Addis Ababa University

College of Development Studies

Center for Environmental and Developmental Studies

Factors Influencing Domestic Wastewater Management and Reuse: The Case of Woreda 04 Yeka Sub-city, Addis Ababa, Ethiopia

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Declaration

I, Fantu Tadesse Shrigeta, hereby declare that the study entitled **" Factors Influencing Domestic Wastewater Management and Reuse: The Case of Woreda 04, Yeka Sub-city, Addis Ababa, Ethiopia "** is my own work, not submitted for a degree at Addis Ababa University or any other universities, and that all sources used for this work have been duly acknowledged.

Submitted by: **Fantu Tadesse Shrigeta**

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This is to certify that the thesis entitled **"Factors Influencing Domestic Wastewater Management and Reuse in Woreda 04, Yeka Sub-city, Addis Ababa,"** is prepared by Fantu Tadesse Shrigeta and submitted to Center for Environmental and Developmental Studies in partial fulfillment of the requirements for the degree of Master of Arts in Environmental Studies is in compliance with the University`s regulations, and meets the accepted standards of originality and quality.

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Advisor: Ermias Teferi (Asst. Professor) Signature _____Date _____

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Abstract

Domestic wastewater management and reuse is a critical issue in Ethiopia, including Addis Ababa. The study therefore employed a mixed-methods research design to investigate the factors affecting domestic wastewater management and reuse in Yeka Sub-city of Woreda 04 in Addis Ababa, Ethiopia. The study used purposive sampling method to select 390 respondents. Descriptive statistics and thematic analysis were used to analyze the data collected through a questionnaire and in-depth interviews. The percentage of male participants in the study was 264 (67.4%), which was higher than that of female participants, 126 (32.3%). The study found that community culture, organizational structures and plans, urban growth, infrastructure and technologies influence domestic wastewater management in Woreda 04. The study revealed that domestic wastewater use is increasing especially for irrigation purposes in the Woreda and surrounding areas, which needs to be duly addressed. Therefore, the Woreda must work in cooperation with communities, governmental and non-governmental organizations to improve the quality of the environment and the healthy life of residents, without which sustainable development could not be achieved.

Keywords: domestic wastewater, culture, institutional arrangements and infrastructure.

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Acronyms

AAWSA____Addis Ababa Water and Sewerage Authority

EPA_____Environmental Protection, USA

GPA_____Global Program of Action, under UNEP

IEAM____Integrated Environmental Assessment and Management

MoUDC____Ministry of Urban Development and Construction, Ethiopia

MoWIE____Ministry of Water, Irrigation and Energy, Ethiopia

UN____ United Nations Organization

UNDP____United Nations Development Program

UNEP____United Nations Environment Program

UNICEF____United Nations International Children`s Emergency Fund

WHO____World Health Organization

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CHAPTER ONE

INTRODUCTION

The introductory part of the study includes the following basic components: First, general background information about the study is given. Secondly, the problems encountered in the management of domestic wastewater and reuse in the study area are boldly stated. Thirdly, the general and specific objectives, and basic research questions are outlined. The chapter also includes the significance of the study, the scope of the study, the limitations of the study and the organization of the study.

1.1. Background of the Study

In many parts of the world, wastewater is not adequately treated. This untreated wastewater causes disease, pollution, ecosystem destruction, death, economic losses, crises, and waste of human, material, and financial resources, and does not benefit from biotechnology as a byproduct of wastewater treatment plants (Attila et al., 2012). Domestic wastewater has increased dramatically in urban centers due to rapid urbanization and increasing industrialization. Throughout the world, there is evidence that the inundation of people from rural areas into urban centers has a direct impact on urban population growth, which in turn drives up wastewater production. Socioeconomic activities associated with housing projects and factories that deposit hazardous wastes on the banks of rivers, lakes, and water bodies have a negative impact on environmental quality. The sanitation system is disproportionate to the number of households and the lack of awareness of the consequences of improper sanitation on the environment and the well-being of residents (IEAM, 2018).

In developing countries, including African countries, the negative impacts of wastewater are further exacerbated by accelerated urbanization, lack of awareness, inadequate management and disposal system, and implementation of cost-effective technologies (Libralato et al. 2012). IEAM (2018) has shown that untreated wastewater is discharged into water bodies in several African countries, resulting in significant health and pollution hazards for downstream areas where uncontrolled and direct reuse of wastewater is common.

The above statement and several other studies have shown that poor management of domestic wastewater is a critical problem worldwide. The negative impacts of poor domestic wastewater management in developing countries, especially in Africa and Sub-Saharan Africa, are getting worse. Unless appropriate measures are taken in collaboration with various environmental actors and stakeholders, wastewater will have a lasting impact on the ecology and socio-economic aspirations of countries. The Van (2021) study, which suggests that several African countries have managed water supply and sanitation separately, they should adopt environmentally sound systems that take into account the entire urban water system-water supply, sanitation, solid waste collection, treatment, and reuse-which requires a holistic approach that involves multiple stakeholders and overcomes the challenges of rural and urban administrative boundaries.

In Ethiopia, only 38 percent of the total population has access to safe drinking water. One of the main factors for this is the lack of sanitation facilities. The rest of the population relies on surface water or rainwater, which is considered unsafe for drinking and other sanitation (UNICEF and WHO, 2019). Fesseha, (2012) has further stated that lack of space for latrine construction is one of the major causes of soil and water contamination and hence many communicable diseases follow.

Addis Ababa, the capital of Ethiopia and the diplomatic center of Africa, should have developed proper management of domestic wastewater and its reuse. However, this is not the case, and the city has not yet modernized its domestic wastewater management system. Morrison (2018) described that the capital's wastewater system is very old and of poor quality, and even the existing system is damaged by the ever-growing construction activity. The study added that liquid effluents are discharged into the rivers and cause pollution as they consist of inorganic chemicals as disinfectants such as alcohol, chlorine, chloride, and chlorine compounds. Domestic wastewater generated and disposed in homes, offices, kitchens, showers, sinks, toilets, and laundries also cause similar problems in Addis Ababa and its surroundings (Basalem, 2019).

Therefore, the above problems are just some of the many that prompted the researcher to study some of the major critical factors affecting the management of domestic wastewater disposal and

reuse, taking Woreda[1] 04 of Yeka Sub-city as a case, and then propose valuable recommendations according to the findings of the study.

1.2. Statement of the problem

Due to rapid population growth and people moving from rural areas to cities, combined with complex socio-economic activities, the generation of domestic wastewater in urban centers has increased. The rapid growth rate of urbanization and the expansion of industrialization contribute significantly to the pollution of the urban environment through the increase of disposable wastewater. This has a direct impact on the healthy life of urban dwellers, socio-economic activities, ecology and all living things around us (Tayler et al., 2010).

Addis Ababa, the capital of Ethiopia and regional center in the Horn of Africa, is a victim of a poor domestic wastewater management system that poses a direct threat to the quality of the environment, the healthy life of the community, and socioeconomic activities as a whole. In Yeka Sub-city of Woreda 04, poor management of domestic wastewater has raised several issues, one of which is human health and environmental quality. Wastewater from the said Woreda, mainly from houses, hotels and restaurants, laundries and kitchens, is discharged into sewers, open spaces, rivers and agricultural lands without physical, biological and chemical treatment. Shiwangizaw (2020) found that most domestic wastewater, i.e. 'gray water', is discharged into open areas and rivers flowing through the city. Communities have developed the habit of disposing of domestic wastewater in the streets and in any open space available to them, at night when it cannot be observed by the public and authorized personnel who monitor environmental hygiene. In addition, several communities do not have domestic wastewater facilities, either on-site (septic tanks) or off-site (sewers), where they could collect and transport wastewater for proper disposal to reduce pollution and impacts on health and biodiversity.

The Addis Ababa Water and Sewerage Authority and its subordinate authorities in the sub-cities and Woredas, which are responsible for managing and treating domestic wastewater originating from various sources, are not fulfilling their role according to the city government's plan and the expectations of the communities (AAWSA, 2022). Municipal governments play an important role in providing the necessary facilities by mobilizing resources from various stakeholders,

[1] . Woreda is a local word used to indicate the lowest administrative organ of the Addis Ababa city administration.

which is essential for improving the domestic wastewater management system (Oladoja, 2017; Tekelehaimanot and Gebreamlak, 2015; and Yohannes and Elias, 2017). However, this is not the case in Woreda 04 of Yeka Sub-city. The low level of community participation in domestic wastewater management and reuse is a major challenge in the Woreda that requires concerted action to address the problems in a timely manner.

Although there are a considerable number of studies on wastewater management and treatment, none of them address the critical problems of the domestic wastewater system in the study area and its far-reaching consequences. These studies do not reflect the current socio-economic dynamics and realities of Woreda 04 in Yeka Sub-city. Therefore, this study takes into account the current socio-economic dynamics and realities of the study area and attempts to identify the factors that affect domestic wastewater management and reuse and fill in the gaps that are not adequately covered and addressed by other studies.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of the study is to examine the factors influencing domestic wastewater management and reuse in Yeka Sub City of Woreda 04, Addis Ababa, Ethiopia.

1.3.2. Specific Objectives

The specific objectives of the study focus on:

- Assessing the influence of institutional arrangements and plans on the management and reuse of domestic wastewater.
- Examining the influence of societal culture such as awareness, knowledge and skills, on the management and reuse of domestic wastewater, and
- Investigating the influence of urban growth, infrastructure and technology on domestic wastewater management and reuse.
- Exploring the current status of the domestic wastewater reuse in the study area

1.4. Basic Research Questions

The study attempts to answer the following fundamental questions at the end of the study:

1. Does the culture of society (awareness, knowledge and skills) influence domestic wastewater management and reuse?
2. How do institutional arrangements and plans influence domestic wastewater management and reuse?
3. How do urban growth, access to infrastructure and technology influence the management and reuse of domestic wastewater?
4. To what extent does the domestic wastewater be reused in Woreda 04 and its surroundings?

1.5. Significance of the Study

The study would primarily provide vital information to the relevant decision makers of AAWSA and its subordinate governmental bodies down to Yeka Sub-city of Woreda 04, to improve the management of domestic wastewater and the reuse system. The research findings would also serve as a point of departure for further research efforts by interested scholars and research institutes.

1.6. Scope of the Study

The main focus of the study is to investigate the factors affecting domestic wastewater management and reuse in Yeka Sub-city of Woreda 04 in Addis Ababa. Woreda 04 was selected as study area mainly because it was accessible to the researcher and it is one of the Woredas that generates large volumes of domestic wastewater that overflows onto open spaces. Including other Woredas in the study would have been challenging due to financial constraints and lack of time. Finally, it should be noted that the study period was from September 2022 to January 2023.

1.7. Limitations of the Study

Self-reporting was used to analyze the factors influencing of domestic wastewater management and reuse. Underestimation and overestimation of the respondents could affect the results of the study, which is expected in any academic or applied research. Due to financial and time constraints, no focus group discussions were conducted to complement the quantitative results. However, great efforts were made to minimize these limitations through careful review of documents and reports from AAWSA and its subordinate governmental bodies, and interviews with selected key informants taking into account their active participation and involvement in the wastewater sector.

1.8. Organization of the Study

The remainder of the chapter is organized as follows: Chapter two deals with the review of the related literature, mainly definitions and concepts, theoretical and empirical literature reviews and the development of a conceptual framework. Chapter three describes the methodology of the study, in particular the description of the study area, the design and approach of the study, the determination of the sample size, the data collection instruments, methods and procedures, the data analysis techniques and ethical considerations. The fourth chapter deals with the presentation of the data analysis, discussions and interpretations, while the last chapter, chapter five, provides the summary of the main findings, conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

In the literature review, components mainly as definitions and concepts of basic terminologies, theoretical and empirical literature reviews, and conceptual framework are discussed. The theoretical review, the theory of planned behavior, was selected after reviewing several theories and models. The theory`s foundation is human behavior which leads to the occurrences of normative beliefs is quite relevant to examine how human behavior influences the domestic wastewater management and reuse in the study area. The selection of the empirical reviews were also selected based on their relevance to Ethiopia`s wastewater management cause, and much attempt was made to review recent case studies that reflect the contemporary domestic wastewater management in Ethiopian urban centers including Addis Ababa.

2.1. Definitions and Concepts of Terms

2.1.1. Definition and Concept of Wastewater

Wastewater is defined as used water generated by domestic, industrial and commercial uses. Its composition is so dynamic and changes from time to time that it is very difficult to determine the definition of the word itself. Wastewater is 99.9% water and only 1% contains organic, microorganic and inorganic compounds. Frequently, wastewater is discharged into the environment, such as lakes, ponds, streams, rivers, estuaries, and oceans. In addition, wastewater includes stormwater runoff as pollutants from streets, parking lots, and rooftops (Tuser, 2021).

Wastewater can also come from non-domestic sources, such as beauty salons or auto repair shops, which may contain hazardous substances and require special treatment or disposal. Industrial wastewater comes from industrial or commercial production processes, such as agriculture, and is generally more difficult to treat than domestic wastewater. The composition of industrial wastewater varies from industry to industry. The pathogens contained in wastewater pollute beaches and thus have negative impacts on human health (Tuser, 2021).

From the above definition, wastewater contains organic and inorganic chemical compounds that are harmful to the environment, human health, and all living things around us. Therefore,

wastewater management and treatment are inevitable if we want to achieve sustainable socio-economic development in the urban centers of Ethiopia, including Addis Ababa.

2.1.2. Definition and Concept of Domestic Wastewater

According to Mara (2003), domestic wastewater is defined as the water used by communities and contains all substances added to the water during its use. It is composed of human bodily wastes, i.e. faces and urine, as well as water used for flushing toilets and wastewater generated from washing, laundry, food preparation and cleaning of kitchen utensils.

Mara goes on to say that domestic sewage is a grey, turbid liquid containing large suspended solids such as faeces, rags, plastic containers, corn cobs and smaller suspended solids such as partially decomposed faeces, paper, vegetable peelings and very small solids in colloidal suspension as well as pollutants in true solution. It looks unsightly and is dangerous, mainly because of the pathogens it contains. In warm climates, sewage can quickly lose its dissolved oxygen content, making it "stale' or 'septic'. Septic wastewater has an unpleasant odor, usually of hydrogen sulphide.

The above explanation shows that domestic sewage is broadly divided into grey, large suspended solids and small solids, whose content of pathogenic organisms causing various types of diseases is dangerous.

2.1.3. Domestic Liquid Waste Management

A strategic document of MoUDC (2015) has shown that liquid waste management in Ethiopia's urban centers is generally poor and still in its early stages. Only in Ethiopia's capital, Addis Ababa, is there limited coverage with sewer line. According to the document, the coverage with sewage pipes at that time did not exceed 10% of the total area of Addis Ababa. Therefore, most areas of the city relied on septic tanks to collect domestic liquid waste before it was safely transported by vacuum trucks to the two treatment plants in Kotebe and Kality, although their operational capacity is limited to 350 and 7500 cubic meters per day due to the inefficiency of liquid waste collection. Solomon et al (2022) supplemented that the liquid waste generated by Addis Ababa residents requires proper handling and treatment as it contains pathogens, 'oxygen consuming wastes, water soluble inorganic chemicals, inorganic nutrients, organic chemicals,

sediments, radioactive wastes, etc.' Solomon et al (2022) further argues that an unhygienic urban environment creates a conducive environment for the outbreak and spread of communicable diseases such as typhoid, trachoma, guinea worm, malaria, cryptosporidium parvum and sleeping sickness, as well as several other health complications.

The waste generated by water use in Addis Ababa has increased in volume and complexity. The decision by the municipality to actively involve the private sector, including small and micro enterprises, in the management of liquid and solid waste is fundamental to reducing the burden on the municipality and improving its management system. Another important point that should be mentioned is that besides reducing the municipal burden and improving the quality of the urban environment, employment opportunities will be created for thousands of youth in the city. However, low awareness among the public, especially communities, lack of basic liquid waste facilities and low enforcement of laws remain challenges for sanitation in the city (Sisay, 2017).

In general, household wastewater management has been given low priority in Ethiopia's urban centers. As the strategic document issued by MoUDC and the above studies show, Ethiopia's governments, cities and municipalities, including Addis Ababa, still have a lot of homework to do to improve the domestic wastewater management and reuse system in the future.

2.2. Overview of Wastewater Management

Wastewater management is an important component of water resource management. Inadequate wastewater management adversely affects the environment and the well-being of the population and leads to the occurrence of waterborne diseases due to the use of contaminated water resources. If wastewater management is underestimated, it means that one of the goals of the 2030 Agenda for Sustainable Development (SDGs) is at risk, which is to:

> *By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.*

Wastewater management remains a major challenge in many countries around the world. This is especially true in low- and middle-income countries, where water supply is still more important than sanitation. For example, in developing countries, about 85% of the population has access to

safe drinking water, while only 32% of the population has access to sanitation. Even in middle-income countries, access to safe drinking water is greater than the provision of sanitation (Hophmayer-Tokich, 2006).

In Africa, especially in sub-Saharan countries, including Ethiopia, the situation is critical in that almost 69% of the African population, most in sub-Saharan countries, do not have access to improved sanitation systems, which requires further action to strengthen sustainable water resource management (Ravina *et al*., 2021). Wastewater management can be done through centralized and decentralized systems, which are discussed in separate sections below:

2.2.1. Centralized Wastewater Management

Wastewater management can be done through a centralized system in which the collection system, i.e., the sewer system, collects wastewater from several distant wastewater producers, such as households, commercial areas, industrial plants, and institutions, and transports it to a centralized treatment plant outside the settlement, and the treated wastewater is usually disposed of or reused far from the point of generation. This is an aged method of sewage disposal, developed in the 19th century in connection with urban development and life, when there were outbreaks of communicable diseases such as cholera, typhoid, and other deadly diseases in the large cities of Central Europe and the United States. The system consisted in the construction of sewer networks that transported human excreta far away from urban settlements into waterways, where self-purification took place. As a result, outbreaks of cholera and typhoid fever were significantly reduced and eventually eliminated altogether. However, as more and more sewage was discharged into surface waters, the self-purification capacity of the receiving sewage body was exceeded and water quality gradually deteriorated. As more and more surface water was needed for drinking water supply, wastewater treatment technology had to be developed (Hophmayer-Tokich, 2006).

The centralized system of sanitation is much more convenient to plan and manage than the decentralized system. This argument is true. However, the experience in cities shows that the peri-urban areas that are outside the city limits are not included in the centralized system to use local resources and receive services (Nabegu, 2010). This shows that the centralized system of

sanitation is not the only reasonable option available for urban centers. Other options for sanitation are possible, as explained in the work of Hawkins and Hoornweg (2013).

2.2.2. Decentralized Wastewater Management

Studies show that centralized sanitation is not the only option available for urban centers. There are several other options, one of which is conceptually known as decentralized wastewater management, or on-site management.

Decentralized wastewater management is a concept where wastewater is collected, treated and disposed of or reused at or near the point of generation (Crites and Tchobanoglous, 1998). Although most engineers and waste experts reject decentralized wastewater management, interest in decentralized wastewater management has increased in recent years. New technologies that support decentralized wastewater management are improving the system used in the 19th century and effectively integrating it with water lorry waste disposal techniques (Burian et al, 2000). This is because centralized sanitation is not feasible or in some cases not cost effective in many areas. Due to high costs, complex construction, operation and maintenance, and high water consumption, the centralized sanitation strategy is not preferred in low-income areas, at urban-rural junctions, in areas with low water supply and in areas with unreliable water supply systems (UNEP/GPA, 2000).

Decentralized wastewater management can be applied to individual households, a group of houses, a neighborhood, public facilities, business parks, industrial estates and small parts of large communities. This strategy could use cost-effective technologies such as septic tanks and pit latrines and some others, whether wet or dry, simple or advanced, with the ultimate goal of treating small volumes of wastewater at or near the source of its generation (Bakir, 2001, and Crites and Tchobanoglous, 1998). When using high-tech components such as membrane bioreactors with aerobic systems, electrical aeration and possibly pumping is required. This technology meets environmental standards and is preferred as a viable alternative to wastewater treatment. The various advantages of the decentralized wastewater disposal strategy over the centralized wastewater disposal strategy are as follows:

- **Low cost**: No extensive infrastructure is required for wastewater collection as is the case with centralized wastewater disposal,
- **Environmental benefit**: The amount of wastewater is less than centralized wastewater disposal, which is an environmental benefit in the event of a failure,
- **Increased opportunities for reuse of wastewater and solids**: The use of treated water is cost effective as it is used close to where it is generated, reducing the cost of the treated water distribution system,
- **Less water intensive compared to a centralized system,**
- **It can be built incrementally**: Its various components can be built incrementally, reducing the immediate investment required for a centralized system. Thus, it provides a good solution for sanitation in places within homogeneous sanitation in urban areas in developing countries (Bakir, 2001).

In conclusion, decentralized wastewater treatment is a cost-effective and better option for low-income communities, for areas where the facilitation of centralized wastewater management cannot be achieved, it provides space for resource mobilization and phased development, and it has a far-reaching significance for the use of technologies available at the local level, which is why it is probably applicable in developing countries such as Ethiopia. However, the decision to adopt a centralized or decentralized or mixed provision wastewater management system or strategy should be made taking into account the available technologies, environmental contexts, and local capacities of urban centers.

2.3. The Benefits of Wastewater Treatment

The implementation of wastewater treatment has a variety of benefits. The World Bank report (2020) states that 80 percent of the world's wastewater is released into the environment without adequate treatment. This means that useful resources, such as clean water, energy, nutrients and other resources, can be recovered and reused. The report emphasizes that "smarter wastewater management, including reuse and resource recovery, and looks at wastewater projects around the world that have paid off in the short and long term for people, the environment and economies." The report goes on to say that:

> *Efficiently investing in wastewater and other sanitation infrastructure is crucial to achieve public health benefits, improve the environment, and enhance quality of life. Safely managed water, sanitation and hygiene (WASH) services are an essential part of preventing disease and protecting human health during infectious disease outbreaks, including the current COVID-19 pandemic. In addition to environmental and health benefits, wastewater treatment can bring economic benefits through reuse in different sectors. Its by-products, such as nutrients and biogas, can be used for agriculture and energy generation. And additional revenues generated from this process can help cover water utilities' operational and maintenance costs.*

UN Water (2017) added that proper wastewater treatment significantly reduces effluent before reuse or disposal into the environment, with the required standard of treatment being site- and use-specific. Since 2014, both scientific knowledge and processes for treating all types of wastewater have advanced significantly. There are now many aerobic, anaerobic, and physicochemical processes capable of treating wastewater to meet all influent removal standards, from simple removal of coarse solids to membrane systems capable of producing drinking water quality. They range from very simple to highly complex processes and each has its own characteristics in terms of efficiency, reliability, cost, affordability, energy consumption, sludge production, land requirements, etc. Treatment strategies range from high-technology, energy-intensive approaches to low-technology, low-energy, biologically and ecologically oriented approaches.

From the above, it can be concluded that water is a scarce resource that should not be wasted and used up in covering wastewater, but should be treated and recovered for reuse using locally available technologies. In doing so, the use of treated wastewater could greatly improve public health, environmental quality, and quality of life, and the byproducts could also be used to generate energy in the form of biogas and electricity, ultimately reducing the operating and maintenance costs of water utilities.

2.4. Wastewater Management Operations System

2.4.1. Domestic Wastewater

According to MoWIE (2015), the main sources of domestic wastewater are currently urban residents and public institutions. Other sources of domestic wastewater are commercial centers and recreational areas. Wastewater consists of black water containing fecal matter and urine, which is referred to as dirty water or sewage or gray water or sullage. Wastewater is also generated from shower, bath, sink, washing machine, laundry trough and kitchen.

2.4.2. Wastewater Management Technology Alternatives

According to the MoWIE (2015) strategy, attempts to transfer sanitation technologies from one area to another proved less successful. As the aphorism "one size does not fit all" states, different approaches should be developed for different regions, rural and urban centers, depending on population size, socioeconomic activities and cultures, sanitation capacity, and management capacity.

A different approach should be adopted depending on the quality standards required for end users or final disposal. The sanitation ladder provides important guidance for assessing and internalizing the sanitation status of a particular community, city, or region in order to optimize sanitation strategies. The strategy attempts to outline some of the basic technological options that are appropriate for different areas of Ethiopia, including:

- **Decentralized on-site and cluster systems**: The main users of these systems are housing estates, universities, industries, and private and government facilities that use wastewater for fertilizer, biogas production, and reuse of water for domestic purposes according to standard permits.
- **Local collection system**: In areas with higher population density, it is possible to develop a local collection system and treat the community's wastewater in a single facility.
- **Lagoons, constructed wetlands, and stabilization ponds** are cost-effective and common biological treatment options with low operating costs.
- **Conventional centralized Systems**: In cases where the above options are deemed insufficient for a desired system, the use of conventional systems can be considered,

which require large volumes of diluted wastewater collected through an extensive sewer system and treated in modern, centralized treatment plants, and also require large capital investments, highly skilled labor, and stable socioeconomic conditions.

2.4.2.1. Centralized wastewater management technologies

Oladoja (2017) described that centralized wastewater management system is one of the best modern waste management practices. However, centralized wastewater management is less attractive in developing countries because it requires a lot of money for construction, operation, management, and maintenance. It also requires well-trained professionals, forcing poor countries to import engineers and experts from abroad who are highly paid on a per diem basis. Consequently, the public is more likely to have access to unsafe water and poor sanitation (Oladoja, 2017).

As part of the wastewater management system, MoWIE (2015) identifies the following technologies that the centralized wastewater management system considers and categorizes them into two components:

- **Separated sewers**: In this system, wastewater flows to a treatment plant or point of discharge, but during a severe storm, the volume of water from untreated mixtures of stormwater and wastewater can overflow into receiving water bodies and municipal settlements, causing severe flooding and pollution.
- **Combined sewer system**: This system allows stormwater and wastewater to be transported through separate storm sewers and sanitary sewers, respectively. For both collection systems, construction costs are relatively high and depend on slope, soil, topography, and water table.

In general, centralized wastewater management technologies are relatively costly in terms of construction, operation, and maintenance, as well as the daily presence of well-trained engineers who would oversee the proper functioning of the system. Considering these challenges, decentralized or on-site wastewater management systems seem to be suitable for domestic wastewater treatment, especially in developing countries such as Ethiopia.

2.4.2.2. Decentralized wastewater management technologies

A decentralized wastewater management system helps save money, protects homeowners' investments, promotes better watershed management, provides a suitable solution for low-density communities, offers suitable alternatives for different site conditions, and provides effective solutions for environmentally sensitive areas (Oladoja, 2017). The system includes:

A. On-site water treatment system

In practice, domestic wastewater treatment systems must be cost-effective, robust, compact, hygienic on-site, odorless, low maintenance, and easy to install and operate (Gray, 1999). The system requires simple, reliable, energy-efficient, and cost-effective technologies that can be afforded by homeowners with limited knowledge. The choice of an on-site system for domestic wastewater disposal depends on the physicochemical properties of the raw water and the intended use.

The ultimate goal of domestic wastewater treatment is to protect public health and the environment in a socioculturally and economically sustainable manner. Management systems should also take into account the willingness and ability of users to operate their own systems (ease of use) and to comply with relevant laws and regulations (Schudel and Boller 1989). In any case, MoWIE (2015) has shown that an on-site wastewater treatment system includes septic tanks, toilets, and any chambers to hold the wastewater, depending on the suitability of the given area. The ministry further states that the system uses seats from toilets to collect human excreta, and when full, the tanks are transported by vacuum trucks and emptied near the residence to provide treatment, significantly reducing environmental impacts.

B. Truck based disposal system

Wastewater could be collected by vacuum trucks, directly through sewers, or at transfer stations and disposed of by burial in ditches, land /dry beds, and septic ponds. However, the sewage sludge must be decomposed until all pathogens are eliminated. Otherwise, the system would pose a threat to the environment, especially in areas where large-scale emptying of waste is practiced (MoWIE, 2015).

C. Septage

"Septage" is the liquid and solid material pumped from a septic tank, cesspool, or other primary treatment source (EPA, 1999). Residents and commercial areas that are not connected to a centralized or off-site wastewater treatment system may use a separate on-site wastewater treatment and disposal facility (MoWIE, 2015). Many wastewater treatment plants also use lime for conditioning and stabilization before dewatering the sludge. The liquid residue can be discharged to a private wastewater treatment plant or further treated and then disposed of. The solid components of the sewage sludge are then either sent to a landfill, composted, applied to the land, or incinerated (EPA, 1999).

D. Recycling

Solids removed from wastewater can be digested or stabilized and spread on the ground, landfilled, incinerated, composted, or otherwise stabilized before being beneficially used. Wastewater, domestic gray water, and sewage contain potential sources of fertilizer and energy. Treated wastewater can recharge waterways or be directly reused for many purposes. Better wastewater management would contribute to a solution to water scarcity (MoWIE, 2015).

2.4.2.3. Technology options and practices

Recent developments offer a wide range of wastewater treatment technologies. Since the 19th century, various types of wastewater treatment technologies have been developed. These include the most widely used conventional activated sludge process, both aerobic and anaerobic, highly mechanized to non-mechanized, trickling filters and bio-towers, anaerobic upflow sludge blanket reactors, rotating biological contactors, aerated lagoons, sequential batch reactors, and others. However, the challenge is selecting the best wastewater treatment for a particular site (Kalbar et al. 2012). According to the statement of Yoon and Hwang (1995), the selection of appropriate technologies for a particular site should consider the following attributes:

- **Utility attributes**: 'Increases monotonic utility, i.e., the greater the value of the attribute, the more it is preferred.' An example is fuel efficiency.
- **Cost attributes**: Decreases monotonic utility, i.e., the larger the attribute value, the less it is preferred. An example is production costs

- **Non-monotonic attributes**: Maximum utility is somewhere in the middle of the attribute range. Examples are the room temperature in an office and the blood sugar level in a human body. For these attributes, the maximum utility is somewhere in the middle of the attribute range. As noted by Kalbar et al. (2012), the most recent technology assessment also added sustainability criteria that include the following:
- **Durability**: This refers to the lifespan of the wastewater treatment technology, which is expected to last at least 40-50 years with minimal maintenance and replacement needs.
- **Accessibility**: It should be easily upgradable to increase its 'additional hydraulic and organic load" The technology must require minimal modifications to achieve an 'additional hydraulic and/or organic load"
- **Acceptability**: It should be designed and accepted from a socio-economic and cultural perspective. The technology should be very simple and odorless for the communities, which is an important criterion for selecting wastewater treatment technologies, especially in developing countries.
- **Participation**: In most cases, community participation is ignored in the selection and procurement of wastewater treatment technologies. This is essential to link the technology to local and broad sustainability concerns.
- **Replicability**: This is to indicate that the design, implementation and operation of the wastewater treatment technology should be simple. Once installed, the involvement of technical experts should be minimized, while the involvement of local communities in replication and maintenance should be encouraged, as many people in developing countries live in rural areas that do not have access to technical experts.
- **Stimulating sustainable behavior**: Sustainable behavior should be encouraged by tailoring the design of the technology to ultimately improve end-user awareness, participation, and responsibility. In this way, the technology will be promoted in a sustainable manner.

When considering a wastewater treatment technology, the above characteristics and sustainability criteria should be considered, especially in developing countries such as Ethiopia. The technology must be environmentally and user friendly and sustainable.

2.4.2.4. Operations and maintenance issues

Installation and operation of the wastewater treatment system should be environmentally friendly so that the wastewater quality meets the established standards. Maintenance of the wastewater system should be either preventive or corrective. However, effective maintenance requires knowing the components that make up the system, where they are located, and what condition they are in. All maintenance, whether preventive or corrective, should be done with proper planning, scheduling, remediation needs, and long-term improvements with an appropriate budget. It is very important to follow the updates, guidelines, and manuals issued by MoWIE on a regular basis (MoWIE, 2015).

This shows that operation and maintenance of the wastewater system requires due attention and must be supported by updates and guidelines issued by the relevant government agencies.

2.5. Current Status of Wastewater Treatment in Ethiopia

Studies show that due attention needs to be paid to wastewater management in Ethiopia. According to Elfu et al. (2017), rapid urbanization, freshwater scarcity, lack of wastewater treatment facilities, increasing demand for water in agriculture, and poor monitoring and enforcement mechanisms make wastewater management complex. Consequently, the use of untreated wastewater, especially for irrigation purposes, is widespread, in violation of national and international obligations.

The WHO (2010) report showed that coverage with wastewater treatment plants in Ethiopia has remained unacceptably high, and collection and transport of wastewater is a major challenge. The long-standing tradition of open disposal of liquid waste is a major cause of soil and water pollution and the spread of infectious diseases. Gabisa et al. (2021) demonstrated that almost half of the total urban pollution is caused by the discharge of wastewater into nearby open spaces, including roads and drainage pipes. The study shows that there are several factors that lead to poor wastewater management, the most important of which are related to the role of communities, their attitudes, practices, and interactions.

The strategy for wastewater management states that implementation efforts will be carried out by MoWIE in collaboration with sectoral ministries such as the Ministry of Health, the Ministry of Urban Development and Construction, federal and regional environmental agencies,

municipalities, research institutions including colleges and universities, non-governmental organizations, donors, and sanitation supply organizations. Although limited to Addis Ababa and some regional cities, efforts are being made to properly manage wastewater, implement national policies, strategies, and programs, and then expand to all urban centers in the country (MoWIE, 2015).

2.5.1. Current Status of Wastewater Treatment in Addis Ababa

The Addis Ababa Water and Sewerage Authority (AAWSA) is the only organization responsible for providing safe drinking water, treating wastewater, collecting, transporting, and disposing of it. Recently, private companies and non-governmental organizations have emerged to participate in wastewater collection and transportation. Wastewater is transported mainly by vacuum trucks (MoWIE, 2015). The existing sewer lines, which connect only 10 percent of Addis, cannot solve the challenges of wastewater transport and treatment as the city grows rapidly. Even if the central treatment plant is expanded, coverage of the wastewater network remains limited (Narayan and Charles, 2017).

Wastewater generation in Addis Ababa is estimated at over 49 million cubic meters, of which most is domestic wastewater and only 13.4% is industrial wastewater, most of which is discharged into rivers and streams flowing through the city. The areas close to the city, which are the main sources of various types of crops, livestock, horticulture and fruits, use untreated wastewater (Beles Engineering, 2014). The safe use of wastewater is not governed by policy and strategy. This is further exacerbated by the lack of qualified personnel to promote and train skills in urban agriculture (Sisay, 2017).

The poor sanitation system, use of outdated technologies, low awareness of waste management, weak enforcement mechanisms to prevent and control pollution, and low income levels of urban residents have worsened the pollution problem and can be considered the major obstacles to wastewater management in Addis Ababa (Mohammed, 2007).

The above shows that the current wastewater management system of Addis Ababa is in great need of improvement. Most domestic wastewater requires a clear policy direction to reduce the negative impact on the environment in Addis Ababa itself and in the peri-urban areas, which are the main source of various types of agricultural products.

2.6. Challenges for Implementing Effective Wastewater Management

Wastewater can be a resource if properly treated and can be a problem if it is discharged into the environment and used for irrigation purposes (Hanjra et al., 2012). The main problems may arise from the mixing of domestic wastewater with industrial wastes, which pose a threat to the environment and living organisms, and from the presence of pathogenic microorganisms. Even the use of treated water for irrigation can lead to excess nutrients, pathogens, heavy metals and salts if not taken care of. Therefore, it is advisable to separate domestic and industrial wastewater to promote the reuse of safe water (Qadir et al., 2010). Moreover, effective implementation of wastewater management is not easy and requires the following points:

2.6.1. Strong Governance

There should be strong monitoring and oversight mechanisms and effective enforcement of laws without which there is little incentive to act(UN Water, 2017). It is also noted that:

> *The lack of good governance, including ineffective policies, enforcement, and institutions, corruption, and the lack of adequate infrastructure, along with a lack of new investment in human capacity building, all contribute to persistent water quality problems. Weak institutions, inadequate water quality policies and regulations, and limited enforcement capacity underlie many water quality problems worldwide (UNEP, 2010).*

This has shown that governance issues, including human and institutional capacity building, are fundamental. Therefore, it is imperative to ensure strong governance in the implementation of effective wastewater management.

2.6.2. Financial Aspects

In the wastewater management system, there should be adequate funding for investment, cost recovery, equity, and economic benefits. Wastewater management is capital intensive, so it requires large investments, or the issue of sustainability would be affected (UN Water, 2017). For this reason, Jouravlev (2004) said that:

> *It is important to note that water pollution affects not only public health, the environment and local economic activities, but also national competitiveness, mainly due to the increasingly close relationship between external market access and the environment and the increase in disputes related to the use of environmental standards as non-tariff barriers in international trade.*

Corcoran et al. (2010) also indicated that funding for wastewater infrastructure should include:

> *Design, construction, operation, maintenance, upgrades, and/or decommissioning. Funding should reflect the fact that wastewater treatment improvements provide important livelihood opportunities.*

This underscores that funding in wastewater management is needed for infrastructure construction, operation, and maintenance.

2.6.3. Innovations

Encouraging innovation that is locally appropriate is important. However, there are a number of barriers to promoting innovation, such as policy, regulations, and monitoring (UN Water, 2017).

2.6.4. Data

The UN Water (2017) has shown that the presence of data is very important to analyze and understand all aspects of water quality and wastewater management system. However, the lack of data, especially in developing countries, is pervasive. For this reason, the UN Water further describes that:

> *A key to understanding water quality challenges and solutions is collecting, storing, analyzing and sharing water quality data. Without adequate data, serious water quality challenges are unlikely to be identified and managed adequately to protect human and ecosystem health.*

This shows that having adequate data is important to identify waste management system challenges and take corrective actions to protect the environment and human health.

2.6.5. Public Knowledge, Attitudes, Practices and Participation

This is one of the most influential components of effective wastewater management. Researchers have found that community knowledge, attitudes, and practices correlate with good household sanitation practices. Although there are various reasons for poor wastewater management at the household level, attitudes, practices, and community participation play a fundamental role (Gabisa, et al, 2021).

2.7. Regulatory Frameworks of Wastewater Management

2.7.1. International Convention

At the United Nations Conference (held in Rio de Janeiro, Brazil, in June 2012), member states emphasized the development of good wastewater management around the world to successfully implement the Sustainable Development Goals (SDGs). The following year, in May 2013, the Wastewater Management Agenda was adopted by the UN -Secretary Generals High Level Panels of Eminent Persons on the Post-2015 Development Agenda and recommended an illustrative target on water and sanitation including a target on wastewater management. This topic was further elaborated through the discussions of various UN bodies and concerned stakeholders of wastewater management under the umbrella of UN -Water. Finally, the proposal to include wastewater management in the Post-2015 Development Agenda was accepted by member states and included in the SDGs agenda under Goal 6: "Clean Water and Sanitation" as one of the targets stating that:

> *By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally (*UN-Water, 2017).

UNDP has indicated that member states must work toward providing safe drinking water to all their citizens by 2030. To achieve this goal, countries must 'invest in infrastructure, provide sanitation facilities, and promote hygiene. Protecting and restoring water-related ecosystems is critical" (www. www.undp.org, accessed February 1, 2023). This shows

that wastewater management is one of the goals of the SDGs and therefore member countries are forced to translate it into actions to achieve the given target.

2.7.2. National Regulatory Frameworks

Ethiopia has accepted and adopted the resolution of the General Assembly (UN) and the Human Rights Council (UN) declaring the human right to water and sanitation as legally binding. This is the human right that everyone has an express right to access to clean water and sanitation, which derives from treaties and obligations to an adequate standard of living, an attainable standard of physical and mental health, and the right to life. The Ethiopian Constitution also affirms in Articles 43 and 44 that everyone has the right to live in an "improved standard of living in a sustainable environment" (MoWIE, 2015).

The MoWIE further states that Ethiopia is determined to work ceaselessly to become a high-income industrialized country by 2050, so priority work on water and sanitation is necessary and implementation of the prospective national plans is fundamental to achieving the desired goal (MoWIE, 2015). Other sectors such as the Ministry of Health, the Environmental Protection Agency, the Ministry of Urban Development and Construction, and the Ministry of Culture and Tourism are just a few of many that are committed to sanitation, whose ultimate goal is to create a clean, green, and livable environment, as well as healthy and productive citizens (MoUDC, 2015).

This is an indication that the Ethiopian government has given due attention to improving the living standards of Ethiopian citizens. This includes access to clean water and sanitation, which is listed as one of the national policies in the agendas for Urban and Rural Development.

2.8. Theory of Planned Behavior

The theory of planned behavior is the result of Ajzen and Fishbein's theory formulated in 1975. The theory discovered that behavior is not voluntary and under control in all cases, which led to a "complement of perceived behavioral control" that made it possible to develop the theory of so-called planned behavior.

Accordingly, the theory of planned behavior takes into account three important considerations. The first is that the behavior one believes leads to the occurrence of normative beliefs. The second is beliefs about the normative expectations of others, and the last is control beliefs about the factors that may facilitate or impede the performance of the behavior. These three considerations are crucial when people's behavior changes. Behavioral beliefs lead to favorable or unfavorable attitudes toward the behavior. Normative beliefs lead to perceived social pressure or subjective norm, and control beliefs lead to perceived behavioral control. Overall, attitudes toward behavioral control lead to the formation of a behavioral intention.

In general, the more positive the attitude and subjective norm, the greater the perceived control, the stronger the person's intention should be to control the behavior in question. Planned action theory explains why simply proving information does not work. Improving knowledge alone does not help behavior much. Campaigns that target attitudes, perceived norms, and control over change produce good and better results. Similarly, in management programs, focusing on explaining meaning is not promising, but a combination of knowledge and attitudes is(Ajzen, 1991).

In the management and reuse of domestic wastewater, it is crucial to change the behavior of communities and even the government agencies concerned in order to achieve sustainable development and produce healthy and productive citizens. Therefore, the theory of planned behavior is much better suited to explain behavior in the management and reuse of domestic wastewater. However, critics of the theory argue that some behaviors may be largely influenced by emotions.

2.9. Empirical Review

Within the empirical literature review, there are several case studies in the field of wastewater management in developing countries, sub-Saharan Africa including Ethiopia, some of which are selected and systematically presented below:

The study conducted in the condominium buildings found that the tradition of sanitation in Addis Ababa is generally poor, although the generation of domestic wastewater is increasing. Residents of the condominium blocks generate a total of 50,715,335 liters of wastewater per day. Of the total number of condominiums, only 24.8 percent have a connection to the sewer system. Wastewater management in condominiums is poor due to inadequate oversight by relevant government agencies, weak policies, weak institutional arrangements, insufficient vehicles, and negligence by residents (Sisay, 2017).

Solomon et al. (2022) studied liquid waste management in Addis Ketema Sub-city and its impact on the Shankla River. They concluded that the main causes of poor liquid waste handling are small and large factories discharging their effluents untreated, in-migration from different parts of the country, residents, and poor garage handling. The study recommended that infrastructure development, awareness creation, and environmental law enforcement must be prioritized if change is to be achieved in the coming years. However, the study did not consider how migration and migrants contribute to the poor management of liquid waste and the extent to which they negatively impact the environment.

The study by Shewamgizaw (2020) on the challenges and opportunities of centralized sanitation in the Akaki-Kaliti Sub-city catchment area showed that the most important factors affecting sanitation in Akaki Kality Sub-city are governance factors, community attitudes, technology, and manpower. The study found that the private sector is not involved in wastewater treatment. Low coverage with sewage lines, lack of awareness, and problems in enforcing laws related to wastewater management were some of the critical issues identified in the study. However, the study could not measure the extent to which the aforementioned variables affect domestic wastewater management in the Sub-city.

Nayaran and Charles (2017) studied decentralized wastewater treatment in Addis Ababa. They showed that Addis Ababa is facing a wastewater crisis due to very low wastewater coverage, which is about 10 percent. Most of the housing estates are not connected to the sewage system. For this reason, it is recommended that a decentralized wastewater management system be established. The study indicated that low capital investment and lack of private sector participation is one of the major challenges in scaling up the decentralized wastewater management system. However, the study did not consider other factors such as institutional capacity that contribute to the failure to expand the decentralized wastewater management system in Addis.

Rooijen and Taddesse (2009) examined various studies on wastewater disposal and treatment in Addis Ababa in the Awash Basin. The researchers arrived at results that led them to recommend that expanding sewerage and improving wastewater treatment capacity would improve the quantity and quality of water, which would change the characteristics of irrigation water used in Addis and its surrounding areas. Although the study addressed the problem of water scarcity in Addis, it failed to calculate it and point it out to researchers and concerned government agencies for further remedial action.

The case study by Gabisa et al. (2021) in northwestern Ethiopia examined public knowledge, attitude, practice, and participation in sanitation. The study attempted to measure the specified variables using multivariate binary logistic regression and concluded that limited knowledge, attitudes, and practices negatively affect wastewater management among the population studied. However, the study would have been more accurate and substantiated if it had included focus group discussions and key informant interviews.

Another study by Elfu et al. (2017) using Mekelle University as a case study on wastewater management found that the use of untreated wastewater for irrigation affects the livelihoods of thousands of people along the supply chain. The study added that the organic concentration of wastewater in Mekele University was well above the recommended limit, so the use of untreated domestic wastewater for irrigation could be unsafe.

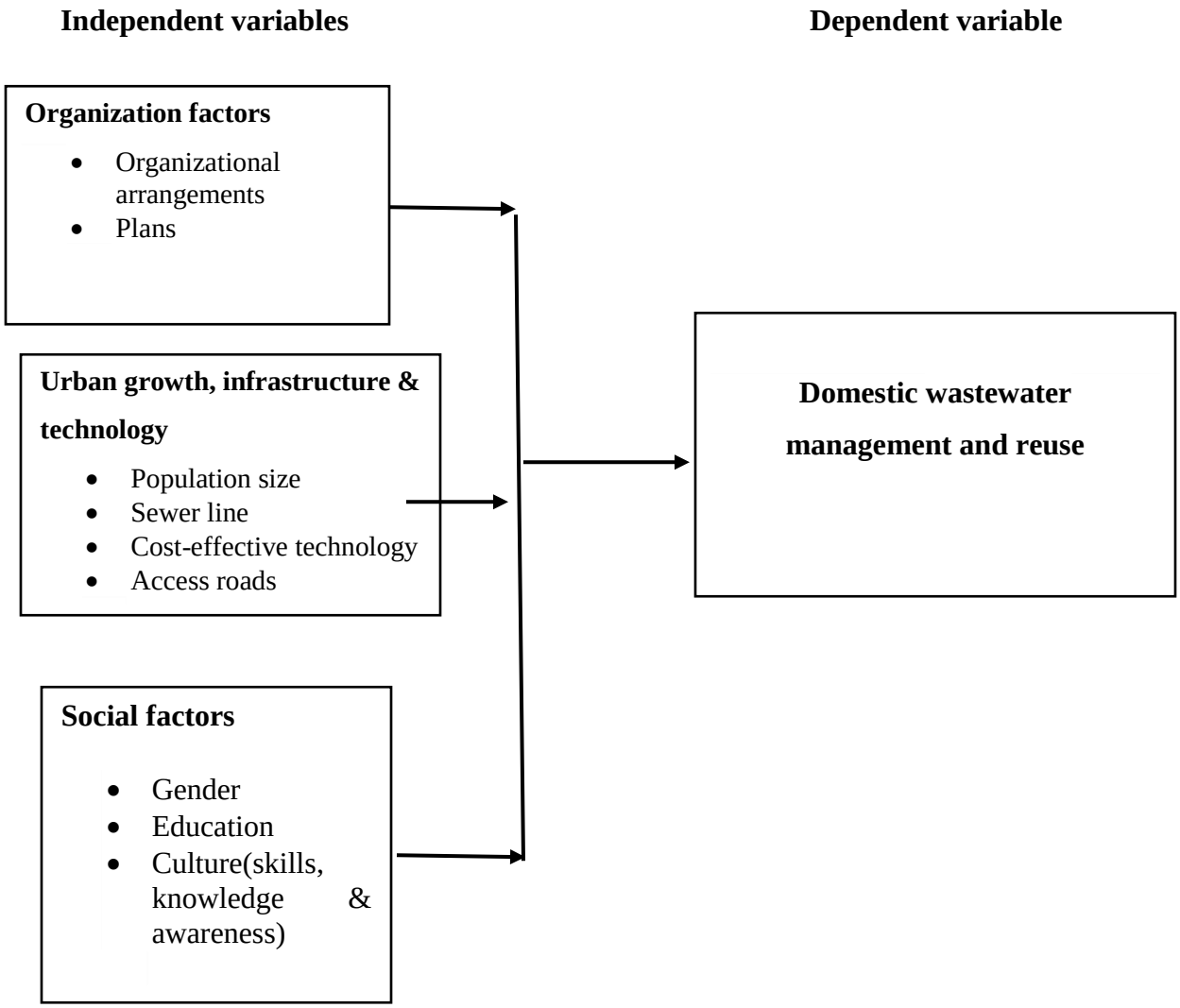
In general, the empirical studies show that various factors such as poor governance, lack of infrastructure, low capital investment, lack of awareness, weak enforcement of environmental laws, lack of appropriate technology and manpower, lack of private sector participation, are just some of many that contribute to poor sanitation in Ethiopia and Addis Ababa. Therefore, addressing these important factors could be the appropriate solution to improve wastewater management in Addis Ababa, including Yeka Sub-city of Woreda 04.

2.10. Conceptual Framework

The section shows the relationship between the independent variables and the dependent variable. According to Kothari (2004), a conceptual framework indicates the position at which the researcher identifies the variables under study and establishes their relationships. Accordingly, in this study, organizational factors, urban growth, infrastructure and technology, and social factors are identified as "independent variables," while factors influence domestic wastewater management and reuse are referred to as "dependent variables"

In the conceptual framework, organizational factors such as organizational arrangements and plans were selected. For urban growth, infrastructure and technology, population size, sewerage, low-cost technology, and access roads were identified. For social factors, gender, education, culture (skills, knowledge, and awareness) were selected. All of these factors are evaluated to determine whether they positively or negatively affect the management and reuse of domestic wastewater in Yeka Sub-city, Woreda 04. Based on this, the schematic conceptual framework is attempted and illustrated as follows.

Figure 1: Conceptual framework



Source: Researcher, 2022

2.11. Summary

The options for wastewater treatment such as centralized, decentralized or mixed supply with their advantages and disadvantages are discussed in detail. The user-friendly technologies that are accepted by the communities need to be promoted to improve the wastewater management system in a given area. Before securing wastewater treatment technologies, criteria must be established to ensure that they are used in a sustainable manner.

There are several factors that influence the management and reuse of domestic wastewater. One of the critical factors is that strong governance influences wastewater management and treatment. Finances are critical for investment in infrastructure, operations, and maintenance, so options for cost recovery must be developed. Knowledge, attitudes, perceptions, and community participation play an important role in the wastewater management system. Another critical issue mentioned in the literature review is the lack of enforcement of the laws. Without the enforcement of the laws, proper wastewater management cannot be achieved.

It is worth mentioning that the literature review allows the researcher to explore the debates of the researchers, their focus, findings and conclusions, and the limitations of the studies that should be covered by other researchers, which eventually helped to design the conceptual framework based on concrete findings.

CHAPTER THREE

RESEACH METHODOLOGY

In this chapter, an attempt was made to present the methods and procedures used in this study. Accordingly, the research design, description of the study area i.e. Yeka Sub-city of Woreda 04, data sources, population and sampling procedure, purposive sampling, data collection procedures and instruments, validity and reliability of the instrument used for data collection, data analysis method which includes quantitative and qualitative analysis, and ethical principles followed in data collection have been discussed.

3.1. Research Design

The research design is the roadmap of the study that provides the general direction of data collection and analysis. In short, the research design is the guideline followed in conducting the study. It helps in planning the collection, measurement and analysis of data (Prabhat and Meenu, 2015).

The study aims to critically analyze the factors affecting domestic wastewater and reuse in Yeka Sub-city Woreda 04 and derive valuable recommendations. Therefore, a mixed method was used for the study. Creswell (2007) describes a mixed research model as follows:

> *A researcher is able to collect the two types of data simultaneously in a single data collection phase. It provides a study with the benefits of both quantitative and qualitative data. Moreover, by using the two different methods in this way, the researcher can gain perspectives from the different types of data or from different levels within the study.*

Based on the description, the study used a mixed method that includes the quantitative and quantitative method to understand a research problem. This method would allow validation of the data collected. The quantitative data were collected through a semi-structured questionnaire, while the qualitative data were collected through interviews with three key informants, namely the AAWSA manager, the environmental protection

expert of Yeka Sub-city, and the practitioner of Woreda 04 health center, in order to obtain all the desired information about the factors affecting the management and reuse of household wastewater.

3.2. Description of the Study Area

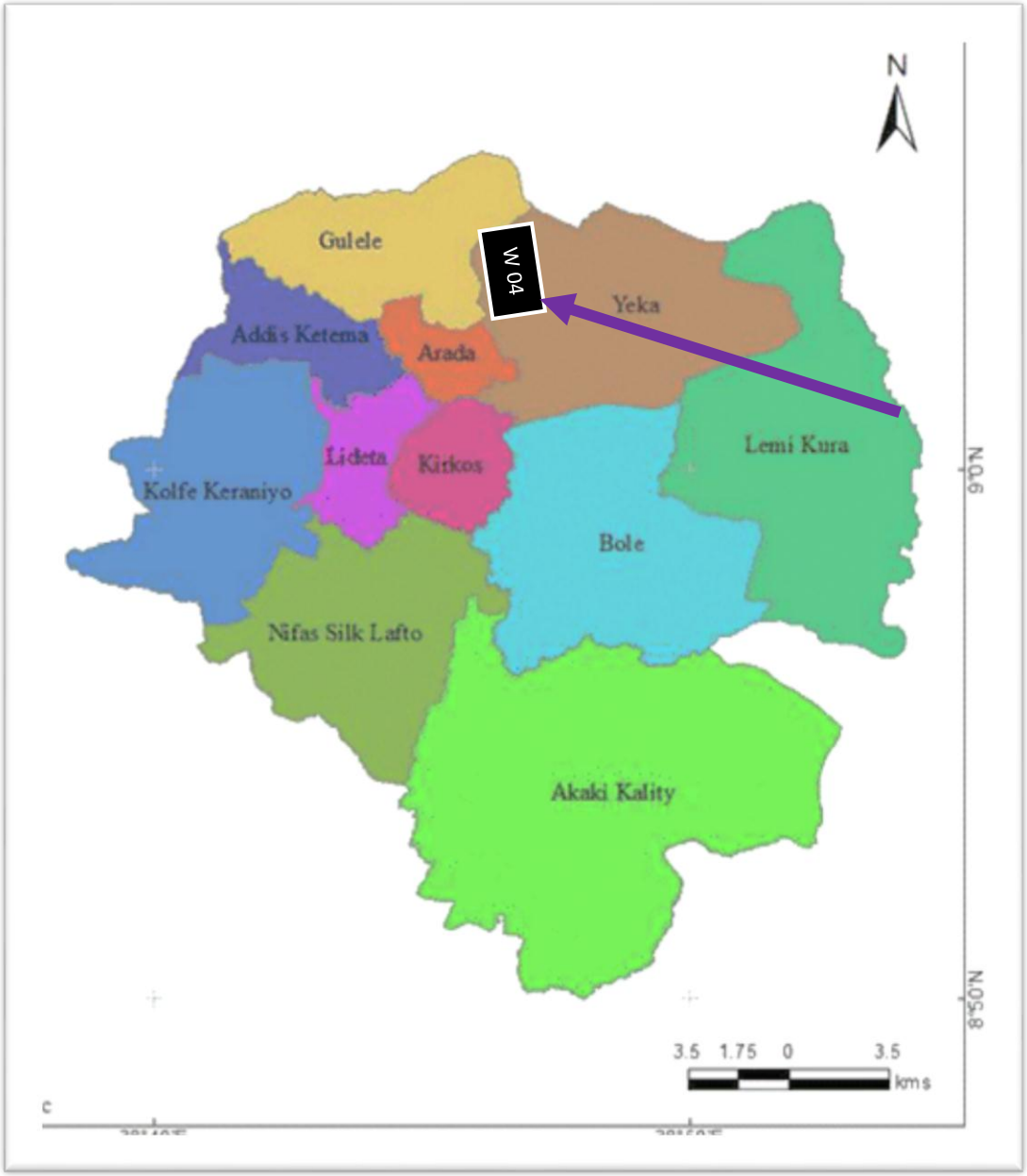
Since its founding in 1886, Addis Ababa has served as the capital of Ethiopia, economic center and diplomatic hub of Africa. With a total area of over 527 km² and a population of over 4.7 million, Addis Ababa lies entirely within the Awash River basin and borders the Abay River basin. The high population growth of 3.8%, exacerbated by in-migration, presents the city with significant challenges in providing safe water and sanitation systems (Addis Ababa Resilience Project office, 2021).

Wastewater management in Addis Ababa began in 1935, when urban wastewater management evolved from individual septic tanks to centralized sewage systems and later to decentralized treatment plants. Vacuum trucks were used to transport fecal sludge from the septic tanks to peri-urban areas. During the Italian occupation (1935-1941), a combined system for sewage and stormwater management was installed in Piassa and Merkato. Later, however, the city implemented a separate system with centralized treatment plant and drainage system. Even today, it is important to note that a significant number of buildings and houses have connected their sanitation systems and indoor pipes to the sewer system, resulting in mixing of wastewater and stormwater (Addis Ababa Resilience Project, 2021).

AAWSA is working to expand the existing sewerage system while continuing to expand decentralized sanitation. As a result, the courage to sewer, which was about 12.9 percent in 2017, requiring further efforts and investments to include additional areas in the sewerage system (Addis Ababa Resilience Project, 2021).

Currently, Addis Ababa Municipality is one of the self-governing cities in Ethiopia divided into 12 Sub-cities and 120 Woredas, of which Yeka Sub-city Woreda 04 was selected for the purpose of this study (Addis Ababa, 2022).

Figure 2: Map of Addis Ababa with Sub-cities and the study area



Source: Ethio-GIS, 2022

3.3. Data Sources

Studies show that most research, whether academic or applied, gathers information from both primary and secondary sources. Consequently, the study collected primary data from residents through a semi-structured questionnaire and interviews with the AASWA manager, the practitioner of Woreda 04 health center, and the environmental expert of Yeka Sub-city. Secondary sources from books, journal articles, theses and relevant reports were also used for the study. In addition, websites were also explored to some extent to obtain additional information.

3.4. Population and Sampling Procedures

The term population is defined as a group of entities with similar characteristics such as individuals, organizations, departments, brands, etc. (Christine and Immy, 2011). Accordingly, of the total population of 16,000 (Yeka Sub-city, 2022), 390 respondents were selected from the total population of Yeka-Sub-city Woreda 04 as the sample population according to the formula of Yamane Taro (1967). Based on Yamane's formula, the sample population was calculated as follows:

$n = N/ [1 + (Ne^2)]$

Where n = the sample size,

N = the population, which is 16,000

e = the margin of error (0.05 based on a 95% confidence level).

Thus, $n = \mathbf{16,000}/(\mathbf{1} + (\mathbf{16,000} * \mathbf{0.05^2})$

$n = \mathbf{390}$ would be the sample size of the study.

Once the sample size is determined, the next step is to determine the proportion of respondents using the proportionality formula. Accordingly, the total population of each Qetena (literally translated as "local") is divided by the target population and must then be multiplied by the sample size, which finally yields the total proportion of participants. Thus, the result of the proportion formula is as follows:

Roll no	Name of Qetena	Total population	Proportion	Sample size
1	Kela	2092	0.131	51
2	Jauar	2380	0.149	58
3	Camp	2380	0.149	58
4	Shola	2708	0.169	66
5	Shankela Meda	2215	0.138	54
6	Addis Birhan	2338	0.146	57
7	Cuba	1887	0.118	46
Total		**16,000**	**1**	**390**

The study then used a purposive sampling technique to collect data through a questionnaire. Christine and Immy (2011) suggested that those individuals who were eligible and met the inclusion criteria should be selected to participate in the study. Accordingly, study participants were selected to respond to the questionnaire based on their involvement in wastewater production and management. In other words, those who were less involved in wastewater production and management were ignored.

3.5. Purposive sampling

Purposive or non-probability sampling is a type of sampling procedure in which there is no basis for selecting the items to be included in the sample. In this type of sampling method, the item for the sample is intentionally selected based on the researcher's interest which means that, the researcher's selection of the items remains primary (Kothari, 2004).

In this study, the respondents who were involved in wastewater generation and management were selected while those who did not meet the inclusion criteria were excluded. This is the decision of the researcher. The researcher also considered the high, middle and low income households and held discussions with the relevant government agencies at Woreda level. This was done to ensure a fair representation of the economic status of the respondents, which again was decided by the researcher. The same applies to the selection of key informants.

The three key informants were also selected by the researcher considering their position and professional duties-a manager of AASWA, a practitioner of Woreda 04 health center, and an expert in environmental protection in Yeka Sub-city. The researcher strongly believed that the selection was just right to have such a combination and to obtain additional qualitative information through the interviews. As indicated above, all the necessary cautions were taken in the selection of the respondents and key informants as Singh (2006) stated that respondents who are selected through an arbitrary method because they are believed to be representative of the target population must consider some important criteria for the particular study, otherwise bias may occur.

Finally, the data collected through the questionnaire was supplemented with key informant interviews to make the results even more relevant, credible and reliable.

3.6. Data Collection Procedure and Tools

Data collection procedures and instruments are crucial in any academic and applied research. Therefore, an orientation was given to each of the respondents to make them aware of the purpose of the questionnaire to be completed. Then, the questionnaire was distributed to the selected respondents with the help and guidance of Woreda 04 administration. In order to avoid losing the completed questionnaire or having it arrive late, the questionnaire was collected on the same day it was completed. This system allowed the researcher to use the Woreda administration to check if the questionnaire was properly filled out and to find additional solutions on the spot. In this way, it took three weeks to complete the data collection.

The next important step was to collect the secondary sources of information, mainly from written documents such as policies, strategies, manuals and guidelines, laws, directives, rules and regulations, and annual reports, and other relevant documents from AAWSA, Yeka Sub-city, and Woreda 04. The collection of all these secondary sources of information would not have been possible without the sincere and diligent support of high-level officials and professionals. The nature of the data collection tools is described in each subsection below:

3.6.1. Questionnaire

As noted by Kothari (2004), the questionnaire is the most popular instrument for data collection, especially for large surveys. It can be either a structured or an unstructured questionnaire. In a structured questionnaire, the questionnaire could contain predetermined, defined, and specific questions. The questions would be prepared with exactly the same wording and presented to all respondents in the same order. In an unstructured questionnaire, the above characteristics of a structured questionnaire are not present and the interviewer is given a general guide to the type of information to be elicited.

However, in this study, a semi-structured questionnaire was created that included both closed and open-ended questions to allow respondents some flexibility to obtain additional information not included in the predetermined questions. The closed or structured questions in the questionnaire were designed to allow only two responses (they are dichotomous variables): Yes=1 or No=0. The collected data were properly coded and analyzed using Statistical Package for Social Sciences (SPSS) version-20.

3.6.2. In-depth Interviews

The in-depth interviews with key informants must be conducted carefully. This is because analysis of quantitative data alone cannot provide a sufficient impression. Therefore, conducting in-depth interviews with key informants was essential to consolidate the findings of the study.

According to Kothari (2004), an in-depth interview requires an interviewer to interview the subject face-to-face in order to assess the respondent's attitude, opinion, and general behavior. Prior to the key informant interviews, guiding questions were prepared to address some of the most sensitive issues related to the domestic wastewater management system. However, key informants were not censored at all; rather, an open dialog was allowed and informants were encouraged to ask further questions about the topic under study. The main task of the research at this point was to raise some critical questions and listen patiently. The in-depth interviews with key informants helped the researcher to gather pertinent information and their experiences with wastewater management in general and domestic wastewater management in particular at the level of city, sub-cities, Woredas, blocks and communities. Finally, the main objective of

conducting the in-depth interviews with AAWSA Manager, Woreda 04 Health Center Practitioner, and Yeka Sub-city Environmental Protection Professional was achieved, and the qualitative information obtained from the interviews was thematically analyzed in a separate section.

3.7. Validity and Reliability of the Instrument

3.7.1. Validity

Cooper and Schindler (2014) defined validity as the ability of the research instrument to measure what it is intended to measure, often questioning whether we are measuring what we want to measure.

The literature shows that there are three forms of validity classified as content validity, criterion-related validity, and construct validity, of which content validity was selected for the purpose of this study. Accordingly, two professionals with sound research skills reviewed the data collection instrument based on the research title, objective, and scale developed to measure the items. The result of the professionals' assessment shows that the validity of the instrument is quite good and meets the required standards. This is confirmed by Cooper and Schindler (2014), which states that determining content validity requires careful judgment by the researcher who designed the data collection instrument or by a panel of experts to assess how well the designed data instrument meets the required standards. Therefore, the method used to assess the validity of the instrument developed for this study was acceptable from an expert perspective. Another measure taken to ensure validity was to conduct a pilot test. The pilot test was conducted with 30 respondents randomly selected from the study area before the actual data collection began. Subsequently, questions that were ambiguous were refined and corrected.

3.7.2. Reliability

Reliability is fundamental in assessing how well the internal consistency of the instrument meets the minimum threshold. It is concerned with assessing the extent to which the measurement is free from random or unstable error, such that the reliable instrument could be used with confidence and transit and situational factors could not affect it (Cooper and Schindler, 2014). Accordingly, the internal consistency of the instrument was measured using a Cronbach's alpha. The reliability coefficient of 0.72 (72%) indicated that the internal consistency met the minimum standard, which is usually 0.65 and above (Appendix-3).

3.8. Data Analysis

The data collected with the help of the questionnaire and the in-depth interviews were analyzed and interpreted both quantitatively and qualitatively. The data collected with the help of the questionnaire were organized, properly coded and the statistical results were presented in frequency tables. The qualitative data were summarized thematically and presented in a separate section to provide a better understanding for the reader and a better impression of the main issues provided by the key informants. For quantitative data analysis, the researcher used Statistical Package for Social Science (SPSS) version-20.

3.9. Ethical Considerations

The application of ethical principles to data collection is essential. With this in mind, survey participants, key informants, managers, and professionals involved in this study were informed about the purpose of the study in order to obtain their consent and conduct the data collection smoothly. Their identities were anonymized. The individuals who were not willing to participate in the study were peacefully ignored. As much as possible, a peaceful relationship was established with all participants during data collection. The researcher's interaction with the study participants allowed her to gather all the necessary data and information for the analysis. It also helped the researcher to complete the data collection in a timely manner. This was all the result of the proper application of ethical principles.

CHAPTER FOUR

PRESENTATION AND ANALYSIS OF DATA

The main objective of this study is to investigate the factors influencing domestic wastewater management and reuse taking Yeka Sub-city of Woreda 04 as a case. The study analyzes and discusses the influence of urban growth, infrastructures and technologies; the influence of institutional arrangements and plans; the influence of culture of the communities such as awareness, knowledge, and skills on the overall domestic wastewater management and reuse in Woreda 04. The current status of the reuse of the domestic wastewater in the Woreda is also depicted. The analysis and interpretation of the results are conducted in an integrated manner throughout the chapter. However, it is worth mentioning that the analysis and interpretation of the results are divided into two main categories. Therefore, the quantitative and the qualitative results are presented and discussed in separate sections.

4.1.Quantitative Analysis and Interpretations

4.1.1. Demographic Characteristics of Respondents

As shown in Table 1, the majority of respondents, 264 (67.7%), were males, while the rest, 126 (32.3%), were females. This means that most of the males were involved in domestic wastewater management. However, in the management of domestic wastewater, women need to be encouraged and involved to the extent that their participation reaches the proportion of men. Several studies show that women are very interested in household management and environmental sanitation. Therefore, governments, in cooperation with non-governmental organizations, should devote their time and energy to raise women`s awareness in the field of wastewater disposal, treatment and reuse. Their participation in domestic wastewater management would obviously bring about a significant change.

In the age category, people aged 41 years and above 198 (50.8%) participated in the study, followed by the age category 20-30 years, while the age group between 31 and 40 years had the lowest percentage. The age category of respondents shows that as residents get older, they take

more responsibility for wastewater management and other social tasks such as *Equb*[2], *Edir*[3] and other development activities at the community level.

The younger age group, 20-30 years old, was the second active participant in the study. This is because young people are energetic and like to tackle new issues to meet the challenges, not only in the field of sanitation, but also in all new initiatives implemented at the community level. This is confirmed by the study of Shiwagnizaw (2020), which states that youth are very eager, energetic, and capable of learning new initiatives, and they want sanitation laws to be enforced and put into action. Gabisa et al. (2021) also describe that youth participation in sanitation is the highest among all respondents.in their study conducted in northwestern part of Ethiopia.

Regarding the marital status of the respondents, majority of them 271(69.5%) were married, 66(16.9%) were divorced and 53(13.6%) were unmarried or single. The result shows that most of the respondents have family responsibilities, so the probability of their participation in environmental rehabilitation including household wastewater management and reuse is high. The married men or women are responsible for family members, especially children, and for all social issues that require discussions and financial, in-kind and material contributions.

Regarding the education level of the respondents, most of the participants were illiterate, 323 (82.8%), and only 67 (17.2%) of them had education. This result is in contrast with the studies of Shewangizaw(2020) and Gabisa et al(2021). However, the studies show that as the level of education increases, so does the awareness of the issue. Therefore, education is essential to bring about change in domestic wastewater management and reuse in the medium and long term periods. Even if most of them are not educated, creating awareness about their participation in domestic wastewater management and reuse would be crucial and must be duly considered in the coming years.

Most of the participants were unemployed, 291 (74.6%), while the remaining 99 (25.4%) had jobs. The idea is that people with lower income or unemployed contribute less to wastewater generation and have a lower perception of wastewater disposal and reuse. In the study by Gabisa

[2]. The traditional saving system often conducted at the community level.

[3] . The traditional institution established by members of the communities for the purpose of mourning, and assisting orphans and elders in time of needs.

et al. (2021), it was found that the higher the education, the greater the awareness of wastewater management.

The main focus needs to be on those members of the community who generate a lot of wastewater, and much needs to be done to improve their awareness of wastewater management and reuse, as potable water scarcity is widespread in the community

In general, the demographic characteristics show that regardless of education level, the age group of 31-40 years old and the age group of 20-30 years old actively participated in wastewater management and reuse in Yeka Sub-city of Woreda 04. Those respondents who were married were more involved and participated in domestic wastewater management and reuse. The results show that the demographic characteristics of the respondents play an important role in the management of domestic wastewater in Woreda 04.

Table 1**:** Demographic characterstics of respondents

Items	**Categories**	**Frequency(N)= 390**	**Percent (%)**
Gender	Female	264	67.70
	Male	126	32.30
Age	20-30	198	50.80
	31-40	168	43.10
	41 and Above	24	6.20
Marital status	Single	53	13.60
	Married	271	69.50
	Divorced	66	16.90
Education status	Illiterate	323	82.80
	Literate	67	17.20
Employment status	With jobs	291	74.60
	Jobless	99	25.40

Source: Survey result, 2022

4.1.2. Influence of Societal Culture on Domestic Wastewater

The following variables, such as the culture of the households in the community, the skills that can be practically implemented, the knowledge and awareness related to the management and reuse of domestic wastewater.

As can be seen in Table 2, most of the respondents, 238 (61%), indicated that the culture of the society influences wastewater management and reuse. An important point to make here is that all relationships between people and their environment are embedded in culture (UNSECO, 2006). UNSECO further stated that:

> *Due to the elementary role of water for people's life, the way to treat, handle and use water has ever been anchored in people's cultural values and traditional practices. Therefore, we have to acknowledge that solutions which are developed and maintained by the local people themselves stand the best chance of long-term success of water and sanitation systems and sustainable resource management.*

From the above quote, we can learn that the culture of society plays a positive role in wastewater management to achieve sustainable development. However, there is also a negative aspect, which is that the culture of society leads to poor wastewater management and reuse. In some communities, there is still a belief that river water is pure and used for various purposes, including drinking. UNSECO (2006) pointed out that in today's urban environment, where water bodies are affected by industrial effluents, the environment, including the living beings around us, is so affected that the direct use of water from rivers would have disastrous consequences. This shows that society's shared values, beliefs, and traditions influence wastewater disposal and reuse either positively or negatively. Therefore, an exit strategy needs to be developed to promote a culture that supports good wastewater management and reuse, and to eliminate cultural aspects that negatively affect wastewater management through education and awareness programs.

Skills are a critical challenge in wastewater management, treatment, and reuse. This is particularly challenging in developing countries such as Ethiopia (UNESCO, 2012).

Accordingly, lack of required skills and capacity at community level would affect domestic sanitation and wastewater reuse. This is confirmed by 287 (73.6%) of the respondents that the handling and utilization of wastewater is affected by lack of skills. This is indeed a critical challenge in Addis Ababa, not to mention Woreda 04 of Yeka Sub-city.

Like skills, knowledge is fundamental to the management and reuse of domestic wastewater. Therefore, 269 (69%) respondents answered that knowledge influences sanitation, which seems to be true. In developing countries, including Ethiopia, this is a critical issue that needs to be addressed through short, medium and long term planning. In addition, communities in the Woreda should be made aware of household wastewater management and reuse through various interventions.

In general, culture of the community which includes skills, knowledge, and awareness are critical factors that influence wastewater management and reuse in Woreda 04. These important factors must be considered if domestic wastewater management is to be improved at the community, Woreda, Sub-city, and city levels. This is because the work requires coordination at all levels.

Table 2: The Influence of culture, skills, knowledge and awareness

Items	Response	Frequency(N)= 390	Percent (%)
Culture	No	152	39.00
	Yes	238	61.00
Skills	No	103	26.40
	Yes	287	73.60
Knowledge	No	121	31.00
	Yes	269	69.00
Awareness	No	143	36.70
	Yes	247	63.30

Source: Survey result, 2022

4.1.3. Influence of Institutional Arrangements and Plans on Domestic Wastewater

As shown in Table 3, respondents indicated that community participation, planning and livelihood, sewerage system, coordination with stakeholders, and resources used for domestic wastewater management could affect domestic wastewater management. Accordingly, most of the respondents, 277 (71%) answered that community participation would influence domestic wastewater management in Yeka Sub-city of Woreda 04. This implies that community participation is necessary to mobilize all needed resources, i.e. finances, materials and even constructive ideas on how to improve the wastewater management system. The community through its representatives should be involved in the planning process, implementation and completion phases of wastewater management in each Ethiopian fiscal year and related projects to improve the wastewater management system. In this context, the findings of Gede et al. (2020) indicate that the provision of "facilities and infrastructure for low-income, slum, and wastewater-prone areas, as well as community-based sanitation activities, need to be introduced." Gede et al. go on to state that this cannot be done without the active participation and involvement of communities.

About 263 (67.4%) of the respondents agreed that planning affects domestic wastewater management and reuse. As discussed above in relation to community participation, planning requires community involvement in the initiation, planning, and implementation phases, as well as in the evaluation of the performance report. This is essential to foster a sense of community ownership and ensure sustainable protection from damage, looting, and abuse. In addition, planning allows activities to be carried out in order of importance and sequence. The results assure that this is quite correct and acceptable.

Regarding the livelihood of the community (income and standard of living), 258 (66.2%) of the respondents agreed that the livelihood of the community affects domestic wastewater management and reuse. This infers that the poor and marginalized members of the community have low awareness of domestic wastewater management and that their activities will have a critical impact on it. This population needs to be sensitized by establishing a system that is directly linked to the Woreda 04 wastewater management. The Woreda 04 administration should

focus on the poor and marginalized society to achieve a comprehensive change in domestic wastewater management and reuse.

Another critical factor affecting domestic wastewater management and reuse is the sewer line. For this reason, 287 (73.6%) of the respondents indicated that the lack of coverage of the sewerage network affects the management and reuse of domestic wastewater. The limited coverage of the sewerage network in the Woreda and the lack of other sanitation facilities have forced a large number of the residents to dispose of domestic wastewater into any open spaces, including drainage systems, creating a favorable environment for pathogenic microorganisms that threaten community health.

About 294 (75.4%) respondents indicated that coordination with stakeholders plays an important role in the management and reuse of domestic wastewater. This indicates the need to promote proper coordination with communities, governmental and non-governmental organizations, self-help associations such as edir, and other interested entities. However, coordination requires proper management and should be guided by a plan so that the expected outcome prevails in the management of domestic wastewater.

Domestic wastewater management and reuse is capital intensive. Nevertheless, these huge capital investments in construction, operation, and management of wastewater technologies are not available in developing countries like Ethiopia (Oladoja, 2017). Therefore, it seems reasonable to see that most of the respondents, 314 (80.5%), expressed their opinion and answered that wastewater resources affect demostic wastewater management. Therefore, the application of cost-effective technology in the study area is feasible given the lack of existing resources for wastewater management.

In conclusion, community participation, planning, community living standard, proper coordination through a plan, wastewater network, and resource availability have an impact on domestic wastewater management and reuse in Yeka Sub-city of Woreda 04. The impact of these factors depends on their proper use in the management system. If used properly, they improve domestic wastewater management. If not, they have disastrous effects on the environment and communities as a whole.

Table 3: The influence of institutional arrangements and planning

Items	Response	Frequency(N)= 390	Percent (%)
Community participation	No	113	29.00
	Yes	277	71.00
Planning	No	126	32.60
	Yes	263	67.40
Community`s livelihood	No	132	33.80
	Yes	258	66.20
Sewerage system	No	287	73.60
	Yes	103	26.40
Coordination with stakeholders	No	294	24.60
	Yes	96	75.40
Domestic wastewater manageable resources	No	76	19.50
	Yes	314	80.50

Source: Survey result, 2022

4.1.4. Influence of Urban Growth, Infrastructure and Technology on Domestic Wastewater

As can be seen in Table 4 below, the majority of respondents 235 (60.3%) indicated that the population size in the Yeka Sub-city of Woreda 04 affects domestic wastewater management. Several studies show that urbanization complicates domestic wastewater management. Rural-urban migration combined with natural growth within urban centers exacerbates domestic wastewater management, showing that population size is one of the most important factors in wastewater management. It is widely recognized that as urban population increases, wastewater generation also increases, which puts tremendous pressure on wastewater management agencies, municipalities, and all governmental and non-governmental organizations concerned. This is also true for the Yeka Sub-city of Woreda 04.

Regarding urbanization, 243 (62.3%) of the respondents answered that urbanization affects management. This problem is clearly stated in IEAM (2018) that rapid urbanization coupled with various socio-economic activities has aggravated wastewater production, operation, maintenance and investment. Therefore, it is inevitable that urbanization pressure in Addis Ababa is likely to directly or indirectly affect the study area, Yeka sub-city of Woreda 04.

About 264 (67.7%) of the respondents indicated that technology has an impact on household wastewater management. In Ethiopia's urban centers, especially in Addis Ababa, cost-effective technology is very important. This is because cost-effective technologies are appropriate to the local conditions of low-income communities and reduce the burden on sanitation authorities such as AAWSA and its subordinate agencies in the Yeka Sub-city down to the Woredas. The cost-effective technologies must be durable, environmentally friendly, accessible, replicable, and easily maintained by the local population, as confirmed by Kalbar et al. (2012). In other words, high-tech wastewater systems are not affordable because they are very expensive and require experts with high technical skills that are not readily available at the local level. Frankly, this could even be a challenge for AAWSA itself. However, the current situation in Yeka Sub-city of Woreda 04 shows that communities do not have technologies to help them manage and reuse domestic wastewater.

About 290 (74.4%) respondents confirmed that access to transportation is essential to improve domestic wastewater management. However, in the Woreda 04 study area, there are slum areas that are not easily accessible to vacuum trucks. This is clear evidence that some residents do not benefit from the vacuum trucks. When this happens, residents prefer to look for other options, one of which could be to dispose of wastewater in open spaces in their neighborhood.

Table 4: Urban growth, technology and transport access

Items	Response	Frequency(N)= 390	Percent (%)
Population size	No	155	39.70
	Yes	235	60.30
Urbanization	No	243	62.30
	Yes	147	37.70
Technology	No	126	32.30
	Yes	264	67.70
Transportation access	No	100	25.60
	Yes	290	74.40

Source: Survey result, 2022

4.1.5. Current Status of Domestic Wastewater Reuse in Woreda 04

As shown in Table 5, the majority of respondents, 275 (70.5%), answered that they use wastewater for toilet flushing. Domestic wastewater generated in the kitchen is used for cleaning toilets. This is probably true not only in Yeka Sub-city of Woreda 04, but also in several communities of Addis Ababa and in other urban centers of Ethiopia. One of the factors driving wastewater reuse may be that Woreda 04 is facing a shortage of piped water. Wastewater reuse for vegetable cultivation is also observed in Woreda.

It is unfortunate to see that domestic wastewater mixed with hazardous liquid wastes from industries, especially tanneries, hospitals, and research institutions, are used for various purposes, including irrigation in peri-urban areas near Woreda 04. Such practice is confirmed by Elfu et al. (2017), increasing water demand in agriculture and poor monitoring and enforcement mechanisms make wastewater management complex. As a result, the use of untreated wastewater, especially for irrigation purposes, is widespread and violates national and international obligations. This is a clear indication that hazardous wastewater from residential areas could be used for the purpose mentioned by Elfu et al.

In brief, the use of untreated domestic wastewater in Yeka Sub-city of Woreda 04 has become common at the household level for toilets and vegetables, while in nearby peri-urban areas it is used for the production of various vegetables, most of which are consumed by residents in the Woreda and other parts of the city. This should be done with caution, as it has chronic effects on the health of residents and the environment.

Table 5: Reuse of the domestic wastewater

Item	Response	Frequency	Percent (%)
Reuse of domestic wastewater	No	115	29.50
	Yes	275	70.50
Total		**390**	**100**

Source: Survey result, 2022

4.2.Qualitative Analysis and Interpretations

There are two basic components to discuss in this section: in-depth interviews and researcher`s observations. The in-depth interviews were conducted with the AAWSA manager, the Yeka sub-city environmental expert, and practitioner of the Woreda 04 health center. The researcher's observations would then constitute the second step. The in-depth interviews and the researcher's observations are analyzed and discussed thematically to consolidate the quantitative results and are presented separately below:

4.2.1. In-depth Interviews

4.2.1.1. Wastewater as a resource

According to key informants, most community members do not believe that domestic wastewater can be recovered through technology and used as a resource. Thus, the key informants say that domestic wastewater could be used as biogas, but this is not the case in the Yeka Sub-city of Woreda 04. Wastewater discharged by residents is mainly used for irrigation and watering animals in the communities. Due to water scarcity in the Woreda and the city as a whole, the use of domestic wastewater for toilets and vegetables is increasing, although most of it is discharged into open spaces, rivers, and drainage systems.

This shows that much needs to be done to raise awareness of how domestic wastewater can be recovered and safely used, and that there should be mechanisms to introduce cost-effective technologies to recover domestic wastewater.

4.2.1.2. Knowledge and awareness of communities on technologies

Key informants said that in the Yeka Sub-city of Woreda 04, domestic wastewater is discharged from houses without being filtered and treated. The community does not have the habit of sorting solids and sewage sludge, and the limited and expensive machines are damaged by oil, solid waste and gasoline, shortening the life of each of the refineries. Municipalities do not have the knowledge or financial resources to acquire the necessary equipment to treat domestic wastewater. This requires concerted action by Woreda to raise awareness of cost-effective and optional technologies for wastewater treatment at the household level.

4.2.1.3. Institutional arrangements and plans

There are several problems related to the poor management and reuse of domestic wastewater. One of them is the organizational structures and planning aspects from AAWSA down to Yeka Sub-city of Woreda 04. The organizational structure needs to be updated to include additional staff, especially in the operations, maintenance, and monitoring and evaluation departments, and to modernize them. There is a shortage of highly qualified professionals in the areas of wastewater facilities, monitoring and evaluation of all activities. At the level of Woreda, the organizational structure is shallow only a few specialists in all departments, which does not meet the ever-increasing demands and interests of customers. The existing organizational structure at the Woreda level is so weak that it is unable to enforce the laws on the ground. Even if the institution in the Yeka Sub-city of Woreda 04 had a plan, the lack and low coverage of the sewage network and infrastructures resulted in the Woreda being forced to connect domestic sewage to the drainage pipe and river. As a result, the likelihood of pollution of the river is high, people living near the river are more likely to be exposed to waterborne diseases, and the area has no master plan for the installation of sewers.

Woreda residents are not involved in the planning process. However, efforts are being made to conduct a needs assessment to prioritize their needs and procure any necessary facilities to improve domestic sanitation and reuse. There is a directorate that is supposed to engage and involve the communities at the grassroots level, but it is not working for various reasons, mainly due to the lack of commitment from the leadership.

In summary, the organizational structure and planning in Yeka Sub-city of Woreda 04 is one of the stumbling blocks in improving the household wastewater management and reuse system. It was not well organized to meet the current needs of customers and enforce local laws.

4.2.1.4. Quality environment for sustainable development

According to key informants, domestic wastewater has caused serious damage to the environment. It disturbs the ecology of the river by stimulating the growth of algae in the water, which in turn contributes to a lack of oxygen for the animals living in the aquatic ecosystem, leading to depletion as well as bad smells when walking near the river. In general, they agreed that the responsible institutions have failed to hold each other accountable for their wrong deeds and actions, and often communicate and blame each other in the wrong way. Key informants said that Addis Ababa faces several problems in the management and reuse of domestic wastewater that need to be addressed by the relevant government agencies. This means that a quality environment is fundamental to sustainable development, which requires a holistic approach to address existing environmental problems in short, medium and long-term plans.

In summary, the in-depth interviews show that improving the organizational structure and hiring the right technical experts for operations, maintenance, and monitoring and evaluation from the sub-city down to the Woreda are necessary. In addition, it is essential to provide cost-effective technologies to recover wastewater for reuse and to raise awareness about the treatment and reuse of domestic wastewater. It should be noted that community participation in planning, implementation, and performance evaluation is an important step in prioritizing problems and addressing them properly.

4.2.2. Researcher`s Observations

The researcher conducted observations in different areas of Yeka Sub-city of Woreda 04 to get an overview of the current overall situation of domestic wastewater disposal and reuse and environmental quality.

As can be seen in Figure 2 below, there is a mixture of solid and liquid waste in Kotebe. This occurs at the sources of generation, either from homes, institutions, hotels and restaurants, or research facilities. From this, we can conclude how wastewater affects Woreda 04 and its surroundings.

Figure 2: Kotebe wastewater treatment showing the mix of liquid and solid waste

Source: Researcher's observation, 2022

To make matters worse, wastewater near the Kotebe sewage treatment plant is used for irrigation purposes. This is the vegetable consumed mainly by the residents of Yeska Sub-city of Woreda 04 without testing to ensure it is free of heavy metals and pathogenic microorganisms. This could have chronic effects on human health.

Figure 3: Irrigation using wastewater nearby Kotebe wastewater treatment

Source: Researcher's observation, 2022

The researcher's observations revealed that domestic sewage pollutes the environment, especially the river, and is used for irrigation along the course of the river, which requires great attention. Even irrigation done near the Kotebe wastewater treatment plant would have disastrous health effects. Even if the water is treated, it could contain heavy metals that have chronic effects on human health and biodiversity in the Woreda and its surroundings.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

The main objective of this study was to investigate the factors affecting the management and reuse of domestic wastewater, using Yeka Sub-city of Woreda 04 in Addis Ababa as a case. The basic questions the study sought to answer were the influences of urban growth, infrastructures and technologies, institutional arrangements and planning, and societal culture which includes awareness, knowledge, and skills on domestic wastewater management and reuse. The study used a mixed research design with quantitative and qualitative methods to conduct the analysis. Descriptive statistics and thematic analysis were used to analyze and interpret the results of the study.

The summary of the main findings is as follows:

- Of the 390 respondents, male participation was higher than female participation, which accounted for 264 (67.4). About 198 (50.8%) of them were over 41 years old, followed by the age group of 20-30 years old. This shows that most of the participants were in the active age range. The results show that participants take more responsibility for wastewater disposal and reuse as they get older.
- Most of the respondents, 271 (69.5%), were married and had more responsibility for domestic wastewater management. However, in terms of education level, it was found that only a small number of respondents, 67 (17.2%), had education, which indeed requires further investigation. The majority of them were unemployed.
- The majority of the respondents, 138(61%), asserted that the culture of the society, such as skills, knowledge and awareness, could influence domestic sanitation and wastewater reuse. Since culture determines the relationships between people and their environment, it could influence wastewater management and reuse either positively or negatively. In addition, culture also plays a critical role in achieving sustainable wastewater management.

- Most of the respondents, 277 (71.1%), affirmed that institutional arrangements are not designed to allow community participation in domestic wastewater management in Yeka Sub-City of Woreda 04. This is because community participation would help mobilize resources in the form of finances and materials to improve the wastewater management system. Community participation would play an important role in creating awareness about the institutional arrangement for wastewater management. Key informants also confirmed that there is a lack of highly qualified professionals in wastewater facilities, monitoring and evaluation from the sub-city down to the Woreda, so wastewater management has remained weak and unable to meet the needs and interests of customers.
- The lack of infrastructure such as access roads and cost effective technology is a challenge in Yeka Sub-city of Woreda 04 in the area of wastewater management. This situation is made much more complex and worse by rural-urban migration. With the increase in urban population, the wastewater generation is also increasing, which is putting tremendous pressure on the wastewater management authorities, municipalities and all concerned governmental and non-governmental organizations.
- Key informants asserted that most residents and households do not consider wastewater as a resource that could be recovered and utilized. This is due to lack of awareness and awareness programs at the Woreda level. Most of the wastewater generated by various organizations, hotels and restaurants, residences, and research facilities is discharged into open spaces and sewage systems, which eventually end up in water bodies. The result is a deterioration of environmental quality.

5.2. Conclusion

The study found that culture, which is the most important foundation of skills, knowledge, and awareness, could influence the management and reuse of household waste. Proper use of culture would promote wastewater management. However, in Yeka Sub-city of Woreda 04, it was found that communities do not have enough skills, knowledge, and awareness to recover and reuse wastewater for various purposes.

Another important factor affecting domestic wastewater management and reuse is institutional arrangements. Institutional arrangements and plans did not create a favorable environment for community participation in resource mobilization. In addition, the study found that there was a lack of technical experts to oversee, track, monitor, and evaluate all wastewater management in the Woreda. This showed that institutional arrangements and plans were so weak that they could not meet the ever-growing demands and needs of customers.

The lack of infrastructure, such as accessible roads for vacuum trucks and cost-effective technologies, affected the management and use of domestic wastewater generated. As a result, the management of domestic wastewater became complex and was unable to serve the existing population. Therefore, the municipalities were forced to discharge the wastewater into some open spaces and sewage system that eventually flows into the water bodies, which deteriorates the quality of the urban environment and affects the health of residents in the Woreda and its surroundings.

The use of domestic wastewater in the Woreda and its surroundings is constantly increasing. It is also used for irrigation in peri-urban areas, which has chronic health impacts on humans, animals, and the ecology as a whole.

In general, the study found that the culture of the society, organizational structure and planning, infrastructure, and cost-effective technologies influence the management and reuse of domestic wastewater in Yeka Sub-city of Woreda 04 in Addis Ababa.

5.3. Recommendations

Based on the results of the study, the following innovative recommendations are forwarded:

- Since the culture of the society is the source of skills, knowledge and awareness, the Woreda which manages domestic wastewater must use it properly. If properly used, there is no doubt that the culture would enable to improve domestic wastewater management as well as society's behavior towards wastewater management and reuse.
- At the Woreda level, there should be well-designed institutional arrangements and comprehensive plans to meet the needs of customers and enable community participation to easily mobilize the needed resources for wastewater resources. In addition, restructuring the organization would enable the hiring of experienced technical experts so that overall wastewater management maintenance, operation, monitoring, and evaluation could be improved at an early stage.
- The provision of infrastructure and low-cost technology is essential. This will certainly help to recover wastewater and reuse it for various purposes. This is one of the best mechanisms to address water scarcity in the Woreda.
- Continuous awareness programs should be part of the Woreda's plan as this would bring a lot of benefits in improving and upgrading domestic wastewater management in the Woreda.
- Great efforts should be made to minimize the use of domestic wastewater, as over time in Woreda 04 and areas close to the city, domestic wastewater is increasingly used for various purposes, including irrigation.

In general, the implementation of the above recommendations should be done in cooperation with the concerned governmental and non-governmental organizations and communities to improve the management of domestic wastewater in Yeka Sub-city of Woreda 04.

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Appendixes

Appendix 1: Survey questionnaire

Introduction

Based on the overall objective of the study, the following questionnaires have been prepared to explore the implications for domestic wastewater management in Yeka sub-city, Addis Ababa, Ethiopia. The purpose of these questionnaires is to complete a master's degree. I invite you to participate in this study and I assure you that the information you provide is very important for this study. If you come up with something out of the ordinary; you have to pass to the next question.

Thank you so much in advance

1. Questions focused on participants' general information

1.1. Gender

1. Male ☐ 2. Female ☐

1.2. Age?

1. 20-30 ☐ 2. 31-40 ☐ 3. 41 and above ☐

1.3. Marital status?

1. Single ☐ 2. Married ☐ 3. Divorced ☐

1.4. What is your educational status?

1. Illiterate ☐ 2. Educated ☐

1.5. What your employment?

1. Jobless ☐ 2. Employed ☐

II. Public inquiries

Instruction two: Please read the following questions carefully and place an automatic check mark (√) with the words "Yes or No" in the table in front of the questions.

No.	**2. Questionnaire based on Skills, knowledge, culture and awareness of societies towards domestic wastewater management and reuse.**	**Yes**	**No**
2.1	Is managing home wastewater and reuse influenced by culture?		
2.2	Is managing home wastewater and reuse affected by skill?		
2.3	Is managing domestic wastewater and reuse influenced by knowledge?		
2.4	Is managing domestic wastewater and reuse i affected by awareness?		

No.	**3. Questions focused on institutional preparation and developmental planning.**	**Yes**	**No**
3.1	Is managing domestic wastewater and reuse influenced by community participation?		
3.2	Is managing home wastewater and reuse influenced by developmental planning?		
3.3	Is managing domestic wastewater and reuse influenced by sewerage line system?		
3.4	Is managing home wastewater and reuse influenced by stakeholder cooperativeness?		

No.	4. Income oriented question.	Yes	No
4.1	Is managing domestic wastewater and reuse influenced by livelihood standard (economy)?		

No.	5. Technology and growth focused questionnaires	Yes	No
5.1	Is managing domestic wastewater and reuse influenced by size of population?		
5.2	Is managing home wastewater and reuse affected by urbanization?		
5.3	Is managing domestic wastewater and reuse influenced by technology use at home?		
5.4	Is managing domestic wastewater and reuse influenced by transportation vehicles and disposal site?		

No.	6. Question based on domestic wastewater management and reuse	Yes	No
6.1	Is domestic wastewater is manageable and reusable resource?		

Thank you

Appendix 2: Leading questions for key informants

I. For Medical Director of Woreda 04 health center

1. How do you recommend the health effects of improper domestic wastewater management?

2. What should be done to improve the existing domestic wastewater management system?

3. How do you react the coordination of your health center with Yeka sub city wastewater management body and the office of environmental protection?

4. If there is anything else regarding the wastewater management and reuse, you are welcome.

Thank you so much for your courtesy

II. For Environmental expert

1. What are the impacts of improper domestic wastewater management in general and in Yeka Sub-city of Woreda 04 in particular?
2. How do you recommend on sewage treatment and infrastructure in the Yeka Sub city of Woreda 04?
3. Your suggestion on improper management and disposal damage on the wastewater infrastructure
4. What actions should be taken (in short, medium, and long term) to improve the domestic wastewater management and reuse in Woreda 04. Hint:

    A. From the government,
    B. From the Public,
    C. From governmental and non-
    D. governmental organizations,
    E. From other actors,

Thank you so much for your courtesy

III. For AAWSA`s manager

1. Is there any clear policy on domestic wastewater management and reuse in the city level? If so, what are the strategic issues identified on the policy?
2. How do you recommend the organizational structure, the plans, and the professional mix of the AAWSA from the center down to sub-city, and then to Woreda.
3. What are the critical challenges in the domestic wastewater management and the actions taken to address them?
4. How do you recommend the participation and involvement of the public and key stakeholders to improve the wastewater management and reuse?

Thank you so much for your courtesy

Appendix 3: Coefficient of reliability result

Case Processing Summary

		N	%
Cases	Valid	390	100.0
	Excluded[a]	0	.0
	Total	390	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.72	20