wastewater is available and close to gardens	7	11.5
			24.6
3	**Agricultural value**		
A	Wastewater contains essential nutrients	19	31.1
B	Improves plant vigour	2	3.3
C	All year vegetable production	5	8.2
D	Plant only make use of the nutrients and therefore safe	3	4.9
			47.5

The majority of respondents (57.8 %) cited public health concerns (disease, hygienic and risk of chemical residues,) as reason for not accepting wastewater to be reused for irrigation.

The high nutrient load that wastewater may contain which could be detrimental to plant growth was the other disadvantage considered for wastewater in irrigation by 13.3 % of the respondents. Others amongst these felt that if the practice is popularised, then prices of vegetables on the market would be distorted. The results also show that wastewater is not acceptable (22.2%) because of its appearance and other cultural connotations. Furthermore, a small group of the respondents (6.7%) felt that popularising wastewater would escalate cases of vandalism of pipes and other installations and therefore make wastewater treatment very costly (Table 4).

Table 4: Perceived disadvantages of wastewater irrigation in Garden Compound, Lusaka City

S/n	Reason	Frequency	Percent
1	**Public health concerns**		**57.8**
	Causes disease (diarrhoea, cholera, worms etc)	17	
	Wastewater is not hygienic/bad odour	4	
	Contains toxic chemical residues	5	
2	**Unsuitable practice for agricultural use**		**13.3**
	High nutrient load causes crop failure	4	
	Would distort market price of vegetables	2	
3	**Social concerns**		**22.2**
	Water is appears dirty and not fit for reuse	8	
	Culturally not acceptable	2	
4	**Potential threats to wastewater treatment**		**6.7**
	Vandalism (of pipes) cases would rise	2	
	Treatment process expensive	1	

Fifty percent (50%) of the respondents were of the view that the vegetative growth and development of wastewater irrigated vegetables was very good and 25% felt that the growth and development was good. Twenty-two percent (22%) instead felt the growth and development was just fair whereas 3% did not know.

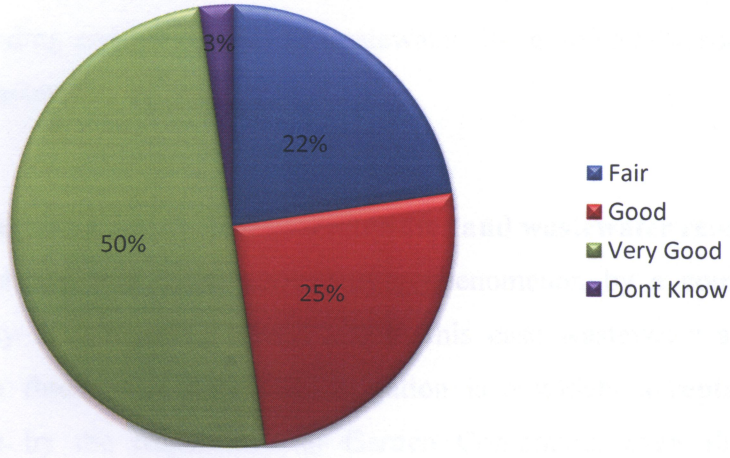


Figure 4.9: Perceptions on the vegetative growth and development of wastewater irrigated vegetables in Garden Compound, Lusaka City.

The majority of the respondents (87.5%) obtained their vegetables from the market while a meagre 5% obtained them from the local gardens (farms). The results also show that 47.5% and 37.5% felt the price of vegetables was fair and expensive respectively (Figure 4.10).

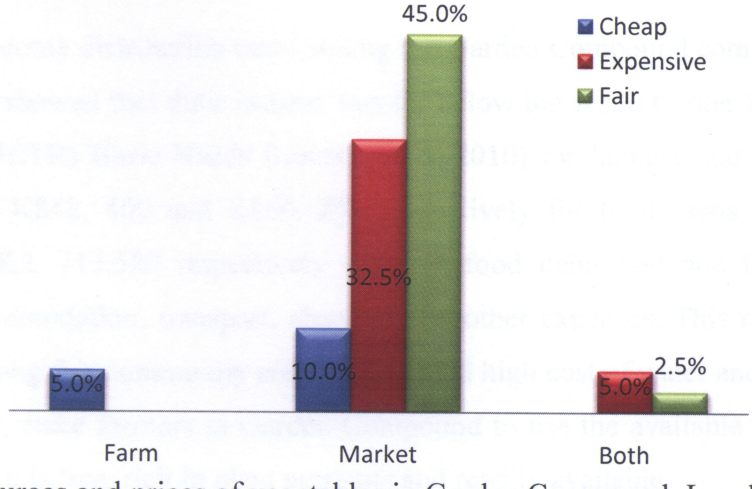


Figure 4.10: Sources and prices of vegetables in Garden Compound, Lusaka City

CHAPTER FIVE: DISCUSSION

This chapter presents a discussion of the results of the respondents in Garden Compound on their understanding and perceptions of wastewater, its reuse and the socio-economic implications of wastewater irrigation.

5.1 Understandings and perceptions of wastewater and wastewater reuse

This study has shown that understanding of a phenomenon by a community does influence the way they perceive it and act; in this case wastewater and its reuse. According to the findings of the study, irrigation is a **widely acceptable** form of wastewater reuse by the respondents in Garden Compound; **even though a few respondents,** despite knowing the health implications associated with wastewater do still approve its reuse for laundry, cooking and drinking.

The high number of people (75%) who accept use of wastewater for irrigation in Garden Compound could be attributed to the high poverty levels being experienced there and (FAO, 1992) this general acceptance of wastewater use in agriculture is usually justified on agronomic and economic grounds.

The general income distribution trend among the Garden Compound community (Figure 4.2) generally showed that their income was far below the Jesuit Center for Theological Reflection's (JCTR) Basic Needs Basket (BNB, 2010) for January and February 2010 which was at K842, 400 and K860, 250 respectively for food items alone and K2, 696,030 and K2, 713,580 respectively for both food items and non food items, for example accommodation, transport, charcoal and other expenses. This noticeable level of poverty among this community and the perpetual high cost of water and unavailability of clean water, force farmers in Garden Compound to use the available wastewater for irrigation which is free, rich in plant nutrients and readily available.

The findings of this study *partly agree* with the notion that, *the poor in developing countries (Drechsel et.al 2010; IWMI, 2006) with less or no education (WHO, 2006) tend to be the ones who utilise wastewater for irrigation of vegetables; and are generally inclined to consume these vegetables.*

According to this study, it is true that the community in Garden Compound is generally poor but is not *uneducated* (Figure 4.1). Zambia is generally a literate country with urban literacy rates reaching 84.65% in 2002 (BBC, undated). The results have shown that majority of the respondents acquired at the minimum, the Basic Education level in which water, hygiene and sanitation are taught (Nyambe and Feilberg, 2009). In addition, there are regular public health campaigns by the Ministries of Health and Local Government through which communities are sensitised on health education and hygiene. These interventions complement their knowledge acquired from formal school. It is against this background that the community demanded very high levels of hygiene and cleanliness in the production, distribution and consumption chain of the vegetables. From this, it becomes clear that there is adequate evidence to demonstrate community's awareness about possible contamination and environmental health risks associated with wastewater reuse.

Poverty rather than literacy is the likely motivation for wastewater irrigation in Garden Compound. It can speculated that the incomes of these relatively educated community members (Figures 4.8 and 4.2) are not adequate to sustain their monthly basic needs thereby have limited choices when it comes to income generating activities. It could be for this reason that the community remains inclined to the practice of wastewater irrigation in order to sustain their livelihoods generate income.

The seemingly similar and negative perceptions and attitudes about wastewater reuse for laundry, cooking and drinking do seem to be influenced by the nature of contact between the reuse type and wastewater. The community observed colour, odour and constituents associated with raw effluent as the major drawbacks to the reuse of wastewater for laundry, cooking and drinking. Consumption of vegetables irrigated with wastewater

was provided indirect contact with wastewater and therefore considered safer than laundry, cooking and drinking-uses where wastewater contact was thought to be more direct.

5.2 Socio-economic implications of wastewater irrigation

The study has shown that there are number of existing and potential social and economic benefits of wastewater irrigation even though there are a number of risks associated with wastewater.

According to the findings, the community in Garden Compound felt that wastewater irrigation was beneficial because it lowered their cost of producing vegetables since the wastewater is free and relatively rich in plant nutrients. One important factor which makes wastewater valuable to this community is that it is a reliable source of water, as it is available all year round and reduces dependence on rainfall or the alternative yet expensive 'tap water.' Its nutrient-rich nature also ensures reduced dependence on chemical fertilisers.

In spite of the several advantages wastewater possesses, the results of the study suggest that wastewater using farmers benefited less, economically from the sale of their produce compared to non wastewater users who it turned out were better off, in terms of their socio-economic status. This assertion was based on the fact that the monthly incomes of farmers using wastewater were relatively less than for non wastewater users (Figure 4.8). It was also observed that the price of vegetables at the main market in Garden Compound was not cheap (Figure 4.9) as one would expect in a place where wastewater is used.

The researcher was of the view that the monthly incomes of wastewater using farmers should have been higher than non wastewater users and; that the price of vegetables in Garden Compound should have been much lower. It is expected that farmers using wastewater have lower costs of production owing to the nutrient rich and free wastewater available to them unlike non wastewater users; who have to pay for the

water and chemical fertilisers or animal manure. In Pakistan, for example, wastewater farmers typically earn 30-40 percent more per year than farmers using conventional irrigation water, while in Ghana; dry-season irrigation with wastewater allows an average extra income of 40-50 percent (Scott et al., 2006).

The researcher is of the view that vegetables sold at the market in Garden Compound are sourced elsewhere other than the wastewater irrigated gardens within the Compound otherwise the price would be very low. The local farmers who use wastewater might instead prefer to sell their vegetables elsewhere to unsuspecting consumers. There, they will incur higher expenses in marketing the vegetables which include transportation, vending and storage. These costs eventually translate into reduced incomes for these wastewater using farmers.

The results revealed that most farmers using wastewater were clustered in the monthly income bracket of under K500, 000 compared to their counterparts whose incomes were generally higher and spread across the all the income brackets (Figure 4.8). This survey result could be attributed to flaws within the methodology of the study. The methodology did not provide for the capture of data on the actual cost of producing the vegetables, for example actual the sizes of plots cultivated a farmer or cost of irrigation water or the cost chemical fertilisers used if any by either farmer. This scenario made meaningful or fair and objective comparison actual cost of production and benefit difficult.

According to the findings of the study, the respondents' perceptions of the benefits of wastewater irrigation were limited to the reduction in production cost and nutrient wealth in the wastewater. However, in reality the benefits of wastewater irrigation are not limited to farmers, that is for its low cost and nutrient value; rather they also extend to other actors in the supply and distribution chain. Buechler et al., 2002 identifies farm labourers, transporters, vendors, processors, and input suppliers as subsequent beneficiaries of wastewater irrigated vegetables. In many West African countries, it is especially attractive to poor migrants looking for jobs in the city (Faruqui et al., 2004).

While the benefits of wastewater irrigation are obvious, the community in Garden Compound pointed out public health and social concerns (Table 4) as the main deterrents for the reuse of wastewater for irrigation.

The community feared the risk of diarrheal diseases such cholera and dysentery even though WHO (2000) and FAO (Pescod M.B, 1992) recommend safety standards (chemical and microbial) for wastewater irrigation to reduce risks that might otherwise be detrimental to public health and the environment. The high levels of hygiene and cleanliness demanded by the community in Garden Compound in consuming wastewater irrigated vegetables are not adequate in meeting these proposed standards. Community members who are aware of the shortfalls in wastewater treatment processes which often fall short of the WHO and FAO guidelines dare not use the wastewater for irrigation let alone consume produce derived from it. The results of the study suggest that the fact that wastewater does not appear clear, owing to its perceived origins (Figure 4.4) and foul odour rendered it unfit for irrigation by the community. To illustrate that, Obosu-Mensah (undated) quoted one lamenting resident of Accra concerning the use of wastewater to irrigate vegetables: "*whenever you have the time I will take you to an area where a man is cultivating, and you will see for yourself the type of water he uses. Anybody who sees the water he uses will not touch his crops. No wonder, his wife sells the crops in Accra Central, far away from the cultivating area. I don't think the man himself consumes his crops.*"

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

This chapter presents the conclusions of the study and recommendations that government and other stakeholders can take on board in deciding the future of wastewater reuse for irrigation.

6.1 Conclusion

The study has shown that wastewater irrigation of vegetables is generally acceptable in Garden Compound of Lusaka City despite the public health implications associated with it. It can be concluded that the potential agronomic and economic benefits of wastewater cause urban farmers to use wastewater to irrigate vegetables even though according to the findings of the study impacted less on their economy.

6.2 Recommendations

Based on the findings of the study, wastewater is a valuable resource and its current disposal method is an expensive way of disposing what has been perceived as *'worthless'* material. The worth of wastewater can be realised if the following recommendations made to policy makers and other development agencies are taken into consideration;

1. There is need for further research in the areas of economic costs and benefits of wastewater irrigation in order to understand the full economic value of wastewater and how it can impact on urban agriculture.

2. When economic costs and befits are fully understood, in the long-term, government should move from the unregulated use of untreated and treated wastewater to the regulated use of treated wastewater for agricultural purposes

3. In future when government is considering making a wastewater treatment plant, the design of the system should allow for production of low-grade effluent which can be utilised by farmers rather than relying on the seemingly expensive and advanced treatment processes which produce effluent which continuously need to meet stringent quality standards

4. There is need for government to recognise wastewater as a resource that can be reclaimed and used beneficially in irrigation and crop production. This can only be done if government incorporates wastewater into the national agricultural policy and irrigation policy and strategy

5. It becomes the role of government, local authorities and wastewater treatment plants to ensure that effluent that is intended for reuse in agriculture or is likely to be utilised for agriculture is treated to the recommended WHO and FAO agricultural reuse safety standards.

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APPENDICES

APPENDIX 1: RESEARCH QUESTIONNAIRE

THE UNIVERSITY OF ZAMBIA

IWRM CENTRE

SCHOOL OF MINES

QUESTIONNAIRE

TITLE: PERCEPTION ON THE USE OF WASTE WATER FOR IRRIGATION IN URBAN AREAS
A CASE STUDY OF GARDEN COMPOUND, LUSAKA

Information for the respondent:

The purpose of this survey is to determine the perceptions and socio-economic implications of using wastewater for irrigation among consumers and producers in urban areas. The information that will be obtained from you is essential in informing policy makers and other key stakeholders in as far as wastewater use for crop irrigation is concerned. The findings have the potential to influence a change in policy direction, for example; to standardize and monitor the quality of wastewater that can be used for irrigation; or to prohibit the wastewater irrigation.

The study is a partial fulfillment for the award of a Post Graduate Diploma in Integrated Water Resources Management at the University of Zambia.

Please feel free to express your views about the use of wastewater for irrigation through the questions listed below.

I wish to thank you very much for accepting to take part in the study

Instructions: Please fill in your information in spaces provided and a tick [√] in the boxes provided

SECTION A: PERSONAL INFORMATION

1 Sex ☐ Male ☐ Female

2 Age ☐ 15-25 ☐ 26-35 ☐ 35-45 ☐ 45 and over

3 Education ☐ Below grade 7 ☐ Grade 7 ☐ Grade 9 ☐ Grade 12 ☐ Tertiary

4 Occupation (Please state).....

5 Monthly Income ☐ Below K500,000 ☐ 501,000-750,000 ☐ 751,000-1,000,000 ☐ 1,001,000-1,250,000 ☐ Above 1250,000

SECTION B: KNOWLEDGE ABOUT WASTEWATER

5 Do you know of any sources of wastewater? ☐ Yes ☐ No

6 If answer to question 5 is Yes, state the sources of waste water that you know.

.....

.....

.....

.....

7 Treated wastewater is clean water ☐ Strongly agree ☐ Agree ☐ Strongly disagree ☐ Disagree

8 a If you agree state the reasons

.....

.....

.....

8 b If you do not agree state the reasons

.....

.....

9 Wastewater is safe to use for the following; Please tick in the boxes provided

A **Laundry**

☐ Very safe ☐Safe ☐ I don't know ☐Unsafe ☐Very unsafe

B **Drinking**

☐ Very safe ☐Safe ☐ I don't know ☐Unsafe ☐Very unsafe

C **Cooking**

☐ Very safe ☐Safe ☐ I don't know ☐Unsafe ☐Very unsafe

Irrigation (watering gardens)

D ☐ Very safe ☐Safe ☐ I don't know ☐Unsafe ☐Very unsafe

SECTION C: SOURCES OF VEGETABLES CONSUMED

10 What are some of the vegetables you regularly eat in your home? Tick the appropriate vegetable

☐ Rape ☐ Spinach ☐ Tomatoes ☐ Other (specify)……,

☐ Cabbage ☐ Chinese cabbage ☐ Pumpkin leaves

11 Where do you get the vegetables that you eat in your home? ☐Market ☐Farm

12 What is your opinion on the price of vegetables? ☐ Expensive ☐ Fair ☐Cheap ☐ I don't know

13 Three (3) reasons have been given below regarding the price of vegetables, which **one** have you experienced?

☐ Price of inputs is high ☐ Price of inputs is low ☐ Price of inputs is affordable

SECTION D: SOURCES OF IRRIGATION WATER

14 Listed below are some of the sources of irrigation water, which ones are commonly used in your area? Please tick in the appropriate boxes

☐ Tap water ☐ Shallow wells
☐ River ☐ Waste water

15 Wastewater is commonly used in my area to irrigate or 'water' vegetables ☐ Strongly agree ☐ Agree ☐ Strongly disagree ☐ Disagree

16 Are there any people in your area that use wastewater to irrigate their vegetables? ☐ Yes ☐ No

17 I am comfortable with the use of wastewater for irrigation ☐ Strongly agree ☐ Agree ☐ Strongly disagree ☐ Disagree

18 Do you have any idea why some people use wastewater to irrigate crops? Please explain

.....

.....

.....

19 The growth and development and general performance the vegetables are.....

☐ Very good ☐ Good ☐ Fair ☐ Poor ☐ Very poor

20 I am comfortable with eating vegetables that have been irrigated using waste water under the following conditions:

☐ Water is well treated

☐ Vegetables are thoroughly cooked

☐ Vegetables are thoroughly washed

☐ Vegetables are not in contact with the water

☐ I cannot eat

21 How would the use of wastewater to irrigate vegetables affect the price of vegetables in your area?

.....

.....

.....

.....

22 In your opinion, what do you consider to be some of the

a) **Advantages** of using wastewater for irrigation? Please state below

1.....

2.....

3.....

4.....

b) **Disadvantages** of using wastewater for irrigation? Please state below

1.....

2.....

3.....

4.....

23 What should the Local Council do about the practice if you consider waste water to be *(Please answer only one question)*

a) Bad: .....

.....

b) Good: .....

.....

24 What should government do about the practice if you consider waste water to be *(Please answer only one question)*

a) Bad: .....

.....

.....

b) Good: .....

.....

.....

.....

Thank you for your taking part in this study

APPENDIX 2a: TABULATED RESPONSES TO OPEN ENDED QUESTIONS

Q 6: If the answer to question 5 is yes, state the sources of waste water that you know

S/n	Source	Frequency
1	Sewer ponds	3
2	Drainage water	6
3	Domestic wastewater (flush toilets, wash sinks, bathing water)	19
4	Industry	11

Q 8a Treated wastewater is clean for the following reasons:

S/n	Response	Frequency
1	Confidence in the treatment process	17
2	Water is not stagnant	2

Q 8b Treated wastewater is not clean for the following reasons

S/n	Response	Frequency
1	Impurities remain	5
2	Treatment process is not perfect	4
3	Bad odour	1
4	Method of treatment	2
5	It is from the toilet	1
6	Causes disease	1
7	There is no way water can ever be considered clean	1

Q 18 Do you have any idea why some people use wastewater to irrigate crops?

S/n	Response	Frequency
1	Water is too expensive	8
2	Fresh water is not readily available	8
3	Wastewater contains essential nutrients	19
4	Wastewater is free	5
5	Lowers cost of production	1
6	Improves plant vigour	2
7	Encourages all season production	1
8	Wastewater is safe like any other source	1
9	Wastewater is in close proximity to gardens	1

Q 21 How would the use of wastewater affect the price of vegetables on the market?

S/n	Response	Frequency
1	Price of vegetables would be lowered	25
2	Increase in the availability vegetables on the market	2
3	Consumers would stop buying vegetables if they know wastewater is used to irrigate them	1
4	There would be no effect on the price	1
5	Price would increase if wastewater irrigation is popularised	4

Q 22a Advantages of using wastewater for irrigation...

S/n	Response	Frequency
1	Wastewater is cheap	19
2	Increase in supply of cheap vegetables	2
3	Improves plant vigour	6
4	Contains vital nutrients	16
5	Offseason cropping can be done	1
7	Wastewater is readily available	7
8	It is a form of reuse/water resource conservation	4
9	Quick growth of crops	4
10	Production is cost lowered	2

Q 22b Disadvantages of using wastewater for irrigation

S/n	Response	Frequency
1	Causes disease (diarrhoea, cholera, worms etc)	17
2	Water is dirty/impure	8
3	High nutrient load causes crop failure	4
4	Would distort market price of vegetables	2
5	Wastewater is not hygienic/bad odour	4
6	Contains toxic chemical residues	5
7	Would cause vandalism of pipes if practiced is allowed	2
8	Culturally not acceptable	2
9	Treatment process expensive	1

Q 23a What should council do about practice if it is bad?

S/n	Response	Frequency
1	Restrict access to area near stabilisation ponds	6
2	Introduce By laws to ban wastewater irrigation	8
3	Monitor wastewater irrigation activities and water quality	7
4	Prosecution of offenders	2

Q 23b What should the council do if the practice is good?

S/n	Response	Frequency
1	Ensure treatment is up to acceptable standard	3
2	Introduce access rights	2
3	Sensitisation and capacity building of community on issues of public health and wastewater handling	4
4	Fence stabilisation ponds to avoid dumping other waste	1

Q24a What should government do about practice if it is bad?

S/n	Response	Frequency
1	Provide alternative sources of irrigation water	1
2	Enforce laws to ban the practice	9
3	Provide alternative treatment and disposal methods to prevent irrigators having access to the water	1

Q24b What should government do about the practice if it is good?

S/n	Response	Frequency
1	Improve maintenance of WWTP and ponds must be fenced	2
2	Government allow wastewater for irrigation	4
3	Improve wastewater treatment standard	2
4	Government to regulate wastewater usage	5
5	Consumer rights awareness	2
6	More research in wastewater treatment and utilisation	3
7	Integrate into school curriculum issues of wastewater	1

APPENDIX 2B: TABULATED RESPONSES TO CLOSED END QUESTIONS

Id	Gender	Grade	Category	Income	WasteWaterSource	Cleanliness	Laundry	Drinking	Cooking	Irrigation	Vegetables	VegSource	OpinionPrice	ReasonPrice	IrrigWaterSources
1	Female	Grade 9	Restaurant Operator	K1,001,000-1,250,000	Yes	Agree	Very Unsafe	Very Unsafe	Very Unsafe	Unsafe		Market	Fair	Inputs Affordable	Shallow Well
2	Female	Grade 12	Restaurant Operator	Over 1,250,000	Yes	Strongly Disagr	Very Unsafe	Very Unsafe	Very Unsafe	Safe		Market	Fair	Inputs High	Wastewater
3	Male	Grade 12	Restaurant Operator	K501,000-750,000	Yes	Strongly Agree	Unsafe	Very Unsafe	Very Unsafe	Safe		Market	Expensive	Inputs High	Tap water
4	Male	Tertiary	Restaurant Operator	Over 1,250,000	Yes	Agree	Very Safe	Safe	Very Safe	Very Safe		Market	Expensive	Inputs High	Tap water
5	Male	Tertiary	Restaurant Operator	Under K500,000	Yes	Strongly Agree	Very Unsafe	Very Unsafe	Very Unsafe	Very Safe		Market	Fair	Inputs High	Tap/wastewater
6	Male	Tertiary	Consumer at home	K751,000-1,000,000	Yes	Agree	Unsafe	Very Unsafe	Very Unsafe	Unsafe		Market	Fair	Inputs High	Tap/wastewater
7	Female	Grade 12	Consumer at home	K751,000-1,000,000	Yes	Agree	Unsafe	Very Unsafe	Unsafe	Safe		Farm	Cheap	Inputs High	Wastewater
8	Male	Tertiary	Consumer at home	Under K500,000	Yes	Strongly Disagr	Dont Know	Unsafe	Unsafe	Dont Know		Market	Expensive	Inputs High	Tap/ wastewater
9	Female	Grade 9	Consumer at home	Under K500,000	Yes	Agree	Safe	Very Unsafe	Very Unsafe	Safe		Farm	Cheap	Inputs Low	Tap/ wastewater
10	Female	Tertiary	Consumer at home	K501,000-750,000	Yes	Strongly Disagr	Unsafe	Very Unsafe	Very Unsafe	Unsafe		Market	Fair	Inputs Low	Tap water
11	Female	Tertiary	Consumer at home	Under K500,000	Yes	Disagree	Unsafe	Very Unsafe	Very Unsafe	Safe		Market	Expensive	Inputs Affordable	Tap water
12	Male	Grade 9	Vegetable Seller	Under K500,000	Yes	Agree	Safe	Very Unsafe	Very Unsafe	Safe		Market	Fair	Inputs Affordable	Shallow Well
13	Male	Grade 9	Farmer Using wastewater	Under K500,000	Yes	Disagree	Safe	Unsafe	Very Unsafe	Safe		Market	Cheap	Inputs Low	Tap/ wastewater
14	Male	Grade 12	Farmer Using wastewater	Under K500,000	Yes	Disagree	Unsafe	Very Unsafe	Unsafe	Very Safe		Both	Expensive	Inputs High	Tap water
15	Male	Tertiary	Farmer Using wastewater	Under K500,000	Yes	Agree	Unsafe	Very Unsafe	Unsafe	Safe		Market	Fair	Inputs Affordable	Wastewater
16	Female	Grade 12	Farmer Using wastewater	Under K500,000	Yes	Strongly Agree	Safe	Very Safe	Safe	Very Safe		Both	Expensive	Inputs High	Tap water
17	Male	Tertiary	Farmer Using wastewater	Over 1,250,000	Yes	Disagree	Very Safe	Unsafe	Unsafe	Very Safe		Market	Expensive	Inputs High	Tap/ wastewater
18	Male	Tertiary	Consumer at home	Over 1,250,000	Yes	Strongly Disagr	Safe	Unsafe	Unsafe	Safe		Market	Expensive	Inputs High	River
19	Female	Tertiary	Vegetable Seller	Under K500,000	Yes	Agree	Very Safe	Safe	Safe	Very Safe		Market	Fair	Inputs Affordable	Wastewater
20	Female	Grade 9	Vegetable Seller	Under K500,000	Yes	Disagree	Unsafe	Unsafe	Very Unsafe	Safe		Market	Expensive	Inputs High	Wastewater
21	Male	Tertiary	Vegetable Seller	Under K500,000	Yes	Strongly Agree	Very Safe	Very Safe	Safe	Safe		Market	Fair	Inputs High	Wastewater
22	Female	Grade 7	Vegetable Seller	K501,000-750,000	Yes	Disagree	Safe	Safe	Very Unsafe	Very Safe		Market	Cheap	Inputs Affordable	Wastewater
23	Male	Grade 12	Vegetable Seller	Under K500,000	Yes	Strongly Disagr	Unsafe	Unsafe	Unsafe	Very Unsafe		Market	Cheap	Inputs Affordable	Shallow well/wastewater
24	Female	Tertiary	Farmer not using wastewater	Under K500,000	No	Disagree	Safe	Unsafe	Unsafe	Safe		Market	Fair	Inputs Affordable	Tap water
25	Male	Tertiary	Restaurant Patron	Under K500,000	Yes	Agree	Safe	Unsafe	Unsafe	Safe		Market	Fair	Inputs High	Tap water
26	Male	Grade 9	Restaurant Patron	K501,000-750,000	Yes	Disagree	Very Unsafe	Very Unsafe	Very Unsafe	Very Unsafe		Market	Expensive	Inputs High	Wastewater
27	Male	Tertiary	Restaurant Patron	K501,000-750,000	Yes	Agree	Very Unsafe	Very Unsafe	Very Unsafe	Safe		Market	Expensive	Inputs Affordable	Tap water
28	Male	Tertiary	Restaurant Patron	Over 1,250,000	Yes	Strongly Agree	Very Unsafe	Very Unsafe	Very Unsafe	Dont Know		Both	Fair	Inputs High	Tap water
29	Male	Tertiary	Vegetable Seller	Over 1,250,000	Yes	Strongly Agree	Very Safe	Very Safe	Very Safe	Very Safe		Market	Fair	Inputs Affordable	Tap water
30	Male	Grade 12	Consumer at home	K501,000-750,000	Yes	Strongly Agree	Safe	Unsafe	Unsafe	Safe		Market	Fair	Inputs High	Wastewater
31	Female	Under Gra	Vegetable Seller	Under K500,000	Yes	Agree	Safe	Dont Know	Dont Know	Safe		Market	Fair	Inputs High	Wastewater
32	Female	Grade 7	Vegetable Seller	Under K500,000	Yes	Agree	Very Unsafe	Very Unsafe	Very Unsafe	Very Unsafe		Market	Expensive	Inputs High	Wastewater
33	Female	Tertiary	Restaurant Patron	Under K500,000	Yes	Strongly Agree	Safe	Unsafe	Safe	Very Safe		Market	Fair	Inputs Affordable	Tap/ wastewater
34	Male	Grade 12	Farmer not using wastewater	Over 1,250,000	Yes	Agree	Unsafe	Very Unsafe	Unsafe	Safe		Market	Fair	Inputs Affordable	Wastewater
35	Female	Grade 12	Farmer not using wastewater	K501,000-750,000	Yes	Strongly Disagr	Very Unsafe	Very Unsafe	Very Unsafe	Very Unsafe		Market	Expensive	Inputs High	Tap water
36	Male	Tertiary	Farmer not using wastewater	Under K500,000	Yes	Agree	Safe	Unsafe	Dont Know	Safe		Market	Fair	Inputs High	Tap/ wastewater
37	Female	Tertiary	Farmer not using wastewater	K751,000-1,000,000	Yes	Strongly Disagr	Unsafe	Very Unsafe	Unsafe	Safe		Market	Expensive	Inputs Affordable	Tap water
38	Male	Grade 12	Consumer at home	Over 1,250,000	Yes	Strongly Disagr	Safe	Very Unsafe	Very Unsafe	Safe		Market	Fair	Inputs Low	Tap water
39	Male	Grade 9	Consumer at home	K751,000-1,000,000	Yes	Agree	Safe	Very Unsafe	Very Unsafe	Safe		Market	Expensive	Inputs High	Tap water
40	Female	Grade 12	Vegetable Seller	K751,000-1,000,000	No	Disagree	Unsafe	Unsafe	Unsafe	Unsafe		Market	Cheap	Inputs Affordable	Shallow Well

	PrevWasteWaterUse	WillingnessToUse	CropPerformance	ConditionForConsumpt	WWT	VTC	NWW	VTW
5	Strongly Agree	Disagree	Good	WWT	Yes	No	No	No
6	Strongly Agree	Strongly Agree	Good	WWT/VTC	Yes	Yes	No	No
7	Disagree	Disagree	Very Good	WWT/VTC	Yes	Yes	No	No
8	Agree	Disagree	Very Good	VTW/VTC/NWW	No	Yes	Yes	Yes
9	Strongly Agree	Strongly Agree	Very Good	WWT/VTW	Yes	No	No	Yes
10	Agree	Strongly Disagree	Fair	NWW	No	No	Yes	No
11	Agree	Agree	Good	NWW	No	No	Yes	No
12	Agree	Strongly Disagree	Fair	WWT/VTC/VTW	Yes	Yes	No	Yes
13	Agree	Agree	Dont Know	VTC/VTW	No	Yes	No	Yes
14	Strongly Disagree	Strongly Disagree	Good	WWT/VTC/VTW	Yes	Yes	No	Yes
15	Disagree	Agree	Fair	WWT/VTW	Yes	No	No	Yes
16	Agree	Agree	Very Good	WWT/VTC/VTW	Yes	Yes	No	Yes
17	Strongly Agree	Strongly Agree	Very Good	VTC	No	Yes	No	No
18	Disagree	Strongly Agree	Fair	WWT/VTC/VTW	Yes	Yes	No	Yes
19	Strongly Agree	Agree	Good	VTW/VTC/NWW	No	Yes	Yes	Yes
20	Agree	Disagree	Very Good	WWT/VTC/VTW	Yes	Yes	No	Yes
21	Disagree	Agree	Very Good	I cant eat	No	No	No	No
22	Strongly Disagree	Strongly Disagree	Good	WWT/VTW	Yes	No	No	Yes
23	Strongly Agree	Strongly Disagree	Very Good	VTW	No	No	No	Yes
24	Strongly Agree	Strongly Disagree	Good	VTC	No	Yes	No	No
25	Disagree	Strongly Disagree	Very Good	WWT/VTC/VTW	Yes	Yes	No	Yes
26	Agree	Agree	Very Good	All conditions met	Yes	Yes	Yes	Yes
27	Strongly Agree	Disagree	Very Good	I cant eat	No	No	No	No
28	Strongly Disagree	Strongly Disagree	Fair	WWT	Yes	No	No	No
29	Agree	Disagree	Good	WWT	Yes	No	No	No
30	Agree	Disagree	Good	I cant eat	No	No	No	No
31	Strongly Disagree	Agree	Very Good	VTW/NWW	No	No	Yes	Yes
32	Agree	Disagree	Fair	WWT	Yes	No	No	No
33	Strongly Agree	Disagree	Very Good	WWT	Yes	No	No	No
34	Strongly Agree	Agree	Very Good	VTC	No	Yes	No	No
35	Agree	Agree	Very Good	VTW	No	No	No	Yes
36	Strongly Agree	Disagree	Very Good	NWW	No	No	Yes	No
37	Strongly Agree	Strongly Agree	Very Good	VTW	No	No	No	Yes
38	Agree	Strongly Disagree	Very Good	VTC/VTW/NWW	No	Yes	Yes	Yes
39	Agree	Disagree	Very Good	NWW	No	No	Yes	No
40	Strongly Disagree	Disagree	Fair	WWT/VTC/VTW	Yes	Yes	No	Yes
41	Agree	Strongly Agree	Fair	WWT	Yes	No	No	No
42	Disagree	Strongly Disagree	Very Good	VTC/VTW	No	Yes	No	Yes
43	Agree	Disagree	Fair	WWT/VTC/VTW	Yes	Yes	No	Yes
44	Agree	Strongly Disagree	Good	I cant eat	No	No	No	No

APPENDIX 2C: CODED RESPONSES TO CLOSE ENDED QUESTIONS

ID	Sex	Age	Education	Category	Income	WastewaterSources	Cleanlinessofwastewater	Laundry	Drinking	Cooking	Irrigation	VegetableSources	OpinionOnPrice	PriceVegetables
1	2.00	3.00	3.00	2.00	4.00	1.00	2.00	5.00	5.00	5.00	4.00	1.00	2.00	3.00
2	2.00	1.00	4.00	2.00	5.00	1.00	4.00	5.00	5.00	5.00	2.00	1.00	2.00	1.00
3	1.00	3.00	4.00	2.00	2.00	1.00	1.00	4.00	5.00	5.00	2.00	1.00	1.00	1.00
4	1.00	3.00	5.00	2.00	5.00	1.00	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	5.00	2.00	1.00	1.00	1.00	5.00	5.00	5.00	1.00	1.00	2.00	1.00
6	1.00	2.00	5.00	5.00	3.00	1.00	2.00	4.00	5.00	5.00	4.00	1.00	2.00	1.00
7	2.00	4.00	4.00	5.00	3.00	1.00	2.00	4.00	5.00	4.00	2.00	2.00	3.00	1.00
8	1.00	2.00	5.00	5.00	1.00	4.00	4.00	3.00	4.00	4.00	3.00	1.00	1.00	1.00
9	2.00	1.00	3.00	5.00	1.00	1.00	2.00	2.00	5.00	5.00	2.00	2.00	3.00	2.00
10	2.00	2.00	5.00	5.00	2.00	1.00	4.00	4.00	5.00	5.00	4.00	1.00	2.00	2.00
11	2.00	1.00	5.00	5.00	1.00	1.00	3.00	4.00	5.00	5.00	2.00	1.00	1.00	3.00
12	1.00	1.00	3.00		1.00	1.00	2.00	2.00	5.00	5.00	2.00	1.00	2.00	3.00
13	1.00	1.00	3.00	3.00	1.00	1.00	3.00	2.00	4.00	5.00	2.00	1.00	3.00	2.00
14	1.00	1.00	4.00	3.00	1.00	1.00	3.00	4.00	5.00	4.00	1.00	3.00	1.00	1.00
15	1.00	1.00	5.00	3.00	1.00	1.00	2.00	4.00	5.00	4.00	2.00	1.00	2.00	3.00
16	2.00	4.00	4.00	3.00	1.00	1.00	1.00	2.00	1.00	2.00	1.00	3.00	1.00	1.00
17	1.00	2.00	5.00	3.00	5.00	1.00	3.00	1.00	4.00	4.00	1.00	1.00	1.00	1.00
18	1.00	2.00	5.00		5.00	1.00	4.00	2.00	4.00	4.00	2.00	1.00	1.00	1.00
19	2.00	1.00	5.00	1.00	1.00	1.00	2.00	1.00	2.00	2.00	1.00	1.00	2.00	3.00
20	2.00	1.00	3.00	1.00	1.00	1.00	3.00	4.00	4.00	5.00	2.00	1.00	1.00	1.00
21	1.00	4.00	5.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	1.00	2.00	1.00
22	2.00	4.00	2.00	1.00	2.00	1.00	3.00	2.00	2.00	5.00	1.00	1.00	3.00	3.00
23	1.00	1.00	4.00	1.00	1.00	1.00	4.00	4.00	4.00	4.00	5.00	1.00	3.00	3.00
24	2.00	1.00	5.00	4.00	1.00	2.00	2.00	2.00	4.00	4.00	2.00	1.00	2.00	3.00
25	1.00	2.00	5.00	6.00	1.00	1.00	2.00	2.00	4.00	4.00	2.00	1.00	2.00	1.00
26	1.00	4.00	3.00	6.00	2.00	1.00	3.00	5.00	5.00	5.00	5.00	1.00	1.00	1.00
27	1.00	2.00	5.00	6.00	2.00	1.00	2.00	5.00	5.00	5.00	2.00	1.00	1.00	3.00
28	1.00	2.00	5.00	6.00	5.00	1.00	1.00	5.00	5.00	5.00	3.00	3.00	2.00	1.00
29	1.00	2.00	5.00	4.00	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	3.00
30	1.00	2.00	4.00		2.00	1.00	1.00	2.00	4.00	4.00	2.00	1.00	2.00	1.00
31	2.00	2.00	1.00		1.00	1.00	2.00	2.00	3.00	3.00	2.00	1.00	2.00	1.00
32	2.00	4.00	2.00		1.00	1.00	2.00	5.00	5.00	5.00	5.00	1.00	1.00	1.00
33	2.00	1.00	5.00	6.00	1.00	1.00	1.00	2.00	4.00	2.00	1.00	1.00	2.00	3.00
34	1.00	3.00	4.00	4.00	5.00	1.00	2.00	4.00	5.00	4.00	2.00	1.00	2.00	3.00
35	2.00	1.00	4.00	4.00	2.00	1.00	4.00	5.00	5.00	5.00	5.00	1.00	1.00	1.00
36	1.00	2.00	5.00	4.00	1.00	1.00	2.00	2.00	4.00	3.00	2.00	1.00	2.00	1.00
37	2.00	2.00	5.00	4.00	3.00	1.00	4.00	4.00	5.00	4.00	2.00	1.00	1.00	3.00

IrrigationWaterSources	PrevalenceWastewaterUse	PrevalenceOfWastewaterUsers	WillingnessToUse	CropPerformance	ConditionsForConsumption
2.00	1.00	1.00	3.00	2.00	1.00
4.00	1.00	1.00	1.00	2.00	2.00
1.00	3.00	2.00	3.00	1.00	2.00
1.00	2.00	2.00	3.00	1.00	14.00
7.00	1.00	1.00	1.00	1.00	3.00
7.00	2.00	1.00	4.00	3.00	10.00
4.00	2.00	2.00	2.00	2.00	10.00
5.00	2.00	1.00	4.00	3.00	12.00
5.00	2.00	1.00	2.00	6.00	6.00
1.00	4.00	2.00	4.00	2.00	12.00
1.00	3.00	2.00	2.00	3.00	3.00
2.00	2.00	1.00	2.00	1.00	12.00
5.00	1.00	1.00	1.00	1.00	5.00
1.00	3.00	1.00	1.00	3.00	12.00
4.00	1.00	1.00	2.00	2.00	14.00
1.00	2.00	1.00	3.00	1.00	12.00
5.00	3.00	2.00	2.00	1.00	0.00
3.00	4.00	2.00	4.00	2.00	3.00
4.00	1.00	1.00	4.00	1.00	8.00
4.00	1.00	1.00	4.00	2.00	5.00
4.00	3.00	1.00	4.00	1.00	12.00
4.00	2.00	1.00	2.00	1.00	15.00
9.00	1.00	1.00	3.00	1.00	0.00
1.00	4.00	2.00	4.00	3.00	1.00
1.00	2.00	1.00	3.00	2.00	1.00
4.00	2.00	1.00	3.00	2.00	0.00
1.00	4.00	2.00	2.00	1.00	9.00
1.00	2.00	1.00	3.00	3.00	1.00
1.00	1.00	1.00	3.00	1.00	1.00
4.00	1.00	1.00	2.00	1.00	5.00
4.00	2.00	1.00	2.00	1.00	8.00
4.00	1.00	1.00	3.00	1.00	10.00
5.00	1.00	1.00	1.00	1.00	8.00
4.00	2.00	1.00	4.00	1.00	13.00
1.00	2.00	1.00	3.00	1.00	10.00
5.00	4.00	1.00	3.00	3.00	12.00
1.00	2.00	1.00	1.00	3.00	1.00