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Economic Analysis and Policy Implications of Wastewater Use in Agriculture in the Central Region of Ethiopia

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Declaration

I declare that this dissertation is a result of my personal work and that no other than the indicated aids have been used for its completion. All quotations and statements that have been used are indicated. Further more I assure that the work has not been used neither completely nor in parts for achieving any other academic degree.

Stuttgart, Hohenheim 3. 12. 2008

Alebel Bayrau Weldesilassie

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Executive Summary

The general objective of this study was to analyze the impact of wastewater use in agriculture. It mainly focused on three aspects of wastewater use for irrigation and their policy implications: impact on crop production and productivity; its impact on the health of farmers; and the value attached to its safe use for irrigation. The main objectives of the study were, therefore, 1) to define the farming system of wastewater farmers and to analyze the impact of wastewater on crop productivity; 2) to analyze the prevalence of the actual health risks to farmers and estimate the health costs associated with the use of wastewater in irrigation; and 3) to estimate the farmer's willingness to pay for improved or safe use of wastewater for crop production.

This study used mainly primary data collected from a household survey conducted on 415 wastewater and freshwater farm households operating irrigated agricultural activities within and around Addis Ababa, a central region of Ethiopia. A Cobb Douglas production function is specified to analyze the impact of wastewater on crop productivity. The production function was estimated using a Censored Least Absolute Deviation (CLAD) econometric model. To analyze the health impact of wastewater, the probability of illness was estimated based on the theory of the utility maximizing behavior of households subject to the conventional farm household production model modified by adding a health production function. The economic value of safe use of wastewater is estimated from data obtained from a contingent valuation survey administered by in-person interviews. A dichotomous choice model is used to elicit the farmers' willingness to pay. Bivariate probit and interval regression models are used to analyze the factors determining the farmers' willingness to pay for safe use of wastewater for crop production.

The study shows that the livelihoods of wastewater farm households depend on the wastewater farm. Income from a wastewater farm accounts for 62% of total annual household income, ranging from 27% to 97%. About 61% of the vegetable market of Addis Ababa, the capital city of Ethiopia with more than five million people, is produced from the wastewater farms. Leafy vegetables, which are eaten raw, are mainly produced in less polluted wastewater farms and root vegetables are produced in more polluted wastewater farms. The study revealed that wastewater farm households use significantly less doses of chemical fertilizer compared to the freshwater irrigators. However, they spend three times more on seed and five times more on farm labor. Net farm return per hectare of plots irrigated with wastewater is significantly higher than for plots irrigated with freshwater. The results also indicate that the predicted median output value per hectare is significantly higher in wastewater irrigated plots compared to plots irrigated with freshwater. The CLAD estimation result shows that higher productivity of wastewater plots is explained by investments in inputs (organic fertilizer, improved seed and agricultural extension services), ownership of plots and levels of pollution of the irrigation water. The overall effect of wastewater on crop productivity is negative and insignificant (compared to freshwater). Plots irrigated with less polluted wastewater are more productive than plots irrigated with more polluted wastewater. The implication of the result is that even if wastewater is a reliable source of irrigation water and contains essential plant nutrients such as NPK, the nutrient content exceeds the recommended level of the plant requirement (e.g. nitrogen) or it contains toxic elements (e.g. nickel, zinc) above the recommended limit, and thereby reduce yield.

Due to unsafe wastewater irrigation systems, wastewater use in irrigation actually poses health risks to farmers. Apart from working on wastewater farms, different risk factors prevail that can

cause wastewater-related diseases in the studied areas. This study shows that major risk factors causing illness are household demographic characteristics, hygienic behavior of farm families and poor access to sanitation services. Lack of awareness on health risk of wastewater as well as working without protective clothing on the farm are also important risk factors in the study area. The distribution of these risk factors varies between the wastewater and freshwater irrigation areas. The most common incidence of illness reported by farm households are intestinal infection due to hookworm and *Ascaris*, diarrhea and skin diseases, which also varies between the two groups of farmers as well as within the different areas of wastewater. The findings of this study show that the prevalence of illness is not only significantly higher in farmers working on wastewater farms compared to freshwater irrigators, but is also significantly higher in wastewater areas where the pollution level is higher. The probability of being sick with an intestinal illness is 15% higher for wastewater farmers than for freshwater farmers. Use of protective clothing during farm work and awareness of health risks in working on wastewater farms significantly reduce illness prevalence. In addition, hygienic behavior of farm families including eating safe raw vegetables, compound sweeping, and washing hands before a meal are important determinants of illness prevalence in wastewater irrigation areas. Therefore, use and provision of protective clothing at affordable prices, creating awareness for safe use of wastewater, and reducing the pollution level of irrigation water can significantly decrease the health risk of wastewater use in irrigation. While each of these policy interventions has a significant effect in reducing health risks, combining these measures will result in more significant reduction of health risks to farmers, and thereby maximize the benefit from the wastewater resource as a source of livelihood and vegetable supply to the residents of nearby cities.

Farmers are willing to contribute money to improve the existing unsafe irrigation system. Two options were suggested by farmers to improve the existing situation: enforcing laws against polluters who discharge their wastewater without any kind of treatment, and awareness creation of safe use of wastewater for irrigation. Farmers are willing to pay for the improvement programs and there is a welfare gain to the society from safe use of wastewater for crop production. The benefit from irrigated-farming, membership to water users' association, yield value, off-farm income and working on a wastewater farm all significantly determine the farmers' probability of accepting offered bids for the improvement program. In addition to these variables, multi-purpose uses of irrigation water as well as education level determines the farmers' willingness to pay. Irrigation method has no significant effect on the farmers' willingness to pay, implying that introducing water saving and improved irrigation techniques has an important role in improving the situation without affecting the farmers' willingness to pay.

Overall, this study shows that wastewater is a means of livelihood for many poor households, but the existing use of wastewater for crop production actually causes health risks both to farmers and consumers. Farmers are willing to contribute to programs designed to improve the existing situation so that it is possible to maximize the livelihood benefit at minimum health risks. However, the results do not necessarily imply that the cost of improving the situation has to be borne by the farmers only. Although the study focuses on the central region of Ethiopia, most conclusions can have a wider application in other parts of the country and in many sub-Saharan African countries where wastewater is used for irrigation.

Zusammenfassung

Ziel der Studie ist es, die Auswirkungen von Abwassernutzung in der Landwirtschaft zu analysieren. Die Arbeit richtet ihren Focus dabei hauptsächlich auf drei Aspekte der Auswirkungen von Abwassernutzung: die Auswirkungen auf die Pflanzenproduktion und deren Produktivität, die Auswirkungen auf die Gesundheit der Landwirte, sowie auf den Wert einer sicheren Nutzung des Abwassers zur Bewässerung. Die spezifischen Ziele der Studie sind 1) die Abwasser nutzenden Anbausysteme zu definieren und die Auswirkungen der Abwassernutzung auf die Produktivität zu analysieren; 2) die Auswirkungen der Abwassernutzung auf die Gesundheitsrisiken der Landwirte zu analysieren und die dadurch anfallenden Kosten abzuschätzen; und 3) die Zahlungsbereitschaft der Landwirte für eine verbesserte oder sichere Nutzung von Abwässern in der Pflanzenproduktion abzuschätzen.

Die Studie nutzt im Wesentlichen Primärdaten aus einer Haushaltserhebung von 415 landwirtschaftlichen Haushalten bei Addis Ababa (Zentral-Äthiopien), die Abwasser und Frischwasser zur Bewässerung verwenden. Eine Cobb-Douglas-Produktionsfunktion wurde spezifiziert, um die Auswirkungen der Abwassernutzung auf die Produktivität zu analysieren, sie wurde mit Hilfe eines ökonometrischen Censored Least Absolute Deviation (CLAD) Modells geschätzt. Um Auswirkungen auf die Gesundheit abzuschätzen, wurde die Wahrscheinlichkeit für eine Erkrankung unter Verwendung einer erweiterten Theorie des nutzenmaximierenden Haushalts durch eine Gesundheitsproduktionsfunktion geschätzt. Der ökonomische Wert der sichereren Nutzung von Abwässern wurde über eine Contingent Value-Analyse von Daten aus persönlichen Interviews geschätzt. Ein Double-Bounded Dichotomes Choice Modell wurde genutzt, um die Zahlungsbereitschaft der Landwirte festzustellen. Bivariate Probit- und Intervall-Regressionsmodelle wurde genutzt, um die Einflussfaktoren auf Zahlungsbereitschaft der Landwirte für eine sichere Nutzung von Abwässern zur Pflanzenproduktion zu ermitteln.

Die Studie zeigt, dass das Haushaltseinkommen zu wesentlichen Teilen aus der Landwirtschaft stammt. Für die Haushalte, die Abwasser für die landwirtschaftliche Produktion nutzen, beträgt das aus landwirtschaftlichen Quellen stammende Einkommen ca. 61 % des Gesamteinkommens, mit einer Spannweite zwischen 27% und 97%. Ungefähr 61% des Gemüsemarktes von Addis Ababa, der Hauptstadt Äthiopiens mit mehr als 5 Millionen Einwohnern, werden durch Betriebe bereitgestellt, die Abwässer zur Pflanzenproduktion nutzen. Roh verzehrtes Blattgemüse wird im Gegensatz zu Wurzelgemüse meist in weniger mit Abwasser belasteten Gebieten angebaut. Die Studie ergab, dass Abwasser nutzende Betriebe signifikant geringere Mengen an chemischen Düngern nutzen als Betriebe, die mit Frischwasser bewässern. Jedoch geben sie drei Mal soviel Geld für Saatgut und fünf Mal soviel für Arbeitskräfte aus. Der Nettoertrag pro Hektar auf den mit Abwasser bewässerten Parzellen ist signifikant höher als auf Parzellen, die mit Frischwasser bewässert wurden. Die Ergebnisse zeigen ferner, dass auch der mit Hilfe des ökonometrischen Modells vorausgesagte mediane Ertragswert pro Hektar bei mit Abwässern bewässerten Parzellen signifikant höher ist als auf Parzellen, die mit Frischwasser bewässert wurden. Die Ergebnisse des CLAD-Modells zeigen, dass die höhere Produktivität der Abwässer-Parzellen mit dem Aufwand an Inputs (organischer Dünger, verbessertes Saatgut und landwirtschaftliche Beratungsdienste), mit den Besitzverhältnissen an den Parzellen und der Höhe der Verschmutzung des Wassers erklärt werden kann. Der Gesamteffekt von Abwasser auf die Produktivität ist negativ und nicht signifikant. Parzellen, die mit weniger verschmutztem Wasser bewässert werden sind produktiver als Parzellen mit stärker verschmutzem Abwasser. Daraus

lässt sich folgern, dass, auch wenn das Abwasser wichtige Pflanzennährstoffe wie NPK enthält, diese die benötigte Menge jedoch übersteigen (z.B bei Stickstoff) oder, dass toxische Elemente (z.B. Nickel, Zink) oberhalb der empfohlenen Grenzen liegen, so dass das Pflanzenwachstum negativ beeinflusst wird und der Ertrag reduziert wird.

Aufgrund gefährlicher Abwasser-Bewässerungssysteme verursacht Abwasser Gesundheitsrisiken für Landwirte. Abgesehen von der Tatsache, dass sie überhaupt auf solchen Betrieben arbeiten, zeigten sich verschiedene andere Risikofaktoren, die mit dem Abwasser zusammenhängende Krankheiten bewirken können. Die Studie zeigt, dass die Hauptrisikofaktoren die demographischen Charakteristika der Haushalte, das Hygieneverhalten der Familien und ein schlechter Zugang zu sanitären Einrichtungen sind. Zudem sind mangelndes Problembewusstsein sowie das Arbeiten ohne Schutzkleidung wichtige Einflussfaktoren im Untersuchungsgebiet. Die Verteilung dieser Faktoren variiert zwischen den Gebieten der Abwasser- und der Frischwassernutzung. Die am meisten auftretenden Erkrankungen sind die durch den Astaris- und den Hakenwurm verursachte intestinale Infektionen, Durchfall- und Hauterkrankungen, die wiederum zwischen den beiden Gruppen der Landwirte sowie den Abwassergebieten variieren. Die Studie zeigt, dass nicht nur Erkrankungen im Bereich abwassernutzender Areale häufiger sind, sondern dass die Zahl der Erkrankungen signifikant höher in Bereichen höherer Verschmutzung ist. Die Wahrscheinlichkeit an intestinalen Infektionen zu erkranken ist bei Abwassernutzern um 15% höher als bei Frischwassernutzern. Schutzkleidung und verbessertes Risikobewusstsein senken die Krankheitswahrscheinlichkeit signifikant. Zudem sind Hygieneverhalten, das Essen von sicherem rohen Gemüse, das Fegen bzw. Reinigen des Hof-Geländes, sowie das Waschen der Hände vor dem Essen, wichtige Determinanten des Gesundheitsrisikos in abwassernutzenden Gebieten. Daher können das Anbieten und Nutzen von erschwinglicher Schutzkleidung, ein verbessertes Risikobewusstsein sowie Maßnahmen zur Reduzierung der Verunreinigung von Bewässerungswasser das Gesundheitsrisiko signifikant verringern. Während schon jede der genannten Maßnahmen selbst eine signifikante Verbesserung darstellt, würde eine Kombination dieser Maßnahmen das Gesundheitsrisiko noch deutlicher reduzieren und somit den Nutzen der Abwasseressource als Quelle des Lebensunterhalts und der Gemüseversorgung für die Anwohner der nahegelegenen Städte verbessern.

Die Landwirte äußerten bei der Befragung die Bereitschaft einen finanziellen Beitrag zu einer größeren Sicherheit der Bewässerungssysteme zu leisten. Zwei Optionen wurden von ihnen zur Verbesserung vorgeschlagen: Die vorgeschriebene Abwasserbehandlung durch die Verursacher, und das Schaffen von Bewusstsein für einen sicheren Umgang mit Abwasser. Die Zahlungsbereitschaft der Landwirte für eine sichere Abwassernutzung bedeutet, dass eine Steigerung der Wohlfahrt möglich wäre. Die Höhe des Nutzens aus der Bewässerungslandwirtschaft, die Mitgliedschaft in Wassernutzungsgemeinschaften, der Wert des Ertrages, das Einkommen außerhalb der Landwirtschaft und die Frage, ob es sich um einen Abwasser nutzenden Betrieben handelt bestimmen signifikant die Wahrscheinlichkeit der Annahme der angebotenen Programme durch die Landwirte. Zusätzlich zu diesen Variablen bestimmt die Frage der Mehrfachnutzung des Bewässerungswassers und der Ausbildungsgrad der Landwirte die Zahlungsbereitschaft.

Zusammenfassend zeigt die Studie, dass die Nutzung von Abwasser für viele arme Haushalte bedeutend für den Lebensunterhalt ist, dass jedoch die gegenwärtige Abwassernutzung Gesundheitsrisiken für Landwirte und für Konsumenten birgt. Die Landwirte sind bereit, für

Programme zu bezahlen, die die Situation verbessern könnten, so dass es möglich wäre die Lebensbedingungen zu verbessern, bei verringertem Gesundheitsrisiko. Jedoch bedeuten die Ergebnisse nicht zwingend, dass die Kosten allein von den Landwirten getragen werden müssen. Obwohl sich die Studie auf Zentral-Äthiopien bezieht, können die meisten Erkenntnisse auf größere Teile des Landes und auf viele afrikanische Sub-Sahara Länder, in denen Abwasser zu Bewässerung genutzt wird, übertragen werden.

List of abbreviations

AAWSSA:	Addis Ababa Water Supply and Sewerage Authority
BOD:	Biochemical Oxygen Demand
COD:	Chemical Oxygen Demand
CLAD:	Censored Least Absolute Deviation
CSA:	Central Statistical Agency of Ethiopia
CV:	Contingent Valuation
CVM:	Contingent Valuation Method
DBDC:	Double-bounded dichotomous choice
DO:	Dissolved Oxygen
EEPA:	Ethiopian Environmental Protection Agency
ETB:	Ethiopian Birr
GDP:	Gross Domestic Product
IWMI:	International Water Management Institute
MM^3:	Million Cubic Meters
MoFED:	Ministry of Finance and Economic Development
NPK:	Nitrogen, Phosphorous, Potassium
SBDC:	Single-bounded dichotomous choice
SS:	Suspended Solids
UNDP:	United Nations Development Program
WTP:	Willingness to Pay
WHO:	World Health Organization
WUA:	Water Users' Association

CHAPTER 1: INTRODUCTION

1.1. Background

Sub-Saharan African countries, in general and Ethiopia in particular, are facing major challenges with regard to alleviating the persistent problem of poverty. Agriculture is the backbone of the economies of these countries, yet it is rain-fed; hence, their people are subject to frequent droughts. Ethiopia's economy is dominated by subsistence smallholder agriculture. The sector contributes the largest share to GDP, export trade, earnings and employment. It accounts for 46.2% of the GDP, 85% of employment and 82.2% of the income from the export trade for 2003/4 (Ministry of Finance and Economic Development (MoFED), 2006; Ethiopian Economic Association, 2005). Of the total population of 77 million, 38.7% live below the poverty line in 2004/05 (MoFED 2006). The performance of Ethiopian agriculture is very low by any standard, which is reflected in the low level of land and labor productivity. The fluctuation of the performance of the Ethiopian economy is highly linked to the performance of the agricultural sector. For instance, between 1999/2000 and 2003/04, the annual agricultural growth rate has been negative for two years due to drought, during which the real GDP growth was negative 3.3%. During the remaining three years the economy grew by 11.6% (MoFED, 2006). The differences in growth rate are mainly due to the high dependence of agriculture on rainfall, which is erratic in nature. Therefore, there is a pressing need for developing the potential of the country through irrigation.

The increase in population numbers and the high dependence of the economy on agriculture contributes to increased demand and competition for limited water resources, thus calling for more efficient management. In light of the growing scarcity and competition for water resources, there are different options for developing and using water for different uses including food production. The options include, among others, rainwater harvesting, development of wetlands, use of surface water and ground water, use of municipal wastewater, and desalination.

A large volume of wastewater is being generated as a result of high rates of urbanization in developing countries. It is projected that 88% of the world population growth (projected at one billion by 2015) will take place in cities, the majority of them in developing countries (UNDP, 1998). This increase in population calls for increased water use, which ensures wastewater because the depleted fraction of domestic and residential water use is typically only 15–25% with the remainder returning as wastewater (Scott *et al*., 2002). These growing populations are also connected with sewers that deliver largely untreated wastewater. In most developing countries, wastewater is discharged to nearby rivers and streams without any kind of treatment.

These rivers are used as source of irrigation water for crop production to feed the urban population and serve as a livelihood asset for many farm families. It is estimated that from 3.5 million to 20 million hectares of land are being irrigated with untreated and semi-treated wastewater in approximately 50 developing countries (Hussain *et al*., 2002; IWMI, 2006). The reasons for using wastewater in crop production vary from region to region and are driven by multiple factors. These factors include water scarcity, reliability of wastewater supply, lack of alternative water sources, livelihood and economic dependence, proximity to markets, and nutrient value of the wastewater. Yet, the use of wastewater in agriculture has both positive and negative impacts that are reflected through crop production, public health, soil resource, groundwater, property value and ecology (Hussein *et al*., 2002; Scott *et al*., 2002).

Evidence of the impact of wastewater on crop production indicates that wastewater is used as a source of irrigation water both in arid and semi-arid regions as well as in areas where rainfall is erratic both in terms of distribution and frequency. If crops are under supplied with essential nutrients such as nitrogen, phosphorus and potassium, wastewater irrigation serves as a supplementary nutrient and thereby increases crop yield, which in turn increases returns from farming. It also decreases the need for artificial fertilizer and reduces farmers' input cost. On the other hand, yield can also be negatively affected if the nutrient content of the wastewater is in excess of the plant requirement. This is because it will add nutrients, dissolved solids and heavy metals, which can accumulate in the soil over time if the wastewater is used for extended periods. This results in increased salinity or alkalinity of the soil and water logging that destructs the soil structure and reduces soil productivity, thereby affecting crop production. From an economic point of view, Hussein *et al*. (2002) identified other impacts on soil resources including depreciation in market value of land, the cost of additional nutrients and soil reclamation measures.

In relation to the negative impact of wastewater use on public health, it has been shown that irrigation with untreated wastewater can represent a major threat to public health. Wastewater contains microorganisms such as bacteria, viruses and parasites and thus increases the exposure of farmers, consumers and neighboring communities to infectious diseases (Shuval *et al.,* 1986). The concentration of fecal coli forms and nematode eggs in the wastewater are the two primary sources of waterborne infection that measure the microbial quality of wastewater. The main concern for wastewater as a source of health risks emanates from its connection to chronic, low-grade gastrointestinal diseases as well as outbreaks of more acute diseases such as cholera and typhoid. The exposure route to farmers is through working with wastewater and contaminated soil as well as through the consumption of raw vegetables produced using the wastewater. For the urban population, this occurs through the consumption of raw vegetables irrigated with the wastewater (Fattal and Shuval, 1999). Furthermore, as wastewater is used to irrigate fodders for livestock consumption, evidence shows that there is also a human health risk due to heavy metal transmission from the consumption of milk produced from livestock fed with fodder (Swarup *et al*., 1997).

The other important potential impact of wastewater is on the environment. This includes impact on the quality of the soil, ground and surface water as well as the biodiversity of contaminated water bodies. The impact on the groundwater is also reflected on human health especially in areas where the water supply source from groundwater is located near the contaminated water bodies or land. The wastewater drained from crop irrigation may serve as a source of groundwater recharge and it is estimated that 50-70% of the irrigation water may percolate to a groundwater aquifer and affect the groundwater quality (Rashed *et al*., 1995). However, this impact depends on factors including depth of the water table, soil drainage and extent of wastewater irrigation. The impact on biodiversity is pronounced when the irrigation water or wastewater from the city is drained to confined and small lakes and creates eutrophication that affects aquatic life and reduces lake biodiversity. This ecological impact can be transformed into economic impacts in so far as the lakes serve the community for fishing activities.

These economic, social and environmental potential benefits and costs of wastewater use in irrigation vary from region to region and from community to community depending on the volume and source of the wastewater, composition of the wastewater, degree of treatment before use as well as its management at the farm level, including irrigation techniques and crops grown. The new WHO guideline on water quality standards for irrigation, which recognizes the Hyderabad declaration (http://www.ruaf.org/node/269), suggests that countries should adapt the guideline to their own social, technical, economic and environmental circumstances based on scientific information (WHO, 2006).

In general, the practice of wastewater use in irrigation is pervasive, but is largely unregulated in low-income countries like Ethiopia, and the actual costs and benefits are poorly understood. The challenge to the decision makers is how to maximize the benefit from the wastewater resources while reducing health and environmental risks. In order to propose realistic, effective, and sustainable management approaches, it is crucial to understand the context-specific tradeoffs between the health of producers and consumers, on the one hand, and wastewater irrigation benefits and farmers' perceptions on the other. This challenge raises the following policy questions: Should the traditional practice of wastewater use in irrigation be banned? If 'Yes', what will be the fate of the poor farm households who have based their survival on the wastewater and what will happen to the source of the vegetables for the residences of the nearby city? If 'No', what will be the health of the consumers and farmers? The other policy question is: Should it be treated and to what level and at what cost? Overall, what should be the basis for policy decisions? These policy questions should be answered so that policymakers can make sound and scientific-based decisions on how to maximize the benefit from wastewater resources while reducing health and environmental risks.

1.2. Objective and scope of the study

1.2.1. Objective

The general objective of this study is to analyze the actual costs and benefits of wastewater use in irrigation in Ethiopia so as to maximize the benefits of wastewater use in crop production while reducing health risks to both farmers and consumers. Specifically, the main objectives of the study are:

1. To analyze the economic costs and benefits of wastewater use in crop production, its productivity impact, and define the farming system of the wastewater farmers and compare with non-wastewater irrigators;
2. To analyze the prevalence of the actual health risks to farmers involved in wastewater irrigation and contrast those risks with non-wastewater irrigators, and to estimate the actual health cost associated with wastewater use for irrigation;
3. To estimate farmers' willingness to pay for improved or safe use of wastewater for crop production and analyze the factors that affect their willingness to pay;
4. Based on the findings, to draw some policy implications on how to maximize the benefit from the wastewater resource at minimum health risks.

1.2.2. Scope of the study

As discussed previously, the potential impacts of wastewater use in agriculture are multidimensional and generally classified into socioeconomic, health and environmental impacts. However, from an economic policy point of view, it is the actual (not the potential) impact that should be valued. A comprehensive valuation of the benefits and costs of the impacts in relation to these aspects is required to identify, assess and examine the actual benefits and costs. The research questions pointed out previously are very broad since the questions are directly related to at least four economic agents both from the demand and supply side of wastewater. These are the farmers, consumers (or society as whole), industries and the municipality or the environmental protection agency. Thus, analysis of the actual impacts of wastewater use in irrigation should incorporate at least these economic agents. First, from the demand side, the farmers are using the wastewater for their survival due to absence of other livelihood means, and their objective is to ensure food security for their family. Second, the residents of a nearby city or society as a whole want to maximize the social gains from the use of wastewater for irrigation with minimum health risks and environmental impacts. Since society acts as a consumer of produce, it benefits from the supply of fresh vegetable produced using wastewater, while at the same time, society acts as a supplier of wastewater by generating and disposing of waste, polluting rivers and streams which are used for irrigation. Third, industries are a supplier of wastewater by generating and discharging it into nearby rivers and streams without any treatment, since their objective is to minimize production costs. Fourth, the municipality or the environmental protection agency is responsible for formulating policy, implementing, monitoring and enforcing rules and regulations so that the residents of the city live in a healthy environment through efficient environmental sanitation services without affecting downstream communities. Therefore, these four economic agents should be taken into consideration when analyzing the impacts of wastewater use for irrigation.

However, our study focuses on the demand side, specifically farmers, for the following reasons. First, farmers, as producers, are more exposed to wastewater and to contaminated soil. Second, as farmers are also consumers of produce, studying the demand side has the advantage of identifying the actual impact of the wastewater that can be considered as a minimum impact from wastewater both from the producer and consumer side. Third, any decision made in relation to wastewater use not only directly affects farmers (since their livelihood is highly linked to wastewater), it also affects the consumers (both through availability of fresh vegetables and its health risks) as well as the small business owners who are linked with the vegetable market of the wastewater farms. As Buechler and Devi (2002) and Drechsel *et al*. (2002) noted, a key factor that needs to be integrated in any future research on this area is the livelihood dimension of the unplanned use and the associated benefits from the use of wastewater in irrigation. Therefore, this study focuses on the livelihood aspects of farmers, their farming system, its impact on crop production and productivity as well as health risks to farmers. The study also examines the value of wastewater based on the farmers' perception in attempting to suggest options to improve the existing wastewater use system. Although the main focus of the study is on the use of wastewater irrigation within and around Addis Ababa, most conclusions of our study can have a wider application in other parts of the country and in many urban and peri-urban areas of sub-Saharan African countries.

1.3. Data source, sampling and survey procedure

1.3.1. Data type and source

The data used in this study is mainly primary data from a farm household survey conducted in 2006. Information from the household survey was supplemented with qualitative data obtained from focus group discussions and key informant interviews as well as with secondary information from relevant institutions. The farm household survey was conducted in both wastewater and freshwater irrigation areas. The focus group discussion was held with few selected irrigators in each wastewater sample area. The key informant interview was held with concerned professionals and officials in agriculture, health, environmental protection offices and the Addis Ababa Water Supply and Sewerage Authority (AAWSSA).

1.3.2. Sampling and Survey Procedures

The household survey was conducted in three sub-cities of Addis Ababa and in one administrative zone of the Oromiya regional state. The three sub-cities included in our survey are Kolfe-Keraneo (*Kolfe*), Lafto-Nifas Silk (*Lafto*) and Akaki-Kaliti (*Akaki-Addis*), all of which are under the administrative structure of the Addis Ababa city municipality. Akaki-Oromiya and Ade'a districts are the other two study areas, which are under the administrative zone of East Shoa of the Oromiya regional state. The location of the different wastewater farm areas is shown in Figure 1. In the figure, the areas shown in green dots are wastewater-irrigated areas. Eight districts were chosen to conduct the household survey. Seven of the districts are from wastewater irrigation areas, and the remaining one is from a freshwater irrigation area. All survey areas are located in the central part of Ethiopia. The survey areas were selected because of the following reasons: first, the quality of irrigation water, which farmers are using, substantially differs. The first group of farmers is using wastewater for irrigation and the other group of farmers are using freshwater. This enables us to conduct comparative analysis. Second, the areas are located within the same basin called the Awash River basin and share similar agro-ecological and climatic conditions. Third, the areas are located within a 40 kilometers radius from the center of the capital city, such that the farmers have the same access to market information and road infrastructure facilities.

To ensure homogeneity among farmers, the wastewater farmers are also divided into different areas based on their location along the Akaki River, which is their source of irrigation water. Accordingly, the Kolfe farm area is located upstream of the Akaki River; the Lafto farm area is located in the middle-stream of the river; and Akaki-Addis and Akaki-Oromiya areas are located downstream of the Akaki River. In freshwater irrigation areas, we divided the farmers into two subgroups based on the source of irrigation water and location. The first group of farmers is from the Godino and Goha irrigation areas and is using government constructed dams diverted from the river, while the other area is the Fultino farm areas, where farmers are using spring water for irrigation developed by the government.

The total number of sample was determined by considering mainly the available budget as well as the minimum number of sample size to conduct statistical analysis at least at zonal or sub-city level. In addition, due consideration has also been given for possible survey errors, outliers and missing values in determining the sample size. Thus, 415 farm households operating irrigation in both wastewater and freshwater areas was included in our survey. The distribution of the number of samples between the freshwater and wastewater areas is determined based on a proportion-principle in that, first, information on the total number of households engaged in irrigated-agricultural activities was obtained from the respective agricultural office and, then, number of sample from wastewater and freshwater farm areas is determined proportional to the total sample size. That is, we first calculate the proportion of farm population in each irrigation areas over the total population, and used this percentage to determine the sample size from each of the wastewater and freshwater irrigation areas. This method ensures the provision of equal chance of representing the farm population in the two farm groups. Accordingly, from a total of 415 farm households, 175 are from freshwater areas and 240 are from wastewater irrigation areas. We also followed similar criteria to determine the number of samples to be included from each wastewater and freshwater irrigation sites. The numbers of farmers in each sub cities were obtained from the respective agricultural office, and the proportions of the farm households in each sub cities were calculated; and we used the result to determine the number of farm households to be included in our survey from each sub cities. Table 1.1 shows the detailed distribution of the sample in each study area.

Table 1.1: Distribution of sample size by quality of irrigation water and districts

District Name	Quality of Irrigation water	Region	Zone or Sub city	Number of sample
Ade'a Liben	Unpollued water (freshwater)	Oromiya	East Shoa	
Godino				62
Goha				63
Fultino				50
Sub total				**175**
Akaki-Oromiya	Polluted water (wastewater)	Oromiya	East Shoa	98
District 22-Lafto		Addis Ababa	Lafto	46
District 23-Lafto				
District 24-Kolfe			Kolfe	40
District 25-Kolfe				
District 26-Akaki-Addis			Akaki-Addis	56
District 27-Akaki-Addis				
Sub total				**240**
Total				**415**

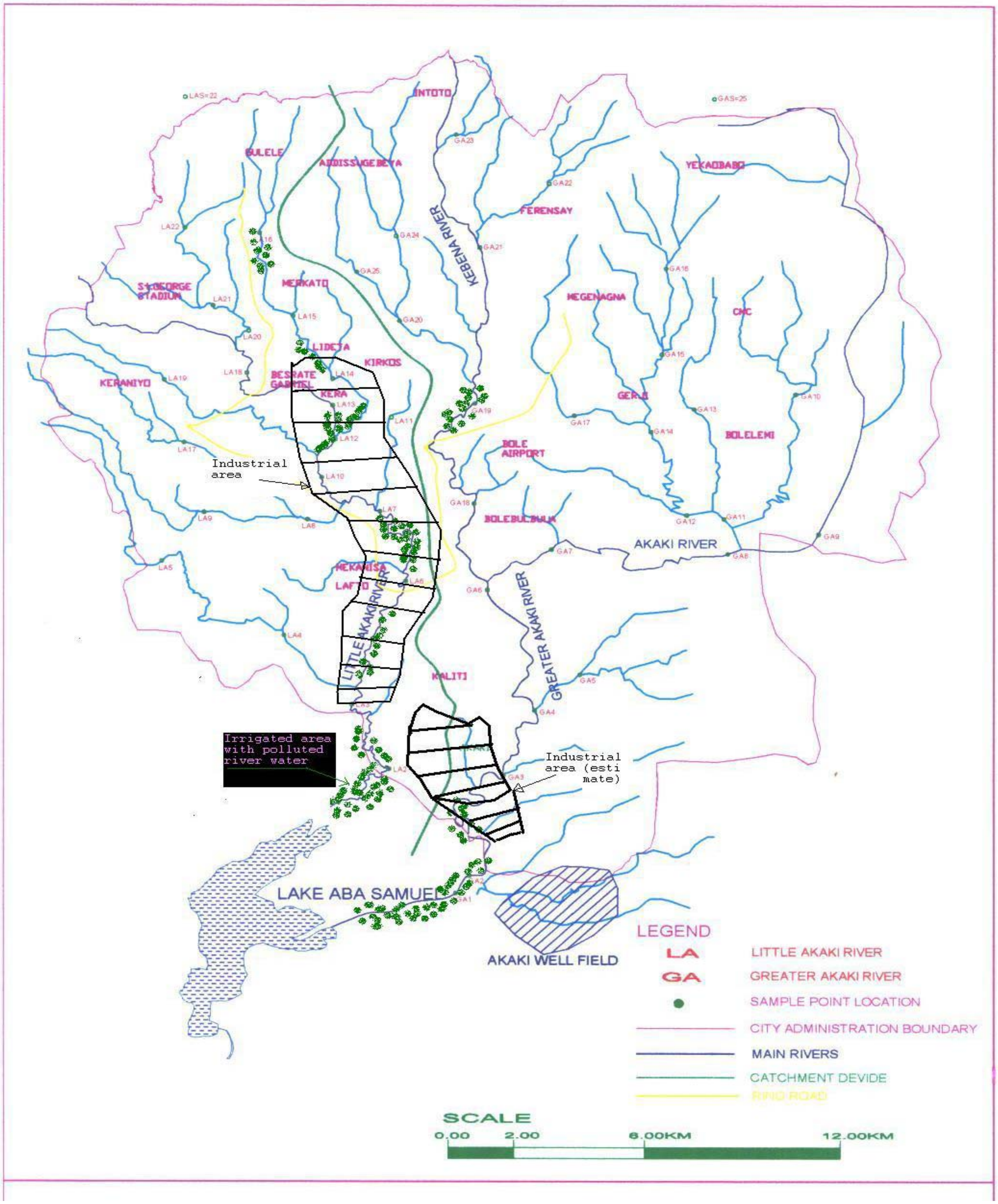
The survey was conducted by ten enumerators who are well experienced in household surveys and hold at least two years of college education. Another two individuals, together with a researcher, supervised the survey. Before the main survey was conducted, the enumerators were given one day training on the details of the questionnaire. A pilot survey was conducted on ten farm households from each area to check the questionnaire in terms of the wordings, ordering, and to determine the length of time the interview would take. The information gathered was classified into ten parts. The data provided information on the socioeconomic characteristics of the farm households, the farming system, irrigation water management, wastewater valuation, livestock ownership, income and expenditure, off-farm employment and remittance, household assets and credit access, food and non-food expenditures. The questionnaire is provided in an annex to this dissertation.

1.4. General framework for analyzing the impact of wastewater irrigation

1.4.1. Definition

The aim of this section is to provide definitions for basic terminologies in the use of wastewater in irrigation and present the conceptual framework for analyzing the impacts of wastewater use in agriculture. This will ensure the understanding of wastewater use in agriculture and its impact on agricultural productivity, livelihood, health and the environment as well as solve the confusion that may arise in relation to terminologies in wastewater. It will also help to clearly convey our aim, areas of focus and our study findings to policy makers and to those who involved in such areas. Discussing the terminology used in this book will also contribute to the worldwide effort being made to estimate the extent of wastewater use in irrigation based on the experiences in different countries.

Figure 1: Addis Ababa Catchments and Wastewater Irrigated Areas



Source: Addis Ababa Water Supply and Sewerage Authority (2002)

Generally speaking, wastewater is made up of domestic and industrial wastewater. Domestic wastewater contains effluents discharged from households, institutions and commercial establishments. Industrial wastewater consists of effluents discharged from manufacturing units. In this study, wastewater refers to domestic effluents (which consists of black water (urine and excreta), grey water (kitchen and bathroom water), wastewater from commercial establishments, hospitals, fuel stations, garages, and industrial wastewaters as well as storm water and urban run-off. Interviews with experts from the Addis Ababa water supply and sewerage authority show that, of the total domestic wastewater production, 76% of the wastes come from households, and 10% from commercial establishments and institutions. The rest comes from street sweeping, hospitals and other sources. It is estimated that 31 million cubic meters of domestic wastewater is being generated per year in the city of Addis Ababa. Wastewater from manufacturing firms include wastes from food processing and beverages; textile, clothing, tanning and leather factories; wood and wood products; paper, paper products and printing; iron and steel factories; and chemical, rubber and plastic factories. Most of the industries do not have treatment plants and discharge their wastewater without any kind of treatment, and thus are a source of wastewater in the study areas. The quantity of wastewater produced from these industries is estimated to be about five million cubic meters per year (Ethiopian Environmental Protection Agency (EEPA), 2005).

The composition of wastewater also determines the level of impact of its use in agriculture. The composition differs from region to region and from community to community. All wastewater is generally composed of organic matter, i.e., nutrients such as nitrogen, phosphorous, potassium, etc; and inorganic matter (dissolved minerals), toxic chemicals and pathogens. In our study area, domestic wastewater is composed of mainly organic matter from household wastes and wastes from commercial establishments. Industrial wastewater varies depending on the raw materials used by each industry, but it generally includes heavy metals, inorganic and organic substances. The most common chemicals found in wastewater of the study area are biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia (NH_3), nitrate (NO_3), phosphate, suspended solids (SS), and dissolved oxygen (DO). Heavy metals found in wastewater include cadmium, chromium, lead, nickel, zinc, copper, iron and manganese. These also contain large quantities of bacteria including coli forms and *E. coli* (EEPA, 2003).

According to Van der Hoek (2002), the distinctions among three types of wastewater use are more relevant in ensuring a clear understanding of the subject matter. These include direct use of untreated wastewater, direct use of treated wastewater, and indirect use of wastewater. As defined in Van der Hoek, direct use of untreated wastewater is the application of wastewater to farmland directly from sewer systems or other purpose-built wastewater conveyance systems. The wastewater is directly taken from the sewage system or from storm water drains. Direct use of treated wastewater is the use of treated wastewater where control exists over the conveyance of the wastewater from the point of discharge of a treatment plant to a controlled area where it is used for irrigation. Indirect use of wastewater is the planned application of wastewater to farmland from a receiving water body in the absence of any control over the use of the wastewater for irrigation. In our study area, the last category of wastewater use is more common. In the study area, only less than 1% of the populations of Addis Ababa are connected with the sewer lines of the city that has been constructed long time ago. As a result, domestic and industrial wastes are discharged into the river passing through the center of the city. Many farmers are extracting water from this river for irrigation purposes and convey the wastewater using traditionally diverted canals and motor pumps. There is no control over its use either for irrigation or domestic purposes.

The other concept that should be made clear at the outset, is the term ‘reuse’ or ‘use’ of wastewater and ‘formal’ and ‘informal’ wastewater irrigation. Wastewater reuse implies that wastewater is used for a second time, whereas wastewater use is the use of the wastewater only once. In our study area, farmers are using the wastewater only once, thus we used the term wastewater ‘use.’ The other terminologies that usually cause confusion in irrigation literature are the terms ‘formal’ and ‘informal’ use of (waste)water. Formal use of irrigation (waste)water refers to the presence of an irrigation infrastructure or to a certain level of permission and control by a state agency. Whereas ‘informal’ use of wastewater refers to the use of the wastewater in many scattered points and is not controlled by a state agency. In the latter case, basic irrigation infrastructures are traditionally constructed by the farmers themselves without state intervention. In our study area, farmers are using wastewater without the formal recognition of the local state agency and irrigation infrastructures are traditionally constructed by farmers and water is extracted from the source either through gravitational force or private- or community-owned motor pumps. Therefore, the wastewater irrigation system of the study area is categorized as an ‘informal’ irrigation system.

1.4.2. Conceptual framework

As mentioned previously, the impact of wastewater use in agriculture is multifaceted, and thus, a comprehensive cost-benefit analysis based on a holistic approach is required.

Towards analyzing the impacts of wastewater use in agriculture through a holistic approach, Hussain *et al*. (2001) developed a conceptual framework for analyzing the socioeconomic, health and environmental impacts. In this study we adopted this framework, and are shown in Figures 2 and 3. Figure 2 conceptualizes the method for assessing the impacts. The framework suggested that the first step is to identify and classify the different impacts of wastewater use in irrigation. The impacts can be identified as economic, social, environmental or other impacts, and are classified into positive and negative impacts. Both the direct and indirect impacts should be considered in classifying the impacts. After identifying all relevant impacts, the next step is to identify indicators or variables to quantify them in physical terms where possible. Since the aim of the analysis is to single out only the impacts that are clearly associated with wastewater irrigation and not include those impacts or changes that would have occurred even without wastewater irrigation, the framework could be developed for two scenarios: with wastewater irrigation and without wastewater irrigation. Thus, the impacts could be measured as the difference between the scenarios “with” and “without” the wastewater irrigation. Once the impacts of wastewater irrigation are quantified, the next step is to value them in monetary terms where possible.

Public policy decision-making often involves balancing the costs of a policy with its benefits. When a policy affects goods and services traded in normal markets, costs and benefits result from consumer responses to changes in prices faced and incomes received. On the other hand, when a policy affects the availability of characteristics of public goods, one does not observe price and income changes, and thus must enter the changes in consumer behavior by using more roundabout methods (Mitchell and Carson, 1989).

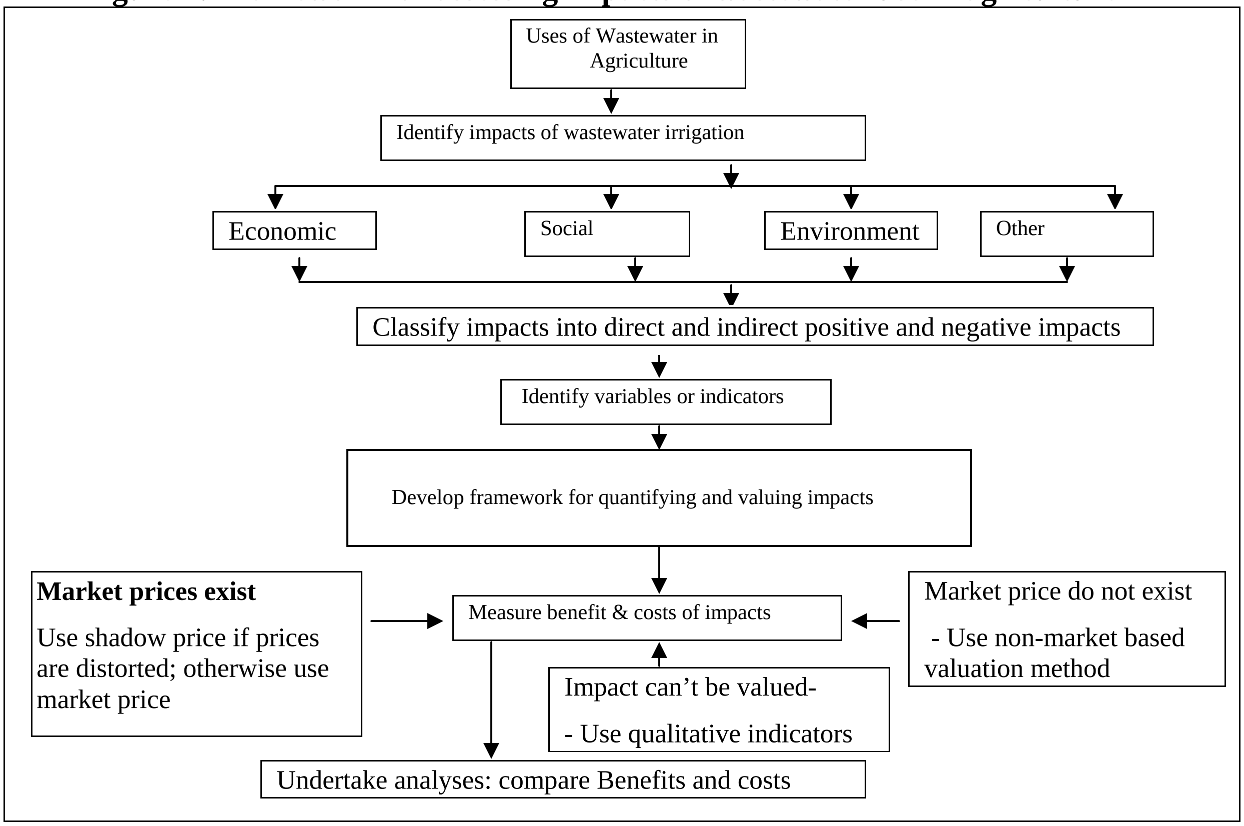
Therefore, in measuring benefits and costs of impacts, market prices are used wherever they exist to compare costs and benefits of wastewater irrigation for the different scenarios. Yet, because of market imperfection, market prices are distorted and may not reflect the true value of the impact. In this case, the use of shadow prices is recommended. Where market prices do not exist, non-market valuation techniques are used to value the impacts. Where monetary valuation is not possible, or impractical, non-monetary value indicators or qualitative indicators need to be developed. However, qualitative indicators may not be particularly useful for determining whether the economic benefits of wastewater use in crop production exceeds costs in quantitative terms, but may be useful to compare similar impacts across the different scenarios. Figure 3 shows the conceptual framework for valuing the impacts. In valuing the health impact, for example, there could be potential risk of disease or mortality (with extreme cases) with wastewater irrigation. Illness caused by wastewater may result in loss of potential earnings, medical cost or inconvenience cost such as leisure and sleeping disturbances. Loss of potential earnings or labor productivity can be evaluated using an opportunity cost principle. These losses can be quantified in economic terms using information on prevalence of illness, daily wage and incidence of disease. Similarly, impact on crop production can be valued from a change in productivity or using econometrically estimated production functions. In the latter case, output is modeled as a function of major inputs such as fertilizer, seed, labor and wastewater, and the marginal value estimate of the wastewater is derived from the estimated model. The major issues in valuing impacts for cost-benefit analysis of wastewater irrigation involve how to conceptualize and estimate the total value of the impacts in a consistent manner and how to integrate various value measures to generate a single representative measure that may be used for policy analysis. As it is clear from the two figures, there is no single method or model that can be readily adopted to assess and value the costs and benefits of wastewater irrigation. A range of models or methods can be used to analyze the impact of wastewater use in agriculture.

1.5. Outline of the thesis

In addition to the introductory chapter, this dissertation has three major parts. The first part deals with 'The impact of wastewater on farm production and productivity.' The second part of the dissertation concerns 'The actual health risks of wastewater use in agriculture;' and the third part is on 'Value of wastewater use in irrigation.' These three different, but related, parts are presented in separate chapters, which are organized as follows.

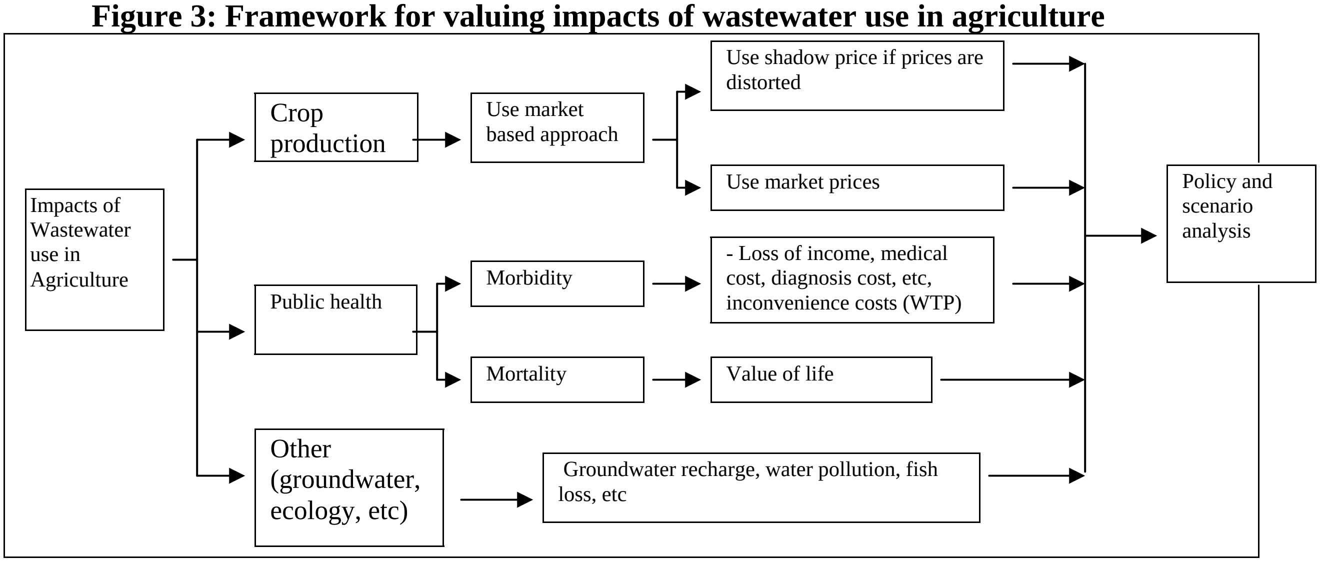
In **Chapter Two**, the impact of wastewater on crop production and productivity is analyzed. This chapter mainly deals with the impact of wastewater on crop productivity and describes the farming system of wastewater farmers, i.e. it focuses on objective number one. Specifically, it investigates the costs and benefits of wastewater use in vegetable production under the 'with and without' scenario. The chapter also describes the farming system of the irrigators and measures the share of wastewater farm income out of the total annual household income. The chapter also determines the factors influencing crop productivity. Accordingly, the chapter is divided into six sections. The first section introduces the chapter, wherein some background on the potential benefits and costs of wastewater resource use in crop production, and the specific objectives and organization of the chapter will be discussed. The second section describes the study area

Figure 2: Framework for assessing impacts of wastewater use in agriculture



Source: adopted from Hussain *et al*. (2001)

Figure 3: Framework for valuing impacts of wastewater use in agriculture



Source: adopted from Hussain *et al*. (2001)

and the dataset. This is followed by a discussion on the conceptual framework based on which the productivity impact of wastewater use in crop production is analyzed. The fourth section presents the empirical model and estimation techniques. Section five discusses the detailed results from the descriptive and econometric analyses. This section discusses in detail the basic characteristics of the farm households, the farming system in the study areas, and compares the financial cost and benefits of wastewater with the freshwater irrigation farms. It also discusses the determinants of farm productivity and identifies the actual impact of wastewater on crop productivity. The conclusion and policy implication of the results are presented in the last section of the chapter.

The **third chapter** focuses on objective number two. The actual health risks associated with the use of wastewater in crop production in comparison with the non-wastewater irrigators of the study area is the focus of this chapter. In this chapter, we described and estimated the prevalence of the actual health risk for the study areas. The analyses was done on both wastewater and non-wastewater irrigation areas to indicate whether the prevalence of the actual health risk is significantly different in the two irrigation areas, conditional on other factors that cause disease. It also aimed at assessing the awareness of the irrigators about the health risks associated with the use of wastewater in irrigation. This chapter is divided into six sections. The potential health risks associated with the use of wastewater in crop production, the specific objectives and organization of the chapter are discussed in the introductory section of the chapter. The second section describes the study areas and the dataset. The third section of the chapter conceptualizes our analyses based on the utility maximization of consumer behavior model and presents the empirical model used to estimate prevalence of illness. Study results are discussed in the fourth section. The different risk factors and the prevalence of wastewater related disease in both wastewater and non-wastewater irrigation areas are also discussed. This section also identifies the factors that significantly determine the prevalence of diseases and estimate the actual health impact of wastewater use in irrigation. Conclusion and policy implications of the study results are presented in the last section of the chapter.

Chapter Four deals with the economic value of safe use of wastewater in crop production. The willingness to pay of farm households for improved wastewater use in crop production, and its determinants are analyzed in this chapter using information generated from a contingent valuation survey. The chapter investigates farmers' perception towards minimizing the health risk from the use of wastewater for irrigation and the contribution they can make to improve the existing unsafe use of the wastewater. The value of the wastewater resource is also compared with the value of freshwater based on the farmers' perception. Hence, the chapter is divided into five sections. The first section is an introduction to the chapter, and discusses some background information of the study and its justification, the specific objectives and organization of the chapter.

The second section describes the methodological approach of this study and lays out the challenges for the application of the CVM in the context of Ethiopia followed by a brief description of the study area for this survey. Section 3 presents the survey design of the actual CVM survey carried out in and around Addis Ababa. Section 4 lays out the empirical model used for data analysis. Section 5 discusses the result from the descriptive and econometric analysis, and estimates the welfare gain from safe use of wastewater for irrigation. This section discusses the existing wastewater irrigation system, the options to improve the situation and the contribution wastewater farmers can make. The willingness to pay of farmers for the improvement program and the factors determining their willingness to pay are identified and analyzed in this section. The total welfare gain from improved use of wastewater for irrigation is also discussed in this section. Section five also presents the robustness of our CV survey results. The last section presents a summary and conclusion.

In **Chapter Five**, a summary of the results of the different parts of the thesis are assimilated and discussed. Based on the findings of the different parts of the study, general conclusions and policy implications as well as suggestions for future research are presented.

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CHAPTER 2: Wastewater Use in Crop Production: Impact on Productivity and Policy Implications

Submitted to Agricultural Economics

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2.1. Abstract

The main objective of this study is to analyze the productivity impact of wastewater use in Ethiopian crop production using recently collected household data. A Cobb Douglas production function is specified to identify the determinants of crop productivity. The incremental productivity gain from the wastewater is obtained from the predicted yield value per hectare using censored least absolute deviation (CLAD). The results revealed that predicted yield value per hectare is significantly higher in wastewater-irrigated plots than in plots irrigated with freshwater. While pollution levels and irrigation with wastewater for an extended period reduces crop productivity, investments in farm inputs and plot ownership increase productivity. To prevent the increase in pollution, and thereby reduce the negative effect on crop productivity, incentive-based policies should be sought for controlling the discharge of industrial and domestic waste into the river, which presently serves as a sink for wastes from Ethiopian cities.

Key words: wastewater*;* irrigation; productivity; Censored Least Absolute Deviation; Ethiopia

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CHAPTER 3: Health Impact of Wastewater Use in Crop Production in Peri-urban Areas of Addis Ababa: Implications for Policy

Submitted to Environment and Development Economics

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3.1. Abstract

The practice of untreated wastewater use in agriculture is being discussed controversially due to its negative health impacts. However, policy makers lack reliable information on the actual health risks associated with wastewater use for crop production. Using data from household surveys, this study employed comparative analysis to examine the actual health impacts, and to evaluate the value of health damages, from such practices. The probability of illness was estimated based on the theory of the utility-maximizing behavior of households subject to the conventional farm household production model, modified by adding health production function. The value of health damages for farmers was obtained from the predicted probability of illness, and compared with the benefits of wastewater use in agriculture. Policy options are suggested to minimize the health risks to farm workers associated with the use of wastewater for crop production.

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CHAPTER 4: The Economic Value of Wastewater: A Contingent Valuation Study in Addis Ababa, Ethiopia

Submitted to Journal of Agricultural and Resource Economics

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4.1. Abstract

In developing countries the use of wastewater for irrigation often causes considerable harm to public health and the environment. This paper scrutinizes the applicability of contingent valuation to estimate the economic value of safe use of wastewater for crop production on farms within and around Addis Ababa, Ethiopia. We estimate a surprisingly large welfare gain to society from policies for safe use of wastewater for irrigation. Our study highlights the potential and the pitfalls of using non-market valuation techniques as an input into public decision making where traditional resource use interacts with public health and environmental concerns in complex ways.

Keywords: contingent valuation; dichotomous choice; Ethiopia; irrigation; wastewater; willingness to pay

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CHAPTER 5: SUMMARY and CONCLUSIONS

The use of wastewater in agriculture is a common practice in low-income countries. The reasons for using wastewater vary from region to region, depending on the specific situation and local context. Its use in agriculture has both positive and negative potential impacts, which are reflected through crop production, public health, soil resource and the ecosystem. The main challenge to policy makers in developing countries is how to maximize the benefit at minimum adverse effect on public health and the environment. As outlined in the 'Hyderabad Declaration on Wastewater Use in Agriculture,' these benefits and costs associated with wastewater call for developing a balanced approach. The new WHO guideline on water quality standards for irrigation, which recognizes the Hyderabad declaration, suggests that countries should adapt the guideline to their own social, technical, economic and environmental circumstances based on scientific information.

As in most developing countries, wastewater is used for agricultural activity in Ethiopia, the second most populous country in sub-Saharan Africa. Even though urbanization is at its lowest level in Ethiopia, its rate of growth is increasing. It is estimated that by 2030 about 29.7% of the Ethiopian population will reside in urban areas. Rural-urban migration and the poor performance of the agriculture sector contribute for the high rate of urbanization in the country. Urban areas in Ethiopia are characterized by a host of problems including, among others, unemployment, inadequate water and sanitation services as well as poor waste management. As a result of the increase in population number and low level of improved environmental sanitation and waste management services, a huge volume of wastewater is being generated and disposed of without any kind of treatment, polluting nearby rivers and streams flowing within cities. This is especially true in Addis Ababa, the capital, where approximately five million people are living. Despite the production of a large volume of domestic and industrial wastes, the sanitation service is very low by any standard. Only 15% of the population has access to improved sanitation services and only 1% of the households are connected to the limited sewer lines of the city. The existing public-owned treatment plants treat only less than 1% of the 36 million cubic meters of wastewater generated per year. As a result, rivers and streams flowing across the city serve as a sink to the huge volume of wastewater being generated. These rivers and streams are tributaries of the Akaki River, which is highly polluted with industrial as well as domestic wastes.

Farmers are growing vegetables using the Akaki River within and around Addis Ababa, and make a living out of the wastewater from the city. This practice has both positive and negative impacts on the producers, consumers and the nearby community, and poses a challenge to policy makers to make decision on the practice of wastewater agriculture. This study, therefore, attempts to answer basic questions like 'should the practice of wastewater within and around the city be discontinued?' In attempting to address this basic question, the study is divided into three major areas including the impact of the wastewater on crop production and productivity; its health impact and on the way to improve the existing unsafe use of wastewater for vegetable production. Both quantitative and qualitative data are used. The quantitative data comes from a household survey conducted on 415 farm households in both wastewater and freshwater irrigation areas. It is supplemented with information from focus group discussions and key informant interviews made on selected individuals from the farm community and professionals and officials from agriculture, environmental as well as water supply and waste management offices.

The first part of this study deals with the impacts of wastewater on crop productivity and the livelihoods of the wastewater farm families. The study investigated the costs and benefits of the wastewater farm and compared the results with the freshwater irrigated farms using descriptive and econometric analytical techniques. The descriptive results show that, on average, income from wastewater farms accounts for 62% of the total annual household income, ranging from 29% to 97%. Major crops grown in wastewater areas are cabbage, lettuce, Swiss chard, beat root, potatoes, tomatoes, spring onions and carrot. Leafy vegetables including lettuce and Swiss chard are exclusively grown in the upstream and middle-stream of wastewater farm areas, where the pollution level is relatively lower, whereas root crops including potatoes, carrot, beat root, onion and tomatoes are grown in the downstream areas of wastewater where the pollution level is higher. Cabbage grows in the middle and down stream farm areas. About 61% of the city's vegetable markets are supplied from these farms. Moreover, physical observation of the central market and some small markets in the city show that the livelihood of many small business households is linked with wastewater farms through the vegetable market channels. These results highlight the importance of the wastewater resource for livelihood of farmers and small business owners as well as for the vegetable market supply of nearby cities.

The bivariate analysis revealed that wastewater farmers use significantly smaller doses of inorganic fertilizer compared to freshwater farmers, but spend three times more on seed input and about five times more on farm labor. This suggests the importance of wastewater to input and labor markets in the study area. Despite the higher cost of production for the wastewater farms, net farm return per hectare of plots irrigated with wastewater is significantly higher than from plots irrigated with freshwater. This is also confirmed from the econometric estimation. The regression result indicated that the predicted median output value per hectare is significantly higher in wastewater-irrigated plots than in freshwater-irrigated plots. The factors determining this significant difference are analyzed using Censored Least Absolute Deviation (CLAD). We found that higher productivity of wastewater plots is explained by investments in inputs (organic fertilizer, improved seed and agricultural extension services), ownership of plots and level of pollution of the irrigation water. The study also found that yield value per hectare is significantly higher in plots irrigated with less polluted wastewater than in plots irrigated with more polluted wastewater.

The second part of the study deals with the actual health impact of wastewater use in vegetable production in the study areas. This part of the thesis analyzed the different risk factors, the prevalence of wastewater-related illness as well as the impacts of wastewater on farmers' illness. We made an attempt to single-out the impact of wastewater (measured by dummies for working on wastewater farm) from the different risk factors. The risk factors, the different kind of wastewater-related illness and their frequency of occurrence or prevalence rate were analyzed using descriptive analyses. The results show that apart from working on wastewater farms, different risk factors are prevalent, which can cause wastewater-related disease in the study areas. The major risk factors in the study areas include household demographic characteristics including education level, age and income; poor sanitation services such as lack of potable water supply, poor toilet facilities, improper solid waste disposal, lack of access to health services as well as poor hygienic behavior of farm families, such as eating unsafe raw vegetables, use of unsafe water for domestic purposes without boiling and irregular compound sweeping.

The study also found that wastewater irrigators do not use protective clothing that protect them from exposing their body to the wastewater and contaminated soils. This is partly explained by lack of awareness of the health risks of working on wastewater farms. The occurrences and distributions of these risk factors differ between the wastewater and the freshwater farm areas.

The most common incidence of illness reported by farmers are intestinal nematodes, diarrhea and skin disease, but these vary significantly between the wastewater farmers (treatment group) and freshwater farmers (control group). The prevalence of intestinal illness due to hookworm or *Ascaris* infection is significantly higher in freshwater areas than wastewater areas since the occurrences of disease-causing risk factors are higher in the freshwater irrigation areas. The prevalence of illness also differs within the different locations of wastewater farm areas, mainly due to differences in the pollution level of the wastewater as well as prevalence of the risk factors. This study revealed that the prevalence of intestinal nematodes and diarrhea is significantly higher in downstream irrigators, where the pollution level is higher, compared to the upstream and middle-stream farm areas.

The probit model estimation shows that marital status, sex and religion of the household head, education, eating unsafe raw vegetable and regular sweeping of compound determine the prevalence of intestinal illness in the study area. Results on the effects of hygienic characteristics of irrigators show that eating unsafe raw vegetable increases illness, while regularly and frequently sweeping compounds reduces it. Illness prevalence rates are also higher in wastewater irrigators who do not have the habit of washing hands before meals. This suggests that general hygienic behavior of farm families correlate with the prevalence of illness.

An important finding of this study is that the dummy coefficient for working on a wastewater farm is found to have a positive sign and is statistically significant in the probit estimation, indicating that illness prevalence is significantly higher in farmers working on wastewater farms than on freshwater farms. This result is also confirmed by the propensity score matching method. On the other hand, use of protective clothing during farm work and awareness of the health risk of wastewater use in crop production also significantly reduces intestinal illness. These results show that the use of wastewater for vegetable production actually causes illness to farmers in the study area. Prevalence of illness due to wastewater is higher for farmers who work in the downstream wastewater farm areas compared to upstream and middle-stream farm areas. This indicates that illness incidence varies with pollution level of the river and that the probability of being sick will increase as the pollution level increases. Off-farm income has significant and negative effects on the probability of illness, indicating that higher off farm income reduces illness incidence.

The study revealed that the marginal impact of wastewater on farmers' heath is 0.15. This means that, holding other risk factors at their mean value, the probability of being sick is higher by 16% for farmers working on wastewater farms compared to those working on freshwater irrigation farms. This marginal effect, together with the predicted probability of illness from the probit model, is used to estimate the value of health risk associated with working on a wastewater farm. The value of the health risk is measured by the time spent away from farm work due to illness caused by wastewater. It is the opportunity cost of the farmer's time spent in bed and visiting local clinics. The results indicate that the marginal health cost of working on a wastewater farm for a representative wastewater farm household is about 1.6% of its annual net farm income. Our study analyzed the possible policy intervention to minimize this health cost. We found that the predicted probability of being ill due to the wastewater significantly decreases with the use and provision of protective dress at affordable prices, creating awareness of safe use of wastewater and through measures taken to reduce the pollution level of the irrigation water source. While each of the policy interventions has a significant effect in reducing health risks, combining these measures will result in more significant reductions of health risks to farmers, and thereby maximize the benefit from the wastewater as a source of livelihood and vegetables for the residences of the nearby city.

The study also estimated the resource value of wastewater based on the farmers' perception in an attempt to analyze farmers' willingness to pay for safe use of the wastewater for crop production and the welfare gain to society from the improved service. This part of the thesis intends to investigate the farmers' perception to reduce the health risk of working on wastewater and the contribution they can make to improve the existing unsafe use of the wastewater for crop production. We used a double bounded dichotomous CV format to elicit farmers' WTP. The survey was administered using an in-person interview. Currently, farmers are operating unsafe wastewater irrigation. They are using the furrow irrigation method and most farm activities including land preparation, weeding and harvesting are done using their hands and farmers work with bare feet on wastewater farms. Besides, the consumption of raw vegetables is unhygienic since farmers eat the raw vegetables directly from the farm area without disinfection. Due to the unsafe wastewater irrigation system, farmers perceived that even if they are benefited from the use of the wastewater for crop production, their health is affected by working on the wastewater farms. In addition to its health effect, the wastewater creates a bad odor for the surrounding community. In addition, the focus group discussion with representatives of the farm households shows that farmers have the risk of losing their farm land since they think that the government may ban the use of wastewater for agricultural purposes due to the health risks associated with the use of wastewater.

Different options were presented to farmers to improve the existing unsafe irrigation system and that minimize the risk of losing their livelihood. Among the options, enforcing the polluters not to discharge wastewater with out any kind of treatment is the most preferred option by the farmers to alleviate the problems associated with unsafe use of wastewater for crop production. Awareness creation on safe use of wastewater is the other option preferred by farmers. Both options are selected by 38% of farm households. Following this, farmers were provided with a hypothetical scenario to improve the existing wastewater use system, and more than 90% of the respondents were willing to contribute to the improvement program in the form of cash. The farmers' willingness to pay for the improvement program is estimated from the valuation questions offered to them. Based on the double-bounded dichotomous and interval regression models, wastewater farmers are willing to pay Birr 39.1 and 39.72 per year per hectare, respectively. This is about 0.26% and 0.28% of their average annual net farm income, respectively. The open-ended and interval regression estimation revealed that wastewater is valued more than freshwater use for irrigation. An attempt was also made to determine the factors that derive farm households to decide to accept the first and second bids as well as the amount they are willing to pay for the improvement program using bivariate probit and the interval-data regression models, respectively. The result shows that sex of head, water shortage, membership to a water users association, number of dependents and income (value of crop output), off-farm income and dummy for working on wastewater irrigation farms affect the probability of accepting the offered bids. In addition to these variables, multipurpose uses of irrigation water and education level of household head significantly affect farmers' willingness to pay for the improvement program. The study also shows that the value of the improvement program is also explained by variation in pollution level within the different wastewater farm areas. We estimated the welfare gain to the wastewater population and the nearby community from the improvement program. The result revealed that the welfare gain is higher from the improved use of wastewater resource in crop production.

Based on the above discussion, the following conclusions can be made.

1. The findings of this study show that wastewater from the city is an important resource for the livelihood of farm households since it is a source of income and employment for many poor farm households and their families. Therefore, increasing the productivity impact of this resource has an important implication on the improvement of living standards of these poor farm households. In relation to this, ensuring tenure security, access to improved farm inputs and technical advice on irrigated agricultural activities significantly improve the productivity of the wastewater farms, and thereby maximize the benefit of the wastewater resource. Technical advice on irrigation water management that considers the chemical composition of the wastewater in terms of the timing of irrigating farms *versus* the release of wastewater, especially from industries as well as frequency of watering, is also important to increase the positive impact of wastewater on crop productivity. These results also show that membership to the water users association (WUA) significantly explains farmers' WTP for improved irrigation systems. An important policy implication of this result is that organizing irrigation water users under WUAs facilitates efficiency and equity in allocating irrigation water among users.

2. Crop productivity is significantly higher in plots irrigated with wastewater than in plots irrigated with freshwater. On the other hand, the result shows that yield value per hectare is significantly higher in plots irrigated with less polluted wastewater than in plots irrigated

with more polluted wastewater, signifying that productivity is not only explained by differences between the two groups of farmers, but is also explained by variation within the wastewater farmers due to variation in pollution level among the different farm locations within the wastewater farm areas. This implies that even if wastewater is a reliable source of irrigation water and contains essential plant nutrients such as NPK, the nutrient content exceeds the recommended level of the plant requirement (e.g., nitrogen) or it contains toxic elements (e.g., nickel, zinc) above the recommended limit in the downstream areas that affect plant growth negatively, which in turn reduces yield. This result in turn implies that the wastewater from the city is highly polluted and has potentially negative effects on productivity, which reduces income of the farm households and thereby affects their livelihood.

3. This study, on the other hand, shows that working with wastewater actually poses health risk to farmers as well as to consumers. This health risk can be reduced through the provision of affordable protective dress. It can also be reduced by creating awareness on safe use of wastewater including irrigation methods, crop types grown, consumption of raw vegetables and educating farmers on the health risks of wastewater use in crop production.

4. The study confirms that safe use of wastewater for irrigation or improved use of irrigation systems is important to farm households. Both the wastewater and freshwater farmers are willing to pay for programs designed to improve the existing unsafe and improper use of irrigation water. This implies that it is possible to introduce an irrigation water user’s fee that can signal scarcity of irrigation water and ability to optimize or gain efficiency in the use of wastewater or irrigation water. In addition, the variable for the water extraction method has no significant effect on farmers’ WTP for the safe use of the wastewater. It implies that other

factors remaining the same, the farmers' WTP for the improvement program is not related to water extraction methods from its source. Therefore, it is possible to introduce water saving and improved irrigation methods such as drip irrigation without affecting the farmers' WTP to implement programs designed for safe use of the wastewater for crop production. The study not only provides useful estimates of farm households' WTP for safe use of the wastewater, it also provides guidance for decision makers to make informed decisions on how to maximize the benefits of wastewater use for crop production at minimum health and environmental risks. In addition, it provides an important input for the existing treatment plant to improve its services through collecting fees from sell of treated (semi-treated) wastewater for farmers since farmers are willing to pay for the improvement program.

5. The above-mentioned findings of the study show that to maximize the benefit from wastewater and minimize its health risk, due consideration should be given to both producers and polluters. The findings suggest that it is advisable for decision makers to act urgently to regulate the disposal of industrial and domestic wastes into the river before pollution reaches some threshold level beyond which one cannot reverse the damage at any reasonable economic cost. Therefore, designing appropriate policy instruments (with monitoring strategies) that prevent the polluters from discharging their wastewater without treatment and passing enforceable legislation for the proper disposal of wastes can have important effects not only in increasing the crop productivity of wastewater, it also has an effect in minimizing the health risk associated with the use of wastewater in vegetable production. In designing such policies, special consideration should be given to certain industries, such as tanning, leather and leather products, textiles and beverage production, because these are the major polluters of the river and wastewater from such industries is more hazardous to human

health. These measures, coupled with programs that enable farmers to operate safe wastewater-irrigated farms and increase their awareness of the health risk associated with the unsafe use of wastewater, will make important contributions towards minimizing health risks and maximizing the benefits from this resource.

6. The findings of this study suggest that prohibition of wastewater use for crop production is not the best option at least for three reasons. First, the existing situation in the study area shows that the livelihood of many poor farm households and small business owners is highly dependent on wastewater. Thus, prohibition of this practice affects the livelihoods of many poor households unless and otherwise other livelihood alternatives are sought. Second, a high proportion of the vegetable market of Addis Ababa is produced from wastewater farms, implying that a ban will require looking for other sources of vegetables to meet at least the current demand for these produce. Third, the available resource for enforcement of prohibition of wastewater use for crop production is very limited, as it is seen from past experience in the study areas and other developing countries. On the other hand, municipal treatment of wastewater, which is the first and best option, is not a realistic option in the study areas both in the short- and medium-terms since it requires large capital investment and operating costs to construct and run wastewater treatment plants in a poorly developed country like Ethiopia, where resources are very limited both at the municipal and country levels. Furthermore, depending on the treatment level, wastewater treatment could also result in an increase in farm input cost for wastewater farmers as our result shows that farmers have a significantly lower cost for fertilizer compared to freshwater farmers. Therefore, awareness of farmers on the health risk, use of protective dress during farming, safe consumption of produce from wastewater farms, use of improved irrigation techniques,

restricting type of crops grown and enforcing the treatment of industrial wastewater before discharge are the second best option in the short-term to maximize the benefit from the wastewater resource with minimum health risk to farmers as well as consumers. In the medium-term, improving the capacity of the existing public treatment plants can be the second best option since the fee collected from farmers can also serve as the source of finance for the treatment plant to improve its existing low capacity. Besides, improving the existing domestic solid and liquid waste management services can also be used as second best option in the medium term, but this requires further study on the perception of the residence of Addis Ababa on improving the existing waste management service.

A number of issues are excluded from our study that should be considered in future research:

1. One of the main limitations of this study is the use of a dummy variable to determine the impact of wastewater on productivity and health impact. We also used dummy variables for location and results from an old study conducted by the Ethiopian Environmental Protection Authority to describe the pollution level of the river. Therefore, future studies should attempt to use the pollution level of the river by measuring the chemical, physical and biological composition of the river water by conducting detailed water sample analysis at different locations of the river both during the dry and rainy seasons of the year.

2. In evaluating the health impact of wastewater use in agriculture, our study considers only intestinal illness due to worm infection. Illnesses including diarrhea, skin and hepatitis, which can also be caused by wastewater, are excluded from our estimation despite their prevalence in the study area. This underestimates the actual health cost. Hence, future research should also consider such illnesses to accurately estimate the actual health risks. Furthermore, our study analyzed only the impact on farmers, excluding the health impact on

consumers and the nearby community. Thus, we suggest further study be made on consumers risk and the nearby community to estimate the health cost to the society. This value should also be weighted against the benefit from wastewater use in agriculture, so as to identify the welfare contributions of the wastewater resource.

3. Our study on improving the existing use of wastewater is made based on the perception of farm households and the result is subject to these limitations. We suggest further study to be made on the attitude and willingness of the residences in Addis Ababa to pay for improved waste management service as they are the source of the waste and at the same time benefit from and are affected by the vegetable supply of wastewater farms.

4. Industrial wastewater is one of the major components of wastewater in the study areas, and poses a human health risk because of the nature of the industries within the city. These industries discharge their wastewater without any kind of treatment. Therefore, a study should be made to determine the optimum level of treatment that can serve as a bench mark to regulate industrial wastewater discharge and mechanisms should be designed to control and enforce the implementation of environmental pollution policy. Since the existing policy on the discharge of industrial wastes to surface water bodies is based on regulatory mechanisms, which have high transaction costs and limited applicability due to poor enforcement mechanisms (as has been seen since this policy's inception), further studies should consider market-based or incentive-based policy options to minimize the pollution level of the Akaki River.

Annex: Questionnaire

Household-level survey Questionnaire for Economic Analyses and Policy Implications of Wastewater Use in Agriculture in the Central Region of Ethiopia (2006)

OUTLINE

General Information

1. **Household Composition**
   1.1. Household Roster, Education, Occupation and Time Allocation
   1.2. Household Holiday
2. **Household Health and Access to Basic Services**
   2.1. Access to Basic Social Services
   2.2. Household Health Situation
   2.3. Health and Agricultural Extension Service
3. **Agriculture**
   3.1. Land Use Information
   3.2. Type of Crop Produced
   3.3. Labor Utilization
   3.4. Input Use
   3.5. Land Rent and Sharecropping
   3.6. Livestock Ownership, Income and Expenditure
4. **Irrigation Water management**
5. **Wastewater Valuation Question**
6. **Off-farm Employment and Remittance**
   6.1. Employment for Wage
   6.2. Remittance
7. **Household Asset and Credit Access**
   7.1. Household Asset
   7.2. Household Access to Credit
8. **Food Expenditure and Consumption**
   8.1. Consumption Habit
   8.2. Food Expenditure and Consumption
   8.3. Non-Food Expenditure
9. **Social Capital**

Sample Code

Name of Interviewer:	
Name of Supervisor:	
Interview Date:	**Time:_____ to _____ *(local time)***

INTERVIEWER'S INSTRUCTION	**NOTICE THAT UPPER CASE BOLD LETTER ARE REFERED AS INSTRUCTION FOR INTERVIEWER WHILE lower case letters are questions and statements to be aloud to the respondent**

Hello! My name is ____________________. I am interviewing a cross section of people living in this and other village about the use of wastewater and freshwater for irrigation. This interview is a main body of a research Mr. Alebel Bayrau is conducting for his Doctorate degree award. Your views will be used for academic purpose.

Let me first begin by saying that most of the questions have to do with your attitudes and opinions, and there are no right and wrong answers. This interview will take some minutes and is completely confidential. Your name will never be associated with your answers. Therefore, honest discussion is the best way ahead.

General Information

1. Region: ________________________ (1=Addis Ababa; 2=Oromiya)
2. Zone/Kifle Ketema: ____
3. Wereda: ____________________________
4. Kebele/Peasant Association: ____________________________
5. Name of the household head: _____________________________
6. Household number (code): _______________________
7. Main respondent: _______________ (1=head; 2=wife; 3 =other (should be >18 years old).
8. Marital status of the respondent: ____________ (1 =married; 2 =single; 3=divorced; 4=widow)
9. Sex of the household Head: _________________ (1=male; 2=female)
10. Number of family member living in the household (both adult and children): _____
11. Religion of the household head: _________________ (1=Orthodox; 2=Muslim; 3=protestant; 4=other (please specify).
12. Ethnic group of the household head: __________________ (1=Oromo; 2=Gurage; 3=Amhara; 4=Tigray; 5=other (please specify ________)

Interviewer's signature: _______________________

Part 1: Household Composition, household Holidays and Time allocation

Section 1.1: Household Roster, Education and Occupation and Time Allocation

1. Name of the household member (start with the head)	2. ID code	3. Sex (male=1; female=2)	4. Age	6. Is (name) born in this village=1 OR came from other area=2?	10. What is the education level? **code a**	11. Primary activity **code b**	12. Secondary activity **code b**	4. time spent Working on the farm	5. time spent Working off farm activities (weaving, pottering, daily worker, etc	Time spent in Fuel wood collection	7. Time spent in Water fetching
								days/week	days/week	Hrs/day	Hrs/day
	01										
	02										
	03										
	04										
	05										
	06										
	07										
	08										
	09										
	10										

Code a (highest level of grade attained or completed): illiterate =0; read and write =1; first grade completed=2, second grade completed =3, etc.

Code b (primary and secondary activities): **farm work**: own or family (wastewater) farm work =1; other farm work =2; own cattle keeping =3; others cattle Keeping =4; domestic work =5; **Off-farm work**: manual work =6, construction work (carpenter, mason, etc) =7, stone (sand) mining =8; tailor =9; Weaver =10; craft worker/potter =11; blacksmith =12; local drink and food seller (tella, teji, injera, bread, Kolo, etc) =13; driver =14; factory worker =15, Gulit sale =16; Guard / Security officer =17; student =18; Housewife =19; other off-farm activity =20. **Professional**: teacher =21; health worker =22; administrator =23; solider =24; trader =25; other professional work =26; does not work at all because he does not have any work =27; unable to work because of disability =28.

Section 1.2: household Holiday

1. Would you please tell us the number of holidays you have in a month? _______________ Days
   1.1. Would you tell me how many days you do not work ploughing, irrigating your farm, weeding and harvesting in a month? _________________.
   1.2. Would you tell me how many days you do not work activities such as fencing, house construction, and collect fuel wood in a month? _____.
   1.3. Would you tell me how many days you do not work off-farm activities (trading, as daily laborer, etc) in a month?_______________.

3. Have you ever violated any of the holidays? _________. Yes =1 No =2
   If 'yes', why? 1. ___________________, 2. ____________________________ 3.____________________________

Part Two: Health of household members and Access to Basic social services

Section 2.1: Basic social services

Now, I would like to ask you about the households' access to basic social services

1. What is your main source of drinking water supply? **Code source of drinking water:** Pond=1; dam= 2; stream or river flowing with in or from the city =2; spring =3; borehole =4; shallow well =5; water from irrigation canal=6; rain water =7; private piped water =8; shared piped water =9; piped water from vendor =10; public tap (Bono) =11; other (specify =12)	
2. Do you have access to the following in your locality?	
2.1. elementary school Yes =1 No =2	
2.2. high school Yes =1 No =2	
2.3. clinic Yes =1 No =2	
2.4. health center Yes =1 No =2	
2.5. hospital Yes =1 No =2	
3. What kind of light do you use in your house? 1= electric with private meter; 2= electric with shared meter; 3= kerosene; 4= other	
4. What do you use as source of energy for cooking and heating? 1= wood; 2=dung; 3=crop residue; 4=kerosene; 5=electricity; 6= charcoal; 7 = other	
5. Where is your main market place? At farm gate =1; within the kebele or neighboring kebele =2; *Atkilt tera* in Addis Ababa =3; *Merkato* = 4; other =5	
6. Where is your secondary market place? At farm gate =1; within the kebele or neighboring kebele =2; no secondary market =3; other =4	

Section 2.2: Health status of household member

Now I would like to ask you about the health situation of your household member

Name of HH member	Code of HH member	1. Does (name) consume raw vegetable? Yes=1; No=2	2. Does (name) work in irrig. Field. Yes=1; No=1)	3. If 'yes' for Q2, does (name) work in barefoot= 1 or dress shoe=2. NA	4. if YES for Q2, does (name) dress protective cloth while farming yes =1 No =2 NA	5.Has (name) suffered from any intestinal nematodes (Hookworm/ ascaris) Yes=1; no=2	6. Has (name) ever suffered from diarrhea Yes=1 No=2	7. has(name) ever suffered from skin disease Yes=1 No=2	8. Has (name) ever suffered from hepatitis /nail. Yes=1 No=2	9. Has (name) ever sick by any illness with in the last one year? Yes=1 No=2	10. If YES for Q9, would you tell me the type of illness? **Code a**	11. If (name) sick by any of these diseases, would you tell me no. of sick days.	12. How many times (name) have been ill within the last one year

	01												
	02												
	03												
	04												
	05												
	06												
	07												
	08												
	09												
	10												

Code a (type of illness): 1 = headache; 2 = stomach (constipation); 3 = leg damage; 4= hand damage; 5 = listening problem; 6 = sight/eye problem; 7 =mental retardation; 8 = lung/trachea/bronchitis; 9 = other illness _______.

Health status …

Name of HH member	Code of HH member	13. How many times (name) have been sick with in the last six months?	14. How many times (name) have been sick with in the last two months?	15. Did (name) obtain any treatment? Yes =1 No=2	16. If **No for Q15**, would you tell us the reason? **Code b**	17. If **Yes for Q15**, where did (name) obtain treatment? **Code c**	18. Where is it located? **Code d**	19. Means of transportation **Code e**	20. Total Time taken (transport, waiting for treatment and diagnosis) in minute	21. Cost for transportation both ways.	22. Cost of diagnosis	23. Cost for pharmaceuticals
	01											
	02											
	03											
	04											
	05											
	06											
	07											
	08											
	09											
	10											

Code b: reason for no treatment: no one available to escort patient =1; no facility available =2; treatment is expensive =3; transport facility too expensive =4; could not spare time away from work =5; low quality of medical facility =6; illness was not serious =7; other specify =8
Code c: health center: hospital =1; health center =2; Clinic =3; home of health worker =4; home of traditional healer =5; 'tsebel' =6; other (specify) __________ =7
Code d location: with in kebele =1; neighboring kebele =2; with in wereda but other kebele =3, other wereda =4;
Code e means of transport: on foot =1; taxi =2; public bus =3; public transport =4; own car =5; horse/mule =6; other means of transportation =7

24. If any member of the household who works in irrigation farm does not wear/dress protective shoes or cloth, would you tell us the reason? (**ALLOW MORE THAN ONE RESPONSE)**

a. it does not have any harm if I work with ordinary dress
b. lack of awareness
c. Even though I am aware of the problem of working with out dressing protective cloths, it is expensive to buy such dress.
d. Other reason (please mention): ________________________________

Hygienic practice of the household

Now I would like to ask you about the hygienic practice in your household

25. What form of toilet do you own? **code f**	
28. How is garbage for solid waste disposed of? **Code g**	
29. Do you boil water before drinking? **Yes =1 No =2**	
30. Do you wash your hands before preparing food? **Yes =1 No=2**	
31. Do you wash your hands before eating? **Yes =1 No =2**	
32. How often is the compound swept? **Code h**	
33. Do you wash vegetables before eating? **Yes =1 No =2?**	

Code f: toilet facility: flush toilet shared =1; flush toilet private =2; pit latrine shared =3; pit latrine private =4; no toilet (use bush) =5
Code g: garbage disposed: Dispose in to river around =1; disposed in to street =2; burned =3; used as green manure =4; buried =5; periodically collected from household =6; disposed in to specific place and periodically collected by private collecting agency =7; periodically collected by government collecting car =8; other =9.
Code h time of compound swept: 1 = once per day; 2 = every two days; 3 = two to three days per week; 4 = once per week; 5 = other (specify) _________.

Section 2.3: Agricultural and Health extension service

Now I would like to ask you about the extension service you obtain on health and agricultural activities.

1. Has any of your household members ever obtained agricultural extension service? YES =1 (**ASK Q2**) NO = 2 **(GO TO Q3)**	
2. If '**Yes' for Q1**, tell me the subject area of training in agriculture? **Code I** **Code I**: Irrigation water management=1; vegetable production=2; livestock production=3; marketing=4; other (specify) =5.	
3. Has any of your household members ever obtained health related training or extension service? Yes=1 **(ASK Q4)** No=2 **(GO TO NEXT PART)**	
4 If '**Yes' for Q3**, tell me the subject area of training in health? **Code K** **Code K**: birth control=1; HIV/AIDS=2; polio=3; Wearing of special cloths during farming activities=4; wearing of special shoe during farming activities=5; health effect of wastewater farming=6; vegetable washing before eating and marketing=7; hygienic and sanitation service such as toilet facility, washing of hands before and after eating, etc =8; (other (specify)=9.	

Part Three: Agriculture

Section 3.1: Land use information

We would like to ask you about all the land used by your household, crops produced and amount sold with in the last one year. Please include **land you and your family member are cultivating whether it belongs to you or others.**

1. Plot number	2. Plot size on which you are farming In ha	3. is the plot yours Yes =1 No=2	4. How do you acquire the plot? **Code a**	5. What is the type of soil? **code b**	6. Slope of the plot **Code c**	7.Distance of the plot from the house In Km	8. For how long do you expect to farm on this plot? For the Next 1 Year=1; 5 year=2; 10 years=3	9. Do you use intercropping in this plot? Yes = 1 (**GO TO; next table and fill Q14-17)** No =2 **(FILL THIS TABLE and GO TO NEXT SECTION)**		10.. Main types of crop grown **code d**		11. Yield in kg		12. Value of yield in Birr		13. Why do you choose to grow this crop **Code e**
								In belg	In meher	belg	meher	belg	meher	belg	meher	
01																
02																
03																
04																
05																
06																

Intercropped plot

FILL THIS TABLE IF THE RESPONDENT USE INTERCROPPING; OTHERWISE SKIP THE TABLE

Plot code	14. Types of crop intercropped **code d**				15. Yield in kg				16. Value of yield in Birr				17. Why do you choose to intercrop these crops **code e**
	14.1. Crop 1		14.2. Crop 2		15.1. Crop 1		15.2. Crop2		16.1. Crop 1		16.2. Crop 2		
	belg	**meher**	**belg**	**meher**	**belg**	**meher**	**belg**	**meher**	**belg**	**meher**	**belg**	**meher**	
01													
02													
03													
04													
05													
06													

Code a: land acquisition: through government allocation=1; inheritance=2; lease in=3; rented in with sharecropping =4; rented in with fixed term =5; other (specify) _______________ =6.
Code b: **soil type**: black soil (clay)=1; sandy =2; red soil=3; other (specify) =4
Code c: slop of the plot: plain (meda)=1; slightly sloppy (mekakelegna daget)=2; steep sloppy(daget) 03
Code d: **crop code**: onion =1; potatoes =2; tomatoes =3; green pepper =4; garlic =5; cabbage =6; carrot =7; beat root =8; chat =10; avocado =11; mango=12; papaya =13; orange =14; banana =15; lemon =16; pineapple =17; maize =19; wheat =20; beans =21; others cereals=22; other vegetables =23
Code e (reason to intercropped): to get high yield =2; other reason (specify) =3; the crops have high value in the market =4; we have sufficient irrigation water =5; since we have shortage of irrigation water problem, these crops require less water =6; other reasons (please specify) =7

Section 3.2: Input use

Now I would like to ask you the use of seed, fertilizer, pesticides and herbicides in each plot for each crop you produce.

Plot number	1. Do you use organic fertilizer (e.g. manure) yes=1; no=2		Use of chemical fertilizer							Use of seed						9. Value of insecticides used in Br?		10. Value of herbicides used in Br?		Any damage due to **code a**		
			2. Do you use chemical fertilizer Yes=1; no=2		3. If yes, type of fertilizer used Urea=1; DAP=2 Both=3		4. Amount used in Kg		5. Total value in Birr	6. Do you use improved seed Yes=1; no=2		7. Do you use local seed? Yes=1; No=2		8. Total value of seed in Br.						11. Insect	12. Disease	13. other
	belg	meher	belg	meher	belg	meher	belg	meher		belg	meher	belg	meher	Belg	Meher	Belg	meher	Belg	meher			
01																						
02																						
03																						
04																						
05																						
06																						

Code a: Any damage on crop: 1 =very small; 2=medium; 3 =sever

Section 3.3: Labor utilization

Now I would like to ask you about the labor utilization for each component of farming activities.

Type of activity	1. Type of labor used* Men=1 Women=2 Children=3		2. Total number of days in work		3. Do you use hired labor Yes=1 No=2		4. If yes for Q3, total value paid in Birr.		5. Do you use family labor? Yes=1; No=2		6. Total No. of days of family labor	
	Belg	Meher	Belg	Meher	Belg	meher	Belg	meher	Belg	meher	Belg	Meher
Bed (land) preparation for seedling production												
Land preparation for main production												
Transplanting seedlings												
Irrigating farms												
Furrow preparation												
Weeding												
Guarding												
Harvesting												
Transporting yield												
Selling yield												

* Men and women are defined as those whose age are >15 years old, whereas children are defined as those whose age are 15 and below.

Section 3.4: Amount of Yield Sold

SKIP THIS TABLE IF THE RESPONDENT USE INTERCROPPING AND FILL THE NEXT TABLE

Plot number	1. Crop code		2. Did you sell part or all of the harvest Yes=1; no=2	3. If you sell, would you please tell us the amount you sold from *belg* production?			4. If you sell, would you please tell us the Amount you sold from *meher* production?		
	belg	**mehr**		3.1. Amount sold In kg	3.2. Price per kg	3.3. Total revenue in Br.	4.1. Amount sold in kg	4.2. Price per kg	4.3. Total revenue in Br.
01									
02									
03									
04									
05									
06									

Intercropped plot (SKIP THIS TABLE IF THE RESPONDENT DID NOT USE INTERCROPPONG)

Plot number	**Crop code**		5. Did you sell part or all of the harvest Yes=1; no=2		6. If you sell, would you please tell us the amount you sold from ***belg*** production?						7. If you sell, would you please tell us the Amount you sold from ***meher*** production?					
					6.1. Amount sold In kg		6.2. Price per kg		6.3. Total revenue in Br.		7.1. Amount sold in kg		7.2. Price per kg		7.3. Total revenue in Br.	
	Crop 1	**Crop2**	**Crop1**	**Crop 2**	**Crop 1**	**Crop 2**	**Crop 1**	**Crop 2**	**Crop 1**	**crop2**	**Crop 1**	**Crop 2**	**Crop1**	**Crop 2**	**Crop 1**	**Crop 2**	**Crop 1**	**Crop2**
01																		
02																		
03																		
04																		
05																		
06																		

26. Would you tell me the types of buyers for your products? **(Code f)**_______________________

Code f buyer code: government organization=1; private trader in local market=2; private traders from *atikilt tera* = 3; Super market =4; individuals from neighborhood=5; consumers at market =6; others (specify) =7.

Section 3.5: Land rent and sharecropping

1. Do you sharecrop in? 1 = Yes (**GO TO Q2)** 2= No (**GO TO Q7**)	
2. If Yes for Q1, from how many owners did you sharecrop in? _____ number of owners	
3. How are costs of input shared? **(Code a)** **Code a Share of input cost:** 1 = equally, but I pay all the costs until harvested; 2 = equally, but the owner advances me the money to buy the inputs; 3 = equally and share at the time of expenditure; 4 = I pay all; 5 = I pay all but the owner advances me the money; 6 = there are no costs; 7 = other (specify) ________	
4. Who supply the following inputs? 5.1. Farm implements (Oxen/other) 1 = I supply 2 = the owner supply 3 = both I and the owner supply 5.2. Fertilizer 1 = I supply 2 = the owner supply 3 = both I and the owner supply 5.3. Seed 1 = I supply 2 = the owner supply 3 = both I and the owner supply	
5. Who decide what type of crop to grow? 1 = I decide; 2 = the owner decides; 3 = I and the owner decide together	
6. How is the output shared?	

1 = all inputs are covered by me and I take three-fourth of the output; 2 = all the inputs are covered by me and I take one-fourth of the output; 3 = all the input costs are covered by me and we share the output equally 4 = all the inputs are covered equally and share the output equally; 5 = other specify ___________	
7. Did you rent out or sharecrop out your own land to others? 1 = Yes 2 = No (**GO TO NEXT SECTION**)	
8. If you rented out or sharecropped out, what was the share of output you received? 1= 1/2; 2 = 2/3; 3 = 1/4; 4=other (specify)	
9. If you rented out or sharecropped out how input costs are covered? **USE CODE A IN Q3 OF THIS SECTION**	
10. If sharecropping, who decides what crop to grow? 1 = I decide; 2=the tenant decides; 3=together	

Section 3.6: Livestock ownership, Income and Expenditure

Would you tell us the number and type of livestock your household own currently?

Type of livestock	1. Livestock code	2. Total number owned (available both at your farm and kept away)	3. If you would sell all what you have now, how much would you receive?
Oxen/bull	01		
Cows	02		
Heifer	03		
Calves	04		
Sheep	05		
Goat	06		
Horses	07		
Donkey	09		
Mules	10		
Chicken	11		
Others (specify)			

4. **Gross income from livestock production**

Type	Unit (Month/Year)	4.1. How much you produce (kg/litre)	4.2. The value of the product in Br.	4.3. Total revenue
Sheep/goat meat				
Beaf meat				
Hides/skin				
Butter/cheese				
Milk				
Chicken				

Eggs				
honey				
other				

5. **Livestock related expenditure**

Would you tell us any expenditure related to the following?

Type of expenditure	5.1. Unit (month/year)	5.2. Total value in Br.	5.3. Who is responsible for this activity in the household (child=1, women=2, men=3
Labor for herding			
Feed cost			
Veterinary service			
Other cost			

Part Four: Irrigation water management

Now I would like to ask you about the use of wastewater (water) in agricultural activities

1. Would you tell me the source of water for your irrigation farm? 1= Akaki river; 2 = the city's sewerage line; 3 = drains/rivers/streams with in the city; 4 = ground water; 5 = piped water; 6 = river diversion or dam constructed by government; 7 = river dam or diversion constructed by NGO; 8 = traditional canal from river diversion constructed by the community; 9 = spring water; 10 = pond constructed by NGO; 11 = pond constructed by local government; 12 = Other (specify)	
2. Would you tell me how water is extracted from the source? 1 = using motor pump; 2 = using gravity; 3 = manually using container (water can); 4 = other (specify)	
3. Would you tell me how you irrigate your farm or how water reaches to the crop? 1= drip irrigation system; 2 = surface irrigation system (furrow system); 3 = sprinkler irrigation system; 4 = manual using container; 5 = other system (specify) _______________	
4. Did you establish water users association? Yes =1 **(ASK Q5)** No =2 **(SKIP TO Q7)**	
5. If Yes for Q4, Would you tell me the composition of the committee which makes up the water users association? Number of women _______; Number of men _________; NK = I don't know	
6. If YES for Q4, What is the role of the water users association? (**ALLOW MORE THAN ONE RESPONSE)** 1= regulate irrigation water distributions; 2= help in supplying farm inputs such as seed, fertilizer and pesticides; 3= manage the overall operation and maintenance of the canals, etc; 4= employ guards; 5= represent the members of the association in some meetings regarding irrigation practices; 6=other specify ___	
7. Do you have rules and regulations for irrigating your farm?	

Yes =1 **(ASK Q8)** No =2 **(SKIP Q8)**	
8. If YES for Q7, If anyone violets the rule and regulation of the water distribution (water users association), what would be the penalty? (**ALLOW MORE THAN ONE RESPONSE**) 1 = he/she will be penalized in cash; 2 = he/she can not get any service from the association; 3 = he/she will miss irrigation turn; 4 = he/she will not get water for the farm at all; 5 = he/she will be outcasted from the society; 6 = other (specify) _____	
9. Would you tell me how you manage irrigating your farm with the other farmers? 1 = Every farmer irrigates his/her farm only during his/her turn; 2 = There is no turn. Every farmer irrigates his/her farm according to his own schedule. 3 = Every farmer has its own turn but there is a possibility of exchanging turn; 4 = Other specify	
10. If there is a possibility of exchanging irrigation turn, would you tell me the reason? 1 = make water availability more responsive to crop water requirement; 2 = In case, if one has other non-farming activity and need to do urgent issue, we exchange our turn; 3 = other reason (specify)	
11. Do you pay for the water you use for irrigation? 1 = Yes 2 = No **(SKIP TO Q16)**	
12. If you pay for the water used to irrigate your farm, would you tell me the terms of payment? 1 = per one irrigation time; 2 = per hectare; 3 = per cropping season; 4 = volume of water used 5 = per month; 6 = other (specify) ___________	
13. How is the payment made? 1 = in cash 2 = in Kind	
14. How much is the payment? 14.1. If it is in cash, how much is the payment? ___________Birr per (one irrigation water application/per month/per hectare/cropping season/volume of water used/other ___ (specify)). 14.2. If it is in Kind, how much is the payment? ___________	
15. who is collecting the water fee 1 = water users association; 2 = wereda agricultural office; 3 = wereda finance office 4 = municipality; 5 = kebele administration office; 6 = other (specify) __________	
16. Are you interested in wastewater irrigation farming? Yes =1 **(SKIP TO Q19)** No =2	
17. If 'No' for **Q16**, would you tell me the reason? 1 = working in wastewater irrigation has negative health impact; 2 = the money I get from wastewater irrigation is very small and is not comparable with the time and effort; 3 = even though I get more money, the work is tiresome and requires much effort; 4 = other reason (specify)	
18. If you are not interested, why is that you involve in wastewater irrigation farming? 1 = lack of other water source for irrigation; 2 = lack of financial resource to use other source (e.g. groundwater/diverting surface water); 3 = I do not have other alternative for earning money; 4 = it is better than other works I can get given my educational level 5 = other reason (specify) _________________	
19. Would you tell me what problem do you face in relation to irrigation farming? 16.1. Problem of water shortage? Yes =1 No =2 16.2. problem of poor distribution of irrigation water Yes =1 No =2 16.3. problem of water logging on farm plot Yes =1 No =2	

16.4. lack of crop extension service Yes =1 No =2 16.5. lack of awareness in the health effects of wastewater irrigation practice Yes =1 No =2 16.6. lack of access to credit Yes =1 No =2 16.7. shortage of farm land Yes =1 No =2 16.8. shortage of improved seed Yes =1 No =2 16.9. problem of low farm gate price for our product Yes =1 No =2	

Use of irrigation Water

Now I would like to ask you about the frequency of water application in your farm.

Plot **code**	Crop **code**	20. How many times you irrigate the farm? **code a**	21. Volume of water used per one time application	22. reason for such irrigation interval **code b**	23. When do you stop irrigation? **Code c**
01					
02					
03					
04					
05					
06					

Code a: number of irrigation: 1 = irrigate my farm once per day; 2 = irrigate my farm twice per day; 3 = two to three days per week; 4 = irrigate my farm once per week; 5 = other (specify) _______________.

Code b: reason for irrigation interval: 1 = Crop does not need much water; 2 = the crop needs much water; 3 = there is no shortage of water; 4 = shortage of water because of many farms; 5 = because the soil needs much water; 6 = because the soil does not need much water; 7 = the area is too hot and needs much water; 8 = the soil holds water for long time; 9 = other reason (specify) ___________.

Code c: when do you stop irrigating water: two weeks before harvest =1; one week before harvest =2; less than one week before harvest =3; I irrigate until harvest ends=4

Part Five: Wastewater Valuation Question

CVM questionnaire

INTERVIEWER: ***Read the following before you start to ask the following questions***

The following questions are concerned with the use of wastewater (fresh water) in irrigated agricultural activities. I would like to know how much the wastewater (freshwater) is worth to your household's livelihood.
First let me begin by saying that most of the following questions have to do with your attitudes and opinions, and there is no right or wrong answers. As I told you before, this interview is completely confidential and strictly for academic purpose. Your name will never be associated with your response. Thus, please answer the questions honestly and as truthfully as you can.

1. When did you start wastewater (fresh water) irrigation? Since ___________ year
2. Do you think that the use of wastewater in irrigation, generally, benefits your household?
    1 = Yes, a lot (**GO TO Q3**)
    2 = Yes, somewhat; (**GO TO Q3**)
    3 = Too little; (**GO TO Q4**)
    4 = Not at all (**GO TO Q4**)

3. If the answer for Q 2 is "a lot", would you tell me how your household is benefiting too much from wastewater irrigation?
    1 = it is the only source of water available
    2 = generate income by growing crop
    3 = supplement food supply of my household
    4 = it is the only work I can get
    5= supplies crop nutrients
    6 = more reliable than other source of irrigation water
    7 = other (specify) _____________

4. If the answer for Q 2 is "too little or Not at all", would you tell me the reason why you work in wastewater irrigation if it does not benefit you or your household?
    1= no other alternative for living
    2= I earn less income, which is not enough for living
    3= other (specify) ______________________

5. Do you know that crops produced using wastewater have a potential effect on the health of the consumer as well as to the producer like you?
    Yes = 1 No = 2

WTP questions

Now, I will read one paragraph, please listen carefully. If you do not understand the paragraph; please feel free to ask me, I will explain to you.

Wastewater is a valuable resource for crop production. It is also a least cost method of sanitation disposal. It is used as a source of irrigation water for a farmer like you. It is also believed that farmers who use wastewater as a source of irrigation have also a cost advantage in terms of reduction in fertilizer cost compared to freshwater irrigators. However, unless the use of wastewater in crop production is practiced with caution, it will have a negative health effect on the consumers and producers. There are different options to minimize the health effects of the use of wastewater in crop production. The first option is that to legally prohibit the use of wastewater for crop production. The second option is to fully treat or semi-treat the wastewater and use the treated wastewater for crop production. The other option is to create awareness to wastewater farmers on the health effect of practicing wastewater irrigation and consumers in consuming crops produced using wastewater. Either of these options can minimize the health effect and requires money to implement.

6. Which option do you prefer (more than one answer possible)?
   - Option 1: legally and completely prohibit crop production using wastewater.
   - Option 2: to treat wastewater and permit the use of the treated wastewater for crop Production
   - Option 3: creation of awareness through education, training, advocacy, etc

ENUMERATOR: BEFORE YOU READ THE FOLLOWING, TELL THE RESPONDENT THAT YOU ARE GOING TO READ ANOTHER PARAGRAPH.

Assume that the government wants to minimize the health effect of the use of wastewater in crop production. It will do this using either by treating the wastewater and permitting its use for crop production and/or by creating awareness through education, training, advocacy and other possible means for safe use of the wastewater. To implement this, government will formulate policy and legislations and develop mechanisms to enforce the laws and policies to be implemented. This requires some money. For this purpose the government will establish fund, in which every wastewater irrigators are participating in contributing some money to cover some part of the cost. The program will have the following advantages. First, you will be able to use the wastewater legally, reliably and sustainably. Second, you will use the wastewater in such away that your health and that of your family will be protected. Third, it minimizes the health risk associated with the consumption of the products, i.e. the health risk to consumers of the produces will be minimized. Fourth, consumers will buy your products without casting any doubt on the health effect of the crops. Fifth, your product will have more demand in the market, and Six, the river will be clean, good looking and the surrounding areas will not have bad odor.

We want to know how much you are willing to pay to the government's program. Your contribution will have an advantage in successfully implementing the government program and getting the above advantages.

Freshwater farmers

Because of irrigation scheme you are producing different kind of vegetables at least twice per year and get income. In addition, your household has access to vegetable consumption. On the other hand, if not used properly and efficiently, water is a scarce resource, and you may not get enough water for crop production. Besides, if not used properly, it will erode the soil and will decrease yield. This will affect your income. The water also logs on the farm and will harbor insects such as mosquito and cause malaria. If the environment is not protected, the amount of water will decrease and affect your farming activity. One means of avoiding such risk is to protect the environment and provide advice how to use irrigation water properly. The government will formulate program that will protect the environment, provide technical advice on irrigation management so that the health risk is minimized, protect soil erosion and enable you to use irrigation water sustainably. This requires some money. For this purpose the government will establish fund, in which every farmer will participate in contributing some money to cover some part of the cost of the government program.

We want to know how much you are willing to pay to the government's program. Your contribution will have an advantage in successfully implementing the government program and getting the above advantages.

Now I will ask you the following questions. Once again I want to remind you that there are no right or wrong answers. Feel free to respond based on your own opinion and attitude.

7. Are you willing to contribute some amount to the government's program?
   1 = Yes (**GO TO Q9**)
   2 = No (**GO TO Q8**)
   3 = do not know (**GO TO Q8**)
   4 = refused to state his/her opinion (**GO TO Q8**)

8. People have different reason for saying No/do not know/refuse to state their preference/, would you tell me your reason to respond like that
   1 = I am paying taxes so this is the responsibility of the government to do to prevent water from being polluted
   2 = I or my family health is not affected by consuming or working in wastewater crop production. Thus there is no need to contribute anything
   3 = I do not want to respond
   4 = other reason (specify)

9. Are you willing to pay? _______________ Birr /ha/per year
   Yes -------- (**GO TO Q10**)
   No --------- (**GO TO Q 14**)

10. If the answer for question 9 is YES, ask the following questions.
   Are you willing to pay _______________ Birr/ha/year?
   Yes -------- (**GO TO Q11**)
   No --------- (**GO TO Q 12**)

11. If the response is YES for Q10, ask the following question.
What would be the maximum amount you would be willing to pay?
I am willing to pay a maximum of _________Birr/ha/year

12. If the answer for question Q10 is NO, ask the following:
What would be the maximum amount you would be willing to pay?
_________ Birr/ha/year

13. If the answer for Q9 is 'NO', ask the following question:
Are you willing to pay ___________ Birr/ha/year?
Yes -------- (**GO TO THE NEXT QUESTION**)
No --------- (**GO TO NEXT QUESTION**)

14. If the answer for question 13 is either 'YES' or 'NO', ask the following:
What would be the maximum amount you are willing to pay?
__________ Birr /ha/year

15. If the respondent is not willing to pay any amount, ask the following question
'Since I am willing to know how much value you attached to wastewater or how important is wastewater for your livelihood, would you tell me how much are you willing to pay for the use of wastewater in crop production if it is must that you have to pay some amount?'
_________ Birr /ha/year
If the respondent states some amount, go to Q9 and ask Q9 and proceed accordingly.
If he/she is not willing to pay any amount, ask Q16.

16. Ask the following for all respondent who are not willing to pay any amount.
'Would you tell me the reason why you are not willing to pay any amount?'
1 = I am not convinced that the issue needs that match concern
2 = I do not believe that the fund will be spent on the purpose it will be raised
3 = it is the government's responsibility to protect us from such risk
4 = I cannot afford to pay any amount
5= I do not know

Part Six: Off-farm employment and remittance
Section 6.1: Employment for Wage

1. Within the last one year, did you or any other members of the household work off the household's land either on someone else's land or in some other employment, against payment in cash or in kind, or as part of a labor sharing agreement?
1 = YES; (**FILL THE FOLLOWING TABLE**) 2 = NO (**GO TO Q8**)

IF YES, GIVE DETAILS.

ID code of HH member	2. Kind of work (**code a**)	3.Location of work (**code b)**	4. Did the work need qualification? **Code c**;	5. Is it permanent (=1) or temporary (=2):	6. Total number of days worked.			7. Total amount earned in Birr		
					6.1. May - August	6.2. September-December	6.3. January – April	7.1. May-August	7.2. September-December	7.3. January – April
01										
02										
03										
04										
05										
06										
07										
08										
09										
10										

Code a- kind of work: farm worker (for Pay**) =**1; Traditional labor sharing =2; Professional worker (teacher, government worker, administration, health worker, clerical) =3; Laborer (skilled i.e. builder, Thatcher) =4; Salesman or saleswoman (trading grain, trading in livestock, etc) =5; selling in guilt (micro market) such as selling wood, selling Tela, Areque, kolo, injera, etc=6; soldier=7; driver/mechanic=8; unskilled worker=9; domestic servant =10; weaving, milling, handcraft, etc =11; other = 12 (SPECIFY)
Code b- location of work: this kebele=1; other kebele with in this wereda=2; neighboring wereda=3; other zone/kifleketema=4; other region= 5; foreign country =6
Code c- work qualification: Experience only=1; Training only=2; Education only=3; Nothing=4.

8. Would you or any other member of the household have liked to work (more) for wages during the last one year? YES =1, NO =2	
9. Why do you choose to work off-the farm? Give at most three reasons. Reason 1___________ Reason 2 ____________________ Reason 3 ___________ (**code d**)	
10. Why do you choose to work on the farm? Give at most two reasons. Reason No. 1_________; Reason No. 2____________ (see **Code e**).	

Code d- reason to work off the farm: 1 =no more labor is needed on the farm; 2 =I do not have enough land to support my family; 3 = I am not interested to work on the farm; 4 = off-farm work is more profitable than on farm work; 5 = farm work is insufficient for living; 6 = I can not rent in additional land; 7 = my education is outside agriculture; 8 = other (specify)
Code e-reason for not seeking other work (reason to wok on the farm): no employment opportunity=1; I need to work on farm =2; job too far away=3; too low wage=4; do not want to work off-farm=5; respect holidays=6; other (please specify) =7.

Section 6.2: Transfer (remittance and Aid)

11. Has the household received any remittance, gifts or transfers with in the last one year? Yes =1; No =2	
12. If yes, what is the amount received? _______________ Birr (________________ in Kind)	

Part Seven. Household Asset and Credit Access
Section 7.1: Household Asset

1. Do you own the house your household currently lives in? 1=Yes (**GO TO Q4**) 2=No **(ASK Q2 & Q3)**
2. If 'No', how do you acquire it?
    1 = Rented from Kebele;
    2 = Rented from government
    3 = Rented from private
    4 = Gift from relatives
    5 = Other (specify) ________________
3. If rented, how much is the rent per month? ____________________________ Birr/month

4. Ownership to Household and Non-household goods?

Household Goods	Item code	4.1. Number owned	4.2. Total value
bed	01		
Tables	02		
Radio/tape recorder	03		
TV	04		
Kitchen with its items	05		
Agricultural equipments			
Donkey cart	06		
Treadle or diesel pump	07		

Plow metal point (*Maresha*)	08		
Plow yoke (*moneco* and *kemba*)	09		
Water carrier made of canvass/skin/inner tire tube	10		
Other agricultural equipments	11		
Non agricultural items			
Bicycle	12		
Business car (taxi, etc)	13		
Small car for family/personal transportation	14		
Weaving equipment	15		
Stone grain mill	16		
Wooden box	17		
Horse/mule	18		

5. What kind of materials are your house made of?

Types of rooms	5.1. Number of rooms	5.2. Main kind of construction materials **(Code c)**	5.3. How much it costs you to replace this? (in Birr)
Bedrooms			
Wall			
Floor			
Roof			
Living rooms			
Wall			
Floor			
Roof			
Kitchen			
Wall			
Floor			
Roof			

Code c (kind of construction materials): stone/brick =1; wood =2; iron sheet =3; mud =4; thatch (sar) =5; other (specify) =6

Section 7.2: Household Access to Credit

1. Did you take any credit with in the last one year? Yes =1 No =2 (**GO TO Q6**)	
2. If yes, would you tell me the purpose of the loan? (**Code a**) **Code a (purpose of loan):** to buy motor pump for irrigation =1; to buy inputs such as seed, fertilizer, pesticides, etc =2; to pay rent for tractor for farming =3; to pay daily laborer for ploughing and other farming activities =4; to pay rents and taxes =5; to pay loan borrowed for farm production =6; to start off-farm activities =7; to buy food items for consumption =8; to pay for health expenses =9; to pay for educational expenses =10; to pay for contribution for social organizations (e.g. ODA) =11; other (specify) =12	
3. If you took any credit, would you tell me the source of loan? (**Code b**) **Code b (source of loan):** individual lender/*Arata abedari* =1; relatives/friend =2; bank =3; local NGO such as AAMFI =4; other NGO (specify) =5; other source (please specify) =6	
3. How much did you borrow? ___________ (in Cash) + __________________ (in Kind)	
4. Did you pay the loan on time? Yes =1 (**GO TO Q6**); No =2	
5. If you did not pay, would you tell me the reason? (**Code e**) **Code e (reason for not pay on time): I** spent the money on consumption (to buy food, cover health expenses, etc) =1; the repayment time is too short to repay =2; bankrupt in my business =3; failure in crop yield =4; low price for my production =5; theft =6; other (specify) =7	
6. If you did not take any credit with in the last one year, would you please tell me the reason? (**Code g)** **Code g (reason for not taking loan**): not available =1; I did not need to borrow =2; high interest rate =3; the lender needs collateral =4; other (specify) =5	
7. Have you ever given a loan to another household with in the last one year? Yes =1 No =2	
8. Are you or any member of the household a member of '*Equb*'? Yes =1 No =2	
9. If yes for question '8', how much is the contribution per week/month? __________ Birr (**total amount per year**	

Part Eight: Food expenditure and consumption

Section 8.1: Consumption habit

1. How many meals per day has your household been eating with in the last one year? 1= Three times per day; 2= two times per day; 3= one time per day ; 4=four times per day	
2. Is all food belonging to your household kept together and shared out at meal times? Or do some members of your household have their own separate stock of food which they use separately from others? 1= all together; 2= separate stock	
3. Is your consumption habit you told me before differ from season to season? 1= yes it different in kiremt from belg; 2= no it is the same **(GO TO NEXT SECTION)**	
4. If it is different, would you tell me how it is different? 1= we eat less in kiremt since we have food shortage; 2= we eat different types of food in belg such as meat since in kiremt every thing is expensive; 3= other reason (specify)	

Section 8.2: Food expenditure and consumption

We would like to ask you about all the food that was bought and/or used from your own stock **for consumption** for last month. **Please do not include food bought for resale even after processing (THE RESPONDENT SHOULD BE THE HOUSE WIFE).**

Food type		5. Code	6. Total food consumed		7. Consumed from purchase		8. Consumed from own harvest		9. Consumed from other sources	
			6.1. Amount in Kg	6.2. Value in Br	7.1. Amount in Kg	7.2. Value in Br.	8.1. Amount in Kg	8.2. Value in Br.	10.1. Amount in Kg	10.2. Value in Br.
Cereals	Teff (injera, etc)	01								
	Barley (bread, etc)	02								
	Wheat (bread, etc)	03								
	Maize (bread, etc)	04								
	Sorghum	05								
	Other cereals	06								
Animal product	Milk/yogurt/ cheese	07								

	meat	08								
Beverage (liter)	Tella, Arequi, teji, etc	9								
	Coffee, sugar, tea	10								
	Cooking oil, Salt	11								
vegetables	Onion, tomatoes, potatoes, etc	12								
	other	13								
Pulses and oil crops		14								

Section 8.3: Non-food expenditure
Now, I would like to ask you about non food expenditure of the household

Types of Expenditure	10. Code	11**. Unit** Week=1 Month=2 Year=3	12. Total expenditure	13. Is all the payment is made by the household Yes =1 No =2
Clothes/shoes, fabric for family	01			
Cosmetics for family	02			
Expense for Entertainment	03			
Transport cost	04			
Ceremonial expenses	05			
Contribution to Edir	06			
School fees	07			
Medical treatment	08			
Water supply fee	9			
Electricity fee	10			
Telephone fee	11			
Expense for charcoal, fuel wood, kerosene, matches, etc	12			
Expense laundry soap and other personal care	13			
Other	14			

Part Nine: Social Capital

Now I would like to ask you about membership to any local or external organization you or your family member belongs.

1. Are you or any of your family member belong to one or more of the organizations or associations listed below (**code a**) (**LIST AS MANY AS THE RESPONDENT STATES**)	
2. Do you or any of your family members obtain or received any support (emotional, economic, or other) from any of the organization(s) or individual(s)? Yes =1 No =2	
3. If 'yes', list the name of the organization/association from which the household obtained support. (**code a**)	
4. What are the different benefits you enjoy from them? (**code b**)	
5. Do you feel that you are the member of the community? Yes =1 No =2	
6. Generally speaking, would you say that most people in your locality can be trusted? **(Code c)**	
7. Do you feel that most people would try and take advantage of you if they could? Yes =1 No =2 I don't know = 3	
8. Do you agree that most people in this village are willing to help you if you need? **(Code d)**	
9. Do you agree that in this village, people generally do not trust each other in matters of lending and borrowing money? **(Code e)**	
10. Have you or any member of your household join together with any person or organization to discuss or address common issues and/or talk with the local authority on problems of the community? Yes =1 No =2	
11. Have you attended any of the following last year?	
11.1. Wedding Yes =1 No =2	
11.2. Mahiber Yes =1 No =2	
11.3. Sedeka Yes =1 No =2	
12. To what extent do you trust the kebele and other authorities? (**Code f**)	
13. What rank do you give your self in terms of happiness compared to other residents of the village? **(Code g)**	
13.1. Now	
13.2. Five years before	
13.3. Ten years before	

Code a Membership: Village associations =1; Peasant association =2; Women association =3; Youth associations =4; Elder association =5; Church/mosque =7; Water users associations =8; Edir =9; Equb =10; Marketing cooperatives =11; Input supply cooperatives =12; other (specify) =14

Code b benefits obtained: Improve access to social services =1; Important in times of emergency/insurance =2; Enjoyment =3; Spiritual, social status, self esteem =4; Fair input price =5; Fair output price =6; Better access to off-farm employment =7; Feeling good about being part of a group =8; Other (specify) =9
Code c: Yes, I strongly agree =1; No, I disagree =2; neither agree nor disagree =3
Code d: Agree strongly =1; Agree some what =2; Disagree =3; I don't know =4
Code e: Agree strongly =1; Agree somewhat =2; Disagree =3; I don't know =4
Code f: Very much =1; Not so much =2; Not at all =3
Code g: Very happy =1; Happy =2; Not so happy =3; I don't know =4

THANK YOU FOR YOUR COOPERATION