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COLLEGE OF DEVELOPMENT STUDIES

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USES OF WASTEWATER FOR URBAN AGRICULTURE AND ITS CONTRIBUTION TO HOUSEHOLD FOOD SECURITY IN AKAKI KALITY SUB CITY, ADDIS ABABA, ETHIOPIA

By: Getahun Chala

DECEMBER, 2022

ADDIS ABABA, ETHIOPIA

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By: Getahun Chala

Thesis Advisor: Meskerem Abi (PhD)

A MSC THESIS SUBMITTED TO CENTRE FOR FOOD SECURITY STUDIES

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DECEMBER, 2022

ADDIS ABABA, ETHIOPIA

DECLARATION

The research of this thesis declared that the undersigned thesis entitled "Uses of wastewater for Urban Agriculture and Its Contribution to Household Food Security in Akaki Kality Sub-City, Addis Ababa, Ethiopia" is based on my original work and has not been submitted for a master's degree or certification in any other universities or institutions, and that all sources of material used for the thesis have been acknowledged.

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Getahun Chala Bayissa

December, 2022

APPROVAL SHEET

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As supervisor of the thesis, I certify that I have read and evaluated the thesis prepared by Getahun Chala Bayissa entitled with "Wastewater for Urban Agriculture and Its Contribution to Household Food Security in Akaki Kality Sub-City, Addis Ababa, Ethiopia" and recommended for open defense as fulfilling the requirement for the degree of Master of science in Food Security and Development

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As members of the examining board of the Open Title Defense, we certify that we have read and evaluated the thesis prepared by Getahun Chala Bayissa entitled with "Wastewater for Urban Agriculture and Its Contribution to Household Food Security in Akaki Kality Sub-City, Addis Ababa, Ethiopia" and recommended that it is acceptable thesis for the degree of Master of science in Food Security and Development

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Name of Internal Examiner | Signature | Date

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ABBREVIATIONS AND ACRONYMS

CFU	Colony Forming Unit
DV	Dependent Variable
FAO	Food and Agriculture Organization
FCS	Food Consumption Score
FGD	Focus Group Discussions
HFIAS	Household Food Insecurity Access Scale
IV	Independent Variable
KAP	Knowledge, Attitude and Practice
KII	Key Informant Interview
UA	Urban Agriculture
USEPA	United State Environmental Protection Agency
UN	United Nations
WHO	World Health Organizations

ABSTRACT

The use of wastewater in urban agriculture (UA) has been a heated topic due to its contribution on food security and extending effect on human health following the presence of microbes and heavy metals. A cross-sectional and experimental-based research design was conducted in the Akaki Kality sub-city of Addis Ababa to investigate the use of wastewater in urban agriculture and its contribution to household food security. Household questionnaire survey data were acquired from 183 individual farmers using a purposive sampling method. Data was analyzed using descriptive statistics such as frequency distritribution and measure of central tendency such as mean, standard deviation, maximum and minimum to describe the data. Meanwhile, ordinal logistic regression was utilized to determine the explanatory variables that had an effect on household food insecurity status. The descriptive statistic shows that about 40% of the households were categorized as food secure, on the other hand 61.05% of the households had acceptable food consumption score (>35). The results of the ordered logistic model reveal that household head family size, education level, farm size, farming experience, on-farm income, off-farm income, household expenditure, access to extension service and access to fertilizer significantly influenced sample households' food security in the study area. Households had poor practices in food handling, personal hygiene, and water sanitation and this was also reflected during personal observation. The level of total coliform and E. coli was found to high in the analyzed sample, and this makes it unsafe for irrigation. The food safety gap showed in practice makes the farmers more exposable for different types of disease. Meanwhile, the heavy metal concentration in irrigation water did not exceed the recommended limit due to dilution of wastewater, environmental monitoring system, seasonal variation, deposition of metals in soil, etc. Despite the low level of heavy metals in the analyzed sample, continuous use of this water may results in different health related disease for the farmers as well as the consumers. Finally, the study concludes the use of wastewater for urban agriculture is safe. Yet, adequate monitoring and analysis of the metals in irrigation water is required to prevent their accumulation in the food chain.

Keywords: Wastewater, Food Security, Urban agriculture, irrigation, Akaki Kaliti sub city

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

Rapid population growth coupled with high urbanization is placing increased pressure on urban food security (Korth *et al*., 2014). Recently, urban agriculture (UA) has emerged as a mechanism to improve food security while also providing employment opportunities for urban populations. UA is not a recent phenomenon to occur in urban areas. For many years, urban farming has served as a vital input towards the livelihood strategies of urban households worldwide (Bairwa *et al*., 2014). UA can be defined as growing crops and raising small livestock on land within the urban boundaries of cities and towns (e.g., home gardens, vacant lots, roadsides, and balconies) for household consumption or sale in urban markets (Poulsen *et al*., 2015). Game and Primus (2015) argue that UA is an active process of growing, processing, and supplying food for urban residents in urban areas where people effectively use space, such as through roof farming and vertical and potted plants.

The UA produces 15% of all food consumed in urban areas globally, and this figure is expected to double in the coming years (Mpofu, 2013). It is estimated that about 800 million people worldwide will engage in UA in the next twenty years. For instance, in Russia, 72% of households are urban farmers, 68% are in Tanzania and in China, and the 14 largest cities produce 85% or more of their vegetables. In Africa, UA is understood to have a long history that starts with the establishment of the first colonial cities and improved food security. The practice was embraced by people in many different socio-economic classes and for many different reasons, including addressing problems related to food supplies and employment opportunities (Nugent, 2000).

Moreover, UA plays a significant role in increasing food availability and incomes, supporting livelihoods, and contributing to the overall economy (World Bank, 2008). Similarly, it is a key factor contributing to improving food and nutrition security and overcoming the problems of environmental effects (Smit and Nasr, 1992). To name a few, UA is distinguished by its proximity to markets, high competition for land, limited space, use of urban resources such as organic solid waste and wastewater, a low degree of farmer organization, a focus on primarily perishable products, and a high degree of specialization. By supplying perishable products such as vegetables, fresh milk, and poultry products, UA, to a large extent, complements rural agriculture and increases the efficiency of national food systems (Veenhuizen, 2006).

Another characteristic of UA is the use of alternative water sources, such as domestic wastewater, to supplement water supplies and lower household costs. Increasing water scarcity hampers agricultural productivity and thus forms a key driver for the reuse of wastewater (Hanjra *et al*., 2012). Consequently, wastewater irrigation is common among urban farmers worldwide (Molden, 2007; Drechsel and Evans, 2010). Evidence shows that about 20 million hectares are irrigated with wastewater in the world, and about 10% of total food production comes from wastewater-irrigated areas (Makoni, 2016; Mateo *et al*., 2017).

In Ethiopia, UA is the final sequence of survival strategies exhibited by households. Households in urban areas respond to the extreme threat of poverty and food insecurity by carrying out urban farming on any vacant space available. UA is also practiced because of the shortage of income and unemployment in urban centres (Lamba, 1993). In addition, UA is essential for the livelihoods of many poor farm households and supplies fresh vegetables at low prices to the nearby cities (Alebel *et al*., 2009). According to a Central Statistical Authority (CSA) report (2007), 30% of vegetables, including 60–70% of leafy vegetables, 60–70% of milk, and 40–60% of eggs consumed in the city are supplied by urban and peri-urban farmers. Addis Ababa city is considered the ideal place for the implementation of UA because of the existence of suitable agro-ecologies for both horticultural crop production and animal husbandry (Mandefro, 2010). Moreover, approximately 62 tonnes of honey are produced in Addis Ababa each year, with an average of 40 kg of honey obtained annually per improved beehive (Gebremichael *et al*., 2014). This output is approximately double that of rural parts of the country, where only 15–20 kg per beehive per year is harvested.

Studies have confirmed that the use of wastewater in UA is common in developing countries, including Ethiopia (Scott *et al*., 2004; Raja *et al*., 2015). The practice of wastewater utilization in crop production is by far the most common and has the longest tradition (Jiménez *et al.*, 2010).

In most cases, the irrigated lands are located in or around the urban areas where the wastewater is generated. In Addis Ababa, large volumes of untreated wastewater are released to water bodies, which farmers use for irrigation (Weldesilassie *et al*., 2011).

Wastewater is regarded as an important source of several essential micro- and macronutrients required for plant growth and development. In fact, wastewater irrigation provides quite a sufficient amount of nutrients (nitrogen, phosphorus, and potassium) to soil and plants (Murtaza *et al*., 2010). Besides that, the use of wastewater is associated with environmental and human health risks due to the accumulation of heavy metals (lead (Pb), cadmium (Cd), nickel (Ni), chromium (Cr), and zinc (Zn)) and microbes (total coliform and Escherichia coli) ().

Similar to other sub-cities in Addis Ababa, the Akaki Kaliti sub-city is endowed with natural and manmade resources, presumably conducive to an agro-ecology for crop and livestock production. Poultry production, dairy production, livestock fattening, and vegetable production are the types of UA practiced by households in Akaki Kality sub-city (Endale, 2011). Akaki farmers in urban and peri-urban areas use the Akaki river system as a source of irrigation water for the continuation of cultivation during the dry season, normally from October to June. Farmers grow mainly vegetables, contributing up to 60% of the vegetable demand for Addis Ababa (Gebre, 2009; Animaw, 2011). As a result, the current study will look into urban agriculture produced with wastewater and its contribution to food security in Akaki Kality Sub City, Addiss Ababa.

1.2. Statement of the Problem

Rapid urbanization and an increase in the urban population have caused the locus of poverty, food insecurity, and environmental pollution to shift and expand from rural areas to cities and towns (Crush and Frayne, 2011; Poulsen *et al*., 2015). Improving urban livelihoods through UA has become a hot topic among those concerned about the co-emerging trends of rapid urbanization and urban food insecurity (Zeeuw *et al.*, 2011; Frayne *et al.*, 2014, 2016; Prain and Smith, 2010; Zezza and Tasciotti, 2010).

UA makes a significant contribution to improving food and nutritional security at the household and community levels. Its implications for food security are the increased supply of fresh and perishable food products like milk and vegetables, satisfying the consumption needs of the urban poor, and increasing the income of households engaged in the production, processing, and marketing of UA products (Korir, 2015). UA is an important activity in many developing countries because it provides local people with low-cost food while also improving nutrition, economic development, job creation, and food security (Korir, 2015).

Various scholars reported the contribution of wastewater use in the UA to livelihood and food security as well as its safety concern. Wastewater irrigation provides essential nutrients and organic matter, saving water and reducing water contamination (Murtaza et al., 2010). Gashaye (2020) reported that the use of wastewater in farming is important in improving the livelihoods of the participants and becoming a source of income and food Besides these benefits, a number of drawbacks are associated with the use of wastewater for UA as it contains potentially toxic elements and contaminants, which can induce severe risks to humans and the environment (Mark *et al*., 2019; Shahid, 2017; Khalid *et al*., 2017; Murtaza *et al*., 2010). However, scientific evidence is limited on the food security status of vegetable and livestock producers that use wastewater in UA in the study area as well as that link the impact of wastewater use in attaining FS. Hence, there is a need for research that will fill aforementioned gap. The objective of this study was, therefore, to investigate the use of wastewater in urban agriculture and its contribution to household food security in Akaki Kality sub-city, Addis Ababa, Ethiopia, 2022.

1.3. Objectives of the study

1.3.1. General objective

The general objective of this study was to investigate the use of wastewater in urban agriculture and its contribution to household food security in Akaki Kality sub-city, Addis Ababa, Ethiopia, 2022.

1.3.2. Specific objective

Specifically, this study aimed to:

1. Identify urban agriculture activities practiced by study participants in the study area
2. Assess the knowledge, attitude, and practices of households using wastewater for urban agriculture practices in the study area.
3. Measure the food security status of households engaged in urban agriculture in the study area.
4. Examine factors determining participation in urban agriculture producers in the study area.
5. Measure the concentration of selected microbial and heavy metals (Escherichia coli, total coliform, arsenic, cadmium, chromium, lead, mercury, and zinc) in wastewater utilized for urban agriculture practices

1.4. Research Question

This research questions included to answer the following basic questions drawn from the research objectives listed above:

1. What are the major types of UA activities practiced in the study area?
2. What is the farmers' level of knowledge, attitude and practice of household food safety in terms of food handling, personal hygiene and water sanitation?
3. What is the prevalence of food insecurity among sample households in the study area?
4. Does a household's socio-economic, demographic and institutional characteristic affect food security status?
5. What is the contamination level of microbes and heavy metals in wastewater utilized for UA practices in the study area?

1.5. Significance of the Study

Studying the contribution of urban agriculture to food security at the HH level will be timely and necessary. Hence, the research outputs will improve knowledge about the role of urban agriculture in improving the food security of urban people and will add to the limited research in the sector. Thus, the findings of this research will benefit local authorities, urban planners, and policymakers in the sub-city to have a good understanding of the role of UA for food security and nutrition at HH level, the constraints of the sector specific to the sub-city, and hence give due consideration to UPA and incorporate the sector into the future town's development plans.

Data generated may help policy makers, researchers, and extension workers in policy design, the development of improved technologies, and enabling the public to recognize the sector's role in the city's economic development and provide priorities to the sector. The study will bring new insight into the most debatable roles of urban agriculture, like food security and economic advantage (i.e., its impact on household welfare like food security and income). This will help researchers and NGOs further analyse their interventions based on what works and what does not work in urban settings.

1.6. Scope and Limitations of the Study

1.6.1. Scope of the study

The study was conducted on individual farmers that reside in Akaki Kality sub-city, Addis Ababa, who are engaged in vegetable and livestock production. The study measured the concentration of selected microbial and heavy metals (Escherichia coli, total coliform, arsenic, cadmium, chromium, lead, mercury, and zinc) found in the wastewater from the downstream of the river used by the farmers in woreda 3 for their agricultural purposes. Moreover, the study considered farmers that use wastewater for agricultural activities, including vegetable and livestock production. Hence, farmers utilizing other water or clean water were not considered in this study.

1.6.2. Limitation of the study

The study group was conducted with farmers that use wastewater and may not represent farmers that use other sources of water. As the food security-related data was collected based on the respondent's memory, the result may be subjected to recall bias in self-reported household-level food security measurement tools. Similarly, the KAP assessment is also subjected to bias as it is affected by the respondent's perception. This is a cross-sectional study that may not adequately show the seasonal variation in the quality of wastewater, which may lead to a variation in the concentration of heavy metals. Furthermore, the heavy metal analysis is subjected to systematic error, so such error may arise from the measuring device and the people who take measurements.

1.7. Organization of the Thesis

The thesis consists of five chapters. The first chapter of the thesis comprises the background of the study, the statement of the problem, the objectives and research questions, the significance of the study, and the scope and limitations of the study. The second chapter is a review of related literature. Theories, concepts, and empirical literature are reviewed and discussed. The third chapter of the study provides an explanation of methodology, which includes a description of the study area, research design, sampling techniques, determination, data sources and collection techniques, a description of variables, and methods of data analysis. The main results and discussions are discussed in Chapter 4. The conclusion and recommendation are present in the last chapter.

CHAPTER TWO: RELATED LITERATURE REVIEW

2.1. Conceptual Foundation and Theoretical of the Study

2.1.1. Conceptual Foundation of the study

UA is a recent phenomenon as compared to rural farming. Different authors described urban agriculture in various ways on the basis of the location or timing of agricultural activities. Zeeuw (2003) in Lemi (2019)) defined UA in terms of the types of products produced, economic activities, location where the practice is carried out, and types of actors involved in the sector (Mireri *et al.,* 2006; Deelstra and Girardet, 2004 in Tewodros, 2007; and Game and Primus, 2015). Therefore, UA is the practice of agriculture in urban areas.

Furthermore, UA is defined as any agricultural activity that grows, raises, processes, and distributes agricultural products within cities and towns, regardless of land size or the number of human resources (FAO, 2000). UA contributes to the improvement of sustainability in cities by increasing the environmental quality of the buildings (Tsuchiya *et al.,* 2015). It can also mitigate the negative effects of urbanization on the environment by adding green spaces to the neighborhood and beautifying the landscape (Shamsudin *et al.,* 2014).

The most widely used definition of UA is as follows:

> "*UA is an industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city, or a metropolis, which grows and raises, processes, and distributes a diversity of food and non-food products, (re-) using largely human and material resources, products, and services found in and around that urban area, and in turn supplying human and material resources, products, and services to that urban area*" (*Mougeot, 2000).*

The concept of food security emerged in 1974 by considering food availability and price stability of basic food items as the central issues. However, because of the diverse geographical, social, and economic configurations of the world communities, the concept is broad, diverse, and dynamic, and as a result, people interpret it differently (Hussein, 2006; Meskerem and Degefa, 2015).

According to Gerster-Bentaya (2013), food security is present when the whole population has sufficient access to healthy food to act in response to fulfill their nutritional necessities. Specifically, food security is defined as the condition where "all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 2009: 1, cited in McCann *et al*., 2021:2).

The Food and Agriculture Organization (FAO) of the United Nations coined the most influential and widely used definition of food security, which goes as follows: "Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996). This definition integrates access, availability, utilization, and stability of food. Furthermore, this definition implies the time dimension, i.e., the long-term sustainability of food security. Sustainability in food security has been introduced as an issue of international concern through the notion of sustainable development. The availability of agricultural products throughout the year determines the sustainability of urban household food security.

The practice of UA has been a major strategy towards improving food security in some major cities all over the world. While some urban local governments regard this practice as a health risk, those who engage in it see it as a good strategy for improving food security at the household level. According to Zezza and Tasciotti (2010), UA may have a role to play in addressing urban food insecurity issues, which are bound to become more important with the secular trend of poverty and population urbanization in developing regions. It is also believed that UA is a solution to the food crisis being faced by urban populations (Stewart *et al*., 2013). It provides the urban poor with food and a source of potential income, while also improving the urban environment and reducing pressure on finite farmland (Satterthwaite and Dodman, 2013)

2.1.2. Theoretical foundation

The closed-loop discourse on waste and wastewater use, in this case, indicates those ideas or thoughts, which are articulated from the positive point of view. McClintock (2010) has used Karl Marx's theory of metabolic rift. According to the theory, rapid urbanization and industrialization as a consequence of capitalism has separated humans from the natural environment. Urban agriculture can help redress the social and ecological alienation by re-establishing the metabolic relationship between human and biophysical environment. The wastewater generated from domestic processes or residential areas possibly contains several plant nutrients. The soil organic matter can be added and the soil structure\s would be improved that resulted in the gradual increment in soil nutrients for better crop yield. As it is economically viable to those who have low investment capacity in urban and peri-urban agriculture, it can generate numbers of employment and efficient returns.

The other discourse associated with wastewater usage is health risk discourse. Risks can be varied by type of waste and wastewater used as well as types of agricultural activities. Waste-fed aquaculture may pose skin infections to the farmers and to the consumers, pathogens can be transformed indirectly through the contaminated fishes. Practices of livestock keeping in and around city areas can be the cause of 'zoonotic diseases' i.e. diseases that can be transmitted from livestock to humans.

2.2. Empirical Literature Review

Stewart *et al*. (2013) in Uttam (2021) clearly mention the role of UA. They categorized the advantages of UA into four categories: health, ecology, social, and economic (Stewart *et al.*, 2013). Towards health, UA practice could provide access to healthy food, food health literacy, healthy eating habits, and physical activity for good health. Social benefits, according to Smit et al. (1996), include social empowerment and mobilization, youth development and education, food security, safe spaces, and socially integrated aging. The economic sector includes local economic stimulation, job readiness, job growth, and food affordability. The ecological sector benefits include awareness of food system ecology, stewardship, conservation, waste management, water management, wastewater management, soil improvement, biodiversity, and habitat improvement.

According to Veenhuizen (2000), UA plays a significant role in ensuring food security for both urban farmers and city dwellers in general. The contribution of UA to food security and nutrition is probably its most important asset. Renewed interest in looking at alternative strategies for improving urban livelihoods, income generation, and urban food security and nutrition, among others, has arisen with the increase in urban poverty, food insecurity, and malnutrition, which are now seen as shifting from rural to urban areas. The report of the World Food Organization also shows that UA has a great role in securing food for low-income societies as well as making a good environment (FAO, 2016).

Mahteme and Akalewold (2020), in Ethiopia, revealed that UA has a very positive role in changing the livelihoods of the urban poor for the better. It has enabled 76% of the respondents to obtain additional income while serving 51.4% as a food source and creating employment opportunities for 29%. They also concluded that UA is a livelihood strategy that positively affects the livelihoods of the urban poor in Hawassa City Administration. Abera *et al*. (2017) revealed in their study on the practices, roles, and challenges of UA in the south-western part of Ethiopia that UA plays a decisive role in generating household income, serving as employment opportunities, contributing to food supply, economic use of land, environmental enhancement, and solid waste management. The study by Maru and Juliet (2016) in Ethiopia also found that urban farmers agreed on the benefits that UA could deliver to them, as it reduces urban heat, for consumption; increases waste recycling or reuse; reduces soil erosion and degradation; increases water availability; and improves environmental beautification and storm water runoff, among other benefits. Dhital (2016) also notes that UA will aid in waste management and contribute to household food security, human resource utilization, health hygiene, and the economic growth of urban communities

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In studies from both developed and transitional (developing) countries, UA activities have been shown to contribute to the availability of fresh and nutritious food items, a reduction in food expenditure on food bills, direct access to a variety of food products, as well as urban waste recycling, pollution, and sustainability (Martellozzo *et al.*, 2014; Grewal & Grewal, 2012; Dubbeling& De Zeeuw, 2011; Kang'Ethe *et al.*, 2007; Mireri *et al.*, 2006). A study conducted in 15 countries by Zezza & Tasciotti (2010) shows that urban agricultural activities are closely related to food security, dietary diversity, and a nutritionally adequate diet.

The study by Myasha and Ernest (2017) in Zimbabwe concluded that UA can contribute immensely to the livelihood status of city dwellers through promoting food security, providing employment, and also encouraging savings among the urban population. Ackerman (2014) also noted that agricultural wastes can be used to enhance food security, mainly through their use as bio-fertilizer and soil amendment, use as animal feed, and energy production. They contain large amounts of organic matter, and many of them can be directly added to the soil without any risk.

One of the economic significance of UA, according to Mpofu (2013), cited in Henok (2012), is its ability to generate income, food supply, employment opportunities, and environmental management. Low- and middle-income farmers practice UA mainly to survive and achieve a combination of nutritional and socio-economic benefits, mainly to provide supplementary food and/or income.

UA can create more awareness about organic waste and its potential to be used as a resource. This way, UA can contribute to more effective waste separation and effective organic waste management. Utilization of these wastes assists urban communities in meeting their food needs and creating a more uplifting environment, whereas backyard gardens assist them in becoming self-sufficient in planting crops (Menyuka, 2018).

Henok (2012), in his study on the socio-economic impact of urban agriculture in the case of Addis Ababa, revealed that urban farmers differ in their social backgrounds, such as age, occupation, and marital status; the sex of the household head; level of education; farm size; and ownership of housing, which might also have implications on their livelihood strategies. Endale (2011) also uses gender, family size, marital status, ethnicity, and education level as socio-economic factors to analyze food security contributions to UA.

According to the World Health Organization (2005), wastewater use in agriculture may have important economic benefits for households and communities that can improve the health of families through better access to health care education, nutritious food, and improved access to both water and sanitation in the household (Van Rooijen *et al*., 2010).

Tekeste (2017) reported that informal wastewater irrigation contributes 60% of major and 90% of leafy vegetables to Addis Ababa's food basket. According to Alebel et al. (2009), waste is the only means of survival, and the average income from wastewater farming accounts for 62% of the total annual household income, with this value ranging from a low of 27% to a high of 97%. Accordingly, 88% of wastewater farm households report that they benefit from the wastewater.

Janssen *et al*. (2005) and Raschid-Sally *et al*. (2005) revealed that wastewater use can contribute to improved livelihoods at the household level, particularly through the recycling of water for irrigation and specifically with the additional direct benefits of nutrients for plant use. It has the potential to address the problem of local water shortages (Jimenez, 2005).

Urban and periurban agriculture increase the quantity and quality of food available for consumption and provide nutrition and income, which improves the urban environment by using the organic solid and liquid wastes of the city, provides aesthetic value to these areas, and helps to achieve optimum land utilization (Boischio et al., 2006; Buechler *et al*., 2014; Lynch *et al*., 2001; Ruma& Sheikh, 2010). Moreover, Ngenga *et al.* (2011), in their study on community-based wastewater farming and its contribution to the livelihoods of the urban poor, confirmed that wastewater farming provides employment opportunities, food sources, and generates income. A study by Gashaye (2020) in Ethiopia also confirmed that the use of wastewater in farming is important in improving the livelihoods of the participants and becoming a source of income and food. According to the FAO (2012) report, wastewater is a reliable supply of water that allows farmers to grow crops throughout the year. It also contains nutrients that can improve crop growth.

Untreated wastewater has been widely used for UA in most urban and peri-urban areas of developing countries, including Ethiopia and, in particular, the Akaki Kality sub-city (Scott *et* *al*., 2004; Gashaye, 2020). The major benefits of urban area crop production are market proximity, high opportunities for income generation, and minimum artificial fertilizer requirements (Qadir *et al*., 2010). Farmers that use wastewater for farming benefit through increased productivity and yields and faster growing cycles while decreasing their needs for artificial fertilizers and additional water sources (Corcoran *et al*., 2010; cited in Javler *et al*., 2013).

Health risks from chemicals are caused by heavy metals (for example, cadmium, lead, and mercury) and many organic compounds (for example, pesticides). These mostly derive from industrial wastewater, and if they are discharged to public sewers, they are present in municipal wastewater. The health effects of prolonged exposure to many of these chemicals are well known, for example, cancer (Scheierling *et al*., 2010).

2.3. Pollutants in wastewater effluents

The contaminants in the discharged wastewater could be biological or chemical in nature. The most common chemical pollutants in wastewater include heavy metal cations, hydrocarbons, pesticides, nitrogenous compounds, pharmaceutical residues, detergents and phosphorus. Microbiological contamination could be from either animal or human faecal wastes containing deferent kinds of protozoa, viruses or bacteria, capable of causing diseases in humans (Akpor, 2011; Ohoro *et al*., 2019)

2.3.1. Microbiological contamination in Wastewater

It is indicated that the majority of waterborne microorganisms that cause human disease are from fecal wastes that are released by humans or animals that contain these diseases (Kris, 2007). The major microbial pathogens in water are bacteria, viruses, fungi and protozoan parasites. Bacteria pathogens are mostly present in feces and a wide variety can be present in wastewater due to fecal contamination. The discharge of untreated or inadequately treated wastewater into the environment can have negative impact on human health due to the release of pathogenic microorganisms into water which could lead to serious health diseases (Rosario et al., 2009).

Water that is contaminated with microbial pathogens is a medium for several waterborne diseases, such as cholera, typhoid fever, shigellosis, salmonellosis, campylobacteriosis, giardiasis, cryptosporidiosis and Hepatitis A (WHO, 2004). Several pathogenic organisms in contaminated water are the basic causes of gastrointestinal illnesses in human. Some of the pathogens are known to cause several outbreaks of diseases by releasing toxins in the human body (Krauss and Gri ebler, 2011). Bacteria are the most common microbial pollutants in wastewater. They cause a wide range of infections, such as diarrhea, dysentery, skin and tissue infections. The major pathogenic protozoans associated with wastewater are Giardia and Cryptosporidium. They are more prevalent in wastewater than in any other environmental source (Akpor and Muchie, 2011).

2.3.2. Heavy Metals Contamination in Wastewater

Heavy metals are elements with an atomic density greater than 6 g/cm3; they are one of the most persistent pollutants in wastewater. They are also referred to as trace elements and are the metallic elements of the periodic table (Salem *et al*., 2000). Heavy metals are highly soluble in the aquatic environments and therefore they can be absorbed easily by living organisms. The most common toxic heavy metals in wastewater include arsenic, lead, mercury, cadmium, chromium, copper, nickel, silver, and zinc. The release of high amounts of heavy metals into water bodies creates serious health and environmental problems and may lead to an upsurge in wastewater treatment cost. Heavy metals also occur in small amounts naturally and may enter into aquatic system through leaching of rocks, airborne dust, forest fires and vegetation (Fernandez and Olalla, 2000; Ogoyi *et al*., 2011). Their occurrence and accumulation in the environment is a result of direct or indirect human activities, such as rapid industrialization, urbanization and anthropogenic sources. The harmful effect of heavy metals in humans depends on their dosage, rate of emission and period of exposure.

The persistence of heavy metals in wastewater is due to their non-biodegradable and toxicity nature (Jern, 2006). Some of the negative impacts of heavy metals on plants include decrease of seed germination and lipid content by cadmium, decreased enzyme activity and plant growth by chromium, the inhibition of photosynthesis by copper and mercury, the reduction of seed germination by nickel and the reduction of chlorophyll production and plant growth by lead (Gardea-Torresdey *et al*., 2005). The impacts on animals include reduced growth and development, cancer, organ damage, nervous system damage and in extreme cases, death (Canada Gazette, 2010).

The nature of heavy metals polluted wastewater effluents on humans may be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic (Duruibe *et al*., 2007). Although it is reported that individual metals exhibit specific signs of their toxicity, the signs associated with cadmium, lead, arsenic, mercury, zinc, copper and aluminium poisoning are gastrointestinal disorders, diarrhea, stomatitis, tremor, hemoglobinuria causing a rust-red colour to stool, ataxia, paralysis, vomiting and convulsion, depression and pneumonia, when volatile vapours are inhaled (Duruibe *et al*., 2007).

Here, we discussed the most common heavy metals encountered in wastewater used for irrigation. These are:-

1. Arsenic (As): Arsenic is found naturally in inorganic and organic forms. Arsenic intoxication is most commonly reported in cases with much toxic inorganic form. Seafood, for example, contains the highest concentration of As in an organic form (Ibrahim *et al*., 2006) . Exposures to high levels of arsenic can cause death, since it is known to coagulate protein, form complexes with coenzymes and inhibit ATP production during respiration (INECAR, 2000).

2. Chromium (Cr) is widely used in metallurgy, electroplating, and in the manufacturing of paints, pigments, preservatives, pulp and papers among others (Jaishankar *et al*., 2014). The introduction of Chromium into the environment is often through sewage and fertilizers22. Hexavalent Chromium compounds including chromates of Ca, Zn, Sr, and Pb are highly soluble in water, toxic and carcinogenic (Jaishankar *et al*., 2014; Wolińska *et al*., 2013). Furthermore, compounds of Chromium have been associated with slow healing ulcers. It has also been reported that Chromate compounds can destroy DNA in cells (O'Brien *et al*., 2001; Matsumoto *et al*., 2006.

3. Cadmium (Cd) is another highly toxic heavy metal even when present in humans at low concentration. It is indicated to be carcinogenic and persistently cumulative poison (Lin *etal*. 2005). A long term exposure to cadmium in humans may lead to renal dysfunction; while high exposure levels could cause obstructive lung disease, cadmium pneumonitis, bone defects, osteomalacia, osteoporosis and spontaneous fractures, increased blood pressure and myocardic dysfunctions (Duruibe *et al*., 2007). The level of exposure to cadmium compounds may determine the symptoms, which may include nausea, vomiting, abdominal cramps, dyspnea and muscular weakness. Severe exposure may result in pulmonary odema and death (McCluggage, 1991; INECAR, 2000; European Union, 2002; Young, 2005, Duruibe *et al*., 2007).

4. Lead (Pb) is a non-essential element that plays no function in human metabolism, with children being more vulnerable than adults (Kirberger *et al*,, 2013). Exposure to Pb can occur through inhalation of contaminated dust particles and aerosols or by ingesting contaminated food and water. According to the International Agency for Research on Cancer (IARC), Lead is a possible carcinogenic substance in humans19.

5. Mercury (Hg) is regarded as one of the most harmful metals for human ingestion because it has no recognized metabolic function. It has been noted that the toxicity symptoms of mercury depend on the chemical form consumed. Ingestion of its inorganic forms results in spontaneous abortion, congenital deformity, and gastrointestinal diseases, whereas consumption of its organic forms results in erethism (abnormal irritation or sensitivity of an organ or body part to stimulation), gingivitis, stomatitis, neurological disorders, brain and central nervous system damage, acrodynia (a pink condition characterized by rash and desquamation of the hands and feet), and congenital malformation (Lenntech, 2004; Duruibe et al., 2007; Simone et al., 2012).

6. Zinc (Zn): is a component of several enzymes in humans (alkaline phosphatase, superoxide dismutase, alcohol dehydrogenase, carbonic anhydrase) and, in excess, can create system dysfunctions that can impact growth and reproduction. The clinical signs of zinc toxicosis include diarrhea, vomiting, icterus (yellow mucus membrane), bloody urine, anemia, kidney failure and liver failure (INECAR, 2000; Nolan, 2003; Duruibe *et al*., 2007).

2.4. Conceptual Framework of the Study

The conceptual framework that is presented in Figure 2.1 below explains the significance of wastewater use in UA towards household food security status. UA provides a significant contribution through providing food and a source of income. The income obtained from agricultural activities was used to cover other household expenses and to buy agricultural inputs such as fertilizer and animal feed; thereby increasing agricultural production and food security.

The conceptual framework further explained the relationship between independent and dependent variables and chose those variables from previous studies. Explanatory variables such as age, household head, education level, marital status, sources of income, household size, household expenditure, extension service, access to fertilizer, access to credit, and family background were analyzed as factors determining food security status. The use of wastewater in the UA is thought to have an effect on food safety and security. With this respect, the study assessed food safety based on knowledge, attitude, and practice towards food handling, personal hygiene, and water sanitation, which helps to identify the gap in food safety. The framework also took into account microbial and heavy metal analysis, as well as how they related to food security.

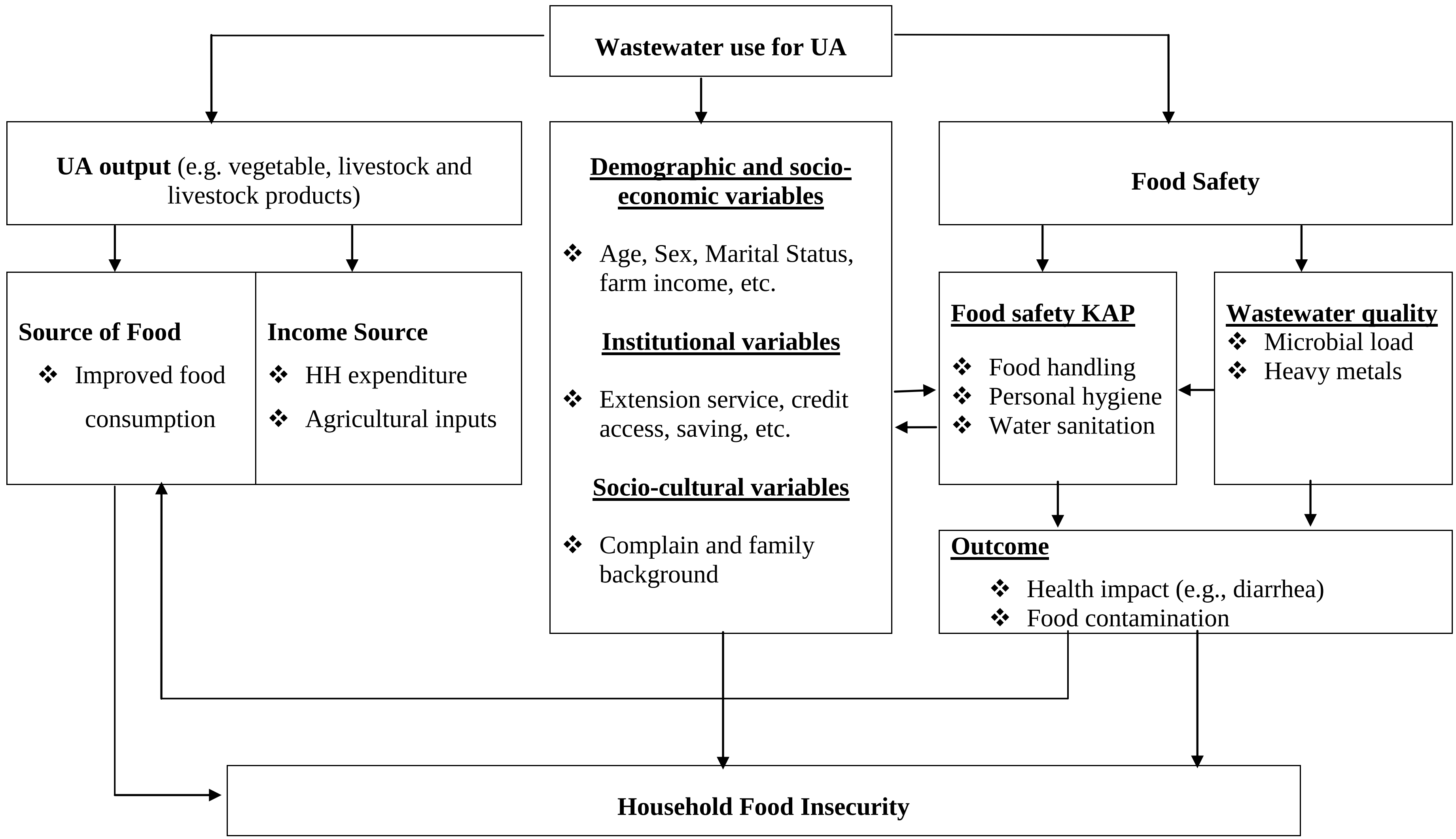

Figure 2.1. Conceptual framework of the study

Source: From literature and researcher development

CHAPTER THREE: DESCRIPTION OF THE STUDY AREA AND RESEARCH METHODS

3.1. Description of the study area

Akaki Kality is one of the eleven sub-cities found in the Addis Ababa metropolitan area. It is one of the most industrial zones in the country (Desybel, 2020). It is located in the southern part of Addis Ababa at 8° 45' to 8° 58' N and 38° 45' to 38° 52' E (Ephrem, 2019). The sub-city shares boundaries with Bole Sub-city in the north, Kirkos and Nifas Silk Lafto Sub-Cities in the north-west, and Oromia Regional State in the south. Its projected population for the CSA of Ethiopia for 2022 was close to 255,348 people, with approximately 123,823 males and 131,525 females. It is one of the capital city's most densely populated neighboring cities, with a population density of 18.16 people per square kilometer (CSA, 2013).

Each woreda has its own administration office that represents the sub-city directly. Currently, the sub-city is composed of 13 administrative woredas, and the structure of farmer and urban development offices has been established in all 13 woredas, which cover a total of 11,808 ha. The residents of the sub-city are factory workers, daily laborers, people working in urban agriculture, civil servants, military personnel, commercial sex workers, and unemployed youth women (Emebet, 2018; Akaki-Kality sub-city farmers and urban agriculture development office, 2020). This specific site was selected as a study area given that the performance of urban farming is relatively higher in this particular sub-city and it is among the sub-cities that use wastewater for irrigation using the Akaki River. According to Sophia (2015), poultry production, livestock and dairy production, cattle and sheep fattening, beekeeping, pig breeding, crop production, and vegetable production are the most common UA practices in the sub-city.

The study participants are individual farming households that engage in vegetable and livestock production that uses the Akaki River as a source of wastewater for irrigation and livestock watering. Currently, there are 460 individual farming households that are engaged in vegetable and livestock production in the sub-city (Akaki-Kality sub-city farmers and urban agriculture development offices, 2022). In the study area, farmers produce different types of vegetables, such as cabbage, tomatoes, potatoes, spinach, onions, Swiss chard, carrots, and kale, using the Akaki River as the main source of wastewater for irrigation. In addition, the farmer used the river to water his livestock.

According to the Akaki-Kality Sub-City Urban Agriculture Office (2013), the sub-city has a mild climate and is found at 2000–2300 meters above sea level. Its average daily temperature is about 22–27^{o}c, which means its annual precipitation is about 300–600 millimeters. Mostly, urban dwellers engage in urban farming during the dry seasons from October to June. Akaki farmers in urban and peri-urban areas use the Akaki River system as a source of irrigation water for the continuation of cultivation during the dry season.

Drainage

On top of the hills and ridges streams are dense and form radial drainage pattern, whereas on slopes and on most parts of the study area they form dendritic pattern. The major river that drains within the study area is the Akaki River. Several perennial and intermittent rivers join the major river. The drainage pattern is governed by the geology and physiographic set up of the area (Tamiru et al., 2006). Most of the tributaries in the study area are estimated to drain from higher topographic place in north eastern part of the sub city and north top ridges of Addiss Ababa as Entoto ridge, and flows towards flat lying locations.

Soil Type

The predominant soil types in Akaki Kality are residual soil at the north and north-east boundaries, black cotton soil at poorly drained portions along the southern boundaries, and alluvial deposits at the downstream portion of the Akaki River.

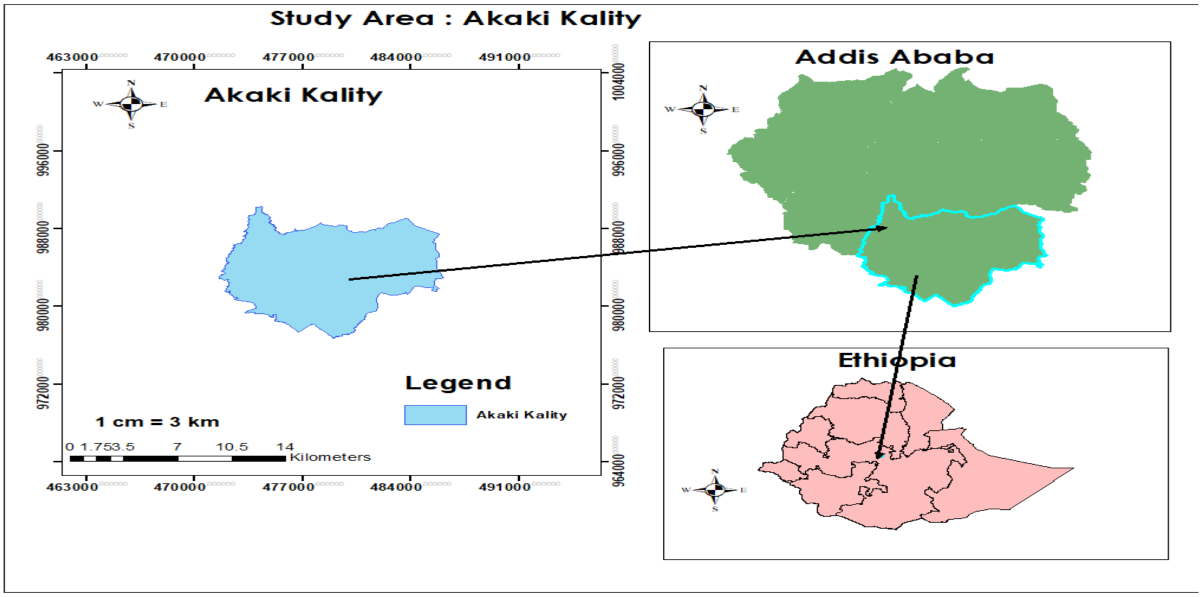

Figure 3.1. Map of the study area (Akaki Kality sub city)

Source: developed by the researcher, 2022

3.2. Research Design and Approach

A cross-sectional and experimental-based research design was employed to address the objectives of this study. A cross-sectional design allowed data to be collected at a single point in time to capture important aspects of the study (Namwata *et al*., 2015). The study employed a mixed-methods design that merged qualitative and quantitative data to provide a comprehensive analysis of the research problem (Creswell, 2003; Creswell, 2014; Creswell and Creswell, 2018). The main purpose of adopting a convergent mixed method design was to triangulate, develop, and complement qualitative and quantitative components. Therefore, quantitative survey data on household food security situations and the different demographic, socioeconomic, institutional, and socio-cultural components of the knowledge, attitude, and practice of farmers was triangulated, developed, and complemented with key informant interview (KII), focus group discussion (FGD), and personal observation on similar issues in the context of the study.

3.3. Data Type and Sources

Both qualitative and quantitative data were generated from the primary and secondary sources of information to address the research question. The primary sources of data were individual household heads' responses to questionnaires, heavy metal analysis, personal observation, and selected individuals who participated in the interview and focus group discussion (FGD). The secondary sources of data were collected from various published and unpublished documents.

3.4. Sampling Techniques and Sample Size Determination

The target population of the study focused on individual farmers engaged in vegetable and livestock production in the study area. A purposeful sampling technique was employed to select sample households due to their familiarity with the researcher and extensive practice of UA using wastewater. The sample households were selected from individual farmers that use the Akaki River in the Akaki Kality sub-city of Addis Ababa. Based on the information in the annual report of the Akaki Kality sub-city agricultural offices (2022), there were 350 individual farmers that practice vegetable and livestock production in the Akaki Kality sub city. Thus, the 350 individual farmers practicing UA were used as a "sampling frame" in as much as they are potential data sources for the study. The actual sample size was determined using the following formula developed by Kothari (2004), cited in Woldemariam (2019), for a finite population. This formula is used to calculate the sample size, as shown below:

$$n= \frac{z2\ p\ q\ N}{e\ 2\ (N-1) + z2\ p\ q\ N} \quad (1)$$

Where n: is the sample size, N is the population size, p: sample proportion of a population with a particular characteristics, q: 1-p (represents the proportion not having a particular characteristics) and e is the level of precision

Thus, N = 350, p = 0.5, z = 1.96 and e = 0.05

Therefore, $n = \frac{(0.96)2\ (0.05)\ (0.5)\ 350}{0.05)2\ (350-1) + (1.96)2\ (0.05)\ (0.5)} = 183 \quad (2)$

Accordingly, the sample size for conducting the household survey among the total of 350 individual farmers was 183. The systematic random sampling method was employed to draw the samples from the population, which was meant to avoid bias while selecting the samples or reduce statistical error.

3.5. Tools of Data Collection

For the purposes of gathering the above-mentioned research data from those sources, different data collection methods were used. In order to triangulate the results of the primary data collected, a secondary source of information was reviewed. Secondary data was generated by reviewing various published and unpublished documents, including reports made available by the Wereda Administration.

3.5.1. Household survey

The household survey for this study was collected using a questionnaire from those selected households. The questionnaire was designed to measure the food security status of a household and its factors, as well as the knowledge, attitude, and practice of individual farmers engaged in vegetable and livestock production. The questionnaire was given in tandem with a face-to-face interview, allowing the enumerators to conduct a home-to-home visit in the sampled households. The questionnaire that was initially developed in English was translated into Amharic, the language that farmers and data collectors understand, which helps to ease the process of conducting the survey. The researcher and a qualified data collector who knows the area and understands the local languages were hired to conduct the survey questionnaire. The enumerators were trained by the researcher (me) for a day on the objectives of the survey, data collection management, and ethical issues that should be considered during fieldwork. Besides, the study also has a practical session that involves wastewater sampling for heavy metal analysis.

The data collection instruments were pre-tested on 5% of the total sample size (N = 9) in one of the woredas in the sub-city. The pre-test helps check for some problems like ambiguities, redundancies, and adjustments has been made as necessary. Ten participants were selected randomly to respond to the pre-test. The questionnaire includes data on household sociodemographic and economic information, information relating to food consumption score (FCS) 7-day recall food security information and HFIAS 4-week recall food security information, and the knowledge, attitude, and practice (KAP) of the study participants.

3.5.1.1. Household food insecurity access scale (HFIAS)

The HFIAS score represents the degree to which a household found itself food secure or insecure for the preceding four weeks at the time of the study. The estimation of a household's HFIAS score was done by adding the frequency of occurrence codes for each question for each household and then adding the codes for each frequency-of-occurrence question. The HFIAS score ranges from 0 to 27 (Coates, 2007). A household that has achieved a higher than average score suggests that it may be food insecure. Similarly, a household that attained a lower than average score would suggest that it may be food secure. The following shows how the HFIAS is calculated (Equation 2):

HFIAS Score = Sum frequency of occurrence question response codes (Q1a + Q2a . . . + Q9a)

The classification of the HFIAS is into four food security groups which the households could fall in namely: "food secure, mildly food secure, moderately food insecure and severely food insecure.

3.5.1.2. Food consumption score (FCS)

The Food Consumption Score is a measure of food security that is commonly used by the World Food Program. It measures both the types of food groups consumed and the frequency of consumption of these food groups. The food consumption groups encompass starches, pulses, vegetables, fruit, meat, dairy, fats, and sugar. The interviewees were asked about frequency of consumption (in days) over a recall period of the past 7 days. FCS was calculated using the formula proposed by WFP and FAO of 2008. In this formula, FCS was derived by multiplying the weight for each food type by the frequency (number of days) these food groups were consumed; the values for all food types consumed during the seven days were summed up to give the FCS, thus,

$$FCS = a \times f(staple) + a \times f(pulse) + a \times f(vegetables) + a \times f\ (fruit) + a \times f\ (animal) + a \times f(sugar) + a \times f(dairy) + a \times f\ (oil),$$

Where FCS = food consumption score = frequencies of food consumption = number of days for which each food group was consumed during the past 7 days, a = weight/nutritional value of each food group.

Food groups were assigned different weights reflecting their nutritional density—nutrient-dense foods such as meats and dairy products that have higher weights than staples, fruits, and sugar. The FCS has thresholds consumption categories of "poor," "borderline," and "acceptable." The FCS indicator is expected to provide a more accurate measure of the quality of the household diet because it accounts for nutritional value of food in addition to the number of different types of food consumed. Generally, FCS can range from 0 to 112, whereby scores of 21 are considered "food insecure," scores between 21.5 and 35 are "moderately food insecure," and scores of 35 are "food secure" (Vhurumuku, 2014). Food security is higher in households with the highest FCS.

3.5.1.3. Food safety knowledge, attitude and practice (KAP)

Qualitative data such as knowledge, attitude, and practice on food handling, personal hygiene, and water sanitation were converted to percentages and used as an indicator of KAP on safe food handling. The assessment was based on the FAO's guidelines for food safety and nutrition-related assessments (Macias and Glasauer, 2014, cited in Ahmed, 2019). To assess knowledge, attitude, and food handling practices, a three-point Likert scale with positive, negative, and neutral responses was used. The knowledge, attitude, or practice of the population is calculated by dividing the total number of correct responses by the number of respondents who answer the particular question (Macias and Glasauer 2014, cited in Ahmed, 2019). Respondents who did not answer the question or for whom information was incomplete were excluded.

% of respondents knowledge/attitude/practice =

$$\frac{\text{Sum of correct responses given by the respondents}}{\text{Total number of respondents}} \quad (3)$$

3.5.1.4. Measurements of biological parameters

1. Sample collection

The wastewater samples were collected in sterilized 500ml plastic bottles to avoid any prior bacterial contamination. The water samples then directly transported in ice box into Bless Agri Foods laboratory for analysis and analyzed within 24hrs of collection as per the method described in ISO **1000:2015**. Akaki River passes through at Woreda 3 of Akaki Kality sub-city was selected as a sampling point to assess the microbial quality of wastewater used for irrigation.

2. Bacteriological analysis

Microbiological analysis of the sample for total coliform and E.coli were performed using the standard membrane filtration technique (standard method Based on ISO). Briefly, 100ml of an appropriate dilution of wastewater sample was filtered in triplicate onto 0.45µm grinded into cellulose made membrane filters that retain bacteria. The filters were then placed onto selective total coliform/ E.coli Endole/mFC agar media and incubated for 24hr at different temperatures (37^{o}c for total coliform and 44^{o}c for E.coli). All dark red color with a golden green metallic sheen seen in the plates were counted as total coliform and all deep blue colonies were counted as E.coli. Confirmatory test was done using **indole test** for total coliform and BFG test for E.coli. Gas production in both confirmatory tests indicated that there is a total coliform/E.coli in the analyzed sample. Bacterial counts obtained were expressed as colony forming units in 100ml (cfu/100ml). Finally, the results obtained were compared with the standard set by WHO (2006) for wastewater irrigation.

3.5.1.5. Heavy metal analysis

1. Apparatus and equipment

The instruments used for this study were Atomic Absorption Spectrophotometers (model) for heavy metal determination of wastewater. The common laboratory apparatus used during the study includes different sized beakers, flasks, funnels, volumetric flasks, block digesters, fume hoods, droppers, glass pipettes, spatulas, measuring cylinders, vinyl gloves, analytical balance, and conical flasks.

2. Chemicals, reagents, and standard solutions

All the chemicals used were analytical reagent grade brought from local market. Deionized water and distilled water were used for all preparation and dilution purposes throughout the study. HNO_3 (69%), KCl, H_2SO_4 (98%), H2O2 (30%) and HCl were used for digestion. Stock standard solutions of 1000 ppm were prepared for the selected heavy metals (As, Cd, Cr, Hg, and Pb).

3. Wastewater sampling, preservation and assay

The wastewater samples were gathered from the Akaki River, which flows through the Akaki Kality Subcity near Woreda 3. Samples were taken in April 2022. A total of three samples were collected from the river's downstream, where it is used for agriculture, and put into clean, dry plastic bottles. These three bottles immediately acidified with 1 ml nitric acid, for later analysis of metal concentrations. The purpose of the acid is to keep the metals in solution and to avoid adsorption to the container walls (APHA, 1999). The collected samples were kept in an ice box until transported to the laboratory of Bless Agri Foods, Ethiopia, for further heavy metal analysis (As, Cd, Cr, Hg, Pb and Zn) using photometry (Palintest Photometer 7500).

Upon reaching the laboratory, the samples were filtered through joint-suction filtration glass Buchner funnel conical flask filters to remove suspended particulates. This is important to avoid the targeted heavy metals being adsorbed onto the suspended particulates in the raw samples; this was carefully performed so the volume of the sample was not altered for final dilution factor estimation. The filtered wastewater samples were preserved (acidified) using a 1.5 mL of HNO_3 to minimize the precipitation and adsorption of heavy metals on the container walls and stored in a refrigerator at 4 ◦C prior to further analyses at the laboratory. The filtered wastewater samples were digested using HNO_3 heated on a block at 150 ± 20 ◦C as described by the EPA, Method 3050B (SW-846) (1996).

The digested samples were filtered using 0.45 µm Acrodisc syringe filters, prior to analysis by inductively coupled plasma optical emission spectrometer (ICP-OES, PerkinElmer, Waltham, Massachusetts, United States) at a selected wavelength. The ICP-OES parameters were: argon gas was set at 415.82 kPa, power at 1.19 Kw, and plasma at 9.99 and auxiliary at 0.60, and carrier flow at 0.70 with a low purge flow. The rotation pump was set at 20 revolutions per minute (20 r.p.m) with a speed temperature set at 37.99 ◦C, while the CCD temperature was operated at -14.99 ◦C and the vacuum level was at 1.5 Pa. The target heavy metals were As, Cd, Cr, Hg, Pb, and Zn. Optimization of the instrument carried out by running the performance check solution and operating parameters like torch position, nebulizer flow rate, Radio frequency (RF) power and the interference corrections were adjusted before sample analysis.

4. Quality Control

A record of every collected sample was made by carefully labelling each sample bottle with the cleared unique sample number. Analytical grade HNO_3 was used in this study to achieve the compatibility of the isolation of metals in the sample, which could aid an effective and direct determination after dilution and minimize the risk of environmental contamination. All the sample containers used in this study were shocked for two days with 10% (*v/v*) HNO_3 and rinsed three times before use with Milli-Q ultra-pure water obtained from bless agri foods laboratory. Blank determinations were carried out for each set of analyses using the same reagents. All the sample preparations were performed timely to minimize the loss of heavy metals in the samples. The analyses were performed in triplicate. Calibration curves were constructed with known concentrations of standards for each element and good linearity was obtained, with correlation coefficients (> 0.998). Spiking experiments were used to assess the accuracy of the method. Accordingly, a known amount of standard of a heavy metal of interest, equivalent to the amount found in the sample, was added to the wastewater sample and subjected to digestion following a similar procedure to that of the unspiked sample. The percentage recoveries ranged from 93.4% to 104.3% indicating that the method was accurate. The limits of detection (LOD) of the method were determined from the measurement of the blank samples that were digested and analyzed along with the samples.

3.5.2. Key informant interview (KII)

The study employed a total of eight key informant interviews to get information on personal thoughts, experiences, and attitudes related to waste practices and their contribution to the food security situation of the people in the study. The most common qualitative technique is the interview, which can provide rich sources of data on people's experiences, opinions, aspirations, and feelings (Kitchin and Tate, 2000). The interview was guided by pre-prepared checklist questions and facilitated by the researcher. The KII of the study involved the participation of four farmers (two from vegetable producers and two from livestock producers) and four experts from agricultural bureaus and woreda administrations who have ample experience and detailed knowledge about the subject area‘s wastewater practices and food security situation and are the authorities on the subject. A total of eight interviews were conducted. The interviews were conducted separately and focused on topics such as urban farming practices such as vegetable and livestock production; issues related to wastewater use for UA; the sector's contribution to engagers' livelihoods and food security; health issues related to wastewater use; and so on.

3.5.3. Focus group discussion (FGD)

A focus group is a small group discussion of issues relevant to a topic and is frequently used to collect qualitative data. The purpose of the FGD in this study is to understand the practice of wastewater for UA and its contribution to food security. Focus group discussions, like other qualitative research methods, can be used to develop an understanding of the meaning and experiences of people's lives from the point of view of those who experience them.

In order to generate more first-hand data for the research, one focus group were conducted with farmers having six participants. Participants for discussion were randomly selected based on gender and age. The objective is to draw opinions from both female and male households as well as elderly and young farmers in order to triangulate the points of view of participants. The major discussion topics were the socio-economic, cultural, institutional, and wastewater practices in the study area that could potentially affect the FS situation of households.

3.5.4. Personal observation

According to Kumar (2011), systematic observation is a purposeful, systematic, and selective way of watching and listening to an interaction or phenomenon as it takes place. It was one way of collecting qualitative data. In this study, personal observation was used to gather data related to the physical asset ownership of the selected household, wastewater practices, as well as sanitary and water facility related data. Thus, the tools used for the observation were pre-prepared checklists.

3.5.5. Secondary data source

The secondary data was collected from published and unpublished works on urban agriculture; the wastewater use situation of the study area (demographics; crop and dairy production; and socio-economic conditions). This information was gathered from the works of researchers and academia, national states, city administrations, sub-city and woreda-level administrations, and websites around the world.

3.6. Techniques of Data Analysis

Descriptive and econometric analysis techniques were used to analyze the data, expressing and testing assumed relationships between variables. The data was coded, cleaned, and entered into the STATA 14.2 version for analysis. Descriptive statistics such as mean, percentage, and frequency distribution were used to analyze explanatory variables in sample households. Pearson chi-squared tests were used to cross-tabulate categorical variables for association. The qualitative data collected through KII and FGD was used to generate themes, which were discussed in relation to the research questions.

Regression analysis

In this study, ordinal logistic regression was used to analyze the factor determining the food security status of study participants. It is used to model the relationship between an independent variable and an ordinal response variable when the response variable category has a natural ordering (Greene, 2003). In this case, the ordinary regression analysis is based on a latent regression of ordinal scales, where there is a clear classification between the categories of the dependent variable (Gujarati and Porter, 2009). For some known integers J, the categorical dependent variable (level of food security) takes the value 0, 1... j. In addition, it is the function of a set of variables. Yi* is the latent regression level of food insecurity (Moon, 1998).

$$Y_i^* = ß'x_i + \varepsilon_i \qquad (4)$$

Where Yi* is household food insecurity with four levels (FS, MiFI, MoFI, and SFI), x_i is the matrix of a set of explanatory variables determining the household food insecurity factors that determine the choices made by households, ß is a vector parameter to be estimated, and ε is the error term and is assumed to be standard normally distributed.

The ordinal variable Yi in the OLM is a function of another variable Yi∗, based on household choice i among the alternatives (0, 1, 2... j) and in relation to several threshold points μj (μ0= −∞ y μj) = ∞, as demonstrated by the following formulas (Wooldridge, 2010):

$$Y_i = \begin{cases} 0 \text{ if } yi^* \leq \mu_1 \text{ (Food Secure)} \\ 1 \text{ if } \mu_1 \leq yi^* \leq \mu_2 \text{ (Mild Food Insecure)} \\ 2 \text{ if } \mu_2 \leq yi^* \leq \mu_3 \text{ (Moderately Food Insecure)} \\ 3 \text{ if } yi^* > \mu_3 \text{ (Severely Food Insecure)} \end{cases} \qquad (5)$$

Where 0 = food security, 1 = mild insecurity, 2 = moderate mild insecurity, and 3 = severe mild insecurity, μ_1 to μ_3 are cutoff points to be predicted for any of the HFI levels.

The logistic distribution function of the model is considered by Moon (1988). In this case, the probability of a response for a given household (i) according to the number of categories (j) is expressed as:

$$P[Yi = j \mid Xi] = P[\mu j-1 < Y* \leq \mu ji] = F(\mu j - Xi\beta) - F(\mu j-1 - Xi\beta) = \frac{e^{(\alpha j+Xi\beta)}}{1 + e^{(\alpha j+Xi\beta)}} \quad (6)$$

Where F represents the standard logistic cumulative distribution function (cdf) of εi, β are the regression coefficients for Xi, and αj is the intercept for j logit. The empirical application of the regression of the OLM, following Grimaccia and Naccarato (2018), is expressed as:

$$g(Y) = \text{logit}(Y) = \alpha j + \beta 1x1 + \beta 2x2 + \ldots + \beta nxn + \varepsilon i \quad (7)$$

The categorical dependent variable (FI levels), measured by the HIFIAS score, is analyzed based on observable exogenous variables. The αj parameters, called thresholds or breakpoints, are in increasing order ($\alpha 1 < \alpha 2 < \ldots$). Their number is $j = 1, 2. . . j - 1$, where j is the number of categories of the ordinal variable (Grimaccia and Naccarato, 2018). In this research, j = 4.

3.7. Description of Study Variables

3.7.1. Dependent variables (DV)

The dependent variables of this study were the food security status of households measured in HFIAS. HFIAS is categorized into four categories: food secure, mild food insecurity, moderate food insecurity, and severely food insecure.

3.7.2. Independent variables (IDV)

The IDV used in this study are demographic, socio-economic, and institutional variables that could affect the dependent variables. The explanatory variables were considered to have positive or negative effects on the food security status of sample households. Demographic and socio-economic characteristics include age, sex, marital status, education status, family size, farm size, on-farm income, off-farm income, household expenditure and farming experience. Institutional variables included access to credit, extension access, access to fertilizer, and saving. Socio-cultural variables included family background and complaints.

1. Sex of the household head (Sex): Gender is defined by the FAO as "the relations between men and women, both perceptual and material." "It is a central organizing principle of societies and often governs the processes of production and reproduction, consumption, and distribution" (FAO, 1997).

2. **Age of the household head (Age):** This could be a potential variable because agricultural operations require physical efforts and experience, both of which vary with age.

3. **Marital status (Mrs.):** Marital status influences the size of the farmers' family and the availability of labor for farm production to some extent because the marriage institution imposes some restrictions on which members of the family may farm (Victor, 2004).

4. **Household size (HHsize)** is regarded as an important variable because food security is directly related to the number of people in a household and the availability of food. It is a continuous variable and is measured in terms of the number of individuals in one family.

5. **Education of the household head (Educ):** is a continuous variable that is measured in terms of the number of years that the farmer spent in formal schooling. It also matters a lot because the level of education expands the knowledge of household heads, which are in a better position to apply improved practices for agricultural production and earn off-farm incomes, which influence household food security.

6. Farm size (Frmsize) is the total amount of farmland owned by a household in hectares. It is expected that households with large farmlands are more likely to be food secure than those who have smaller farmlands.

7. **Farming Experience (Famexp):** This was measured in years given that the respondent engaged in vegetable growing and livestock production activities. Farmers with more experience appear to have more complete information and knowledge, as well as the ability to evaluate the benefits of technology.

8. **On-farm income (Farminc)** refers to the total amount of income households earn from the sale of agricultural products such as vegetables, livestock, and livestock products after fulfilling dietary requirements. Household income is regarded as the most critical determinant of household food security status. Low-income households are more likely to suffer from food insecurity as compared to middle-income and wealthier households (Jacob, 2009).

9. **Off-farm income (Offinc)** was measured based on whether or not the household had engaged in off-farm income-generating activities. This is a dummy variable that takes the value 1 if the household received extension service and 0 otherwise.

10. **Household monthly expenditure (Hhexp)** matters in the context of food security because expense on food items improves food availability, and expense on non-food items may improve access to food.

11. Extension service (Exte): is the provision of advice, information, and other support to farmers. This is a dummy variable, which takes the value 1 if the household received extension service and 0 otherwise.

12. Credit service (Crdt): is measured in terms of whether households had access to credit sources and the possibility of getting credit. This is a dummy variable, which takes the value 1 if the household had access to credit and 0 otherwise.

13: Saving (Save) refers to the saving habit of the household head, who gives a value of 1 for yes and 0 for no. It is expected that households with a saving habit are more likely to be food secure than those households that don't have a saving habit.

14. Fertilizer access (Ferti) is an institutional variable that measures whether or not households have access to inorganic fertilizer for vegetable production**.** This is a dummy variable, which takes the value 1 if the household had access to fertilizer support and 0 otherwise.

15. Family background (Famback): It is a socio-cultural variable that measures the family background of the household head (from which family the household head comes). This is a dummy variable with a value of 1 if the household head hails from an agricultural family and a value of 0 otherwise

16. Complaint (Comp) is also a socio-cultural characteristic that measures the reaction of the community towards wastewater practice in the study area. This is a dummy variable, which takes the value 1 if the household head receives any complaints about his or her farming practices and 0 otherwise. It is expected to have a negative effect on household food security.

Table 3. 1. List of independent variables with respective name and category codes

Explanatory variables	Type	Measurement	Exp. Sign
Demographic and socio-economic variables			
Sex of the HH	Dummy	0 female 1 male	+/-
Age of the HH	Continuous	Age in years	+/-
Marital Status of the HH	Categorical	Single, married, widowed and divorced	+/-
Educational status	Continuous	Years in school	+/-
Household income	Categorical	In Birr	+/-
Household size	Continuous	Number in the household	+/-
Land size	Categorical	Hectare (ha)	+/-
Household expenditure	Categorical	In Birr	+
Off farm income	Categorical	In Birr	+
Farming experience	Continuous	In years	+
TLU	Continuous	In Number	+
Institutional variables			
Access to credit service	Dummy	Access to credit or not 1= Yes 0= No	+

Extension service	Dummy	1= Yes 0= No	+
Access to fertilizer	Dummy	1= Yes 0= No	+
Access to saving	Continuous	In Birr	+
Socio-cultural variables			
Complain	Dummy	1= Yes 0= No	-
Family background	Dummy	1 for farming family otherwise 0	+

Note: (+) sign indicates that as the explanatory variable increase, the probability of being HFIAS increases (the variable worsens food insecurity). (-) sign shows the inverse relationship that when the explanatory variable increases, the probability of being HFIAS score decreases.

3.8. Validity and Reliability of Data and Techniques

Two-day training for enumerators was provided to ensure the quality of the data and that all assessment team members could effectively administer the questionnaires. All necessary scientific study protocols, including suitable sampling, data collection, entry, and analysis, were created. A trustworthy project that can present the true picture of wastewater practices in UA and their impact on household food security was undertaken.

3.9. Ethical Consideration

The study was undertaken after the approval of the institutional ethical review committee of Addis Ababa University. Official letter was written from the university with a detailed explanation of the purpose and importance of the study to Akaki Kality sub city Bureau of Agriculture. The purpose of the study was explained to each study participant and informed verbal consent was obtained from all study subjects before conducting the actual interview and discussions. For this purpose, a consent form was read to each questionnaire which explains about the purpose and importance of the study, confidentiality, and the respondent's full right to answer the questions or not before the beginning or at any time of the study. Each interview was conducted after informed verbal consent was secured. All the collected data are kept in safe custody by the responsibility of the primary investigator.

CHAPTER FOUR: RESULT AND DISCUSSION

This chapter presents the results and discussion of the study. There are five subsections in it. The first section discusses the socio-economic, demographic and institutional characteristics of the study participants in relation to the determined independent factors. The second subsection addresses the different types of UA practices practiced by sample respondents in the study area and their assessed contribution. The third sub-section covers the assessment results of study participants' knowledge, attitudes, and practices regarding UA wastewater practices. The fourth subsection presents the food security status of the study households as measured by HFIAS and FCS, as well as the ordered logit model for factors affecting UA participation and producer food security status. The last sub-section presents the findings of the microbiological analysis (i.e., E. coli and total coliform) and the concentration of specific heavy metals (i.e., As, Cd, Cr, Pb, Hg, and Zn) in the wastewater.

4.1. Description of Study Households

This sub-section discusses household factors that explain socio-economic, demographic, institutional characteristics such as sex, age, marital status, family size, education level, farm size, farm income, off-farm income, farming experience, food expenditure, access to extension, access to credit, access to fertilizers, saving, family background, and complaints that are anticipated to have a positive or negative impact on UA and food security. Below Table 4.1 presents the results of descriptive statistics for explanatory variables.

4.1.1. Socio-economic characteristics of continuous variables

The mean age of sample household heads was 43.34 years, ranging from 26 to78 years with a standard deviation of 10.12. The fact that the majority of household heads are in this age group shows that they are still economically active and productive, capable of pursuing several livelihood strategies, and capable of guaranteeing household food security through a variety of sources of income. The finding is in agreement with national demographics, which reveal that 56.87% of the Ethiopian population is between the ages of 15 and 64 (World Bank, 2021). The finding further explained that, the average household size among study participants was 4.74, ranging from one to twelve, with a standard deviation of 1.73. The current finding is congruent with the national demographic who found an average of 4.6 individuals per household (EDHS, 2016). It was also coinciding with the finding of Nsabuwera (2019), who found that the average household size in Rwanda's Burera district was 4.5 people.

The average farm size was determined to be 0.16 hectare, indicating that they are smallholders with land sizes of less than 5 ha. This study supports the findings of Rapsomanikis (2015), as mentioned in Nsabuwera's (2019), who stated that the average size of smallholder farms in Bangladesh and Vietnam was 0.24ha and 0.32ha, respectively, while in Kenya and Ethiopia it was 0.47ha and 0.9ha. Only in Latin American countries were smallholder farmers discovered to have an average farm size of 2 to 5 hectares. The average farming experience among study participants was 11 years, with a low of 2 and a high of 56 years, with a standard deviation of 10.99. This indicates that the majority of the sample respondents had extensive agricultural experience and was likely to have developed the necessary skills for better operation.

Table 4.1. Socio-economic and demographic characteristics for continuous variables in the study area, 2022

	Mean	**SD**	**Minimum**	**Maximum**
Demographic and socio-economic characteristics				
Age of household heads (Years)	43.334	10.107	26	78
Number of family members)	4.738	1.73	1	12
Farm size (ha)	0.16	0.230	0	2.5
On-Farm income (ETB)	268950.1	217915.2	24980	1058400
Non-farm income (ETB)	6621.639	26821.01	0	300000
Household expenditure (ETB)	8911.175	3598.108	1535	20960
Farming experience (Years)	10.978	9.91	2	56
Saving (ETB)	26298.67	43381.008	0	250000

Source: Computed from field survey, 2022

Moreover, the average yearly on-farm income and off-farm income were 268950.1 ETB and 6621.64 ETB, respectively, indicating that the sample households would be living above the international poverty line of 133.5042 ETB (2.5USD) (World Bank, 2022). Moreover, average monthly spending among the sample households was 8911.175 ETB. Surprisingly, about 80% of study participants saved a portion of their income in formal financial institutions on an annual basis. On average, the households saved about 26298.67 EBT on a yearly basis. The total number of livestock within livestock producer's households was 2.73, with a minimum of 0 and max of 45.

4.1.2. Demographic characteristics of categorical variables

Out of 183 respondents, about 83.06% (n=152) were male-headed households with the remaining 16.94% (n=31) being from female-headed households. This suggests that households headed by men were more likely to participate in UA activities in the study area than their female counterparts. This result is in line with the findings of Chagomoka (2018). In his study in the Burera district of Rwanda, he found that about 61% of household heads came from male-headed households. Study conducted by Tilahun and Adelegn (2019) also confirmed similar results. They reported that about 62.5% of household heads were male.

The marital status of survey respondents ranged from single to widower, with married respondents making up 95.08%, followed by single (2.73%), widowed (2.73%), and divorced (2.19%). This suggests that the majority of research participants were married. The result is in agreement with the finding of Tilahun and Adelegn (2019). They reported the majority of study households (62.5%) were married. Moreover, about 11.48% of respondents were illiterate, of which 57.38% completed primary school, 27.87% attended secondary school and 3.28% were diploma/degree holders. This indicated that the majority of the respondents had completed their primary and secondary education.

Table 4.2. Demographic characteristics of dummy and categorical variables (n=183)

Demographic variable	Category	Frequency	Percentage
Sex of the HH	Male	152	83.06
	Female	31	16.4
	Single	5	2.73
Marital status of HH	Married	169	92.35
	Divorced	4	2.19
	Windowed/ widower	5	2.73
	Illiterate	21	11.48
Educational status of HH	Primary school (Grade 1-8)	105	57.38
	Secondary school (Grade 9-12)	51	27.87
	Diploma/ Degree	6	3.28

Source: Field survey, 2022

4.1.3. Institutional and socio-cultural characteristics of categorical variables

About 57.92% (n=106) of study participants had access to extension services, while 42.08 % did not. Access to artificial fertilizer was reported by 72.13% of the study participants. The descriptive statistics further indicated that, financial support among the sample households was relatively low, with only 4.37% of the study participants having access to credit. This result was consistent with Nsabuwera's (2019) finding that just 10% of respondents had received credit.

The descriptive statistics of socio-cultural characteristics shows that about 90.16% (n=165) of study participants reported that they came from farming families and about 85.25% (n=156) reported that they joined the farming sector with prior experience. Only 6.01% (n=11) claimed that they had received complaints about their farming operations from their neighbors. This was also reflected by FGD and KII participants. The participants thought that it is common to hear complaints, especially about wastewater usage, application of chemicals and odour of livestock animals.

Table 4.3. Institutional and socio-cultural characteristics of dummy variables

	Category	Frequency	Percentage
Institutional variables			
Access to credit	Yes	8	4.37
	No	175	95.63
Access to extension service	Yes	106	57.92
	No	77	42.08
Access to fertilizer	Yes	132	72.13
	No	51	27.87
Socio-cultural variables			
Complain	Yes	11	6.01
	No	172	93.99
Family background	Yes	165	90.16
	No	18	9.84
Prior experience	Yes	156	85.25
	No	27	14.75

Source: Computed from field survey, 2022

4.2. UA Production System in Akaki Kality sub-city

According to the study, farmers in the study operated different types of agricultural activities, such as vegetable production, livestock production, and both vegetable and livestock. The results are presented in the following sub sections:

4.2.1. Types of UA production systems in the study area

The types of UA practiced by the sample individual farmers are categorized into three sub systems, as indicated in Table 4.4 below: vegetable production, livestock production, and both vegetable and livestock.

Table 4.4.Urban agricultural activities practiced by sample households in the study area, 2022

	Types of UA	Example	Frequency
1	**Vegetables Production**	Cabbage, Carrot, Lettuce, Spinach, Tomatoes, Potatoes, Beetroot, Swiss-chard, Onion and Kale	47.54%
2	**Livestock production**		34.43%
	Animal fattening	Cow, ox, calf, sheep and goat	
	Poultry	Chicken and egg	
	Dairy production	Milk, cheese and yoghurt	
	Draft animals	Donkey	
3	**Both vegetable and livestock production**		18.03%
Total			100%

Source: Computed from survey, 2022

4.2.1.1. Vegetable production

In the study area, a variety of vegetables are cultivated either for domestic consumption, for the market, or for both. The farmers sold their products to the nearby market and for sellers. The cost of selling was determined by the negotiation between the farmers and the buyers and is affected by price fluctuation from time to time and this could affect the income of the household.

Growing vegetables was discovered to be the most common agricultural activity in the research area, with 47.54% of the sample respondents engaged in it. This is owing to the fact that there is a huge market demand for this form of produce as well as the fact that it is cheap for all economic categories of communities (poor, middle-income, and high-income groups) when compared to other types of UA agricultural operations (KII and FGD).

The most extensively grown vegetables in the study area are cabbage, lettuce, and tomatoes (Table 4.4). Potatoes, beets, carrots, spinach, onions, Swiss chard, and kale are some of the crops grown and sold in the study region. 85% of respondents used this produce for both home consumption and market sale, while 15% used it exclusively for market sale. This shows that the farming industry is concerned with helping farmers make money so they can buy things and pay for other family needs, in addition to supplying fresh food for human consumption. The leftovers are used as a fertilizer and animal feed.

Farmers in the study area undertake their farming operations in a range of locations, such as backyards and in open spaces (near to the river). Accordingly, the majority of respondents (54.73%) conducted their agricultural operations in their own backyards followed by open space (45.27%) using the river water as a source wastewater. Furthermore, over 60% of the farmers in the study use this water sources to irrigate their farmlands twice a year.

4.2.1.2. Livestock production

Livestock production is as prevalent as vegetable production in the study area, and it is practiced by more than 34.43% of the entire sample households. The sample households kept their livestock animals for a variety of uses, either for household consumption (e.g., meat, milk, cheese, and yoghurt) or market sale (e.g., selling of fattening animals, dairy products, eggs, and chicken). Poultry farming, which includes raising chickens and selling their eggs, was among the most popular livestock activities practiced by interviewed households, followed by dairy farming. This was to be predicted because chicken farming is inexpensive and chicken meat is in high demand as the world's most consumed meat type. Milk, cheese, and yoghurt production are among the dairy farming activities practiced by the respondents. Animal fattening (e.g., oxen, sheep, and goats) was another livestock alternative used by the sample households, which these households claimed they kept for the purpose of selling and generating additional income for their household. It was conducted by a significant proportion of agricultural households for market sale. However, donkeys were the least popular animal type reared by interviewed farming households, and they claimed that they mostly used donkeys for transportation. Additionally, approximately 20% of sample households are involved in both vegetable and livestock production. In this case, the use of the produce is similar to that of vegetable and livestock producers, who mostly sell their products to support their livelihoods by purchasing food and other household items.

Most of the sample household members who kept livestock did so in their backyards, and they used piped and river water for watering their livestock. Moreover, about 20% of livestock owners bought animal feed for their animals from the market, and the remaining 60% of livestock producers used grass, "atela," and crop residue as a source of feed.

Furthermore, approximately 18.03% of sample households are involved in the production of both vegetable and livestock (Table 4.4). In this case, the use of the produce is similar to that of vegetable and livestock producers, who mostly sell their products to support their livelihoods by purchasing food and other household items.

4.2.2. Perceived contribution of UA for income and food sources

UA is believed to help food security by enhancing access to food and boosting income (Mougeot, 2005). Most survey participants' responded that taking part in UA helped them meet their food demands and earn money, while some said it helps them meet their food security. Farmers in the study area made their living primarily through a variety of on-farm and non-farm activities. The average yearly income obtained from different sources i.e., on-farm and non-farm income was estimated to be 282047.18 ETB. The daily share of HHs' income was estimated to be 163.02ETB/day. The results in Table 4.5 revealed that agricultural activities had taken the larger share of total income with 97.65%. The result further explained that, about 64.85% of the total on-farm income was covered by vegetable production. Thus, it is clear that the main sources of agricultural income in the research area are the raising of livestock animals and the production of vegetables.

In addition to farming operations, the sample households were engaged in off-farm activities just to supplement their livelihood and this assists them in diversifying their income sources and hence reducing their vulnerability to food insecurity. However, the share of off-farm activities to households' total income was found to be extremely low, accounting for only 2.1% of total income (Table 4.5). The households' average yearly income from these activities was found to be 6621.64 ETB. House rent, formal employment, and child care were some of the off-farm activities that the households used to diversify their income sources.

Table 4.5. Households' sources income and its share in the study area

Source of Income	Types of UA	Average Income	Share (%)	Average income/day	Avg income/day/HH	Average income/day/person
On-farm	Vegetable	92528.6	**64.85**	501.09	105.71	22.3
	Livestock	182896.95	32.81	253.5	53.48	11.28
Off-farm		6621.64	2.35	18.14	3.83	0.81
Total		**282047.18**	100	**772.73**	**163.02**	**34.39**

Note: Sample size: 183, Average household size: 4.74 and Unit: ETB

Off-farm activities: e.g. Formal employment, children care, house rent, guard, etc.

Source: Computed from survey, 2022

4.3. Food Security Status of Study Participants

4.3.1. Food Security Status of Study Participants based on HFIAS

The prevalence of food insecurity during the previous month was measured by the HFIAS score. It was estimated for each household based on the answers to the nine "frequency of occurrence" questions. The household food insecurity score has a range from 0 to 27, with a higher number suggesting a higher risk of food insecurity. Families can be classified as food secure (FS), mildly food secure (MiFI), moderately food insecure (MoFI), or severely food insecure (SFI). Table 4.6 shows occurrence and affirmative responses of HFIAS conditions among sample households in the study area.

Table 4.6. Occurrence and affirmative responses of HFIAS conditions of household in the study area, 2022

Incidence questions	No	Yes	Repetitiveness of food insecurity conditions		
			Rarely	Sometimes	Often
	Freq	Freq	Freq	Freq	Freq
Worried about not enough food?	78 (45.66%)	105 (57.34%)	89 (48.6%)	16 (8.74%)	-
Eating food you did not like?	91 (49.73%)	92 (50.27%)	68 (37.16%)	22 (12.02%)	2 (1.09%)
Eating monotonous foods?	83 (45.36%)	100 (54.64%)	62 (33.88%)	33 (18.03%)	5 (2.73%)
Eating food you did not want to eat?	87 (47.54%)	96 (52.46%)	50 (27.32%)	42 (22.95%)	4 (2.19%)
Eating smaller sizes of foods?	92 (50.27%)	91 (49.73%)	49 (26.77%)	35 (19.13%)	7 (3.83%)
Skipping some meals in a day?	98 (53.55%)	85 (46.45%)	48 (26.23%)	27 (14.75%)	10 (5.47%)
No food to eat at all?	104 (56.83%)	79 (43.17%)	42 (22.6%)	34 (18.58%)	3 (1.99%)
Go to bed hungry?	125 (68.3%)	58 (31.7%)	26 (14.21%)	26 (14.21%)	4 (3.28%)
Went without food for a day and night?	138 (75.41%)	46 (24.59%)	25 (13.66%)	21 (10 .93%)	-

Source: computed from field survey, 2022

The results in Table 4.6 below show that about 45.66%, 49.73%, 45.36%, and 47.54% of the sample respondents did not encounter questions 1-4 (responded "no" to the occurrence questions), and about 50.27%, 53.35%, 56.83%, 68.3%, and 74.41% of them responded “no” to questions 5–9. The remaining sample households answered affirmatively (saying "yes") to the nine HFIAS questions. The study further revealed a consistent rise in the proportion of households that gave "no" answers, but there was a downward trend in the proportion of households that gave "yes" answers to the nine HFIAS questions with a 30-day recall period.

The results in Table 4.6 further revealed that the percentage of farming households that were worried about not having enough food was 57.34% (n = 105). Approximately 50.27% (n = 92) of study participants responded "yes" to being unable to eat their chosen food over the 30-day recall period prior to survey due to a lack of resources. The number of respondents who had consumed a limited variety of foods (monotonous foods) in the previous four weeks due to a lack of resources was 54.64% (n = 100). The proportion of respondents who had eaten fewer meals or skipped some meals in a day during the previous four weeks were 49.73% (n = 91) and 46.45% (n = 85), respectively. Furthermore, the proportion of households that responded positively to the severe conditions of going to bed hungry or going a whole day and night without food was 31.67% (n = 58) and 24.59% (n = 46), respectively.

Figure 4.1 displays the prevalence of food insecurity among study participants. Thus, out of 183 respondents, the prevalence of food insecurity was determined to be 39.34%, 27.87%, 26.23%, and 6.56% as food secure, mild food insecure, moderately food insecure, and severely food insecure, respectively. This showed that the majority of sample respondents (60.66) are experiencing food insecurity. Considering only food insecure households (n =111), about 45.95% (n =55) were mildly food insecure, while 43.24% (n =48) and only 10.81% (n =12) of the households were moderately and mildly food insecure, respectively, over the 30 day recall period. This was somehow in agreement with the study conducted by Tesfaye (2021). In his study in Akaki Kality sub city, he found that about 29.77%, 33.68%, 23.76% and 12.79% of the household were food secure, mild food insecure, moderate food insecure and severe food insecure, respectively. It was contrary to Nsabuwera's (2019) who found that about 6.3%, 15.6%, 34.7% and 43.4% households food secure, mild food insecure, moderate food insecure and severe food insecure, respectively.

The observed findings in the study could be attributed to the fact that farmers in the study were able to consume their products and generate adequate food at the home level. Furthermore, there is an expanding market need for their products in growing cities, where an increasing population hardly requires vegetables, livestock, and other marketing items. Diversification of agricultural operations could also contribute to increased food security (see section 4.1.2). Sophia (2015) reported that household who engaged in farming have earned food and cash income; this has contributed both in improving households' food security by improving food availability and nutrition of variety of food intake at household level.

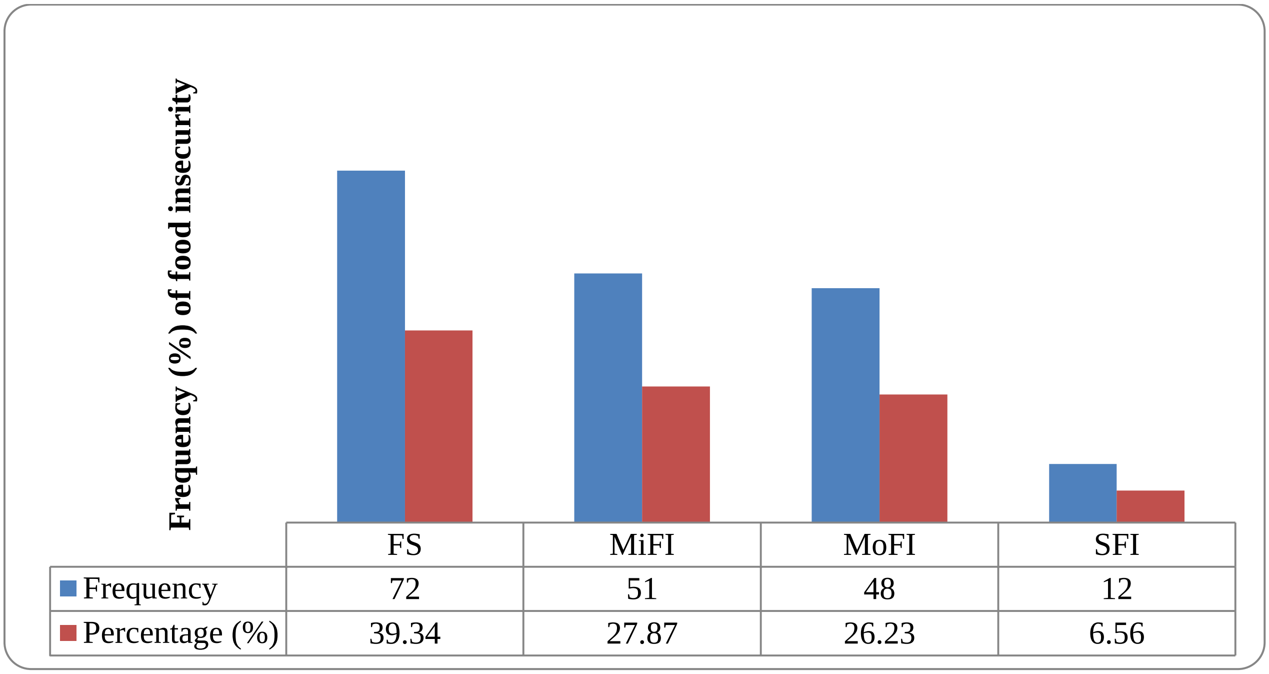

Figure 4.1. Household food insecurity prevalence in Akaki Kality sub-city, 2022

Source: Computed from field survey, 2022

4.3.2. Food security based on FCS

This study gathered FCS data from sample households to document the variety and frequency of various foods consumed over the course of the past 7 days. The results in Table 4.7 below indicated that about 100%, 93.99%, 99.45%, 33.33 and 44.81% of the sample respondents responded as they consume staple foods, pulses and legumes, vegetables, fruits and meat over the past 7 days prior to survey, respectively. Similarly, about 29.51%, 92.53% and 93.99% of the respondants reported consumption of dairy products, fat and oil, and sugar, respectively.

Table 4.7. Occurrence of food groups based on FCS

Food groups	Yes	No
Staples	183 (100%)	-
Pulses	172 (93.99%)	11 (6.01%)
Vegetables	182 (99.45%)	1 (0.55%)
Fruit	61 (33.33%)	122 (66.67%)
Meat	82 (44.81%)	101(55.49%)
Milk	54 (29.51%	129 (70.41%)
Oil	169 (92.35%)	14 (7.65%
Sugar	172 (93.99%)	11 (6.01%)

Source: Computed from survey, 2022

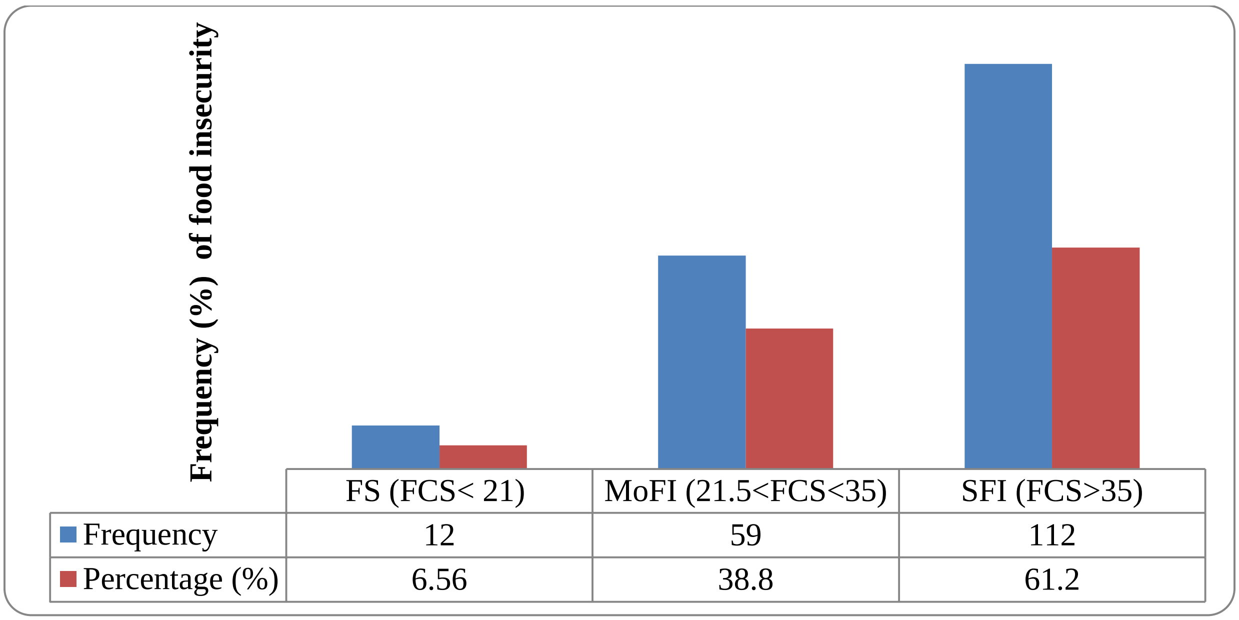

Figure 4. 2. Household food security status based on FCS, 2022

Source: computed from field survey, 2022

The finding in Figure 4.2 above reveals that about 61.2% of families had an appropriate level of food consumption score (FCS > 35), followed by 38.8% of borderline food consumption (between 21.5 and 35) and 6.56% of poor food consumption (less than 21). Accordingly, the households with poor food consumption are labeled as food insecure, while households with borderline consumption are labeled as moderately food insecure and the households with acceptable food consumption are labeled as food secure. The higher FCS might be due to the households expend more on food to supplement their households with diversified food.

Table 4.8. Food groups consumed by households within a week in the study area, 2022

Food groups	Number of days a given food group was consumed by			
	Mean	SD	Min	Max
1. Main staples (e.g.injera, bread, rice, etc.)	7.00	0.00	7	7
2. Pulses and legumes (e.g. Beans, peas, lentils, etc.)	3.84	1.7	0	7
3. Vegetables (e.g. cabbage, potato, tomatoes, etc.)	3.7	1.76	1	7
4. Fruits (e.g. banana, orange, etc)	1.41	1.29	0	6
5.Meat	1.41	1.29	0	7
6. Dairy products (e.g. milk, yoghurt, etc.)	0.92	1.72	0	7
7. Oils	6.05	2.08	0	7
8. Sugars	5.57	1.85	0	7

Source: computed from field survey, 2022

As indicated in table 4.8 below, all sample households reported consuming main staples and edible oils almost daily in the weeks preceding the study. Sugar, another potential carbohydrate source, was also found to be consumed frequently, on average 5.57±1.85SD days per week. Pulses and legumes, and vegetables were consumed on average on 3.84±1.7SD and 3.7±1.76SD days per week, respectively. The least often consumed food groups were meat (1.41±1.29SD days per week), fruits (1.41±1.29SD days per week), and dairy products (0.92±1.72SD days per week). The study's findings clearly indicated the existence of an inadequate diet for a healthy and active lifestyle, as crucial foods such as meat, fruits, and dairy were reported to be taken less frequently in the week preceding the survey. These food groups provide households with proteins, fats, vitamins, and minerals. The majority of households in the study area are engaged in vegetable production, but consumption is still low due to the fact that most items are sold to the market. The lower consumption of vegetables and animal products by sample respondents was due to the fact that they sold about 80% of their produce to support their livelihood and cover other household expenses.

4.4. Determinant factors of food security status

Before running the ordered logistic regression model, the explanatory variables were subjected to a collinearity diagnosis or association between the independent variables to identify the determinant factors affecting household food security status using the variance inflation factor (VIF) test. VIF estimates how much the variance is inflated. Studies show that an explanatory variable with a high VIF (usually 5 to 10 and above) suggests a problem of multicollinearity and that the violating predictors be excluded from the model. Accordingly, the total VIF was found to be 1.48, indicating that there was no multicollinearity issue observed.

In ordinal logistic regression modeling, a p-value greater than 0.05 ($p>0.05$) indicates a better fit of the model data. The number of observations is 183. The LR Chi-squared test with a value of 160.40 ($p=0.000$) showed that models fit the data well compared to the null. The pseudo-R^2 is 0.3498, which means that about 34.98% of the variation in the dependent variable is explained by the independent variables; this suggests the goodness of fit of the model.

In this study, an ordered logistic regression model was used to predict the effect of wastewater use on the food security status of study participants. It is used to analyze the effect of certain categories of relationships on the food insecurity status of the sample households. The output of the ordinal logistic regression model in the table below showed that nine (9) explanatory variables were found to have a statistically significant effect on the food security status of study participants at the 1%, 5%, and 10% significance levels. The variables include family size, education level, farm size, farming experience, on-farm income, off-farm income, household expenditure, access to extension service, and access to fertilizer. The remaining explanatory variables were not statistically significant.

Family size was found to be significant and positively correlated with the food insecurity status of households at a 5% confidence level (0.025) (Table 4.9). The findings suggest that households with lower families are more likely to be food secure and less likely to be mildly, moderately, or severely food insecure. The value of the marginal effect shows that as the household size of a food-secure household increases by one person, the probability of the household being in the category of food secure decreases by 0.598 times. This was consistent with Bejiga (2021) findings, who found that household size had a significant ($p<0.05$) and negative effect on household food security status in the Akaki Kality sub-city of Addis Ababa.

The results of ordered logistic regression reveal that the educational level of the household was found to have a statistically negative significant relationship with food insecurity in the sample households at the 5% significance level ($p=0.005$). The coefficient of educational level indicates that the probability of the household being food insecure decreases with an increase in educational level. According to Sulaiman et al. (2015), there is a negative and significant relationship between education level and food insecurity. Moreover, this suggests that the higher the educational level of the household head, the less food insecurity the household experiences. In other words, a farm household head with a low education level is more likely to be food insecure. The marginal effect revealed that for every one unit increase in educational attainment, the household's probability of being food secure increases by 0.302 times, holding other factors constant. It was in line with the findings of Gebremariam (2019) and Begiga (2021).

Land size is defined as the farm area covered by vegetable production during the survey period and measured in hectares. Land size was found to have a significant at 1% ($p=0.000$) and negative relationship with household food insecurity, implying that the greater the land size, the better the household food security status. The model predicts that as the size of a household’s farm land increases by one unit, the probability of the sample households being food secure increases by 0.5073 times. This result emphasizes the need for increasing home agriculture for greater productivity and revenue, as this reduces the likelihood of food insecurity for households. This was also in line with the findings of Gebremariam (2019) and Begiga (2021). It was also in agreement with the findings of Osei *et al. (2013)*, Ahmed (2015), Sulaiman *et al. (2015)*, and

Adimasu *et al*. (2019), who found that farm size had a significant and positive effect on household food security status.

Farming experience, measured in years, was found to be significant at 5% (p=0.045) and was negatively associated with household food insecurity status. The marginal effect results reveal that an additional year of farming experience raises the likelihoods likelihood of being food secure by 0.1617 times. This suggests that a**s** farming experience increases, so does the probability that households will have enough food. It was consistent with Samim *et al.,* (2021). In their study in Takhar Region Afghanistan, the found that a negative relationship between farming experience and food insecurity. It was also in agreement with the finding of Otekunrin (2021).

On-farm income was found to be statistically significant at 1% (p=0.000) and had a negative relationship with food insecurity. This negative sign implies that the larger the household's farm income, the more likely the family will be food secure. The model predicts that a unit increase in annual on-farm income raises the likelihood of a household being food secure while lowering the likelihood that such a household will experience mild, moderate, or severe food insecurity (Table 4.7). This means that the higher the household farm income, the more likely the household will be food secure, all else being constant (Table 4.7). This is because agricultural income increases a home's bargaining power, allowing the household head to have access to available food from the market and thus improving the likelihood of that household being food secure. This was in line with Nsabuwera's (2019) conclusion that on-farm income was positively associated with food security at the 5% level of significance. It was also in agreement with Mannaf and Uddin’s (2012), Olotosin et al.’s (2021), and Wondim *et al*.'s (2022) findings.

Engagement in off-farm income activities was found to be significant at 5% (p=0.014) and negatively correlated with household food insecurity status The negative coefficient of off-farm income activities indicates that an increase in off-farm income improves the likelihood of households being food secure while decreasing the likelihood of being mildly, moderately, or severely food insecure. Accordingly, the marginal effect revealed that engaging in off-farm activity increases households' food security (Table 4.7). This could be because income from off-farm activity would increase household purchasing power or income to purchase food and cover other expenses, lowering the risk of food insecurity. The outcome is in line with the findings of Regassa (2011) and Gebremariam (2019). However, the results differ from those of Wondim et al. (2022) and Oulotosin et al. (2021). The authors found that off-farm income is positively associated with household food insecurity status.

The household expenditure was found to be statistically significant at the 1% significance level (p=0.004) and demonstrated a negative relationship with farm households' food insecurity. The negative sign suggests that the higher a household's expenditure, the more likely it is to be food secure. It further showed that the respondent expended more on food. Moreover, the marginal effect result revealed that a unit increase in respondent expenditure increases the household's chance of being food secure by 0.000041times.

Table 4.9.Ordinal logistic regressions

Variable			Marginal effect			
	Coefficient	p-value	FS	MiFI	MoFI	SFI
Sex	.1177705 (.46402290)	0.800	-.0280956 (.10977)	.0143348 (.05418(	.0126958 (.05142)	.001065 (.00437)
Age	.-.0036304 (.023047)	0.875	.0008732 (.00555)	-.000461 (.00294)	-.0003806 (.00241)	-.0000316 (.0002)
Marital status	-.0298121 (.4033857)	0.941	.0071705 (.09703)	-.0037859 (.05124)	-.0031253 (.0423)	-.0002593 (.0035)
Household size	.248729 (.1110527)	0.025**	-.0598255 (.02692)	.031587 (.01651)	.0260747 (.01245)	.0021638 (.00124)
Educational status	-.1259299 (.0548365)	0.022**	.0302893 (.01323)	-.0159923 (.00817)	-.0132015 (.00615)	-.0010955 (.00063)
Farm size	-2.109108 (.6563716)	0.001***	.5072932 (.16265)	-.2678434 (.1173)	-.2211019 (.07195)	-.0183478 (.00886)

Variable	Marginal effect					cont...
	Coefficient	p-value	FS	MiFI	MoFI	SFI
Farming experience	-.0469965 (.0234273)	0.045**	.0113038 (.00564)	-.0059683 (.00335)	-.0049267 (.0026)	-.0004088 (.00026)
On-farm income	-.0000119 (1.69e-06)	0.000***	2.86e-06 (.00000)	-1.51e-06 (.00000)	-1.25e-06 (.00000)	-1.04e-07 (.00000)
Non-farm income	-.0000288 (.0000117)	0.014**	6.93e-06 (.00000)	-3.66e-06 (.00000)	-3.02e-06 (.00000)	-2.51e-07 (.00000)
Household expenditure	.0001781 (.0000613)	0.004***	.0000428 (.00001)	-.0000226 (.00001)	-.0000187 (.00001)	-1.55e-06 (.00000)
Family Background	-.1363581 (.4845289)	0.778	.0330757 (.11835	-.0181348 (.06714)	-.0138086 (.04758)	-.0011323 .00385)
Complain	-.0279409 (.7153757)	0.969	.0067041 (.17121	-.003503 (.0885)	-.0029551 (.07634)	-.000246 .00638)

Access to extension was found to be significant at 5% level (p=0.028.) and negatively connected to food security in the research area The model predicts that as the frequency of extension agents visit increases by one day, the likelihood of a household being food secure decreases by 0.3126 times. It was consistent with the finding of Sulaiman et al. (2015), who found that access to extension service had a significant and favorable effect on household food security status in Ibadan city, Oyo state, Nigeria. He concludes that contact with extension services increases the likelihood of households having access to higher crop production, improved inputs, and other production incentives that enhance farm productivity and thus household food insecurity. It was also consistent with Samim *et al.*, (2021). It was contrary to the finding of Bejiga (2021) who found that access to extension was not significantly correlated with household food security status.

Access to fertilizer was found to be statistically significant at 5% (p=0.043).and was negatively correlated with household food security. The model predicts that access to fertilizer by a household would improve the likelihood of the household being food secure.

4.5. Assessment of food safety Knowledge, Attitude and Practice (KAP)

4.5.1. Farmers' food handling KAP

4.5.1.1. Households food handling knowledge

Food handling knowledge was assessed with regards to washing raw vegetables. All (100%) of the sample respondents stated that they wash raw veggies with clean water before eating them to remove unwanted materials and keep them safe (Table 4.5). Farmers, on the other hand, have been observed eating raw vegetables without washing their hands, which could be affecting their health, particularly those who use wastewater on their farm land (Personal observation). The overall performance of respondents towards food handling knowledge was 100%.

Table 4.10. Farmers’ Food Handling Knowledge in the study area

Food handling Knowledge		
What should you do before eating raw vegetable		Frequency
1	Wash them with clean water	183 (100%)
2	Other	-
3	Don’t know	-
	Total	100%)

Source: Own survey, 2022

4.5.1.2. Households Food Handling Attitude

Attitude is one of the most important factors influencing food safety and practice, as well as reducing the occurrence of food-related illnesses. Study participants showed a positive attitude towards the likelihood, seriousness, benefits, and difficulties arising from food handling methods. Accordingly, a majority of respondents (88.52%) believed they would become ill if they ate contaminated food, while around 2.19% believed the disease was not serious (Table

4.13). The total positive attitude among respondents was 91.79%. Those who had a negative attitude toward food handling saw illnesses from contaminated food as not being too serious.

Table 4.11. Farmers' food handling attitude in the study area

	Category (Food Handling Attitude)	No	Not Sure	Yes
1	Likelihood of getting sick from eating contaminated food	4 (2.19)	17 (9.29)	162 (88.52)
2	Seriousness of getting sick from eating contaminated food	4 (2.19)	39 (15.85)	150 (81.97)
3	Goodness of washing fruits and vegetables with clean water	-	1 (0.55)	182 (99.45)
4	Difficult of washing fruits and vegetables with clean water	178 (97.2)	2 (1.09)	3 (1.64)
	Average food handling attitude: **91.79%**			

Source: Own survey, 2022

4.5.1.3. Households food handling practice

Food handling practices were evaluated with respect to storage practices of perishable food commodities like fruit, vegetables, meat, and the like. The majority of the respondents kept their foods in the refrigerator (below 5^{o}c) or cool place (66.12%) or by separating them from cooked/ready-to-eat foods (28.42%). Only a very small number of respondents were keeping perishable foods by covering them. The level of acceptable practices among the respondents was 33.3%

Table 4.12. Food handling practice in the study area

Food Handling Practice		
How do you store perishable foods like fruit, meat, etc.		Frequency
1	In the refrigerator (below 5^{o}c)/ cool place	121 (66.12%)
2	Covered (protected)	10 (5.46)
3	Separated from cooked/ ready-to-eat foods	52 (28.42%)
4	Don’t know	-
	Total	100%

Source: Own survey, 2022

4.5.2. Farmers' personal hygiene KAP

4.5.2.1. Households personal hygiene knowledge

Personal hygiene knowledge focuses on actions taken to prevent food poisoning caused by unsanitary practices. Data reveals that about 61.75% of farmers washed their hands before preparing/handling foods and another 19.67% before eating and after using the toilet (Table 4.15). Soon et al. (2011) and Powell et al. (2011) stated that proper food safety knowledge is useful to minimize food-borne diseases and to improve attitudes towards the practice of food safety knowledge. Adequate training on food safety would be helpful to food handlers. The level of acceptable practices among the respondents was 33.3%.

Table 4.13.Farmers’ response on personal hygiene knowledge in the study area

Personal Hygiene Knowledge: Key moments for hand washing?		Frequency
1	Before preparing/handling foods	113 (61.75%)
2	After handling raw food	34 (18.58%)
3	Before eating and after using the toilet	36 (19.67%)
4	I don’t know	-
	Total	100%

Source: Own survey, 2022

4.5.2.2. Households Personal Hygiene Attitude

The results in Table 4.16 showed that most households had positive attitudes toward personal hygiene and were aware of the benefits and risks of performing proper hand washing. The magnitudes of perceived susceptibility, severity, advantages, barriers, and self-efficacy were 91.8%, 91.8%, 100%, 1.09%, and 61.75%, respectively. The overall acceptable practice rate among responders was around 95.63%. About how frequent are the hhs exposed to the aforementioned disease?

Table 4.14. Farmers' response on personal hygiene attitude in the study area

	Category (Personal hygiene attitude)	No	Not sure	Yes
1	Likelihood of oneself having stomach/ diarrhea from not washing your hands	1 (0.55%)	14 (7.65%)	168 (91.8%)
2	Seriousness if one gets sick from oneself not washing one's hand	-	15 (8.2%)	168 (91.8%)
3	Goodness of washing one's hand before preparing/ eating foods	-	-	183 (100%)
4	Difficulty to wash one's hand before preparing/ eating foods	181 (98.91%)	2 (1.09%)	-
5	Confidence in washing one's hand properly	12 (6.56%)	58 (31.69%)	113 (61.75%)

Source: Own survey, 2022

4.5.2.3. Households Personal Hygiene Practice

Proper implementation of personal hygiene practices aids in the production of safe food and the prevention of food-borne illness. It was evaluated based on the procedures they used to wash their hands. The finding demonstrated that about 1.64% of respondents had poor hand washing practice (washing their hands in a bowl of water while sharing with others), making them susceptible to food-borne disease, whereas the remaining participants followed appropriate hand washing practice using different methods (Table 4.10). The overall acceptable practice rate among responders was around 33.33%.

Table 4.15. Farmers' response on personal hygiene practice in the study area

Personal hygiene practice		
	Could you please describe step by step how you wash your hands	Frequency
1	Wash hands in a bowl of water (sharing with other people) - poor practice	3 (1.64%)
2	With someone pouring a little a little water from a jug onto one's hand- appropriate practice	78 (42.62%)
3	Under running water- appropriate practice	26 (14.21%)
4	Washes hands with soap/ashes- good practice	76 (41.53%)
	Total	100%
	Total positive personal hygiene practice: 33.33%	

Source: Own survey, 2022

4.5.3. Farmers' water and sanitation KAP

4.5.3.1. Households water and sanitation knowledge

The respondents' knowledge of water sanitation was examined in terms of how they treat contaminated water (Table 4.15). All the respondents stated that they treat contaminated water before using it. About 72 (37.9%) of respondents knew about treating unsafe water by boiling or adding chlorine, but 93 (48.95%) discarded unsafe water in order to obtain water from a safe source. The remaining respondents (10.01%) treated contaminated water by straining or by using a water filter. The overall acceptable attitude rate among respondents was around 60%.

Table 4.16. Respondents' response on water and sanitation knowledge in the study area

	Water and Sanitation Knowledge	Category	Frequency
1	Treating unsafe water	Yes	183 (100%)
		No	
	If you know that the water you are going to use for cooking/ drinking is not safe, what should you do?		
2	Boil it		22 (12.02%)
	Add bleach/chlorine		50 (27.32%)
	Strain		18 (9.84%)
	Discard it and get water from other source		88 (48.09%)
	Use a water filter		4 (2.18%)
	I don't know		1 (0.55%)
	Total		100%
	Total positive water and sanitation knowledge: 60%		

Source: Own survey, 2022

4.5.3.2. Households water sanitation attitude

The vast majority (98.5%) of sample households believed contaminated water could cause diarrhea and were aware of the dangers of drinking contaminated water. The percentages of perceived benefits, barriers, and self-efficacy were 100%, 100%, and 66.92%, respectively. The total positive attitude among the respondents was 93.11%.

Table 4.17.Farmers' response on water and sanitation attitude in the study area

	Category (Water and Sanitation Attitude)	It's not	Not	It's
1	Likelihood of oneself to get diarrhea from using unsafe water	-	-	183 (100%)
2	Seriousness of getting diarrhea from using unsafe water	-	1 (0.55%)	182 (99.45%)
3	Goodness of boiling water before drinking/ using it	183 (100%)	-	-
4	Difficulty of boiling water before drinking/ using it	183 (100%)	-	-
5	Confidence in boiling water before drinking/ using it	1 (0.55%)	61 (33.33%)	121 (66.12%)
	Total positive attitude: 93.11%			

Source: Own survey, 2022

4.5.3.3. Households water and sanitation practice

The findings show that all of the respondents gathered water from a pipe for drinking, cooking, and hand washing. It further shows that the majority (79.51%) of farmers report they routinely wash their hands, wear gloves and clothes for protection, and disinfect and sterilize their hands to guard against infections associated with wastewater consumption. Only 20.49 percent of respondents said they didn't take any safety precautions (Table 4.17). The total positive towards sample respondents was 62.5%.

Table 4.18. Farmers' response on water and sanitation practice in the study area

Water and Sanitation practice		
Main source of water for drinking, cooking and hand washing		Frequency
1	Pipe water	183 (100%)
2	Piped in yard/ plot	-
3	Surface	-
What should you do to protect yourself from danger agricultural operations?		
1	Washing hands frequently after finishing my work	97 (53.01%)
2	Wearing protective glove and cloth	30 (16.39%)
3	Cleaning and sanitizing	21 (11.47%)
4	I do nothing	35 (19.13%)
	Total positive practice: 62.5%	

Source: Own survey, 2022

4.5. Microbiological and Heavy Metal Analysis of Wastewater:

This section summarizes the findings of a study conducted in Akaki Kality sub-city to evaluate the quality of irrigation wastewater utilized by study farmers. The results of microbiological and heavy metal analysis are presented in the following subsections:

4.5.1. Microbial analysis of wastewater

The biological properties of water and wastewater are critical to human health, both in terms of disease control caused by pathogenic organisms of human origin and in terms of waste breakdown. Untreated wastewater contains a wide range of excreted organisms, including pathogens in high concentrations. Microbial evidence can thus be used to detect the presence of a human hazard in the environment. According to WHO (2006), there is no perfect indicator organism for wastewater because ejected organisms range from bacteria to helminthes, protozoa, and viruses. The most often used fecal indicator organisms for monitoring water quality are total coliform and E. coli.

In this study, fecal indicator microorganisms are used to measure the levels of microbiological contamination in wastewater used irrigation and livestock watering by sample farmers in the study area. The maximum allowable limit of total coliform and E.coli set by WHO is 100-1000 CFU per 100 m/l and 1000 CFU per 100 m/l, respectively (WHO, 2006). Table 4.19 presents the outcomes of the microbiological analysis. Accordingly, the mean total coliform and E.coli concentrations were found to be 4.56×10^5 and 8.96×10^4 CFU/100 ml, respectively which was above the maximum allowable limit set by WHO (2006). The result further shows that the water used for irrigation in the study area is exposed to microbial contamination and can be not used for irrigation purposes based on microbial analysis and may increase the likelihood of bacterial diseases being transmitted to farmers directly using river water or to people consuming the vegetables causing problems.

The increase in microbial count could be caused by anthropogenic activities in and around the river, such as the discharge of human and animal wastes into the river, as well as runoffs of animal manure used to fertilize soils in vegetable farms into irrigation water. Mengesha et al. (2021) confirmed the findings, reporting that the Akaki River, like many Addis Abeba streams, has been significantly affected by anthropogenic impacts from upstream to downstream. Moreover, domestic animals looking for water to drink may contaminate the river water by urinating and fecating right into it. The high load of total coliform and E. coli bacteria indicates poor sanitation services and management in the town and in the study area. All of these factors could have contributed to the greater microbial load in the irrigation water used for the study's fieldwork.

The current study is supported by the findings of Abdallah and Mourad (2021). They conclude that total coliform and E. coli levels in water samples were high and exceeded WHO recommendations. This makes the water unsafe for use for agricultural purposes without proper treatment. Furthermore, farmers and consumers are at risk of contamination. It also coincides with the finding of Linge *et al*. (2021), who found that Akaki Rivers is heavily polluted with both total coliform and E. coli bacteria. This study also agrees with recent research conducted in

Ethiopia (Mengesha *et al*., 2017; Assegide *et al*., 2022) and other countries (Anim-Gyampo *et al*., 2012).

Table 4.19. E. coli and total coliform in irrigation water of study area

Parameters	Mean concentration (cfu/100ml)			Mean	WHO guideline
	Trial 1	Trial 2	Trial 3		(2006)
Total coliform CFU/100ml	4.5×10^5	4.6×10^5	4.6×10^5	4.56×10^5	100-1000
E.coli CFU/100ml	9.1×10^4	8.9×10^4	8.9×10^4	8.96×10^4	1000/100ml

Source: result, 2022

The presence of coliform in irrigation water may contaminate vegetable products following poor farming techniques, resulting in food poisoning if these items are consumed without being thoroughly cleaned. The researcher observed that the farmers in the study area were not protected from contact with the wastewater in order to avoid illness. They even eat raw vegetables on their farm and frequently go barefoot into the river since they feel it has no negative health effects. Such malpractices increase the probability of developing a variety of ailments. Eating bacteria-contaminated vegetables exposes farmers and consumers to microbiological hazards that can lead to a variety of infectious disorders, including gastroenteritis, diarrhea, and typhoid and paratyphoid fevers. Approximately 50% of study participants reported having had various diseases such as skin infections and diarrhea in the previous year, with 20% of them attending a clinic as a result.

4.5.2. Heavy metal analysis of wastewater

Trace quantities of many heavy metals can be found in wastewaters. Many of these metals are essential for biological life to thrive, but only in trace amounts. If the appropriate quantities are surpassed, however, they can become poisonous and prevent wastewater from being used for its intended purposes (Metcalf and Eddy, 2003 cited in Nugusu, 2015). In this study, a total of six heavy metals (Hg, Pb, Cr, As, Zn, and Cd) were assessed in the samples. Table 4.21 below shows the level of heavy metals in the analyzed wastewater sample.

According to the finding, the mean Mercury (Hg) concentration in the analyzed sample was less than 0.001 mg/l, which was less than the WHO (2006), USEPA (2012) and Italian Decree (2003). Pb has been classified as potentially hazardous to most biological forms. It is a non-essential heavy metal. Lead poisoning causes anemia, colic, headaches, brain damage, and central nervous system illnesses (Rehman et al., 2013). The result of laboratory analysis revealed that the average Pb level for wastewater samples was found to be 0.01mg/l). This was lower than the recommended limit of Pb for irrigation water set by WHO (2006), USEPA (2012) and Italian Decree (2003) (below Table 4.20). A decrease in the mean concentration of Pb from sampling point may be due to the settlement effect.

Chromium (Cr) plays a vital role in the metabolism of cholesterol, fat, and glucose. Its deficiency causes hyperglycemia, elevated body fat, and decreased sperm count, while at high concentration it is toxic and carcinogenic (Chishti *et al*., 2011). The average concentration of Cr measured in this study was found to be 0.01mg/l, which was below the maximum limit set by WHO (2006), USEPA (2012) and Italian Decree (2003). Likewise, the average concentration Arsenic (As) level was found to be 0.013±0.0058 mg/l, which was again below the limit set by WHO (2006), USEPA (2012) and Italian Decree (2003) for wastewater irrigation.

Zinc (Zn) is the least toxic and is an essential element in the human diet as it is required to maintain the proper functioning of the immune system, normal brain activity and is fundamental in the growth and development of the foetus, but a very high concentration of zinc is very toxic, hence harmful to the human body (Helen and Othman, 2014). The average concentration of Zn in the river water was found to be 0.1mg/l and all the samples were below the recommended maximum concentration for wastewater irrigation of WHO (2006), USEPA (2012) and Italian Decree (2003). The decrease in mean concentration of Zn might be due to formation of some insoluble salts with certain anions that might be discharged from the nearby effluent. Like Pb, Cadmium (Cd) is also a non-essential heavy metal. It is extremely toxic even at low concentration toxicity (Hunt, 2003). The average Cd concentration in the wastewater was found to be 0.002mg/l, which was below the permissible limit set by WHO (2006), USEPA (2012) and Italian Decree (2003) for wastewater irrigation.

The current finding was in agreement with Woldetsadik et al. (2017). In his study in wastewater-irrigated urban vegetable sites of Addiss Ababa, he found that that the mean concentration of Cd, Cr, Pb and Zn in the irrigation water were 3.54 - 58.8, 2.26 - 6.74, 105 - 938 and 17.8 - 48.8 times below the recommended limit for irrigation water Aschale et al.(2015) in his study in reported lower concentration of Cd (0.04-0.06µg/l), Pb (1.4-5.1 µg/l) and Pb (10.9-22.5µg/l) but higher mean range Cr (2.4-255 µg/l) in the irrigation water samples. Similarly, Alemayew (2006) reported low level of Cd, Cr and Zinc in the Akaki Rive/ irrigation water. Contrary to this, Weldegebriel (2012) have reported have reported Cd and Zn as high as 33 µg/l and 618 µg/l. A study conducted by Mengesha (2017) reported that the overall concentration of Zn, Cr, Pb and Cd in the Akaki River water samples ranged from 0-0.42µg/l,.22 µg/l, 0-26.22 µg/l and 0-7.47 µg/l with median value of 0.12, 5.33mg/l, 5.33 µg/l, and 6.23 µg/l, respectively.

Table 4. 20. Heavy metal concentration of irrigation water (Akaki River at woreda 3)

Heavy Metal	Concentration (mg/l)			Average	WHO	USEPA	Italian Decree
	Trial 1	Trial 2	Trial 3	conc. (mg/l)	(2006)	(2012)	(2003)
Arsenic (As)	0.02	0.01	0.01	0.013±0.006	0.1	0.1	0.02
Cadmium (Cd)	0.002	0.002	0.002	0.002	0.01	0.01	0.005
Chromium (Cr)	0.01	0.01	0.01	0.01	0.1	0.1	0.1
Lead (Pb)	0.01	0.01	0.01	0.01	5	5	0.1
Mercury (Hg)	0.001	0.001	0.001	0.001			0.001
Zinc (Zn)	0.1	0.1	0.1	0.1	2	2	0.5

Source: Laboratory result, 2022

Lower concentrations of these heavy metals in the present study may be very few localized industrial activities and the dilution of wastewater with stream. Moreover, wastewater discharged into the river and irrigation canal might be more of domestic origins. Environmental activities in and around the river such as wastewater treatment, presence waste deposition sites and the like could be a possible factor for the low levels of heavy metal concentration. The implementation of environmental management policy plan could also be taken as one factor. The policy prohibited industries and other staffs from releasing effluents directly into the river without treatment.

In addition, the variations in heavy metal concentrations between the current and earlier investigations are due to differences in sample point placement and proximity to industrial areas. Furthermore, the difference in sample period may have contributed to the observed disagreement in the results, as the current study only used one sampling point and one time. Despite the low level of heavy metals in the analyzed sample, continuous use of this water may result in different health related disease for the farmers as well as the consumers.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Conclusion of the Study

The aims of this study were to investigate the use of wastewater in urban agriculture and its contribution to household food security in the Akaki Kality sub-city of Addis Ababa, Ethiopia. The study covered the types of UA practices practiced by sample households and measured food security status using HFIAS and FCS. It also addressed food safety KAP based on food handling, personal hygiene, and water sanitation, as well as wastewater quality analysis for irrigation and livestock watering.

The current finding revealed that vegetable production accounted for the largest share of agricultural production and household total income, with 45% and 45%, respectively. The result further explained that the share of off-farm income to total income was found to be relatively low (2.35%). According to the food consumption score (FCS), 62.1% of the households had an adequate food consumption score (>35). The household food insecurity access scale (HFIAS), on the other hand, suggested that about 40% of the household were food secure. Moreover, the ordinal logistic model revealed that household size, education attainment, farm size, farming experience, on-farm income, off-farm income, household expenditure, access to extension and access to fertilizer were statistically significant at 1% and 5% in determining household food insecurity status. Especially, educational level, farm size, farming experience, on-farm income, off-farm income, household expenditure, extension service and access to fertilizer had a negative influence on respondents. Other variable such as household size was found to have a positive effect.

The result of the food safety KAP assessment revealed that there were food safety gaps in terms of practice of food handling, personal hygiene and water sanitation. The results of bacteriological analysis have shown that the wastewater used irrigation at the sampling point (woreda 3) was heavily contaminated with E.coli and total coliform (surpass the maximum limit set for wastewater irrigation), mainly due to anthropogenic activities in the study area. This tells us the wastewater used for irrigation and livestock water was heavily contaminated with microbes and not safe for irrigation purposes and resulting in different health complications.

The heavy metal analysis, however, revealed that all the analyzed metal (Hg, Pb, Cd, Zn, AS and Cr) were below the detection limit. This could be due to dilution of wastewater with stream water, reduced localized industries activities, presence of wastewater treatment plant, deposition of metal in soil and vegetable, seasonal variation, implementation of environmental management policy and the like. It is possible to conclude that the wastewater was safe irrigation as per the current finding but adequate monitoring of the metals from irrigation water may be required to prevent their buildup in the food chain.

5.2 Recommendations

Based on the findings, the following recommendations were forwarded.

1. Although the study households had positive attitude towards food safety, this was barely practiced and this could be due to poor knowledge of study households on basic food safety principle. Therefore, in addition hence, agricultural extension workers and government official should work to raise farmer's awareness on safe food handling and other related issues.

2. The microbiological analysis showed there was high microbial contamination in the sampling site, and this makes the sample households susceptible to different diseases such as diarrhea, which in turn affects agricultural production and hence food security. So, awareness should be given to farmers as well as the community on the safe use wastewater and safety related issues. Enhancing the environmental awareness of the community through different campaigns at the local and national levels is very important.

3. Despite the low level of heavy metals in the analyzed sample, continuous use of this water may lead to different health complications to the farmers as well as the consumers. It also affects the utilization component of food security. So, Intermittent monitoring of the metals from irrigation water may be required to prevent their buildup in the food chain. In addition, further investigation should be undertaken to understand the effect of wastewater on human health and food security.

4. In general, in order to minimize the effect of wastewater use in UA towards health and food security, enhancing the environmental awareness and empowering the local authorities to take part in environmental policy regulations and its implementation is crucial. Besides, there should be an intervention of appropriate regulatory bodies to ensure the quality of wastewater released from industries and domestic homes. In addition, government, NGOs and different stakeholders should work in collaboration with the sub-city environmental management bureau.

5. The present study is limited to a few biological and heavy metal analyses and sampling frequencies. So, further investigation should be undertaken to understand the effects of microbial and heavy metals by taking additional parameters and adding more sampling points.

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APPENDICES: HOUSEHOLD SURVEY QUESTIONNAIRES AND INTERVIEWS

Addis Ababa University College of development studies center for food Security studies

Appendix I: Consent Format

Greeting! My name is ______________________. I am working as a data collector for an investigator doing his research as partial fulfillment of his Masters Degree study at Addiss Ababa University. The aim of the study is to investigate wastewater use for urban agriculture and its effect on Food security and safety of farmers in Akaki Kality Sub city, Addiss Ababa. Your involvement in the study is important for the successful accomplishment of the study as you are among the individual farmers that engaged in UA in the area. The decision on your involvement is made by your willingness. You will be asked to answer different questions about your household food composition pattern, farming related information's, expenditures, food handling, sanitation, water quality and hygiene issues. Besides, water that uses for your farming practice will be checked in laboratory for heavy metals.

Risk: There is no physical or psychological risk expected to be involved in the study.

Benefits: You have fully right to know the output of the study. You will be given information about the risk level of the water that you use for your farming practice and safe food handling and sanitation practice and water utilization.

Confidentiality: your personal information will only be used for this study, and you will not be personally identified in the study report.

Participation: You have to know that your participation in the study is based on your willingness and approval. You have the right to say 'no' and not be the part of the study. If you want to stop the interview, you have the right to withdrawn from this study at any time without any penalty.

Question: You have full right to ask any question about the study

Confirmation of agreement: I have read the consent form/ the interviewer has read the consent form. I have understood the aim of the study and the things that I have to do if I agreed to participate in the study. I know that my participation is based on my will and have the right to not to do so if I don't want to engaged in.

Please tell me if you agree or not

Yes ☐ No ☐

Date of interview: ___________________________________

Place of interview: ___________________________________

Code of interviewee: ________________

Supervisor name and signature: ______________________

If you have any question, please contact!

Getahun Chala

Phone number: 0919151297/ 0900624584

Appendix II. Household survey questionnaire (English version)

The aim of this study will be to investigate the urban agriculture produced using wastewater and its effect on food security and safety in Akaki Kality Sub City, Addis Ababa, Ethiopia. The information you provide is used only for academic purposes. So, please put a thick mark and short answer for the following

Part 1: Demographic characteristics

1. Sex of the household head 0. Male 1. Female

2. Age of the household: _________________________

3. Education level of the household: ________________

4. Marital Status: 1. Single 2. Married 3. Divorce 4. Windowed/ widower

5. Household size: ___________________

6. Farming experience: ________________

Part 2. Socio-cultural Information

1. Where do you come from? 0. Farming family 1. Non-farming family

2. Do you receive any complain about your farming activity? 0. Yes 1. No

Part 3: Farming and income information

1. What type of UA do you practice? 0. Vegetable 1. Livestock 2. Both

2. If vegetable to question 1, Please specify the type of vegetable that you grow and about how much was produced and sold in the last one year? (You can choose more than one)

Vegode	Vegetable name	Quantity harvested	Quantity sold	Price per unit
0	Cabbage			
1	Spinach			
2	Onion			
3	Tomatoes			
4	Carrot			
5	Potato			
6	Lettuce/ kale			
7	Beet root			
99	Other specify			

3. Where do you practice your vegetable and livestock?

0. In Open space 1. In urban fringe area 2. Road side 3. Backyard garden

99. Other (specify) __________________

4. Land size owned by the household for vegetable production (Hectare): __________

5. What is your source of water for irrigation?

0. Pond 1. River 2. Fresh waters 99. Other (specify) _______________

6. If livestock to question 1, do you own livestock? 0. Yes 1. No

7. If yes to question (5), Please specify the types and number of livestock owned

Livcode	Animal	Number currently owned	Unit value	Amount of money getting from selling
0	Cows			
1	Bulls			
2	Calves			
3	Sheep			
4	Goat			
5	Chicken			
99	Other specify			

7. Amount of money getting from selling milk: ________________

8. Amount of money getting from selling egg: _________________

9. Amount of money getting from other livestock selling: _______________

10. Where do you keep your livestock animals?

0. In backyard 1. In peri-urban areas 2. Other (specify)

11. What is your source of feed for livestock?

0. Grass hay 1. Crop residue 2. Furishka 3. Other, specify

12. What is your source of water for drinking your livestock animals?

0. Pond 1. River 2. Fresh waters 99. Other (specify) _______________

13. Do you engaged in off farm income generating activity? 0. yes 1. No

14. If yes to question 13, please specify the type of off farm activity you are engaged in and the amount of money you got from such activities?

Code	Activities	Amount of money getting per month (Birr)
0	Own trading	
1	Casual work	
2	Remittance	
3	Employed	
99	Other (specify) 1. 2. 3.	

15. Please specify how much you spent on the following items in the last month? (**Expenditure**)

Expenditure item	**Amount spend on the purchased items**
1. Cereals and Pulses	
2. Maize, wheat, millet, sorghum flour	
3. Protein foods (Meat, Milk, Egg)	
4. Fruit and vegetables	
5. Bread, sweet potatoes	
5. Cooking oils, salt, sugar and beverages	
6. Cooking and lightning fuel (Charcoal, gas and electricity)	
7. Other household consumables (soap and personal care items)	
7. Domestic water	
8. Irrigation water	
9. Transport	
10. House rent	
11. Medical care	
12. School fee	
13. Other household expenditure 1. 2. 3.	

16. What is the ultimate use of your produces?

0. Own consumption 1. Market sale 2. Both

17. Are you using wastewater for your vegetable and livestock production? 0. Yes 1. No

18. How many times do you produce vegetables per year using wastewater for vegetable production? 0. One 1. Two 2. Three

19. What are the benefits of using wastewater for farming?

0. Improved livelihood 1. Income generation 2. Reduces the use of fertilizer 3. Employment opportunity 99. Other (specify) __________________________

20. Are you aware of the health risk of wastewater use for producing vegetables?

0. Yes 1. No

21. If yes to question (20), which one of the following experiences in your household?

0. Fever 1. Malaria   2. Skin infections   3. Diarrhea   99. Other (specify) _____________

22. Have you ever visit any clinic due to any of the cases?   0. Yes   1. No

23. If yes to question (22), how many times do you visit clinic over the last one year? _________

Part 4. Institutional information's

1. Do you have access to extension services?   0. Yes   1. No

2. If yes to question (1), please list some of the benefits get from extension officers?

1. ____
2. ____
3. ____

3. Do you have access to organic fertilizer?   0. Yes   1. No

4. Do you have access to credit for vegetable production?   0. Yes   1. No   (**crdt**)

5. If yes to question (8), please indicate the amount of money you got? _____________

6. Amount of saving per year: _____________

Part 5: Knowledge, attitude and practice of farmers

1. Food handling Knowledge, attitude and practice of farmers

a. Food handling Knowledge

1. What should you do before eating raw vegetables?

a. wash them with clean water   b. other   c. don't know

b. Food handling Attitude

1. How likely do you think you are to get sick from eating contaminated food?

a. Not likely b. you are not sure c. Likely d. If not likely, can you tell me the reason why it is not likely? ______________________________

2. How serious do you think it's to be sick from eating contaminated food?

a. Not serious b. you are not sure c. Serious d. If it is not serious, can you tell me the reason why it is not serious? __________________________

3. How do you think it is to wash vegetables with clean water?

a. not good b. you're not sure c. good d. If it is not good, can you tell me the reason why it is not good? ____________________________________

4. How difficult is it to wash vegetables with clean water?

A. not difficult b. so difficult c. difficult d. If it is difficult, can you tell me why it is difficult? ____

c. Food handling practice

1. How do you store perishable foods like fruit, meat, etc.

a. In the refrigerator (below 5^{o}c)/ cool place b. Covered (protected) c. Separated from cooked/ ready-to-eat foods d. Don't know

2. Personal Hygiene Knowledge, attitude and practice of farmers

a. Personal Hygiene Knowledge

1. What can you do to avoid sickness from germs/ contaminants using wastewater at farm?

a. washes hands b. wearing gloves c. other (specify) ____________ d. don't know

2. Are there key moments when you need to prevent germs/ contaminants from reaching foods? What are those moments?

a. before preparing/ handling foods b. before eating c. after handling raw food
d. Other (specify) _____________________ e. don't know

b. Personal Hygiene Attitude

1. How likely do you think you will become sick, such as having stomach ache, diarrhea, from not washing your hands? a. Not likely b. you are not sure c. Likely
d. If not likely, can you tell me the reason why it is not likely? _______________

2. How serious do you think it is to be sick from not washing your hands?

a. Not serious b. you are not sure c. Serious d. If it is not serious, can you tell me the reason why it is not serious? ________________________

3. How difficult is it for you to wash your hands before preparing/ eating food?

A. not difficult b. so difficult c. difficult d. If it is difficult, can you tell me why it is difficult? ____

4. How confident do you feel in washing your hands properly?

a. not confident b. ok c. confident d. If you are not confident, can you tell me the reason why you don't feel confident? _____________________

c. Personal hygiene practice

1. Could you please step by step how to wash your hands?

a. Washes hands in a bowl of water (sharing with other people): poor practice
b. With someone pouring a little clean water from a jug onto one's hands: appropriate practice
c. Under running water: appropriate practice d. Washes hands with soap or ashes
e. Other ______________________ f. Don't know/no answer

3. Water and sanitation Knowledge, attitude and practice of farmers

a. Water and sanitation Knowledge

1. If you know that the water you are going to use for drinking and cooking is not safe, what should you do?

a. boil it b. Add chlorine c. strain it through a cloth d. Use a water filter e. discards it and get safe water from other sources f. other (specify) ___________ g. don't know

b. Water and sanitation attitude

1. How likely do you think you are getting sick such as having diarrhea from using wastewater?

a. Not likely b. you are not sure c. Likely d. If not likely, can you tell me the reason why it is not likely? ______________________________________

2. How serious do you think it is to be sick from using wastewater?

a. Not serious b. you are not sure c. Serious d. If it is not serious, can you tell me the reason why it is not serious? _____________________________________

3. How good do you think it is to boil water before drinking or using it??

a. not good b. you're not sure c. good d. If not, can you tell me why it is difficult? ________

4. How difficult is it for you to boil water before drinking or using it?

a. Not difficult b. So-so difficult c. difficult d. if difficult, why it is difficult? __________

5. How confident do you feel in washing your hands properly?

a. not confident b. ok c. confident d. If you are not confident, can you tell me the reason why it is not good? ____

c. Water and sanitation practice

1. What is the main source of water used by your households for drinking, hand washing and cooking?

a. piped water b. water from spring c. surface water d. bottled water e. tanker truck f. bore hole g. piped into the yard/ plot h. other specify _________ i. don't know

2. Do you treat your water in any way to make it safe to drink? A. Yes b. No

3. If yes, what do you do to make it safer to drink?

a. boil it b. Add chlorine c. strain it through a cloth d use a water filter e. discard it and get safe water from other sources f. other __________ g. don't know

Part 6: Household Food Security Assessment

A. Household Food Insecurity Access Scale (HFIAS) Measurement Tool

No	Question	Response Options	Code
1.	In the past four weeks, did you worry that your household would not have enough food?	0 = No (skip to Q2) 1=Yes	|___|
1.a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	|___|
2	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	0 = No (skip to Q3) 1=Yes	|___|
2a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	|___|
3	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	0 = No (skip to Q4) 1=Yes	|___|
3a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	|___|

4	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	0 = No (skip to Q5) 1 = Yes	|___|
4a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	|___|
5	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0 = No (skip to Q6) 1 = Yes	|___|
5a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	|___|
6	In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	0 = No (skip to Q7) 1 = Yes	|___|
6a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	|___|
7	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	0 = No (skip to Q8) 1 = Yes	|___|
7a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks)	|___|

		3 = Often (more than ten times in the past four weeks)	
8	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	0 = No (skip to Q9) 1 = Yes	|___|
8a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	|___|
9	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	0 = No (questionnaire is finished) 1 = Yes	|___|
9a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)	|___|

B. Food consumption Score (FCS)

Questions for FCS (7days dietary recall)	Frequency of eating in the last 7days (0-7)
A. Any Injera, bread, rice and pasta	
B. Any roots/tubers (Potato, sugar beet, carrot, beetroot)?	
C. Any vegetables (Cabbage, lettuce, tomato)?	
D. Any fruits (Banana, mango, orange, papaya)?	
E. Any beef, chicken, mutton, poultry meats?	
F. Any eggs?	
G. Any fish?	
H. Any foods made from beans, peas, lentils, or nuts?	
I. Any cheese, yogurt, milk or other milk products?	
J. Any foods made with oil, fat, or butter?	
K. Any sugar or honey?	
L. Any coffee, tea?	

Part 7. Checklist

A. Checklists for Key Informants (farmers)

1. In your opinion, what is the contribution of urban agriculture to the farmer, community, and economy of the sub-city in general?

2. Please mention the major vegetable and livestock products in your area?

3. What is your source of water for irrigation and rearing of livestock animals?

4. What is the source of feed for your livestock animals?

5. Do you feel that using wastewater for urban agriculture is a worthwhile activity? Give reason

6. How do you evaluate the contribution of wastewater practice in urban agriculture to food security and health in your area?

B. Checklist For extension officers

1. How do you evaluate the performance of urban agriculture in your working woreda?

2. Why do farmers use wastewater for their farming activities (vegetable production and drinking of their livestock animals)?

3. Do you feel that using wastewater for urban agriculture is a worthwhile activity? Please give reason

5. What are the major services given to farmers activities by the extension officer?

4. How do you evaluate the overall performance extension services in the study area in increasing production and productivity?

C. Checklist for Focused group discussion

1. What are the major urban agriculture activities in your area (vegetable, dairy, poultry, horticulture, beekeeping…)?

2. Why do farmers in the area use wastewater farming practices?

3. What is the perception of the local communities regarding the use of wastewater in urban agriculture?

4. Discuss the contribution of wastewater practice in urban agriculture to the farmers, community, and the economy of the sub-city in general?

5. Discuss the effects of wastewater practice on the health of humans and livestock?

6. Your opinion on the overall performance of urban agriculture in your area?

D. Checklist of personal observation

1. Types of urban agriculture practiced

2. Types of wastewater used

3. Practices related food safety

E. Checklist for microbial and heavy metal analysis

1. Taking wastewater samples based on sampling protocol

2. Wastewater samples: from Akaki river passes through Akaki Kality sub-city Woreda 3

3. Transporting the samples to laboratory for microbes and heavy metal analysis such as total coliform, E.coli, (Lead (Pb), Chromium (Cr), Arsenic (As), Zinc (Zn), Cadmium (Cd) and Mercury (Hg))

4. Following the analysis (how the analysis done)

5. Receiving the laboratory result

6. Analyzing the test result using appropriate analysis technique

Appendix III. Amharic Translation Version 2

የዚህ ጥናት ዓላማ በቆሻሻ ውሃ በመጠቀም የሚመረተውን የከተማ ግብርና መመርመር ይሆናል:: በአቃቂ ቃሊቲ ክፍለ ከተማ፣ አዲስ አበባ፣ ኢትዮጵያ በምግብ ዋስትና እና ደህንነት ላይ የሚያሳድረው ተጽእኖ:: የሚገኘው መረጃ ለአካዳሚክ ዓላማዎች ብቻ ጥቅም ላይ ይውላል. ስለዚህ፣ እባክዎን ቀጥለው ለሚቀርቡት ጥያቄዎች አስፈላጊውን መልስ እንዲሰጡን እንጠይቃለን

ክፍል 1፡ ስነ-ህዝብና ማህበራዊ ጉዳዮች

1. ጾታ ሀ. ወንድ ለ. ሴት
2. የቤተሰብ አስተዳዳሪ እድሜ፡ ____________________
3. የትምህርት ደረጃ: ____________________
4. የጋብቻ ሁኔታ

ሀ. ያላገባ/ች ለ. ያገባ/ች ሐ. የተፋታ/ች መ. ባሏ የሞተባት ሠ. ሚስቱ የሞተችበት

5. የቤተሰብ ብዛት፡ ____________________
6. የግብርና ልምድ፡ __________________

ክፍል 2. ማህበራዊና ባህላዊ መረጃ

1. ከየት ነው የመጡት? ሀ. ከገበሬ ቤተሰብ ለ. ገበሬ ካልሆነ ቤተሰብ
2. በእርሻ ሥራዎ ላይ ቅሬታ ገጥምዎታል? ሀ. አዎ ለ. አይ

ክፍል 3፡ የግብርና እና የገቢ መረጃ

1. በምን አይነት የከተማ ግብርና ላይ ነው የሚሳተፉት?

ሀ. አትክልት ለ. የእንስሳት እርባታ ሐ. ሁለቱም

2. ለጥያቄ 1 መልስዎ አትክልት ከሆነ፣ እባኮትን የተከሉትን የአትክልት አይነት፤ ባለፈው አንድ አመት ውስጥ ምን ያህል እንዳመረቱ እና እንደተሸጠ ይግለጹ? (ከአንድ በላይ መምረጥ ይችላሉ)

መለያ	የአትክልት ስም	የተመረተው መጠን	የተሸጠ በዛት (ኩንታል)	ዋጋ (ኪሎ)
ሀ	ጎመን			
ለ	ስፒናች			
ሐ	ሽንኩርት			
መ	ቲማቲም			
ሠ	ካሮት			
ረ	ድንች			
ሰ	ሰላጣ / ጎመን			
ሸ	ቀይ ስር			
ቀ	ሌሎች ይግለጹ			

3. የግብርና ስራዎትን የት ነው የሚያከናውኑት? ሀ. ክፍት ቦታ ላይ ለ. በከተማ ዳርቻ አካባቢ ሐ. መንገድ ዳር መ. በጓሮ

ሠ. ሌላ (ይግለጹ) ____________________

4. አማካይ የመሬት ይዞታ (በሄክታር): ____________________

5. ለመስኖ የሚሆን የውሃ ምንጭዎ ምንድነው?

ሀ. ኩሬ ለ. ወንዝ ሐ. ንጹህ ውሃ መ. ሌላ (ይግለጹ) ________________

6. ለጥያቄ 1 መልስዎ ከብቶች ከሆነ፤ እርስዎ በከብት እርባታ ነው የሚተዳደሩት?

ሀ. አዎ ለ. አይደለም

7. ለጥያቄ (6) አዎ ከሆነ እባክዎን የከብት ዓይነቶችን እና ቁጥርን ይግለጹ

መለያ	የእንስሳው አይነት	ብዛት	የአንዱ ዋጋ	ገቢ
ሀ	ላሞች			
ለ	ወይፈኖች			
ሐ	ጥጃዎች			
መ	በጎች			
ሠ	ፍየል			
ረ	ዶሮ			
ሰ	ሌሎች ይግለጹ			

7. ከወተት ሽያጭ የሚገኘው ብር መጠን፡- ________________

8. ከእንቁላል ሽያጭ የሚገኘው ብር መጠን፡- _________________

9. ከሌሎች የቁም እንስሳት ሽያጭ የሚገኘው ብር መጠን፡- _______________

10. የከብት እርባታዎን የት ነው የሚያከናውኑት?

ሀ. በጓሮ ለ. በከተማ ዳርቻዎች ሐ. ሌላ (ይግለጹ)

11. ለከብቶች መኖ ምንጫችሁ ምንድነው?

ሀ. ሳር ለ. ገለባ ሐ. ፉሪሽካ መ. ሌላ, ይግለጹ.

12. ከከብቶቻችሁን ውሃ ለመጠጣት የምትጠቀሙት የውሃ ምንጭ ምንድነው?

ሀ. ኩሬ ለ. ወንዝ ሐ. ንጹህ ውሃ መ. ሌላ (ይግለጹ) _______________

13. ሌላ የገቢ ምንጭ አለዎት? 01. አዎ 02. አይ

14. ለ13ኛው ጥያቄ መልስዎ አዎ ከሆነ፤ እባክዎን የስራውን አይነትና የገቢ መጠን ይግለፁ?

ሀ. የስራውን አይነት፡____

ለ. የሚያገኙት የገቢ መጠን፡ ____

15. እባክዎ ባለፈው ወር ከዚህ በታች ለተዘረዘሩት ነገሮች ምን ያህል እንዳወጡ ይግለጹ?

ተ.ቁ	የወጪው አይነት	ወጪ መጠን
1	ምስር፤ አተር፤ ጠፍ የመሳሰሉትን ነገሮችን ለመግዛት በወር ስንት ያወጣሉ	
2	የእንሰሳት ተዋፅኦችን (ወተት፤ ስጋ፤ እንቁላል፤ አሳ) ለመግዛት በወር ስንት ያወጣሉ	
3	ፍራፍሬ ነገሮችን ለመግዛት በወር ስንት ያወጣሉ	
4	ዳቦ፤ ፓስታ፤ ሩዝ የመሳሰሉትን ነገሮችን ለመግዛት በወር ስንት ያወጣሉ	
5	ዘይት/ስኳር የመሳሰሉትን ነገሮችን ለመግዛት በወር ስንት ያወጣሉ	
6	ለመብራ፤ ለከሰል፤ ለጋዝ የመሳሰሉትን ነገሮችን ለመግዛት በወር ስንት ያወጣሉ	
7	ለሳሙና እና ለመሳሰሉት ነገሮችን ለመግዛት በወር ስንት ያወጣሉ	
8	ለውሃ ክፍያ በወር ስንት ያወጣሉ	
9	ለትራንስፖርት በወር ስንት ያወጣሉ	
10	ለት/ት ቤት ክፍያ በወር ስንት ያወጣሉ	
11	ለቤት ኪራይ ክፍያ በወር ስንት ያወጣሉ	

ተ.ቁ	የወጪው አይነት	የሚያወጡት ወጪ መጠን
12	ለእንሰሳት መኖ በወር ስንት ያወጣሉ	
13	ለእንሰሳት ህክምና በወር ስንት ያወጣሉ	
14	ለመዳበሪያ ግዢ በወር ስንት ያወጣሉ	

16. የሚያመርቱትን ምርት ለምንድነው የሚጠቀሙት?

ሀ. ለራስ ፍጆታ ለ. ለገቢያ ሽያጭ ሐ. ሁለቱም

17. ለአትክልትና ለከብት እርባታ የቆሻሻ ውሃ ይጠቀማሉ? ሀ. አዎ ለ. የለም

18. የቆሻሻ ውሃን በመጠቀም በዓመት ስንት ጊዜ ያመርታሉ? ሀ. አንድ ለ. ሁለት ሐ. ሶስት

19. ቆሻሻ ውሃን ለእርሻ መጠቀም ምን ጥቅሞች አሉት?

ሀ. የተሻሻለ መተዳደሪያ ለ. ገቢ ማመንጨት ሐ. የማዳበሪያ አጠቃቀምን ይቀንሳል መ. የስራ እድልን ይፈጥራል ሠ. ሌላ (ይግለጹ)

20. አትክልቶችን ለማምረት ቆሻሻ ውሃን መጠቀም ለጤና ጉዳት ያውቃሉ?

ሀ. አዎ ለ. አይደለም

21. ለጥያቄ (20) መልስዎ አዎ ከሆነ፣ ከሚከተሉት ውስጥ በቤተሰብዎ ውስጥ ያጋጠመዎት በሽታ የትኛው ነው?

ሀ. ትኩሳት ለ. ወባ ሐ. የቆዳ ኢንፌክሽን መ. ተቅማጥ ሠ. ሌላ (ይግለጹ) _______________

22. በማናቸውም ጉዳዮች ምክንያት የትኛውንም ክሊኒክ ጎብኝተው ያውቃሉ?

ሀ. አዎ ለ. አይደለም

23. ለጥያቄ (22) አዎ ከሆነ፣ ባለፈው አንድ አመት ውስጥ ስንት ጊዜ ክሊኒክን ጎበኙ?

ክፍል 4. ተቋማዊ መረጃ

1. የኤክስቴንሽን አገልግሎት ያገኛሉ? 0. አዎ 1. አይደለም

2. ለጥያቄ (1) አዎ ከሆነ፣ እባክዎን ከኤክስቴንሽን ኦፊሰሮች የሚያገኟቸውን አንዳንድ ጥቅሞች ይዘርዝሩ?

1. ____

2. ____

3. ____

3. የማዳበሪያ ድጋፍ አሎት? 0. አዎ 1. አይደለም

4. የብድር አገልግሎት ያገኛሉ? 0. አዎ 1. አይ

5. ለጥያቄ (8) አዎ ከሆነ፣ እባክዎ ያገኙት የገንዘብ መጠን ያመልክቱ? ______________

6. በአመት የሚቆጥቡት የብር መጠን፡ ______________

ክፍል 5፡ የገበሬዎች እውቀት፣ አመለካከት እና ተግባር

1. የምግብ አያያዝ እውቀት፣ አመለካከት እና ተግባር በተመለከተ

ሀ. የምግብ አያያዝ እውቀት

1. ጥሬ አትክልቶችን ከመመገብዎ በፊት ምን ማድረግ አለብዎት?

ሀ. በንጹህ ውሃ መታጠብ ለ. ሌላ ሐ. አላውቅም

ለ. የምግብ አያያዝ አመለካከት/ አስተሳሰብ

1. የተበከለ ምግብ መብላት ለበሽታ ሊያጋልጥ ይችላል ብለው ያስባሉ?

ሀ. አላስብም ለ. እርግጠኛ አይደለሁም ሐ. አዎ አስባለሁ መ. መልሱ አላስብም ከሆነ አላስብም ያሉበትን ምክንያት ሊነግሩኝ ይችላሉ) ______________

2. የተበከለ ምግብ በመብላት የሚመጣ በሽታ ምን ያህል ከባድ ነው ብለው ያስባሉ?

ሀ. ከባድ አይደለም ለ. እርግጠኛ አይደለሁም ሐ. ከባድ ነው መ. መልሱ ከባድ አይደለም ከሆነ) ከባድ አይደለም ያሉበትን ምክንያት ሊነግሩኝ ይችላሉ? ____________

3. አትክልቶችን በንጹህ ውሃ ማጠብ ምን ያህል ጥሩ ነው ብለው ያስባሉ?

ሀ. ጥሩ አይደለም ለ. እርግጠኛ አይደለሁም ሐ. ጥሩ ነው መ. *መልሱ ጥሩ አይደለም ከሆነ* ጥሩ ያልሆነበትን ምክንያት ሊነግሩኝ ይችላሉ?________________________________

4. አትክልቶችን በንጹህ ውሃ ማጠብ ምን ያህል ይከብድዎታል?

ሀ. ከባድ አይደለም ለ. እርግጠኛ አይደለሁም ሐ. ከባድ ነው መ. መልሱ ከባድ አይደለም ከሆነ) ከባድ አይደለም ያሉበትን ምክንያት ሊነግሩኝ ይችላሉ? ____________

ሐ. የምግብ አያያዝ ልምድ

1. ቶሎ ሊበላሹ የሚችሉ ምግቦችን (እንደ ፍራፍሬ፣ ስጋ) እስኪሰሩ ድረስ እንዴት ያቆዩዋቸዋል?

ሀ. ፍሪጅ ውስጥ ለ. ዝንብ፣ አቧራ ወይም አይጥ እንዳይደርስበት መሸፈን ሐ. ለምግብነት ከተዘጋጁ ምግቦች ጋር እንዳይነካካ መለየት መ. ሌላ

2. የግል ንፅህና እውቀት፣ አመለካከት እና ተግባር በተመለከተ

ሀ. የግል ንፅህና እውቀት

1. በእርሻ ቦታ ላይ ቆሻሻ ውሃ በመጠቀም ከጀርሞች/ ተላላፊ በሽታዎች ለመከላከል ምን ማድረግ ይችላሉ? ሀ. እጅ መታጠብ ለ. ጓንት ማድረግ ሐ. ሌላ (ይግለጹ) ______________ መ. አላውቅም

2. ጀርሞች ምግብ ውስጥ እንዳይገቡ ለማድረግ እጅመታጠብ የሚያስፈልግባቸው ወሳኝ ጊዜያ ት አሉ፤ እነዚህ ወሳኝ ጊዜያት መቼ መቼ ናቸው?

ሀ. ምግቦችን ከማዘጋጀት/ ከመያዙ በፊት ለ. ከመብላቱ በፊት ሐ. ጥሬ ምግብ ከተያዘ በኋላ መ. ሌላ (ይግለጹ) ___________________________ ሠ. አላውቅም

ለ. የግል ንፅህና አመለካከት/ አስተሳሰብ

1.እጅዎንባለመታጠብዎየተነሳለሆድህመምወይምለተቅማጥየመጋለጥዎአጋጣሚምንያህልነውብለ ውያስባሉ?

ሀ. የሚታመም አይመስለኝም ለ. እርግጠኛ አይደለሁም ሐ. ሊታመም ይችላል መ. መልስ የሚታመም አይመስለኝም ከሆነ የሚታመም የማይመስልዎ ምክንያት ምን እንደሆነ ሊነግሩኝ ይችላሉ?_________

2. እጅዎን ባለመታጠብዎ ምክንያት ቢታመሙ ምን ያህል ከባድ የሚሆን ይመስልዎታል? ሀ. ከባድ አይመስለኝም ለ. እርግጠኛ አይደለሁም ሐ. ከባድ ነው መ. መልሱ ከባድ አይደለም ከሆነ) ከባድ አይደለም ያሉበትን ምክንያት ሊነግሩኝ ይችላሉ?

3. ምግብ ማዘጋጀት ከመጀመርዎ በፊት እጅዎን መታጠብ ምን ያህል ያስቸግርዎታል? ሀ. አያስቸግረኝም ለ. እንደነገሩ ሐ. ያስቸግረኛል መ. የሚያስቸግር ከሆነ ለምን እንደሚያስቸግርዎት ምክንያቱን ሊነግሩኝ ይችላሉ?_____________

4. እጅዎን በአግባቡ መታጠብዎ ምን ያህል በራስዎ መተማመን ይፈጥርልዎታል?

ሀ. አልተማመንም ለ. በመጠኑ/ እንደነገሩ ሐ. እተማመናለሁ መ. አልተማመንም ካሉ በራስዎ የማይተማመኑበትን ምክንያቶች ሊነግሩኝ ይችላሉ?____________

ሐ. የግል ንፅህና ልምድ

1. እጆችዎን እንዴት እንደሚታጠቡ በቅደም ተከተል ሊነግሩኝ ይችላሉ?
ሀ. እጆችን ሰሃን ውስጥ ባለ ውሃ ውስጥ እየነከሩ ከሌሎች ሰዎች ጋር አብሮ መታጠብ (መጥፎ ልምድ)
ለ. ሌላ ሰው ትንሽ ንጹህ ውሃ አያንቆረቆረ መታጠብ (ትክክለኛ ልምድ)
ሐ. ከቧንቧ በሚወርድ ውሃ መታጠብ (ትክክለኛ ልምድ)
መ. እጆችን በሳሙና እና ውሃ መታጠብ ሠ. ሌሎች ረ. መልስ የለም

3. የውሃ እና የንፅህና አጠባበቅ እውቀት፣ አመለካከት እና ተግባር በተመለከተ

ሀ. የውሃ እና የንፅህና አጠባበቅ እውቀት

1. ለመጠጥ እና ለማብሰያ የሚጠቀሙበት ውሃ ደህና እንዳልሆነ ካወቁ ምን ያደርጋሉ?
ሀ. ማፍላት ለ. በረኪና መጨመር ሐ. በጨርቅ ማጥለል መ. የውሃ ማጣርያ መጠቀም ሠ. መድፋትና እና ከሌሎች ምንጮች ንጹህ ውሃ መቅዳት ረ. ሌላ ሰ. አላውቅም/መልስ የለም

ለ. የውሃ እና የንፅህና አጠባበቅ አመለካከት/ አስተሳሰብ

1. ጤናማ ያልሆነ ውሃ መጠቀም ተቅማጥ ሊያመጣ እንደሚችል ምን ያህል ያስባሉ?
ሀ. አላስብም ለ. እርግጠኛ አይደለሁም ሐ. አሰስባለሁ መ. የማያስቡ ከሆነ ተቅማጥ አያመጣም ብለው የሚያስቡበት ምክንያት ምን እንደሆነ ሊነግሩኝ ይችላሉ?
2. ጤናማ ያልሆነ ውሃ መጠጣት የሚያስከትለው በሽታ ምን ያህል ከባድ ነው ብለው ያስባሉ?
ሀ. ከባድ አይደለም ለ. ቀለል ያለ ነው ሐ. ከባድ ነው መ. መልሱ ከባድ አይደለም ከሆነ ከባድ አይደለም ያሉበትን ምክንያት ሊነግሩኝ ይችላሉ?
3. ውሃን ለመጠጥ ወይም ለሌላ ስራ ከመዋሉ በፊት ማፍላቱ ምን ያህል ጥሩ ነው ብለው ያስባሉ?

ሀ.ጥሩ አይደለም ለ. እርግጠኛ አይደለሁም ሐ.ጥሩ ነው መ. ጥሩ አይደለም ከተባለ ጥሩ ያልሆነበትን ምክንያት ሊነግሩኝ ይችላሉ?

4. ውሃን ለመጠጥነት ወይም ለሌላ ስራ ከመጠቀምዎ በፊት ማፍላቱ ምን ያህል ያስቸግርዎታል?

ሀ. አያስቸግረኝም ለ. እንደነገሩ ሐ. ያስቸግረኛል መ. የሚያስቸግር ከሆነ ለምን እንደሚያስቸግርዎት ምክንያቱን ሊነግሩኝ ይችላሉ?___________

5. ለመጠጥነት ወይም ለሌላ ስራ ከመዋሉ በፊት ውሃን ማፍላቱ ምን ያህል መተማመን ይፈጥርልዎታል?

ሀ. አልተማመንም ለ. በመጠኑ/ እንደነገሩ ሐ. እተማመናለሁ መ. አልተማመንም ካሉ በራስዎ የማይተማመኑበትን ምክንያቶች ሊነግሩኝ ይችላሉ?___________

ሐ. የውሃ እና የንፅህና አጠባበቅ ልምድ

1. ቤተሰቦችዎ ለመጠጥ፣ ለእጅ መታጠብ እና ለምግብ ማብሰያ የሚጠቀሙበት ዋናው የውሃ ምንጭ ምንድነው?

ሀ. የቧንቧ ውሃ ለ. የምንጭ ውሃ ከ ሐ. የገፀምድር ውሃ መ. የታሸገ ውሃ ሠ. የተጠራቀመ ውሃ ረ. የጉድጓድ ውሃ ሰ. ሌላ ይግለጹ __________ ረ. አላውቅም

2. የቀዱት ውሃ ለመጠጣት ጤናማ እንዲሆን የሚያክሙበት መንገድ አለ?

ሀ. አዎ ለ. አይ

3. አዎ ከሆነ፣ ለመጠጥ ደህንነቱ የተጠበቀ እንዲሆን ምን ታደርጋለህ?

ሀ. ማፍላት ለ. በረኪና መጨመር ሐ. በጨርቅ ማጥለል መ. የውሃ ማጣርያ መጠቀም ሠ. መድፋትና እና ከሌሎች ምንጮች ንጹህ ውሃ መቅዳት ረ. ሌላ ሰ. አላውቅም/መልስ የለም

ክፍል 6፡ የቤተሰብ የምግብ ዋስትና ግምገማ

ሀ. የቤተሰብ የምግብ ዋስትና እጦት መዳረሻ ልኬት (HFIAS) መለኪያ መሣሪያ

ተ.ቁ	ጥያቄ	የመልስ አማራጭ	መለያ
1	ባለፉት አራት ሳምንታት ቤት ውስጥ በቂ ምግብ አይኖረኝም ይሆናል ብለው ሰግተው ያውቃሉ?	0 = አይደለም (ወደ ጥያቄ 2) 1=አዎ	|___|
1a	ባለፉት አራት ሳምንታት ውስጥ ይሄ ስጋት ስንት ጊዜ ደርሶብዎታል;	1 = አልፎ አልፎ (አንድ ወይም ሁለት ጊዜ) 2 = አንዳድ ጊዜ (3-10 ጊዜ) 3 = ሁልጊዜ(ከ 10 ጊዜ በላይ)	|___|
2	ባለፉት አራት ሳምንታት ቤት ውስጥ በቂ ምግብ ባለመኖሩ ምክንያት ርስዎ ወይም ማንኛውም የቤተሰብ አባል የወደዱትን ምግብ ሳይበሉ ቀርተው ያውቀሉ?	0 = አይደለም (ወደ ጥያቄ 3) 1=አዎ	|___|
2a	ባለፉት አራት ሳምንታት ውስጥ ይሄ ስጋት ስንት ጊዜ ደርሶብዎታል;	1 = አልፎ አልፎ (አንድ ወይም ሁለት ጊዜ) 2 = አንዳድ ጊዜ (3-10 ጊዜ) 3 = ሁልጊዜ(ከ 10 ጊዜ በላይ)	|___|
3	ባለፉት አራት ሳምንታት ቤት ውስጥ በቂ ምግብ ባለመኖሩ ምክንያት ርስዎ ወይም ማንኛውም የቤተሰብ አባል የተወሰኑ የምግብ አይነቶች ብቻ በልታችኋል?	0 = አይደለም (ወደ ጥያቄ 4) 1 = አዎ	|___|
3a	ባለፉት አራት ሳምንታት ውስጥ ይሄ ስጋት ስንት ጊዜ ደርሶብዎታል;	1 = አልፎ አልፎ (አንድ ወይም ሁለት ጊዜ) 2 = አንዳድ ጊዜ (3-10 ጊዜ) 3 = ሁልጊዜ(ከ 10 ጊዜ በላይ)	|___|

4	ባለፉት አራት ሳምንታት ቤት ውስጥ በቂ ምግብ ባለመኖሩ ምክንያት ርስዎ ወይም ማንኛውም የቤተሰብ አባል መብላት የማትፈልጉትን ምግብ በልታችኋል?	0 = አይደለም (ወደ ጥያቄ 5) 1 = አዎ	|___|
4a	ባለፉት አራት ሳምንታት ውስጥ ይሄ ስጋት ስንት ጊዜ ደርሶብዎታል;	1 = አልፎ አልፎ (አንድ ወይም ሁለት ጊዜ) 2 = አንዳድ ጊዜ (3-10 ጊዜ) 3 = ሁልጊዜ(ከ 10 ጊዜ በላይ)	|___|
5	ባለፉት አራት ሳምንታት ቤት ውስጥ በቂ ምግብ ባለመኖሩ ምክንያት ርስዎ ወይም ማንኛውም የቤተሰብ አባል ሳትጠግቡ ለመነሳት ተገዳችኋል?	0 = አይደለም (ወደ ጥያቄ 6) 1 =አዎ	|___|
5a	ባለፉት አራት ሳምንታት ውስጥ ይሄ ስጋት ስንት ጊዜ ደርሶብዎታል;	1 = አልፎ አልፎ (አንድ ወይም ሁለት ጊዜ) 2 = አንዳድ ጊዜ (3-10 ጊዜ) 3 = ሁልጊዜ(ከ 10 ጊዜ በላይ)	|___|
6	ባለፉት አራት ሳምንታት ቤት ውስጥ በቂ ምግብ ባለመኖሩ ምክንያት ርስዎ ወይም ማንኛውም የቤተሰብ አባል ቁርስ፣ ምሳ ወይም ራት መብላት ሳትችሉ ቀርታችኋል?	0 = አይደለም (ወደ ጥያቄ 7) 1 = አዎ	|___|
6a	ባለፉት አራት ሳምንታት ውስጥ ይሄ ስጋት ስንት ጊዜ ደርሶብዎታል;	1 = አልፎ አልፎ (አንድ ወይም ሁለት ጊዜ) 2 = አንዳድ ጊዜ (3-10 ጊዜ) 3 = ሁልጊዜ(ከ 10 ጊዜ በላይ)	|___|
7	ባለፉት አራት ሳምንታት ቤት ውስጥ በቂ ምግብ ወይም ገንዘብ ባለመኖሩ ምክንያት በቤተሰቡ ውስጥ የሚላስ የሚቀመስ ያልነበረበት ጊዜ ነበር?	0 =አይደለም (ወደ ጥያቄ 8) 1 = አዎ	|___|
7a	ባለፉት አራት ሳምንታት ውስጥ ይሄ ስጋት ስንት ጊዜ ደርሶብዎታል;	1 = አልፎ አልፎ (አንድ ወይም ሁለት ጊዜ) 2 = አንዳድ ጊዜ (3-10 ጊዜ)	|___|

		3 = ሁልጊዜ(ከ 10 ጊዜ በላይ)	
8	ባለፉት አራት ሳምንታት ቤት ውስጥ በቂ ምግብ ወይም ገንዘብ ባለመኖሩ ምክንያት ርስዎ ወይም ማንኛውም የቤተሰብ አባል እየራበው ወደ መኝታ የሄደበት ጊዜ ነበር?	0 = አይደለም (ወደ ጥያቄ 9) 1 = አዎ	|___|
8a	ባለፉት አራት ሳምንታት ውስጥ ይሄ ስጋት ስንት ጊዜ ደርሶብዎታል?	1 = አልፎ አልፎ (አንድ ወይም ሁለት ጊዜ) 2 = አንዳድ ጊዜ (3-10 ጊዜ) 3 = ሁልጊዜ(ከ 10 ጊዜ በላይ)	|___|
9	ባለፉት አራት ሳምንታት ቤት ውስጥ በቂ ምግብ ወይም ገንዘብ ባለመኖሩ ምክንያት ርስዎ ወይም ማንኛውም የቤተሰብ አባል ቀኑን ሙሉ ሳይበላ ውሎ ሳይበላ ያደረበት ጊዜ አለ?	0 = የለም 1 = አዎ	|___|
9a	ባለፉት አራት ሳምንታት ውስጥ ይሄ ስጋት ስንት ጊዜ ደርሶብዎታል?	1 = አልፎ አልፎ (አንድ ወይም ሁለት ጊዜ) 2 = አንዳድ ጊዜ (3-10 ጊዜ) 3 = ሁልጊዜ(ከ 10 ጊዜ በላይ)	|___|

ለ. የምግብ ፍጆታ ውጤት (FCS)

ጥያቄ	መልስ
ሀ. ማንኛውም ከማሽላ፣ በቆሎ፣ ሩዝ፣ ስንዴ የተሰራ ማንኛውም ዳቦ፣ ሩዝ ፣ ፓስታ፣ ብስኩት ወይም ሌላ ማንኛውም ምግብ	|___|
ለ. ከድንች፣ ያም፣ ፣ ካሳቫ ወይም ሌላ ማንኛውም ሥራ ስሮች የተሠሩ ምግቦች?	|___|
ሐ. ማንኛውም አትክልት?	|___|
መ. ማንኛውም ፍራፍሬ?	|___|
ሠ. ማንኛውም የበሬ ሥጋ፣ የበግ፣ የፍየል፣ የዶሮ፣ ዳክዬ፣ ወይም ሌሎች የሥጋ አይነቶች?	|___|
ረ. ማንኛውም ከእንቁላል የተሰሩ ምግቦች?	|___|
ሰ. ማንኛውም ትኩስ ወይም የደረቀ ዓሳ?	|___|
ሸ. ማንኛውም ከባቄላ፣ አተር፣ ምስር ወይም ለውዝ የተሰሩ ምግቦች?	|___|
ቀ. ማንኛውም አይብ፣ እርጎ፣ ወተት ወይም ሌላ የወተት ተዋጽኦዎች የተሰሩ ምግቦች?	|___|
በ. በዘይት፣ በስብ ወይም በቅቤ የተሰሩ ማንኛውም ምግቦች?	|___|
ተ. ማንኛውም ስኳር ወይም ማር?	|___|
ቸ. እንደ ማጣፈጫዎች፣ቡና፣ ሻይ ያሉ ሌሎች ምግቦች?	|___|

ክፍል 7. ዝርዝር ጥያቄዎች

ሀ. ለአርሶ አደሮች

1. በእርስዎ አስተያየት የከተማ ግብርና ለክፍለ ከተማው አርሶ አደር፣ ማህበረሰብ እና ኢኮኖሚ ያለው አስተዋፅኦ ምን ይመስላል?
2. እባክዎን በአካባቢዎ ያሉትን ዋና ዋና የአትክልት እና የእንስሳት ምርቶች ይጥቀሱ?
3. ለመስኖ እና ለከብት እርባታ የሚጠቀሙት የውሃ ምንጭ ከየት ነው?
4. ለከብቶቻችሁ መኖ ምንጩ ምንድነው?
5. ቆሻሻ ውሃን ለከተማ ግብርና መጠቀም ጠቃሚ ነው ብለው ያስባሉ? ምክንያት ስጥ

6. በከተማ ግብርና ውስጥ ያለው ቆሻሻ ውሃ በመጠቀም ማምረት ለምግብ ዋስትና እና ጤና ያለውን አስተዋፅኦ እንዴት ይገመግማሉ?

ለ. ለኤክስቴንሽን ኦፊሰሮች ዝርዝር ጥያቄዎች

1. በአካባቢዎ ላይ ያለውን የከተማ ግብርና አፈጻጸም እንዴት ይገመግሙታል?
2. በአካባቢዎ ላይ ያሉ አርሶ አደሮች ለምንድነው ለግብርና ስራቸው (ለአትክልት ምርት እና ለእንስሳት ውሃ መጠጥ) ቆሻሻ ውሃ የሚጠቀሙት?
3. ቆሻሻ ውሃን ለከተማ ግብርና መጠቀም ጠቃሚ ነው ብለው ያስባሉ? ምክንያት ይስጡ?
5. በከተማ ግብርና ኃላፊዎች ለገበሬዎች የሚሰጡት ዋና ዋና አገልግሎቶች ምን ምን ናቸው?
4. ምርትና ምርታማነትን ከማሳደግ አንፃር በአካባቢ ያለውን አጠቃላይ የኤክስቴንሽን ባለሙያዎችን ክትትልና ድጋፍ እንዴት ይገመግማሉ?

ሐ. የቡድን ውይይት ዝርዝር ጥያቄዎች

1. በአካባቢዎ ያሉ ዋና ዋና የከተማ ግብርና ተግባራት (አትክልት፣ የወተት፣ የዶሮ እርባታ፣ አትክልትና ፍራፍሬ፣ ንብ ማነብ...) ምንድን ናቸው?
2. በአካባቢው ያሉ አርሶ አደሮች ለምን ቆሻሻ ውሃ ለማምረት ይጠቀማሉ?
3. የቆሻሻ ውሃ በከተማ ግብርና አጠቃቀም ዙሪያ የአካባቢው ማህበረሰቦች ያላቸው አመለካከት ምን ይመስላል?
4. በከተማ ግብርና ያለው ቆሻሻ ውሃን መጠቀም ለአርሶ አደሩ፣ ለህብረተሰቡ እና ለክፍለ ከተማው ኢኮኖሚ ያለው አስተዋፅኦ አለው?
5. የቆሻሻ ውሃን መጠቀም በሰው እና በእንስሳት ጤና ላይ ያለውን ተጽእኖ ተወያዩበት?
6. በአካባቢዎ ስላለው የከተማ ግብርና አጠቃላይ አፈጻጸም ያለዎት አስተያየት?

መ. የግል ምልከታ ዝርዝር ተግባራቶች

1. በአካባቢ ላይ እየተከናወኑ ያሉ የከተማ ግብርና ዓይነቶች
2. ለግብርና ጥቅም ላይ የዋሉ የውሃ ዓይነቶች
3. ከንፅህና አጠባበቅ ጋር የተያያዙ ልምዶች በተመለከተ

ሠ. የሄቪሜታል ትንተና የማረጋገጫ ዝርዝር

1. በናሙና አወሳሰድ ፕሮቶኮል ላይ ተመስርቶ ናሙናዎችን መውሰድ
2. ናሙናዎችን ለምርመራ ወደ ላቦራቶሪ መውሰድ
3. የናሙናዎቹ ምርመራ እንዴት እንደሚሰራ መከታተል
4. የላብራቶሪ ውጤቱን መቀበል
5. ተገቢውን የትንታኔ ዘዴ በመጠቀም የምርመራውን ውጤት መተንተን
6. ውጤቱን መተርጎም