College of Development Studies Master's Program in Water Resource Management

MSc Research Thesis

Investigating the Challenges and Opportunities of Centralized Domestic Wastewater Management in Kaliti Catchment, the Case of Akaki-Kaliti Sub-City, Addis Ababa

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This is to certify that this MSc thesis prepared by Shewangizaw Amare entitled: "Investigating the Challenges and Opportunities of Centralized Domestic Wastewater Management in Kaliti Catchment, the Case of Akaki-Kaliti sub city, Addis Ababa" Submitted in partial fulfillments of the requirements for the Degree of Master of Science in Water Resource Management complies with the regulations of the Addis Ababa University and meets the accepted standards with respect to originality and quality.

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Declaration

This Thesis is carried out in partial fulfillment of the requirements for the degree of Master of Sciences in Water Resource Management. The thesis is wholly the original work of the researcher and has not been submitted in any form for any degree or diploma to any other University.

Shewangizaw Amare Gebresilassie

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Signed Date

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Acronyms

AAWSA	Addis Ababa Water and Sanitation Authority
BOD	Biochemical Oxygen Demand
CE	Cost Effective
COD	Chemical Oxygen Demand
EPA	Environmental Protection Authority
MoWIE	Ministry of Water, Irrigation and Energy
TF	Trickling Filters
UASB	Up flow Anaerobic Sludge Blanket Reactors
UWWTP	Urban Wastewater Treatment Plant
WASA	Water and Sanitation Authority
WWTP	Wastewaters Treatment Plant

Tables of contents

List of figure

List of tables

Abstract

Efficient ways of managing domestic wastewater discharges is the foundation of sustainable and modern urban city development. Sustainability of urban water system stands on appropriate treatment mechanisms and reuse of wastewater discharges. As a result, wastewater can be considered not as a problem that requires to be disposed of but rather as a variety of local resources. The background of this study in general relays on human factors, a cause to pollute the environment with various day to day activities. So the Objective of the study is to examine the challenges and opportunities of domestic wastewater management in Addis Ababa city based on study conducted in Akakii Kaliti subcity. The data was collected through survey questioners, interview and physical observation of the study area. Primary and secondary data was collected from households and relevant stakeholders in Addis Ababa Water and Sanitation Authority and Kaliti treatment plant. Various aspect of wastewater management was inspected on site. Simple random sampling was applied to select the sample households, whereas, Purposive sampling was used to select the sample Sub-city, and key informants for interview. By this sampling technique 138 respondents were selected from the 181202 total populations. Descriptive statistics analysis used to analyze data and the collected data were analyzed using statistical software (SPSS version 24.0). The capacity of government, societal attitudinal change, and technology and manpower are the major factors of efficient and effective wastewater managements respectively. Most of the respondents do not accepted the treated wastewater purity and the treatment efficiency of Kaliti treatment plant below 50% for irrigation, carwash and toilet purpose. In the field study there is no private organization, which participates in the treatment processes. However government is not attending the demand of wastewater treatment. The Luck of adequate sewerage system in the city and deteriorations of sewer line and luck of regular repair and maintenance are the main factors to reach the waste at central level. In the study area wastewater become more complex and the quantity has also increased from time to time. Lack of awareness and enforcement are some of the challenges facing wastewater treatment plant in Addis Ababa city administration. Kaliti wastewater treatment plant is currently used up flow anaerobic sludge blanket reactors trickling filters technology, but it operates under its design capacity. Therefore, domestic wastewater discharges from the city households should be administered sustainably.

Key words: **Domestic Wastewater, Addis Ababa, Wastewater Management, Impact of Wastewater Treatment**

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Urban communities and cities all over the world are facing a range of dynamic global and regionally changing pressures and problems in related to improper local wastewater discharges. They are facing difficulty in efficiently and transparently managing ever scarcer water resources, delivering water supply and sanitation services. There is serious of challenges on disposing of wastewater and minimizing negative impacts to the environment in general and eco-system in particular. In order to develop better solutions to manage urban water more effectively, these global and regional pressures must be recognized and used to drive the design and management processes of urban water systems (Ali& Eyasu, 2017)

The history of modern water and wastewater handling started with the health challenges in large cities and towns. To provide safe water supply when the local sources ran dry or became polluted, water was piped from reservoirs outside the city. To transport wastewater out of the city, large collection and drainage systems were constructed. About 150 years ago, the flush toilet was introduced and human excreta were flushed out through the sewers into receiving water bodies. The discharge of untreated wastewater resulted in a local and often regional deterioration of water quality. However, it took almost a century before wastewater treatment became standard practice in rich countries and still 90% of the world's wastewater is discharged untreated. Water and wastewater management are still lacking in many countries. Whereas in most industrialized countries safe water is supplied to the population and wastewater pollution control has progressed substantially, in low and middle income countries the situation is different, with lower coverage of both water supply system and sanitation services. Still, water supply coverage is usually higher than the sanitation coverage (Temesgen, 2018).

In developing countries, rapid population growth and urbanization is creating an added demand for housing, infrastructure services including sanitation services. Providing sanitation services especially for the poor who are living outside the designated residential areas like illegal settlements or slums is a challenge. The World Bank estimates that almost 26% of the global urban population, over 400 million people, lack access to the simplest latrines (Worled Bank, 2012).

In developing countries, for example 85% of the population has access to safe drinking water, whereas only 32% has access to sanitation services (Temesgen, 2018). Recent reports indicate that worldwide more than half of the population of developing countries does not have access to sanitation and more than 80% of the wastewater generated is directly discharged into surface and ground water bodies (WHO, 2010).

In Ethiopia, the sanitation facility coverage gap remains unacceptably large and collection and emptying mechanisms are one of the challenges. The habit of open field disposal of liquid waste is one of the main causes of soil and water contamination and consequently a cause of many communicable diseases (WHO, 2010).

The sanitation sector is often worse than water supply. Some 2.6 billion people, half of the developing world, live without improved sanitation. Sanitation coverage in developing countries (49 per cent) is only half that of the developed world (98 per cent). In sub-Saharan Africa the coverage is a mere 36 per cent, and over half of those are without improved sanitation. Similarly, nearly 1.5 billion people live in China and India without access to improved sanitation services. The number of deaths attributable to poor sanitation and hygiene alone may be as high as 1.6 million a year (Who & UNICEF, 2006).

Statistics on wastewater treatment revealed that almost 85% of global wastewater is discharged without treatment leading to serious impacts on public health and the receiving water environmental. At the same time, the drainage services are not adequate in most of the developing countries. The systems are either poorly planned and designed, or operated without inadequate maintenance, which means that the existing services are often of poor quality. Most of the city wastes are dumped and discharged directly to the open environment. As a result, untreated urban wastes pollute surface as well as ground water sources. The situation is even worse in the area of low-income settlements. Septic Tanks and feeder networks regularly discharge effluent into street gutters, open streams (UNICE, 2006).

Developing countries are burdened with a multiplicity of problems, and wastewater management is increasingly becoming a priority issue. The management of wastewater system in developing countries is exacerbated by accelerating urbanization, inadequate management and disposal of wastewater and the implementation of sophisticated treatment technologies that are highly centralized (Libralato et al, 2012).

The current wastewater management systems are riddled with a plethora of irregularities that calls for a paradigm shift from the current centralized system to the decentralization in wastewater treatment management. The principal reason for this has been that the provision of centralized systems is not technically, economically or environmentally feasible (DeGisi et al, 2014).

Indeed, the environment is repeatedly experiencing highly stressing phenomena related to deficient or non-existent wastewater and waste treatment plants, compromising the accessibility to water and sanitation with the resulting health troubles. To cope with this problem, decentralization, in association with local governance, is increasingly recognized as a potentially suitable way to contribute towards reducing the world's population with lacking proper sanitation as well as increasing the efficiency of wastewater treatment and treated wastewater recovery and reuse (Larsen & Maurer, 2011).

Advanced Decentralized Wastewater Treatment is rising as a better option in order to satisfy the demand of domestic wastewater treatment with more affordable and appropriate manner. The Decentralized Wastewater Treatment system is established in various countries including Ethiopia in order to treat the wastewater rising in domestic area. Along with installation the performance monitoring is also important. Performance evaluation has the benefit of assessing the performance of the wastewater treatment plant after commissioning the plant based on the removal efficiency of major parameters such as BOD, COD, TSS, TDS, and Phosphate. Suitable remedial measures can be adopted to improve the performance of treatment plant (Sonawane, 2015).

Decentralization seems to increase the possibility of achieving some of the United Nations Millennium Development Goals, i.e. mainly to halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation, ensuring environmental sustainability and reversing the loss of environmental resources. Increasing the accessibility to water and sanitation does not imply overexploitation of the existing resources, but improving their management by reducing, recycling and reusing as well as identifying new water sources such as storm water and reclaimed wastewater (UN, 2010).

The population of Addis Ababa City and provision of water supply and other socio economic developmental activities are increasing from time to time. In line with this, the amount of domestic and industrial wastewater is also increasing. The Kaliti wastewater treatment plant which was designed for a maximum capacity of 47,500m3/d of wastewater is currently operating beyond its design limit (AAWSA, 2017).

However, it is not in a position to satisfy the needs of the city. As a result, sewage waste overflows on to streets and into the water courses. Septic pump-out trucks do not access all areas to service the new high volume customers. Sewage from septic tanks and latrines continue to pollute groundwater. There are uncontrolled and open wastewater disposal, illegal connections of sewerage to storm drainage lines and to nearby rivers. The situation is affecting public health and aesthetics of the city.AAWSA was first established through the proclamation no. 68/1971 G.C as Addis Ababa Water and Sewerage Service Authority and it was reestablished through the proclamation no. 10/1995 as Addis Ababa Water & Sewerage Authority. It has the power and responsibility of supplying safe and adequate water as well as management of wastewater (sewage) and sludge collection and disposal for the Addis Ababa City (MoWIE, 2015).

About 49 million m3 of wastewater is annually generated in the city of Addis Ababa. From these Wastewaters mainly the majority of waste has domestic origin with 13.4% industrial waste. The Kaliti WWTP has a design capacity of treating 47,500m3/day of wastewater and 3,500 kg/day of biochemical oxygen demand. This is equivalent to population of 200,000. The estimates of waste generated in Addis Ababa per capita per day varies in volume from 0.4 to 1.23 lit/capita/day, in weight from 0.11 to 0.25 kg/capita/day and in density from 205 to 370kg/m3 (AACA, 2002). Regardless of increasing volume of waste generated, the performance of the city‘s disposal system is poor (WHO, 2010).

The City Administration has been taking different measures in different times to combat the situation, still there are many problems related with wastewater management. Wastewater management is in very difficult; particularly during the rainy season.

1.2 Statement of the Problem

The rapid increase of population growth in developing countries and economic poverty in rural areas has led to the establishment and expansion of urban centers. These will in turn accelerate pressure on the environment from time to time. Growth in population, industrialization and urbanization are the causes for environmental problems due to the disposal of undesirable wastewater. Such changes and pollutions in the characteristics of water and air may have direct effects on the health of people eco-system and all other living things. This condition of being impure or unclean is termed as polluted state and the process of producing this state known as pollution. The presence of these pollutants in water bodies, soil, and atmosphere will make the existence of life very difficult (Tayler, 2010).

Now days, Ethiopia especially Addis Ababa is facing environmental pollutions due to wastewater and it is becoming the most serious challenges of socio-economic activities of people in the study area. The Addis Ababa city administration need to expand, improve and establish wastewater management systems will have to be supported by institutional and legal reforms and changes in attitude.

However, legal, institutional and administrative framework for the environmentally sound management of wastewater remains either lacking or inadequate despite considerable progress in formulation and adoption of waste management policies. Adopting Environmentally Sound Management of wastes focused on the promotion of the ―3Rs – Reduce, Reuse and Recycle is needed. Moreover, waste to wealth Initiatives; Corporate Social Responsibility by producers of consumer products; involvement of multiple stakeholders; Public-Private Partnerships and Waste Exchange program should be explored. Although waste management responsibilities primarily lie with cities and municipalities, the key to success is to collaborate with private sector, communities and in some cases with the informal sector (UN-Water, 2011).

The majority of wastewater has domestic origin, most of this grey water is disposed into the rivers and streams flowing through the city, like the Akaki River. AAWSA has two water treatment plants in Addis Ababa, one of which is the Kaliti WTP which is located in southern Addis Ababa. In connection with this AAWSA planned to rehabilitate and expand the Kaliti wastewater treatment system.

Unsaved disposal is a serious environmental hazard for all, especially in areas where the roads are not accessible for collection deteriorating aesthetic quality of the city. Thus, the health situation of the community is under serious threat. Improper waste disposal has resulted in poor hygiene and lack of access to clean water and sanitation in particular by the urban poor (ENDA, 2010).

Since wastewater are inevitable by-products of consumption and production processes, sound management of waste is therefore necessary to avoid substantial adverse human, health and environmental effects.

Wastewater results from human and animal activities that are unwanted or hazardous. Human pollute their environment with industrial and domestic wastes. In this case, when people do their daily activity, they bring negative effects on the environmental, environmental pollution increase as the density of people increase. Unsanitary environment are favorable for the outbreak and spread of different type of communicable diseases. Most of the disease causing agents that contaminate water and food come from human and animal wastes. Without proper management they result in communicable diseases and around the city create bad odor and breading sites for different insects. Many diarrhea diseases such as cholera, typhoid and hepatitis caused by poor sanitation conditions are serious threats (damage) to life, particularly childhood diarrhea, which is a leading cause of morbidity and mortality in children under five years. The high prevalence of intestinal parasites among the population, especially worm burden in children is the direct results of fiscal contamination of food and water (Wendland, 2014).

Access to sanitation by most of the households remains poor and people are vulnerable to a high incidence of diarrheal disease and typhoid. The improvement, even development of onsite sanitation is made more difficult because of weak pro-poor conditions within the sector. An alternative to unsuccessful onsite sanitation methods in urban areas might be low cost sewerage systems such as pit and sand recycling, which is a new concept locally and has not been developed extensively. Although pit and sand recycling are said to offer comprehensive benefits in other regions where they have been implemented, no study has been conducted locally to understand their performance under the local conditions. The knowledge gained from the study will be helpful to practitioners, experts and others in the water sector who seek to develop the technology for poor urban areas (UNDP, 2006).

Similarly different researches have been conducted in the city in relation to wastewater management including environmental sanitation and extent of bacterial contamination through the different sources of wastewater, but none of these studies addressed the concern of wastewater management sustainability. Therefore, this study will investigate the challenges that affect the sustainability of wastewater management and the possible opportunities in the study area. Due to this end, it will bridge the existing research gap and come up with different planning solutions for the sustainability of the wastewater managements.

1.3 Research Agenda

1.3.1 Research Questions

1. How much domestic wastewater discharge in the Addis Ababa city?
2. What are the major challenges in the implementation of domestic wastewater management?
3. Are there opportunities of domestic wastewater management in Addis Ababa city?

1.3.2 Objectives

The overall objective of the study is to examine the challenges and opportunities of centralized domestic wastewater management in Kaliti catchment area in Addis Ababa city.

The specific objectives of the research:

1. Analyze the domestic wastewater generation rate at the household level in the study area.
2. Investigate the attitudes on the domestic wastewater management systems in Akaki Kaliti sub city.
3. To assess the advantages for wastewater management in study area.

1.4 Benefits and Beneficiaries of the Research

This study would recommend

- appropriate and sound management solutions for decision makers and project planners for Wastewater treatment and

- reduce untreated wastewater disposal that are dangerous to human health and natural environment
- Contribute technical recommendations for having effective waste management.
- how decentralization of wastewater management improves decision making and stakeholders participation contributes for sustainable wastewater management

The beneficiaries from this study will be policy makers, researchers, decision makers and the peoples who are living in the study who are exposed to problems related to the centralized domestic wastewater, decision makers in AAWSA and treatment plant project planner as well as academic researcher.

1.5 Scope of the Study

The scope of the study is investigating the challenges of centralized domestic wastewater management in Kaliti catchment the case of Addis Ababa city, Ethiopia. This study was conducted from August 2018 up to 2019 in Kaliti catchment area. Sample size of the study is 138 from the total population.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Definitions of Terms and concepts

BOD/Biochemical Oxygen Demand: a measure of the amount of oxygen used by bacteria to degrade organic matter in wastewater (expressed in mg/L). It is a proxy measure for the amount of organic material that is present in water: the more the organic content, the more oxygen required degrading it (high BOD); the lower the organic content, the less oxygen required to degrade it (low BOD).

Black water: the mixture of urine, faeces and flushing water along with anal cleansing water (if anal cleansing is practiced) or dry cleansing material (e.g. toilet paper). It is high in organics and pathogens.

Domestic Wastewater: Wastewater principally derived from households, business buildings, institutions, etc., which may or may not contain surface runoff, groundwater or storm water.

Effluent: the general name for a liquid that leaves the place or process from where it originated

Grey water: the total volume of water generated from the washing of food, clothes, dishware and people. It does not contain excreta, but it does contain pathogens and organics.

Influent: the general name for the liquid that enters into a place or process; the effluent of one process is the influent of the next

Municipal Wastewater: A mixture of domestic wastewater, effluents from commercial and industrial establishments, and urban runoff.

Pit Latrine: Latrine with a pit for the accumulation and decomposition of excreta and from which liquid infiltrates into the surrounding soil.

Sewerage Connection – the private sewer pipe connecting a house or business to the public sewer in the street or alley

Sewerage service: the safe and proper disposal of waste whether it is domestic or industrial

Sewerage Coverage: the ratio of people served by infrastructure that conveys sewage/ system for removal and disposal of chiefly liquid waste.

Sanitation: general term used to describe a battery of actions that all aim to reduce the spread of pathogens and maintain a healthy living environment. Specific actions related to sanitation include, wastewater treatment, solid waste management and storm water management.

Sewage: general name given to the mixture of water and excreta (urine and faeces), although it referred to as black water.

Sewerage: all the components of a system used for collecting, transporting and treating sewage (including pipes, pumps, tanks, etc.).

2.1.1 Definition and Components of Domestic Waste

Domestic wastes are wide variety produced from household activities such as food preparation and consumption, sweeping, washing clothes, burning, and garden wastes, and used items like clothing, furnishings, and abandoned equipment's. It includes both solid and liquid and sometimes hazardous wastes generated from residential areas and sometimes referred to as household wastes (MoWIE, 2015).

2.1.2 Domestic Liquid Waste

Domestic liquid waste from overflowing and seeping pit latrines, septic tanks, public and communal toilets, open ground excreta defecation, etc. comprise the municipal liquid waste. It is estimated that approximately 100,000 cubic meter wastewater is produced in Addis Ababa per day from domestic activities such as bathrooms and kitchens alone as 80% of the consumed water is disposed in the form of waste. In addition to this 30% of the city dwellers have no facility at all to dispose of their liquid waste (Mohamed, 2003). The city administration is only capable of treating 10% of the liquid waste produced in the municipality. So, sanitation and sewerage management and disposal is a serious socioeconomic problem of the city as the system is not well developed.

The sewage system which was commissioned in 1981 serves only the central part of the city and less than 10 percent of its residents. Moreover, the system does not operate its full capacity. For example, the Kaliti wastewater treatment plant, which according to the 1993 Addis Ababa Master Plan Study for the Development of Waste Facilities, should be capable of serving up to 1 75,000 people, actually serves less than one third of its capacity (Sisay ,2017).

The available on-site sanitation systems include septic tanks and various types of dry-pit latrines. Of Addis Ababa's total population, about 1,459,000 use dry-pit latrines, 175,000 use septic tanks and some 700,000 people do not have access to any sanitation facilities. According to the 2011 survey study of CSA, 14.9% of housing units of Addis Ababa had flush toilets, 70.7% pit toilets (both ventilated and unventilated), and 14.3% had no toilet facilities (WASA,2010) .

Girma (2004), Examined that most public and private shared latrines in the city are unventilated, overused, unlined, collapsing and overflowing. On average, 34 people share a pit latrine. The shared latrines, sandwiched in between houses in collapsing superstructures, are overused and

overflowing with raw sewage. Due to the lack of toilet facilities, roads often overflow with human excreta and garbage. The communal latrines provided are often blocked with all types of garbage and overflow into the streets.

However, since most of these toilets are not connected to the main sewer network, septic tanks, cesspools and open waterways are used instead for discharging sludge. Most of the sludge is washed into the nearby streams during the rainy season or percolates into the underground water table - the main source of borehole water for domestic use in most parts of the city (AAWSA, 2017).

Recently, efforts have been made to restructure and improve the system through utilization of new technologies in the existing treatment plant and establishing three centralized waste water wastewater plants in three catchments: Kaliti, Akaki and one at the eastern catchments. And decentralized waste treatment plants will be installed in selected areas especially around condominium houses (AAWSA, 2017).

2.1.3 Domestic Liquid Waste Management

The absence of sewage networks and treatment plants complicates the collection and treatment of wastewater in Addis Ababa. It has a very limited sewer network coverage accounting for 7.5% of the built-up areas (MUDHCo, 2015). Since parts of the older sections of the city are only connected to the central sewer system, both residential and business premises use septic tanks although their availability is severely limited in many of the old neighborhood (MUDHCo, 2015). Even though the city has a centralized sewerage system (sewer line) and two Waste Water Treatment Plants (at Kotebe and Kaliti) they are currently operating below their capacities of, 350 and 7500 cubic meters per day respectively due to inefficient waste collection. Nowadays it can be said Kaliti site is the only functional wastewater treatment plant. The majority of the transportation service is covered by private vehicle owners and investors.

The main burden of the city‘s municipal wastes comes from residential areas, making them the main focus for the waste management strategy. Despite the long history of the practice, for almost 60 years, of waste management the progress when compared with the degree of urbanization and population pressure is not as expected. Nowadays wastes become more complex and the quantity has also increased from time to time. Addis Ababa city administration

is also working to increase the efficiency of waste collection and disposal practices. Although the burden of managing the municipality‘s waste is on the city administration, recent involvement of private sectors and micro and small enterprises is the good decision. It plays a great role in creating job opportunities and improving the socio-economic status of the city‘s poor. Lack of awareness and enforcement are some of the challenges facing liquid waste management (Sisay, 2017).

2.2 Overview wastewater management

2.2.1 Centralized Waste Water management

Wastewater management can be conducted through centralized systems (which are large-scale systems that gather wastewater from many users for treatment at one or few sites) or decentralized systems (typically on-site systems, dealing with wastewater from individual users or small clusters of users at the neighborhood or small community level) (Wahyu, 2018). Tradition-ally, much of the urban wastewater management in developed countries has relied on centralized systems. Indus-trial effluent in developed countries is generally treated on-site, although some may also be sent to centralized municipal systems following pre-treatment on-site (UNP, 2010).

The choice between centralized (sewerage) or decentralized (on-site/neighborhoods-level) wastewater management systems will depend upon a number of factors, but it is important that full consideration be given to both options rather than the situation that has existed in the past where sewerage is of-ten considered to be the only ‘proper’ form of urban sanitation (Hawkins, 2013). The flip side of this mindset is that on-site systems are often seen as temporary or stopgap solutions and primarily for illegal or in-formal settlements, which may then be reflected in local building regulations and/or technical standards which fail to specify appropriate on-site systems but are based on the assumption that new housing will be provided with networked sewerage.

Whichever approach is preferred, there needs to be an emphasis on continued management aspects; no system has the capability to be ‘fit and forget’. There is a need for appropriately trained staff and capacity (financial, technical etc.), irrespective of wastewater management system. Traditionally the operation and maintenance of many on-site systems has been left to homeowners or local authorities, leading in many cases to system failure due to lack of, or

improper, maintenance. The effectiveness of the decentralized approach could therefore be improved by an enforced regulatory framework that includes incentives and sanctions and the establishment of a management program that ensures the regular inspection and maintenance of the system (Massound, 2009).

2.2.2 Wastewater Treatment

The aim of treatment is to reduce the level of effluents in the wastewater before reuse or disposal into the environment, the standard of treatment required will be location and use-specific. The year 2014 marks the centenary of the publication of the seminal paper on activated sludge which provided a basis to treat sewage by biological means. Since then there have been extensive developments in both scientific knowledge and processes to treat wastewaters of all types. There are now many aerobic, anaerobic and physical-chemical processes that can treat wastewaters to almost any standard of effluent from the simple removal of gross sol- ids to membrane systems that can produce drinking water quality (WASA,2010).

They vary from the very simple to the highly complex and each has its own characteristics in terms of efficiency, reliability, cost, affordability, energy consumption, sludge production, land requirements and so on. Treatment strategies range along a continuum from high technology, energy-intensive approaches to low-technology, low-energy, biologically and ecologically focused approaches (UNEP, 2011). for example, explored the potential of natural treatment technologies (i.e. those based on natural processes that use attenuation and buffering capacity of natural soil aquifer and plant-root systems, where the process of contaminant removal is not aided by the input of significant amounts of energy and/or chemicals) including waste stabilization ponds, duckweed and hyacinth ponds and constructed wetlands for wastewater management in India. In an examination of 12 cases they found that performance varied widely and that institutional and organizational issues were very important for sustainable system operation.

2.2.3 Wastewater Management Operation Systems

2.2.3.1 Domestic Wastewater

At present time the principal sources of domestic wastewater are residential districts and predominantly public institutional facilities. Other important sources of waste water include

commercial facilities and recreational areas. It is mainly composed of Black water, used to describe wastewater containing fecal matter and urine. It is also known as foul water or sewage and grey water or silage, wastewater from the shower, bath, basins, washing machine, laundry troughs and kitchen (MoWIE, 2015).

2.2.3.2 Wastewater Management Technology Alternatives

The intention to attempt to transfer technologies from one place to another is fails. Different approaches to wastewater management are required for different regions, rural and urban areas, with different population sizes and different stages of economic governance depending on capacity to manage wastewater and capacity for governance. Approaches can also vary depending on the quality standard required for end users or end-point disposal. The sanitation ladder provides a useful instrument to assess the local status of sanitation in a community, municipality or region, pointing to optimal wastewater management strategies. The following are appropriate wastewater management technologies applicable to different area of Ethiopia; (MoWIE, 2015)

2.2.3.3 Onsite Decentralized and Cluster Systems

The main users for these systems are condominium areas, universities, industries, and private and government institutions to use the effluent for fertilizer, biogas production and recycling of the water to domestic uses as per the standard permits. In areas with higher population densities, It is feasible to develop a local collection system and use a single facility to treat the community‘s wastewater. Lagoons, constructed wetlands and stabilization: ponds are inexpensive and common biological treatment options with low operational costs (UNEP, 2011).

Conventional centralized systems: Where the above options are considered insufficient to a desired system the use of conventional systems is practically considered which require large volumes of diluted wastewater, which is collected through an extensive sewer system and is treated in modern, centralized treatment works and also require large investments, highly skilled labor, and stable socio-economic conditions (Worled Bank, 2012).

2.2.3.4 Centralized Wastewater Managements

Separate Sewer Systems: under this system its entire flow goes to a waste treatment plant or discharge point, but during a heavy storm, the volume of water may be so great as to cause

overflows of untreated mixtures of storm water and wastewater into receiving waters and community settlements causes series flooding and environmental contamination.

Combined Sewer: The second option is the separate system where it transports storm water and wastewater through separate storm water drains and sanitary sewers respectively. For both collection systems, the construction costs are relatively high, depending on slopes, soil, and topography and groundwater level (WASA,2010).

2.2.3.5 Technology Options and Practice

Selection of storage, collection, transport and treatment technology and the requirements of treated wastewater in accordance with the grounds size and features of the urban area. In addition the technology option encompasses current status of the existing sanitation, economic characteristics, technical capacity, natural conditions, and reliability of the technology, habits and customs of the local areas as well as the professional level and capacity to manage and operate the facilities in the future (Corcoran, 2010).

The two key issues in choosing a treatment technology are affordability and appropriateness. Affordability relates to the economic conditions of the community while appropriateness relates to the environmental and social conditions. As such, the ‘‘Most Appropriate Technology’’ is the technology that is economically affordable, environmentally sustainable and socially acceptable. Improper wastewater management such as: overflows, poor infrastructure maintenance, insufficient treatment, over-irrigation, inadequate lagoon lining lead to surface and groundwater pollution. The lack of adequate treatment prior to storage or irrigation could also lead to odor generation. An evaluation done early during the design process has the advantage of providing early warnings if an alternative design is too costly relative to the available resources, saving the trouble of preparing final designs for those technologies that are outsides the bounds of affordability. The high costs for construction, maintenance and operation of conventional treatment systems exert economic (and social) pressure, even. Therefore, selection of treatment systems need sustainable, cost-effective and environmentally sound ways to control water n pollution (MoWIE, 2015).

2.2.3.6 Operation and Maintenance

The installation and operation of wastewater treatment systems ensures an environmentally friendly effluent quality meeting the determined border values. Maintenance for wastewater systems can either be preventive/predictive or corrective activity. Effective maintenance programs are based on knowing what components make up the system, where they are located and the condition of the components. With that information, preventive/predictive maintenance can be planned and scheduled, rehabilitation needs identified, and long-term improvement programs planned and budgeted. The MoWIE (2015) from time to time will issue a generic operation and maintenance manuals and guidelines for sustainable application of any WWM the system.

2.2.4 Current Status of Wastewater Management

2.2.4.1 Implementation Effort

There are efforts exerted by various governmental and non-governmental organizations including the private sector towards improving the sanitation sub–sector. These include: Ministries of Health, MoWIE (2015), Urban Development and Construction, Education, and Agriculture, as well as the Federal and Regional EPA Authorities/ Bureaus, Municipalities, NGOs, Academic Institutions, private sector sanitary suppliers and donors. Efforts are made in the areas such as policy and strategy formulation, planning, co-ordination, infrastructure provision, monitoring and evaluation. Urban wastewater management activity in the country in a planned manner is limited to Addis Ababa and few other cities.

2.2.4.2 Addis Ababa Metropolitan city

The Addis Ababa Water Supply and Sewerage Authority provide, among other services, water and wastewater (mainly human excreta) collection and disposal services. There are also other actors (such as the private sector and NGOs) involved in the area of wastewater collection and disposal activities. The major wastewater disposal system in Addis Ababa, as it is the case in other big cities and medium towns of the country, is by use of vacuum trucks. As regards sewerage, it has separate sewerage system built 25 years before with additional recent extension works. The magnitude of the wastewater disposal problem is severe.

Out of the total amount of wastewater produced in the city, only 7.5% is entertained by this system. It has two treatment plants, the Kaliti and Kotebe wastewater treatment plants. According to the recent reports of AWSA Wastewater practices in the Metropolitan is poor. The estimated waste water in the Metropolitan is 398,985m3/day where as currently the authority removal capacity of this waste is 1727 m3/day. From the total wastewater which should be removed in the Metropolitan only 0.43% are disposed every day (AAWSA, 2017).

2.2.5 Challenges Wastewater Management

Wastewater has been described as both "a resource and a problem" (Hinjira, 2012), as such the challenges relate to maximizing the resource potential and minimizing the problems. Some of the challenges in relation to the use of reclaimed water for irrigation are outlined in this section. Potential problems principally relate to the presence of toxic chemicals (from industrial sources of effluent) and the presence of pathogenic microorganisms. Irrigation with even treated wastewater can lead to excess nutrients, pathogens, heavy metals and salts building up on the irrigated land, unless care is taken. The separation of industrial and domestic wastewater will facilitate the likelihood of safe reuse, (Quadir, 2010) from a toxic chemical standpoint and showed that in India there were financial benefits associated with wastewater farming compared to fresh-water agriculture, but only where domestic wastewater was not mixed with industrial sewage.

Wastewater can be treated to minimize the risks from pathogenic microorganisms. Existing WHO guidelines (WHO, 2006) promote an integrated risk assessment and management approach along the chain from the waste-water source to the consumption of produce grown with wastewater (or excreta). This approach is similar to the water safety planning approach promoted for drinking-water supply (from source to tap). Where wastewater treatment is not available or is insufficient to reduce risks to accept-able levels, additional risk mitigation measures, such as appropriate crop choice, irrigation type and protective clothing for farmers can be implemented to protect public health (WHO, 2006). Although, as (Quadir, 2010) point out, many farmers and consumers are unaware of the potential negative health impacts of wastewater and suggest that public programmers' informing farmers and consumers about health impacts and mitigation measures could be a valuable public health measure.

Perception of water quality and also control over irrigation choices may play an important role in the acceptability of the use of wastewater in agricultural irrigation. In Greece, farmers were more willing to use reclaimed water when it was referred to as recycled water rather than treated wastewater (Menegaki*et al.*, 2009). In Jordan, for example, farmers who had no control over the use of treated wastewater (i.e. indirect use, through its provision in rivers) had a more negative perception of the water and its quality than farmers choosing to adopt direct reuse (Hinjira, 2012).

Plant nutrients in wastewater may not be present in the ideal concentration for direct crop production and meeting one nutrient requirement may lead to an imbalance in another nutrient level. It has been determined that wastewater can meet about three quarters of the fertilizer requirements of a typical farm in Jordan, but excess nutrients have also been found to reduce productivity, depending upon the crop (Hanjra*et al.*, 2012). It is likely that farmers would use the nutrient content of reclaimed water more effectively if they had better information about crop requirements and also nutrient levels in the wastewater and in the soil (Quadir, 2010). The lack of information on nutrient levels can lead farmers to combine nutrient-rich irrigation water with chemical fertilizers. An additional challenge is presented by the cross-cut- ting nature of wastewater management, where collaboration and dialogue are required between partners who may not traditionally talk to each other, including farmers, public health officials, municipal and waste managers, water utilities, regulatory agencies, environmental authorities, planners and developers (Quadir, 2010)

The main issues in the wastewater management are insufficient stakeholder awareness and involvement and the high mitigation costs, besides here are the basic challenges which identified by different actors in the field of wastewater according to (MoWIE, 2015)are: Wastewater management infrastructures (sewerage lines, vacuum tracks, public toilets, disposing sites, and treatment plants) not adequate, there is no guidelines, standards, and manuals that help to support the implementation, low priority given by government and actors when compared to water supply, duplication of Roles among the implementers that create confusion among respected sectors and Poor coordination among different sector offices, there is no clear role & responsibility for urban sanitation development program that carries out the specified activities with an adequately organized institutional manpower in Ethiopia, the liquid waste management requires high investment(sewer line installation and absorption trench construction, lack of

aggregated data on wastewater management status, high population growth(demand) and incompatible of service, failure to mobilize the community and make them active participants in wastewater service provisions, gap of both skilled staff or experts and knowledge about appropriate technologies on liquid waste management system Ground and surface waters pollution due to poor liquid waste management systems in majors cities, poor Attitude, Practice and culture of the community towards liquid waste management, Sewer Drains are generally not adequately interconnected and do not form a network, inadequate legal framework and unclear institutional responsibilities and Lack of access and monitoring of wastewater services

2.2.6 Factor Affecting Centralized Wastewater Management

2.2.6.1 Waste Accumulation and Inappropriate Disposal

Liquid waste generation in Addis Ababa city is directly related with population growth, industrial expansion and economic status of its residents. The daily per capita solid waste generation of the city is estimated to be 0.4Kg. Of the total solid waste generated per day, about 80% is collected (SWMA, 2010). The remaining 20% of the waste is disposed of on an open sites, drainage channels, rivers, valleys, and on the streets. Even the collected solid waste is dumped in open dumping site with no daily cover with soil, leaching containment or treatment, rainwater drain-off, odor or vector control, and fence. The Ripe open dumping site of the city is already full and surrounded by residential houses and institutions.

In addition to the solid waste, liquid waste is important source of pollution in Addis Ababa city. Only 7.2% of the liquid waste is disposed in appropriate way and the remaining 92.8% is disposed inappropriately in to rivers and rainwater channels (WASA, 2010). Excluding the recently constructed condominiums and real estates, the number of sewerage line customers is estimated to be only 4000 households. Furthermore, industrial wastes are important source of river water pollution. According to Gbre & Rooijen (2009) among 2000 registered industries in Addis Ababa, most of them were located along riverbanks. About 90% of these industries lack on-site treatment facilities for some degree, and subsequently discharge any effluents into adjacent streams.

River and spring water are important source of domestic and irrigation water sources to per urban communities. However, inappropriate solid and liquid waste disposal is polluting urban and pre-urban water, soil, and the air. Based on the discussions made with per urban

communities in the study area, due to such poor waste disposals, some per urban water sources become out of use. Human and livestock health problems were also reported Gbre&Rooijen (2009) reached similar conclusions. They undertook water quality test in Great and Little Akaki rivers, which is important source of irrigation agriculture in the city. They found the rivers were very/badly polluted. This shows pre-urban communities and their livestock are highly vulnerability to various health problems. As a result, some households reported they either destock or cease livestock production.

The land use and land cover dynamics analysis results have shown the increase in built-up areas in Addis Ababa city is characterized by horizontal physical expansion against crop, forest and grasslands. Even though this phenomena is inevitable, the highest rate of built-up area expansion against highest rate of forest and cropland decline entails the sustainability of the provisioning, regulating, and supporting services of the ecological resources in pre-urban areas is in question. Despite agriculture takes the highest share in terms of labor force participation and household income contribution, regardless of such pressures exerted on its resource bases, urbanization-induced industry and service sectors are also playing a vital role in this regard. The multinomial log it model analysis, however, has shown variables like gender, education, and locations have created disparities in accessing such employment opportunities. Furthermore, as human population continues to grow and urbanize, the challenges for securing water resources and disposing of wastewater will become increasingly more difficult (James, 2015).

Obviously, urbanization in Ethiopia is in its infant stage. Given the direct relation of urbanization and economic development, the country still deserves integrated urban development. In order to maximize the benefits of urbanization and minimize its negative externalities in pre-urban environment and livelihoods, the following actions need to be considered. The promotion of urban greeneries needs to be strengthened. This may include checking the conversion of agricultural land in to urban land use by introducing land saving construction designs and enhancing the effective utilization of inner city land, and protecting and developing greeneries. Even though this may help to some extent, due to internal and external factors farm size reduction along the peripheries seems inevitable (Wahyu, 2018).

As agriculture still plays important economic role, agricultural extension service focusing on promoting agricultural intensification and high value crop productions need to be strengthened.

Parallel to this, pre-displacement precautionary measures and post-displacement adaptation measures need to be taken. The former helps to reduce livelihood vulnerability of urbanization-induced displaced people while the later enhance their resiliency. This may include, despite compensations, devising pre-displacement skill development program, encouraging participation in cooperatives and micro and small-scale enterprises, and facilitating joining alternative livelihood strategies. As sex, education and access to road were significant in determining participation decisions in non-agricultural livelihoods, these needs to be considered in future intervention planning (WASA,2010).

2.2.6.2 Strong Governance

There is a need for strong and effective governance; without regulations backed up by monitoring, control and enforcement, there is little incentive to act. In the UNEP document 'Clearing the waters' UNP (2010) the central role of governance is stressed with the statement "there is a water crisis, and there is an increasing under- standing that it is a crisis of governance rather than one of physical scarcity". It is also noted that "the lack of good governance, including ineffective policies, enforcement, and institutions; corruption; and the lack of appropriate infrastructure, along with a shortage of new investments in building human capacity, all contribute to ongoing water quality problems. Weak institutions, inadequate water quality policies and regulations, and limited enforcement capacity underlie many water quality problems world- wide". This clearly highlights a number of issues, including the problems caused by a lack of human and institutional capacities. With the best will in the world, if countries lack the necessary human, technical, financial and institutional capacities they will be unable to meaningfully implement policies, as they will lack the capabilities to measure and monitor water quality parameters and identify violations and thus will be unable to enforce compliance.

The need for governance is recognized in the pro- posed UN-Water goal (section 6), with the target 'all countries strengthen equitable, participatory and ac- countable water governance', which aims to promote an enabling environment such that institutional structures relevant to water are effective and that their administrative systems function for the benefit of society as a whole. The governance target underpins all the other water targets and supports linkages to other development themes (UN- water, 2014).

It is helpful, however, if policies and regulations are harmonized. Kvarnstrom (2011) Highlight the problem when regulations and policies are not coherent. In South Africa, for example, they note that the White Paper on Sanitation is based on principles rather than technology, which allows for innovative and appropriate solutions to be adopted. The National Building Regulation, however, is not function-based and thus specific options tend to be prescribed (such as the compulsory connection of buildings to sewers), essentially cancelling out the flexibility to implement alternatives.

2.2.6.3 Financial Aspects

This section encompasses financing investments, cost recovery, equity and economic benefits. Water, sanitation and wastewater management are expensive and capital-intensive, but the available evidence all suggests that the costs of inadequate investment are far, far greater, in terms of actual money spent and also both direct and indirect dam-ages to health and socioeconomic development. As noted by Jouravlev (2004) “it is important to note that water pollution does not only affect public health, the environment and local economic activities, but also national competitiveness, mainly owing to the increasingly close relationship between external market access and the environment, and the increase in disputes relating to the use of environmental standards as non-tariff barriers in international trade.”

In order to create a sustainable system, policies are needed to support more effective water- and waste- water-pricing systems that permit sufficient cost recovery, ensure adequate investments and support long- term operation and maintenance (UN-Water, 2011). As pointed out by Corcoran (2010) “financing of appropriate wastewater infrastructure should incorporate design, construction, operation, maintenance, upgrading and/or decommissioning. Financing should take account of the fact that there are important livelihood opportunities in improving wastewater treatment processes”. It is also important to consider that wastewater management requires finance for more than just infrastructure and running costs. Most funding, which is typically grossly inadequate, goes to infrastructure development, much less is invested in operations and maintenance and even less goes towards developing institutions and human capacities (UNESCO, 2012).

2.2.6.4 Financing Investments

There are multiple pressures and calls on finances and, in the past, wastewater management and water quality have not been seen as a priority. Indeed, it has been estimated that there is an annual global shortfall in funds (between 2002 and 2025) for municipal wastewater treatment of US$ 56 billion (Hutton & Wood, 2013). To date, few countries have put in place sector financing strategies for urban sanitation and some governments are reluctant to allocate funds because improvements (often assuming sewerage as the norm) are perceived as capital intensive, rarely generate significant revenue, do not always deliver the intended benefits and are relatively 'invisible'. One reason for the unfavorable view of sanitation and wastewater management is the development paradigm of the last 50 years which typically involves the "building of infrastructure and service capacity, with major emphasis on getting the money out of the door within the project cycle and on having a 'handover' infrastructure to governments" (Hutton & Wood, 2013). This approach gives very little attention to factors that en- sure sustainability, efficiency and affordability of services related to governance, behavior change, operations and maintenance and capacity building.

Traditional financing sources are commonly categorized as the 3Ts, namely: taxes, tariffs and transfers, which refer to government, private sector and donors/ non-governmental organization sources, respectively. As noted by Hutton &Wood (2013) "in general, taxes and transfers are subsidies spent primarily with the aim of enhancing social welfare and producing services that people need or demand, even in the absence of the people's ability to pay. There are many types of subsidy that can be channeled through a variety of mechanisms. Private financing, however, is attracted to the … sector primarily not to provide subsidies but for the purpose of making a financial return."

Frequently, services are provided using a mixture of financing sources including public-private partner- ships (PPP), which might include community contractors, service contracts, management contracts, leases, concessions (build-operate-transfer), divestures and public-private companies (Hutton & Wood, 2013). However, highlighted a number of specific risks for the participation of private providers in the water sector (which also apply in relation to wastewater management) including, absent, weak and/or inconsistent regulations (further highlighting the

need for appropriate and enforced regulations), low rate of financial return and the risk of political pressure on contracts and tariffs (Camddessus, 2003).

Given the current shortfall in funds and the failure of some past investments it has been suggested that a new financing model is required, which draws on new sources of capital (blending different capital sources from the private sector, philanthropic sources and government) and focuses on outcomes (where the financial incentive is based on the delivery of tangible, auditable social outcomes) rather than inputs (amount of money to be invested) – (Hutton & Wood, 2013).

2.2.6.5 Cost Recovery

In many countries, wastewater management services are undervalued, under-priced and regulations (where they exist) may not be rigorously enforced, as a result cost recovery may be difficult. In a survey of 27 Asian cities, it was found that less than three quarters of the O&M costs for water and sanitation provision were met from tariffs (ADB, 2009). However, there are signs that, in some regions among larger utilities, tariffs are being used to cover not only O&M costs but also some depreciation costs (Ferro &Lentini, 2013). Cost recovery options include economic instruments and creating business opportunities. As noted by UN-Water (2013), regulation has to set standards regarding pricing. While water and sanitation may be a human right, this does not imply that they should be provided free of charge. To meet human rights, any tariff and connection costs need to be designed in a way that makes them affordable to everybody.

Tariffs can serve multiple objectives including financial sustainability (cost recovery), environmental sustainability (reduced water consumption) and social protection (UNECE&WHO, 2012). Although wastewater discharge charges are the most common method of raising funds, it has been suggested that other economic instruments could aid in the implementation of water quality regulations where behavior, such as reducing pollution, is encouraged through market signals (including water pollution charges or taxes and water quality or nutrient trading).

2.2.6.6 Economic Benefits

There are few studies that capture the full benefits from sanitation and good wastewater management, as studies need to include the benefits of toilets and other domestic systems as well as those due to the safe containment, collection and treatment of the wastewater and related sludge (UN- water, 2014) and also positive externalities in terms of health, school attendance, employment opportunities and economic growth (including tourism and agriculture) (Hutton & Wood, 2013)Estimated the costs and benefits of expanding the coverage of drinking-water and sanitation services and suggested that, in the Latin America and Caribbean region, universal access to drinking water supply with a household connection and sewerage with a household connection would cost US$ 14.1 billion a year, while delivering benefits of US$ 69.2 billion a year. A Water and Sanitation Program study for India suggests that the benefits in 2006 from avoiding the costs of inadequate sanitation could amount to approximately USD 33 billion, around 3.9% of GDP (WSP, 2010).

2.3 Theoretical Review

According to the 'Resilience Theory' the lack of consensus in the definition of resilience, and the elements of a resilient assessment, is hindering the implementation of interventions to build resilience in wastewater management. The first is a pioneer in resilience theory, as it presents a measure (scenario planning) for better wastewater management within the context of resilience; the definition used is "the ability to gracefully degrade and subsequently recover from a potentially catastrophic disturbance that is internal or external in origin", considering two properties: robustness and rapidity, and including reliability measurement. The second introduces Real in Option (RIO) analysis (a technique to handle uncertainties in infrastructure at managerial level) as a method to identify an optimal set of adaptive strategies to increase resilience to climate change (Corominas, 2017).

In this case resilience is simply defined as the ability to recover from disruption, and four properties are considered: Robustness, Redundancy, Resourcefulness and Rapidity. The guide stays at a general level and does not provide sufficient details for practical implementation; it also recognizes the need for future resilience implementation in the water sector and the integration within broader infrastructure management frameworks. These two reports aim to set the role of resilience in wastewater, explain how service providers can implement it in their

systems, and how to assess resilience and regulate it, from the point of view of the providers and the regulator. These guidelines define resilience as the ability of assets, networks and a system to anticipate, absorb, adapt to and/ or rapidly recover from a disruptive event, and defines five properties: Resistance, Reliability, Redundancy, Response and Recovery. Resilience to various stressors is commonly used in pioneering projects for wastewater service options in urban planning and investigates wastewater infrastructure resilience to long-term changes (e.g. urban expansion and massive population movements) (Corominas, 2017).

To this end, a grid-based database is used to build a map of land-use that estimates the impact over the years that this stressors will have on infrastructure systems. The study highlights the tradeoff between infrastructure capacity, environment needs and urban expansion; and suggests that governance and infrastructure resilience must be taken into account in urban planning. On a different line, three works have contributed to the study of performance of centralized versus decentralized wastewater systems and investigates the resilience of a regional water supply system through a criticality analysis of five water supply components, of which wastewater reuse is analyzed under two design conditions: (1) centralized versus decentralized wastewater treatment, and (2) decentralized wastewater plant location. On the other hand, carry out a technological resilience assessment that includes centralized/decentralized wastewater systems and centralized drinking water systems with water reuse scenarios (Corominas, 2017).

According to 'Environmental Management Accounting Theory' Environmental management was first related to management accounting in the 1980 s, when the experience of several us firms in particular was that pollution prevention could often be profitable. Management accounting expertise was necessary to assist in determining the exact costs and benefits of pollution prevention. In addition, a more theoretical contribution which was sought from management accounting was to explain the obvious inefficiencies of producing waste: why had so many seemingly profitable pollution prevention opportunities remained undiscovered? How could engineers and controllers in firms that operate in competitive industries have overlooked the cost saving potential?

To evaluate environmental investments, new management accounting tools such as calculation methods and checklists for the inventory of environmental costs and benefits were developed. Often the development and adoption of these techniques were initiated by governmental agencies

or NGO's, but have nevertheless been noticed at a business level and seem to have been adapted to some extent. These practices became known as 'environmental management accounting' (EMA) defined environmental management accounting as the generation, analysis and use of financial and nonfinancial information in order to optimize corporate environmental and economic performance and achieve sustainable business. Such an exclusive positioning may be understood from a perspective that new tools have still to be developed, and that we should not waste time by recycling old concepts. Four costs categories in particular were selected that are especially important for environmental management: waste management costs, energy costs, water costs and wastewater cost (Markvander , 2002).

Based on 'Environmental Tax Policy in Romania in the Context of the EU: Double Dividend Theory', the spread of public services and social infrastructure has been essential to reduce poverty and inequality in developing countries. Water and sanitation infrastructure has proved to be particularly relevant in any development strategy. However, in spite of improving water and sanitation availability, the great majority of people in developing countries have to cope with very low coverage of wastewater treatment plants. Sewer is usually disposed into watercourses without any treatment whatsoever. This has had serious consequences in terms of spreading diseases and reducing well-being, particularly of the poor. The main explanation for this low coverage is the required high investment costs of wastewater treatment plants. On their turn, high investment costs are closely dependent upon an engineer decision in terms of technological option to achieve very high environmental standards for the wastewater treated. This standard is usually aimed at 100% cleanup goal. Theory of 'Economics of wastewater treatment: cost-effectiveness, social gains and environmental standards' argues that environmental standards should be based upon the optimum level of pollution subjected to safe health requirements and overall environmental gains. This means that investments on wastewater treatment plants must be based on cost-effectiveness (CE) considerations, allowing a gradually crescent environmental standard implementation process. If CE procedure is followed, wastewater treatment will have higher social gains per monetary unit of investment in the initial stages of implementation due to an achieved less degraded watercourse (Madeira, 2010).

According to Environmental Tax Policy in Romania in the Context of the EU: Double Dividend Theory: environmental tax policy increases economic growth and environmental protection. The

environmental taxes support mainly the greenhouse CO_2 emissions reductions (support environment protection and have significant economic benefits) (Magdalena, 2017).

2.4 Empirical Review

The liquid waste generated is direct link to sewer line of the city from bole Lemi, Yekaand Jemo condominium site, collecting by vehicle from Libe, Kotobe and Lideta one condominium site and onsite liquid waste management by Miklil and Gerji condominium site. All condominium houses generate 50,715,335 liter liquid waste per day (93.5 l/d/p) is liquid waste discharged. 24.8 % of the total condominium houses connected their waste to sewer lines and 24,400 m3 amount of effluent waste of the city inters to Kaliti treatment plant. But the treatment plant is not enough to treat the effluent waste come by sewer line and vehicles from the whole corner of the city because the plant was built to serve 50,000 people. But now it serves above 70,000 people (AAWSA, 2017).

The awareness of the condominium dwellers towards liquid management is very poor. They discharge solid waste together with the liquid part. Regarding the solid & liquid waste management and other administrations of the condominium houses of Addis Ababa has no legally nominated body except the voluntary committees. Same times the condominium houses of Addis Ababa transfer to beneficiary before they have finished the sanitary system. Due to this the waste water over flow simply to open ground (Wahyu, 2018).

In generally almost all of Addis Ababa has yet series problem of effluent waste management during study period, peoples who live in A.A condominium houses are 18.7%.The liquid waste generated by direct link to sewer line of the city, collecting by vehicle and onsite management. The condominium houses generate 50,715,335 liter liquid waste per day (93.5 l/d/p) is liquid waste discharged. 24.8 % of the total condominium houses connected their waste to sewer lines and 24,400 m3 amount of effluent waste of the city inters to Kaliti treatment. Wastewater management practice in the condominiums site, sewer line and other was unsatisfactory because of the lack of waste management supervision of concerned bodies, weak policies and institutional frame works, slope of the constructed treatment plant, sewer line damaging due to road construction in the city, an adequate number of vehicle and carelessness of resident (Sisay, 2017).

Domestic liquid waste from overflowing and seeping pit latrines, septic tanks, public and communal toilets, open ground excreta defecation, etc. comprise the municipal liquid waste. It is estimated that approximately 100,000 cubic meter waste water is produced in Addis Ababa per day from domestic activities such as bathrooms and kitchens alone as 80% of the consumed water is disposed in the form of waste. In addition to this 30% of the city dwellers have no facility at all to dispose of their liquid waste (Mohammed & Elsa, 2003). The city administration is only capable of treating 10% of the liquid waste produced in the municipality. So, sanitation and sewerage management and disposal is a serious socioeconomic problem of the city as the system is not well developed.

Wastewater generation and treatment in Addis Ababa for 2008 and 2019

	2008	**2019**
Wastewater generation 1000 m3 d-1	130	453
Installed treatment capacity 1000 m3 d-1	39	238
Potential wastewater treated %	30	53
Untreated wastewater volume1000 m3 d-1	91	215

Source (Van Rooijen et al., 2009)

The sewage system which was commissioned in 1981 serves only the central part of the city and less than 10 percent of its residents. Moreover, the system does not operate its full capacity. For example, the Kaliti plant, which according to the 1993 Addis Ababa Master Plan Study for the Development of Waste Facilities, should be capable of serving up to 1 75,000 people, actually serves less than one third of its capacity. The available on-site sanitation systems include septic tanks and various types of dry-pit latrines. Of Addis Ababa's total population, about 1,459,000 use dry-pit latrines, 175,000 use septic tanks and some 700,000 people do not have access to any sanitation facilities. According to the 2011 survey study of CSA, 14.9% of housing units of Addis Ababa had flush toilets, 70.7% pit toilets (both ventilated and unventilated), and 14.3% had no toilet facilities (Wahyu, 2018)).

Girma (2004) examined that most public and private shared latrines in the city are unventilated, overused, unlined, collapsing and overflowing. On average, 34 people share a pit latrine. The shared latrines, sandwiched in between houses in collapsing superstructures, are overused and overflowing with raw sewage. Due to the lack of toilet facilities, roads often overflow with

human excreta and garbage. The communal latrines provided are often blocked with all types of garbage and overflow into the streets. However, since most of these toilets are not connected to the main sewer network, septic tanks, cesspools and open waterways are used instead for discharging sludge. Most of the sludge is washed into the nearby streams during the rainy season or percolates into the underground water table - the main source of borehole water for domestic use in most parts of the city.

Recently, efforts have been made to restructure and improve the system through utilization of new technologies in the existing treatment plant and establishing three centralized waste water plants in three catchments: Kaliti, Akaki and one at the eastern catchments. And decentralized waste treatment plants will be installed in selected areas especially around condominium houses (Ali & Eyasu, 2017)

2.5 Conceptual frame work

The researcher will be developing a conceptual framework for sustainable wastewater management to addresses the challenges of wastewater management improvement and indicate the possible opportunities. Figure (2.1) shows the deriver force for wastewater management, linkages among various aspects in managements system. There is drive force like socio-economic development, population growth which led to increase for wastewater generation. To achieve the intended goal in wastewater management system identifies role of federal and regional states of government /city administration/ creating an enabling environment to support the sanitation sector in taking final jurisdiction and responsibility in wastewater management by setting overall policy to perform the management functions where appropriate. Such as, develop and assist stakeholders in exercising policies, regulations, legal authority, standards, manuals and other external limitations as well as ensure that a transparent subsidy mechanism is in place ensure that financial resources are allocated according to plans for the provision of sanitation in Addis Ababa and develops different wastewater treatment plant projects. Enforcement mechanism wastewater management and regulations that Ensure appropriate technology options have been developed, as well as capacity development and provide technical support on sanitation issues capacitating skilled manpower and experience sharing and training. In addition to this reduced wastewater discharge and development of treatment plant activates to be sustain wastewater management.

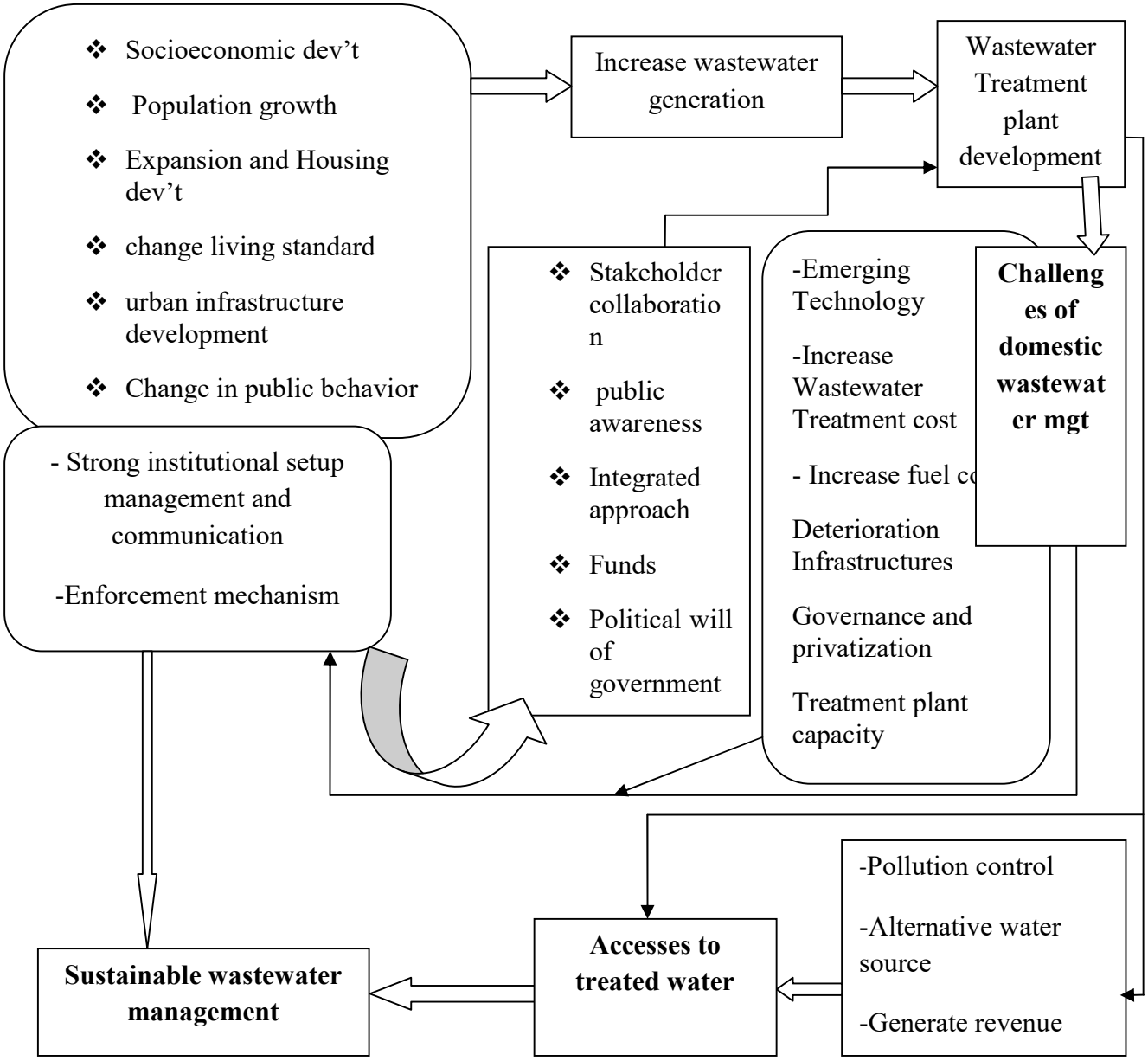

Figure 2- Conceptual frame work of the study

Source: *Researcher own development from literature*

CHAPTER THREE

3 METHODOLOGY

Methodology in research is an important process that determines the direction and validity of research work. According to Hoggart (2010) it is a philosophy of the research process, which includes assumptions and values, which are the basis for research, and the criteria for data interpretation and drawing up of conclusions. The data were used for this work gathered from various sources. The main sources include field observation and interviews and questioner. The main approach to this study was to make a closer investigation of the existing challenges wastewater resources management and practices in Addis Ababa in Kaliti catchment in particular. Based on this, objectives were set and scientifically based procedures were developed. Accordingly, the required data/information was obtained from both primary and secondary sources.

The primary data were collected from AAWSA employees, household and through key informants' interviews. Both open and closed ended questions were used. Secondary data collected and used from the relevant literature and institutions. Both qualitative and quantitative techniques were explored, because they complement each other (Neuman, 2000). Qualitative data is essential because it provides insight into the lived experiences of respondents and supports the quantitative data.

3.1 Study Area

3.1.1 Land Use

Kaliti catchment; the land is predominantly used for mixed development. This involves any urban, suburban or village development, or even a single building, which combines residential, commercial, cultural, institutional, or industrial uses, where those uses are physically and functionally integrated. There are also forests and landfill sites.

The Kaliti Catchment is covering a large part of the city and it is the only one where a sewerage facility is exists with a central wastewater treatment system introduced before 30 years. It is the North West part of the city covering an area of 210Km2, including the centre of Addis Ababa. The Eastern Catchment is located at the North East part of the city with an area of 145Km2 and

the Akaki Catchment is located at the South part of the city with an area of 150km2. Eastern and Akaki are the areas where mainly the city is expanded.

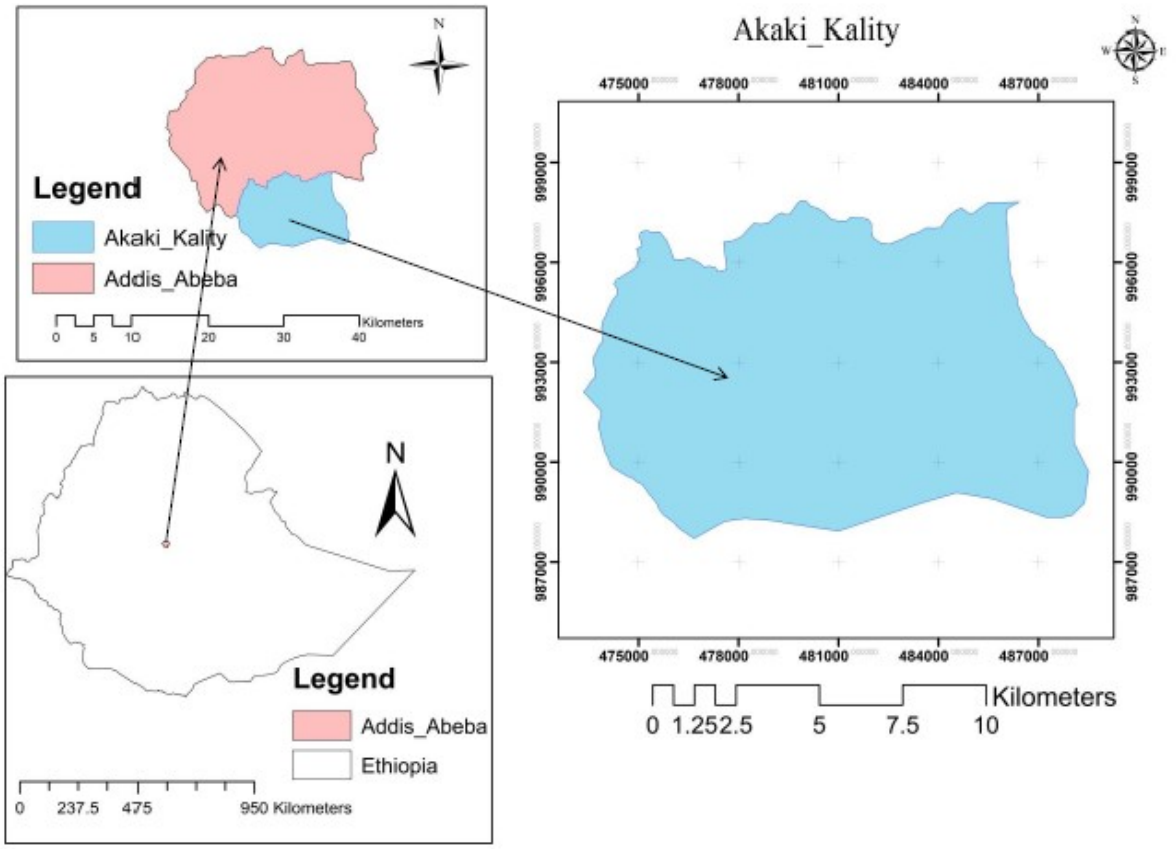

Figure 3- Map of Akaki Kaliti sub city

Source; *own sketching*

Addis Ababa is the largest city as well as the dominant political, economic, cultural and historical city of the country. It has the status of both a city and a state. It is the capital of the Federal Government and a chartered city. It is where the African Union and its predecessor, the OAU are based. It also hosts the headquarters of the United Nations Economic Commission for Africa (UNECA) and numerous other continental and international organizations.

The city is divided into ten sub cities which are the second administrative units next to city administration. In terms of area coverage, Bole is the largest sub-city followed by "Akaki-Kaliti" and "Yeka". "Addis Ketema" is the smallest and followed by Lideta and "Arada" Sub-cities. The sub-cities are sub-divided in to116 Woreda, which are the smallest administrative units in the city. The number of Woreda in each sub city varies based on their size. The city

administration has a cabinet with executive power led by a Mayor. The sub cities are organized in a similar fashion. They are mandated to administer matters in their jurisdiction, and provide support to Districts. The Districts are empowered to administer local matters such as community mobilization, Neighborhood Improvement and Building Code Enforcement. The Stud Focus on Akaki Kaliti sub city.

3.1.2 The Akaki-Kaliti Sub-City Study Site

The Akaki Kalitisub-city is one of ten sub-cities of Addis Ababa and consists of 13 Woredas. Akaki sub-city has at about 181202 people (CSA, 2007). There were major reasons for selecting the Akaki Kaliti sub-city for this study. Akaki Kaliti sub city is one of the most wastewater affected urban areas of the city, and Kaliti centralized wastewater treatment plant also found in Akaki Kaliti sub city Werda-7.

3.2 The Research Method

The respondent (135 respondents) of the prepare questions were literate, because of this they gave the responses as numerical (quantitative) and as explanation (qualitative). Qualitative methods of research methods more preferred to investigate data from respondent and to collect data especially interview questioner with open ended question. On the other hand quantitative research is a systematic and scientific investigation of quantitative properties and phenomenon and their relationship. The processes of measurement are central to quantitative research to provide the fundamental connection between empirical observation and mathematical expression. Due to this fact the methods of the research would be both qualitative and quantitative

A cross sectional study design would be used to assess the status of wastewater management. The sample size was calculated using a population proportion formula and distributed proportionally to population size (number of employees and number of households) in the study area and treatment plant. Structured questionnaire and observational check list was used to collect data.

3.3 Source of Data

In this study both primary and secondary data were used. Primary data sources: The primary data was gathering from sample respondents which were chosen through sampling from the total

population who are living in the study area and AAWSA employees. The primary data was collected through questionnaire and observation. Secondary data sources: the main sources of secondary data were reports of AAWSA bureau, EPA, different books, journals, magazines and internet.

3.4 Data collection

A number of data collection methods were considered in this study. In addition to gathering of written document related to wastewater resources management, structured interview was chosen as the primary instrument of investigation. The research was carried out by conducting AAWSA employees, household survey and interviews with major informants who represented from the community and Woreda administration.

Different kinds of literature were reviewed by the researcher. These included books, journals, government documents and reports, and the internet. Various official and public documents in the holdings of a range of national wastewater-related institutions have also been reviewed. This included the relevant and accessible documentation of practices in the holdings of the Ethiopian Ministry of Water Resources, Addis Ababa Water and Sewerage Authority (AAWSA), Environmental Protection Authority, Documentation units of Food and Agriculture Organization, and World Bank.

3.5 Sampling Techniques

In order to conduct this study the overall objectives of this thesis to examine the challenges and opportunities of centralized domestic wastewater management in Kaliti catchment area in Addis Ababa city this aimed to generalize from a sample to a population. To conduct such kind of research, one obviously needs to collect primary data through field research from each and every customer of the service However, due to finance and time constraints; the research was made to focus on selected households. Sampling technique was introduced to select the target population. To this end, to get the representative population and the necessary information accordingly, this research used the combination of random and purposive sampling techniques to select household respondents. Simple random sampling was applied to select the sample households using lottery system through their house numbers to get representative informants and it is a sampling technique in which every number of the population in the study area will have a known, non-zero or equal probability of selection, whereas, Purposive sampling: is a sampling technique in which

units of the sample are selected on the bases of personal judgment or convenience due this end purposive sampling was used to select the sample Sub-city, and also centralized Kaliti wastewater treatment plant.

3.6 Sample Size Determination

3.6.1 Sample size and selection

According to Isreal (1999) for any sample, given the estimated population proportion of 0.5 and 95% confidence level, the sample size is given by

$$n = \frac{z^2\, P(1-P)}{\alpha^2}$$

Where n = Actual sample size

Z= standard normal deviation (1.96)

P= proportion of the target population estimated to have at a particular study (10%)

$$\alpha = .05$$

$$\boldsymbol{n} = \frac{\mathbf{(1.96)^2\,.10(1-.10)}}{\mathbf{.05^2}} = 138$$

Based on this formula it was desirable to have a sample size that is representative of the population as much as possible. Therefore, by considering limitations in time and costs, selected 138 sample from AAWSA employees' and households from the total population.

Simple random sampling was applied to select the sample households to get representative informants whereas purposive sampling was used to select the sample Sub-city. To carry out this study the researcher would stratified the study area into 13 strata and make proportion to extract sample size of 138. Assume the total population N and the population of each strata to be N1, N2, N3.the sample (n) drawn from each strata calculated as $n_i = (N_i/N)*138$

Table 3- Sample size of the population

Stratified by Woreda	Number of population in each Strata (Ni)	Proportion total	The sample selected from each strata
1	15351	8.5	12
2	13910	7.7	11
3	15638	8.6	**12**
4	15830	8.8	**13**
5	11934	6.6	**9**
6	13287	7.4	**10**
7	17,074	9.4	**13**
8	12358	6.8	**9**
9	13697	7.5	**10**
10	14236	7.8	11
11	13596	7.5	**10**
12	13695	7.6	**10**
13	10596	5.8	**8**
Total(N)	**181 202**	**100**	**138**

3.7 Methods of Data Analysis

Descriptive statistics is used to analyze the data to discover useful information, suggest conclusions and support decision-making. Hence, the collects data were analysis using statistical software (SPSS version 24.0). Explanatory and Descriptive statistics such as percentage, mean, frequency and tables were used to summarize and present the data in a manageable form.

CHAPTER FOUR

4 RESULTS, DATA ANALYSIS AND DISCUSSIONS

This chapter presents the results; analysis of data collected from a research conducted in Kaliti Catchment Addis Ababa City, Ethiopia. The main purpose of the study was to investigating the challenges of centralized domestic wastewater management in Kaliti catchment the case of Akaki Kaliti sub city, Addis Ababa**.** Furthermore, the study is aimed at: investigating wastewater types, sources and volume; investigating wastewater management process; ways and amount of treated waste water investigating purpose of wastewater management and suggesting better methods of wastewater management. Lastly, the findings from this study can be relied upon to make major decisions in development by both city administration municipals and county governments.

4.1 General Background of the Respondent

According to table (4.1) shown below 81.2 % of the correspondents were men and 18.8% women. There is need for gender mainstreaming in relation to wastewater management. This is in pertinent to two different perspectives while considering gender and wastewater management. That is; women like to apply or develop short term initiatives when solving a given issue whereas men tend to engage in long term measures to solve the same problem. Secondly, as day-to-day activities in the household are carried out by women most of the time and these activities involve utilization of water hence generation of wastewater; any initiative that is to be developed in relation to wastewater management should incorporate this group of people‘s views.

Table 4-Sex of Respondents

sex		Frequency	Valid Percent	Cumulative Percent
	Female	26	18.8	18.8
	Male	112	81.2	100.0
	Total	138	100.0	

Source: *From own field survey, in June, 2019.*

As shown in figure (4.1), Most of respondents are youths whose ages mostly range between 20 years and 45 years; this is according to study undertaken in the field. This information is essential since youths are innovative, willing to learn about new developments and are energetic.

In addition, they have a desire in wastewater management initiatives enforcement and implementation.

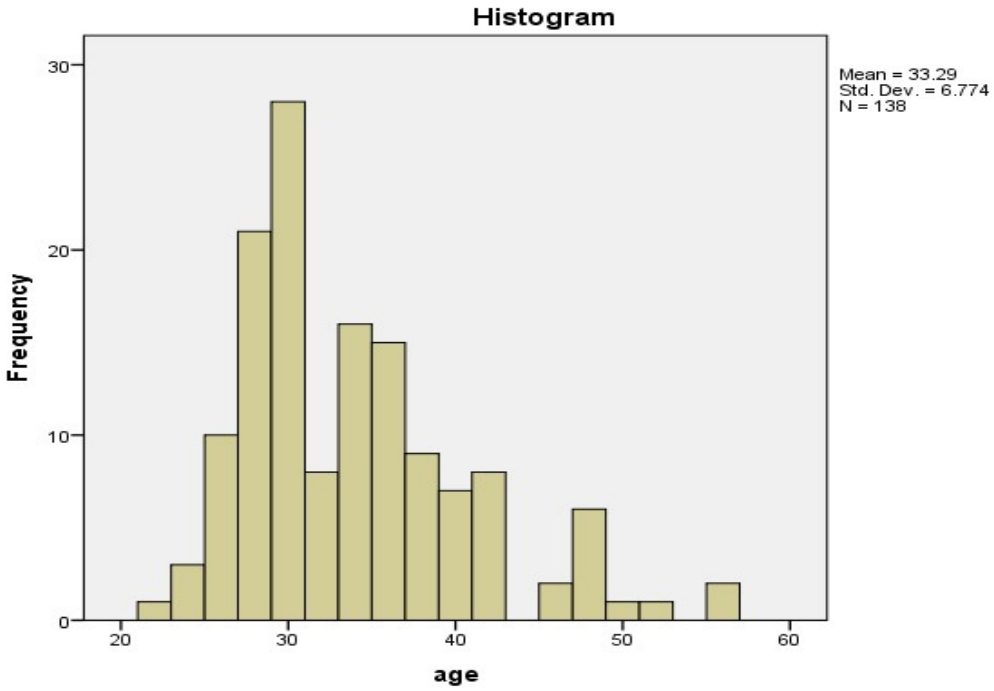

Figure 4-Age of Respondents

Source: *From own field survey, in 2019*.

As shown in figure (4.2) the number of family in each household concentrated around five family members in averages in average. The number of family size increases, the contributions of wastewater also increases. This is related to the management of domestic waste water is one of the challenges facing urban areas in developing nations. The problem is compounded as they continue to urbanize rapidly; 30-50% of populations in many developing countries is urban and in many African countries the growth rate of urban areas exceeds 4%. Rapidly growing cities will greatly worsen existing wastewater disposal problems since much of the urban development is unplanned and informal, with community members and informal-sector developer taking advantage of the fact that the regulatory capacity of government authorities is weak (Aliyu, 2010).

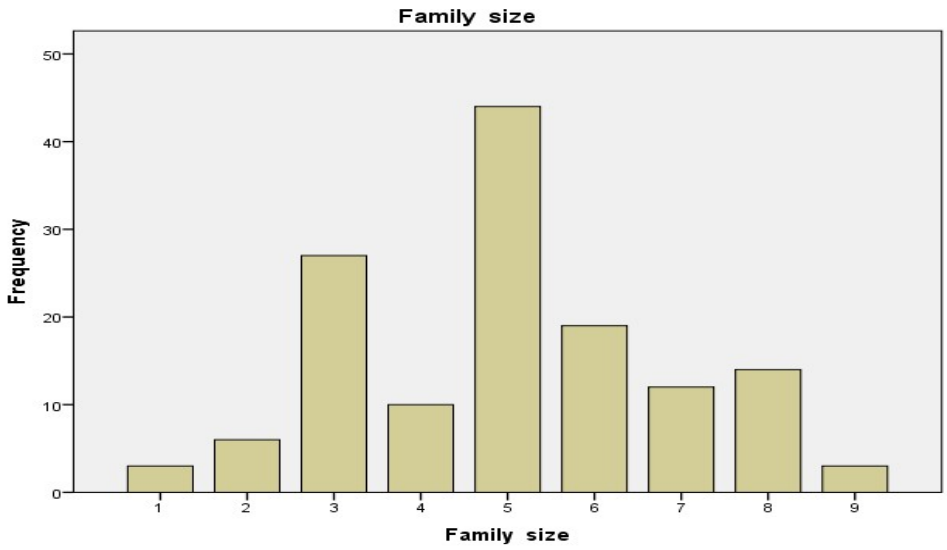

Figure 4- Family size of the Respondent

Source: *From own field survey, in 2019.*

Level of education and awareness creation/ advocacy on environmental management issues related to wastewater treatment and management goes hand in hand and according to the data collected from the field, more than fifty percent of populations are bachelor degree holders, 16.6 % of respondents are master's and above, 19.2% of respondent have diploma. In Overall around 89.1 % of the populations are educated above diploma. This is therefore very important when embracing advocacy as a tool in wastewater management on initiatives and projects developed.

Table 4-Educational status

Level of Education	Valid Percent	Cumulative Percent
Adult education	2.2	2.2
Primary School	2.2	4.3
Secondary School	4.3	8.7
Secondary (Preparatory)	2.2	10.9
Diploma	19.6	30.4
Bachelor Degree	52.9	83.3
Master's Degree And Above	16.7	100.0
Total	100.0	

Source: *From own field survey, in 2019.*

From table (4.3) monthly level of income of the respondent relies below 10,000 birr; the contribution of respondents on wastewater management is not effective. Wastewater

management and treatment requires huge investment at a central level, but respondents not accomplish participation of wastewater treatment due to lower income**.**

Table 4- Level of monthly income of respondent

monthly income in birr		Frequency	Percent	Valid Percent	Cumulative Percent
	Below 2000	7	5.1	5.1	5.1
	2001-6000	49	35.5	35.8	40.9
	6001-10000	51	37.0	37.2	78.1
	above 10000	30	21.7	21.9	100.0
	Total	137	99.3	100.0	
Missing	System	1	.7		
Total		138	100.0		

Source: *From own field survey, in 2019.*

The occupation of people in Kaliti central catchments are employed in AAWSA and on low wage jobs, for instance, driving and businesses practiced are small and medium scale enterprises which, they use to boost their source of income; hence majority‘s household income range between birr 6001 and birr 10000 respectively and majority‘s business profit is less than birr 10000 per month. Large volume of wastewater entering streams and rivers from the numerous car washes and garages is a treat to the ground water resource and this income level restrict the household capacities in related to both centralized vacuum truck payment and decentralized domestic wastewater treatment.

Table 4- Respondent occupation

Occupation	Frequency	Valid Percent	Cumulative Percent
Government employed	88	63.8	63.8
Unemployed	18	13.0	76.8
Business person	27	19.6	96.4
I don’t know	5	3.6	100.0
Total	138	100.0	

Source: *From own field survey, in 2019.*

4.2 Challenges of Household Wastewater Management Systems

Many cities in developing countries have problem in managing the household wastewater, especially in big and densely populated cities. Addis Ababa city is one of most densely populated and business area; such massive person needs adequate sanitation infrastructure services, and fulfilling these needs was the challenges faced by the city. Hence, the result of finding the main constraints are; shortage of household wastewater management infrastructures, lack of awareness and sense of ownership on the communities, lack of policy and strategy on the safe use of wastewater in agriculture, and inadequate coordination between institutions were the main challenges of household wastewater management in the study area.

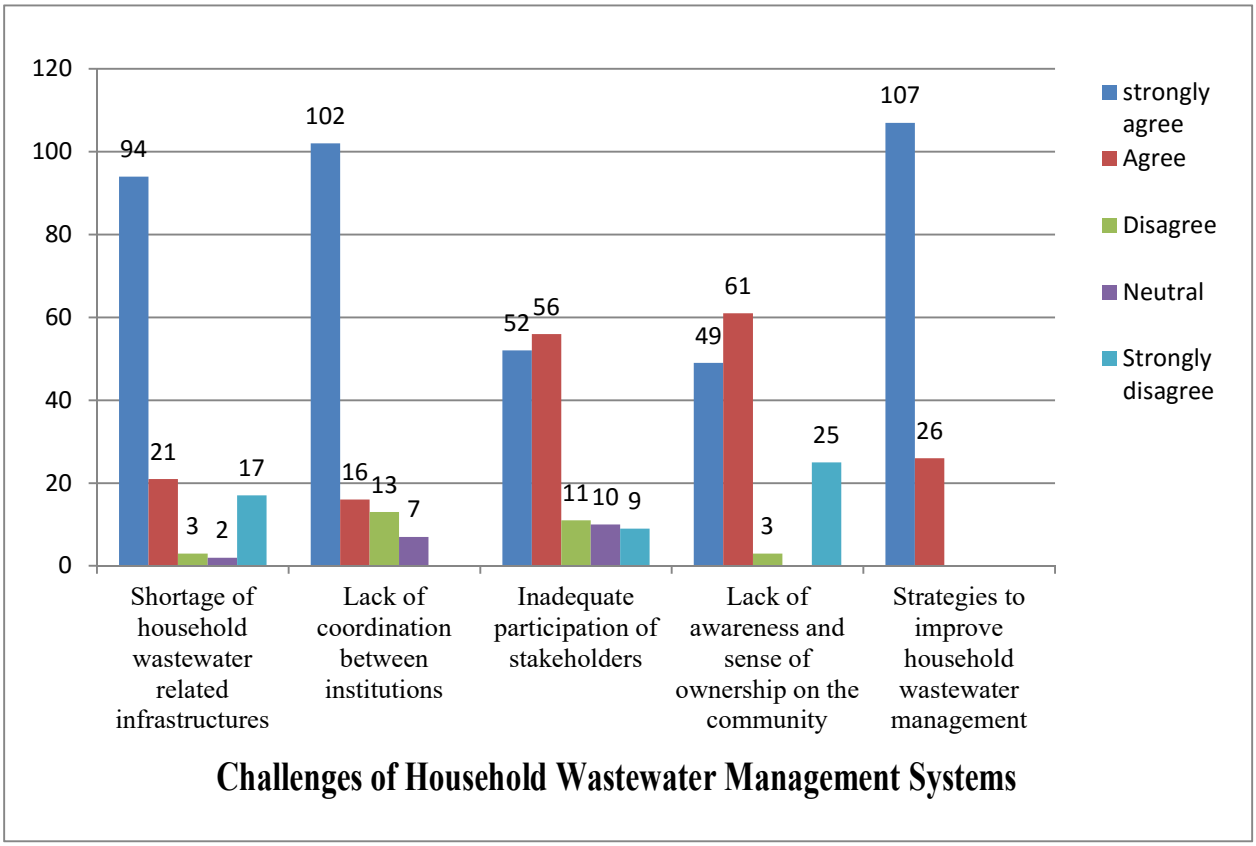

Figure 4- Family size of the Respondent

Source: *From own field survey, in 2019*

4.2.1 Shortage of Household Wastewater Related Infrastructures

Infrastructure accessibility and sufficient services is the base for urban development. In Addis Ababa, some of the communities were in accessed with basic sanitation infrastructures like toilets and drainage canals as the result, used open space, street road, river bank and streams

defecation and discharging mechanism. Similarly, due to shortage of trucks to collect the wastewater, some of the communities are also discharging their wastewater through direct connect to river and drainage canals. Therefore, due to shortage of the trucks, some community has no access to get truck to emptying their toilet, and prefers to discharge their toilet illegally through directly connecting in to the river and drainage canal at rainy season. Hence, from the findings it can summarized that, shortage of infrastructures, produced household wastewaters are not managed properly, and discharging in to river and stream, street road, open space and open defecation creates an adverse impact on health problems of the communities, air, river and stream pollutions in the study area.

4.2.2 Lack of Coordination between Institutions

The provision of effective and efficient household wastewater management service is not possible alone; rather coordination of other sector is important to provide adequate services to the community. As the result of inadequate coordination, the management of household wastewater is very poor as shown in figure (4.3). Similarly, according my observation the coordination between AWASA, the city solid waste management office, health, land and planning administration office was poor on proper management of household wastewater in the city. As a result, due to the lack of coordination and integration between institutions this fuels the environmental problems like river and air pollution and health problems on the community in the study area.

4.2.3 Inadequate Participation of Stakeholders

Household wastewater management is not government task only, but NGOs and private sectors should also participate. There were private sector that participates in collecting and transporting wastewaters in to disposal site (Kaliti wastewater treatment plant) in Addis Ababa but limited in number. Hence, due to the private sectors are small, they are less providing services to the community, charged high price and select the nearest areas that accessible to transportation as compared to the government sectors. Therefore, it can be generalized that in adequate participation of concerned private sector was the challenge for household wastewater management in the study area.

4.2.4 Lack of Awareness and Sense of Ownership on the Community

Increasing public understanding and know how on the value of proper household wastewater management is critical. Household wastewater management is the most important basic function for protecting public health, wellness and the environment. In the study area, due to lack of awareness and sense of ownership of the communities, the management of household wastewater is very poor. According to the report from Kaliti Wereda-7 health office, some of households are, directly connect their toilet and gray water with drainage canal, river and streams at rainy season and it is very difficult to control its odor and contamination. Therefore, it can have generalized that, due to the absence of awareness and sense of ownership of local communities, the dispose their wastewaters in to the environment without treatment which causes a health problem of the community, air, rive and stream pollution in the sub city.

4.2.5 Strategies to Improve Household Wastewater Management

The creation of suitable and favorable environment requires the proper management and disposal of household wastewaters through involving concerning stakeholders like government sectors, private companies, NGOs, local communities, and associations by involving them from planning to implementations. In addition, the involvement of major stakeholders by itself do nothing without continuous monitoring and evaluation and undertaking remedial measures for the identified gaps and problems in relation to household wastewater management. The findings of the study also revealed that, government sectors to properly manage household wastewaters, design mechanisms that are cost, time and effort effective in order to minimize the costs of the tasks accomplishments in the study area but it is beyond strategically design capacity.

Similarly, the government cannot be encouraged local communities to participate; to contribute indigenous, valid ideas, have strong sense of ownership by members of the community. It is also very important to engage local investors, 'gatekeepers or influential community leaders and existing community in to maintenance and cleaning of wastewater related activities in the study area but it is not encountered.

4.3 Challenges of Kaliti Wastewater Treatment Plant Wastewater Management System

Figure 4-: photo of Kaliti WWTP taken during field observation, in 2019

According to AAWSA Report (2017), the design capacity of the works for the first phase was about 7,500m^3/day with a biochemical oxygen demand load of 3,500kg/day. Currently, the sewage flow in to the treatment plant s is up to 47,500m^3/day. During the rainy season, surface water inflow can double dry season flows. The Kaliti wastewater collection system was designed on the basis of average water consumption of 150l/capita/day to serve an equivalent population of 200,000 people. The Kaliti WWTP is currently over loaded and new expansion and rehabilitation of the treatment plant is presently under construction. The Kaliti WWTP is currently used UASB & TF Technology, Design capacity 100, 000 m^3/d, and Current capacity 47,500 m^3/d to serve an equivalent population of 400,000 people. Due to this fact the treatment plant capacity is the most challenges in wastewater treatment at a central level.

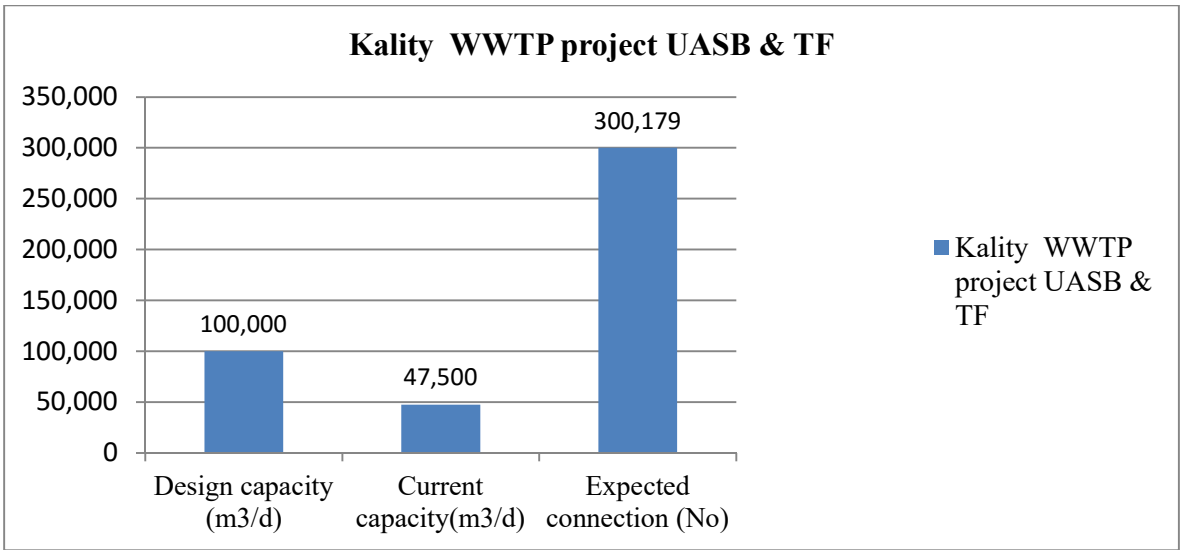

Figure 4-Wastewater Treatment capacity of Kaliti WWTP

Source: *From analysis of AAWSA report, 2017*

According to figure (4.6) the design capacity is not actually treated wastewater as the expected manner. On the other hand this is also on the paper, actually on the ground less than 20 % rather than 43.2 %.

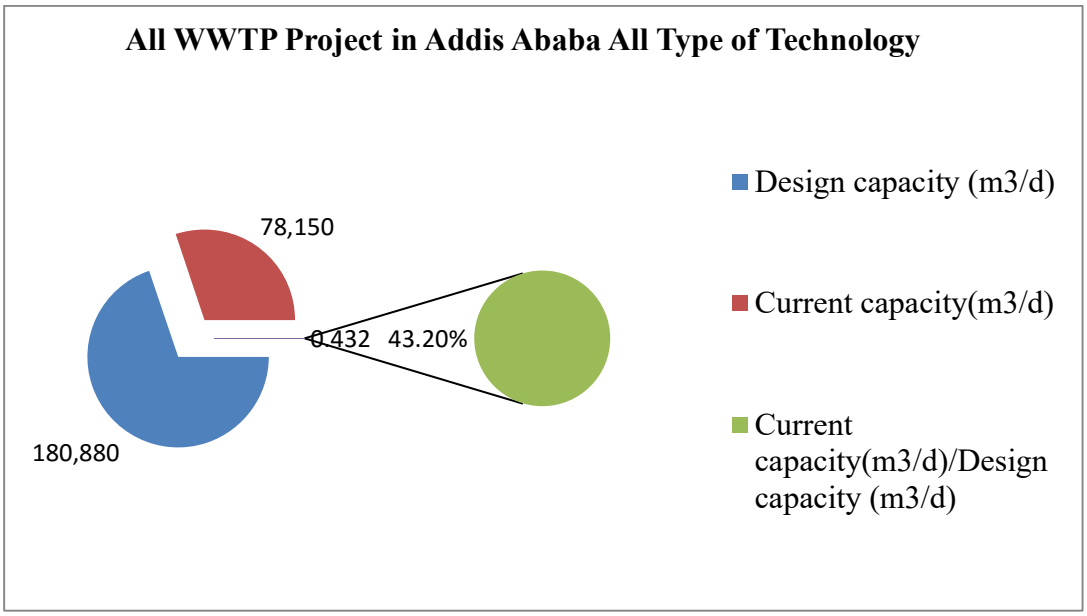

Figure 4- current capacity wastewater treatments plant in Addis Ababa.

Source: *From analysis of AAWSA report, 2017*

4.3.1 Main Factors to Manage Wastewater Effectively and Efficiently

Figure (4.7) shows that, the capacity of government, societal attitudinal change, and technology and man power are the major factors of efficient and effective wastewater managements respectively.

Cost-effective technologies to reuse effluents are an international priority. The Emerging technologies such as on-line sensors with real-time feedback certainly play a major role in wastewater treatment and reuse processes but it is not encountered in the study area. Advances in membrane technologies are also critical in lowering energy needs and increasing water recovery rates and these technologies advancement prioritized comprehensively for achieving the correct wastewater quality for the application needed. Creating ultra-high purity wastewater for irrigation, toilet flushing, and clothing washing only does not make good sense rather using the treated water for domestic purpose. However lack of government capacity, due to skill gaps of technical man power, lower technological advancement Kaliti wastewater treatment plant treated waste only for irrigation purpose and discharges as effluent to the river. Therefore, WWTP efficiency is limited in quality and quantities.

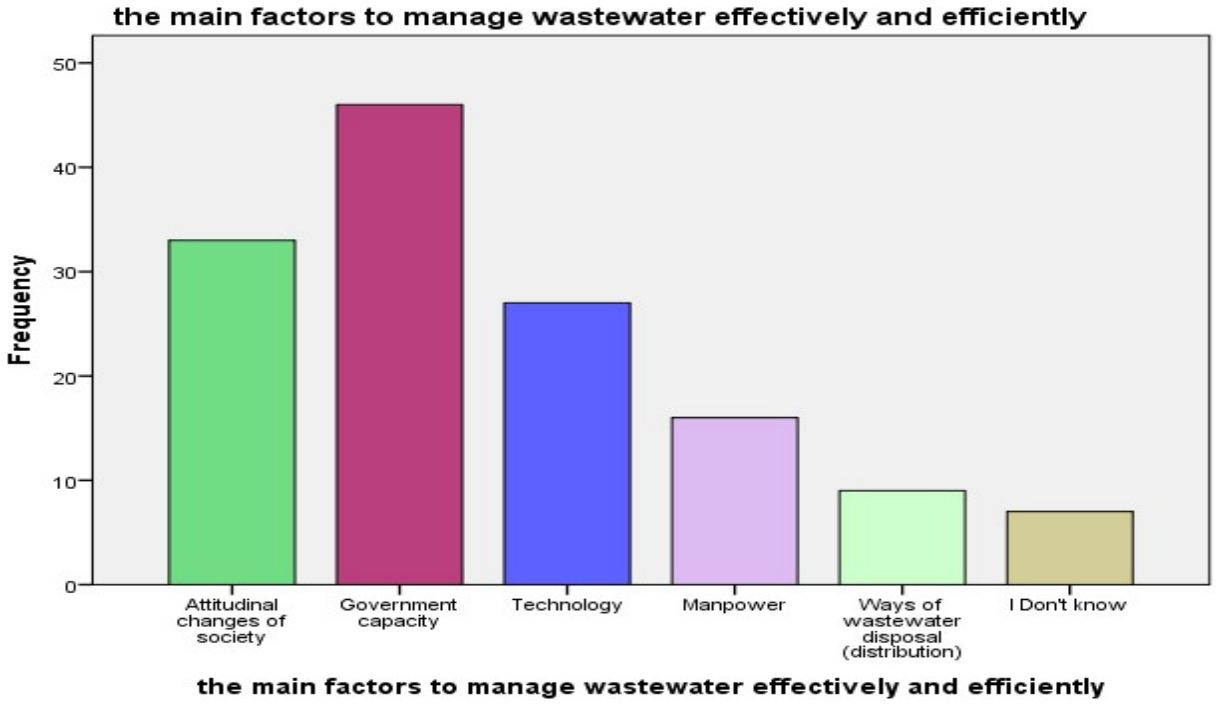

Figure 4- Factors of effective and efficient waste water managements

Source: *From own field survey, in 2019*

As human population continues to grow and urbanize, the challenges for securing water resources and disposing of wastewater become increase and more difficult to manage. In the study area Wastewater is usually transported through collection sewers to Kaliti centralized WWTP at the lowest elevation of the collection system near to the point of disposal site through sewerage line. Currently the AAWSA has reached to a stage where the numbers of sewer connections to the central and decentralized wastewater treatment units have reached to about 86,535 connections. Some of the connections are related to the condominium housings connection to decentralized treatment units. With these connections about 12 % sewerage service coverage has been reached for the city of Addis Ababa.

The lack of sewage networks and treatment plants complicates the collection and treatment of waste water in Addis Ababa. It has a very limited sewer network coverage accounting for 7.5% of the built-up areas .Since parts of the older sections of the city are only connected to the central sewer system; both residential and business premises use septic tanks although their availability is severely limited in many of the old neighborhoods. Even though the city has a centralized sewerage system (sewer line) and two Waste Water Treatment Plants (at Kotebe and Kaliti) they are currently operating below their capacities (Ali & Eyasu, 2017).

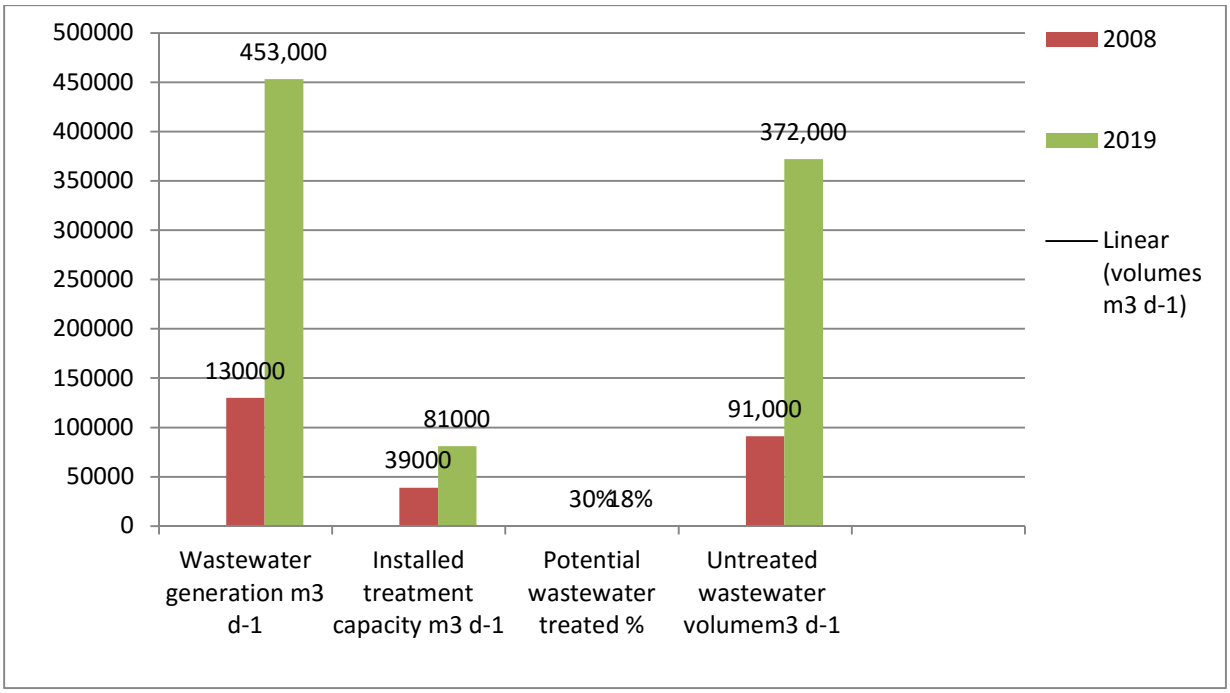

Figure 4- Sewerage service coverage in Addis Ababa

Source: *From analysis of AAWSA report, 2018/9*

During field study 77.5% of the respondent not accepted the treated wastewater purity and 15.9% of them understand how much the treated wastewater level of purity. On the other hand about 6.5 % of respondents explain that treated wastewater is not use for domestic purpose other than irrigation but in other countries use for in different purpose like car wash, landscaping for toilet and different domestic purpose.

Table 4-Treated wastewater purity acceptance

purity acceptance	Frequency	Valid Percent	Cumulative Percent
No	107	77.5	77.5
Yes	22	15.9	93.5
I Don't know	9	6.5	100.0
Total	138	100.0	

Source: *From own field survey, in 2019*

In the field study there is no private organization, which participates in the treatment processes. Without participation of government organization only government is not attend the demand of wastewater treatment.

There are efforts exerted by various governmental and non-governmental organizations including the private sector towards improving the sanitation sub-sector. These include: Ministries of Health, MoWIE, Urban Development and Construction, Education, and Agriculture, as well as the Federal and Regional EPA Authorities/ Bureaus, Municipalities, NGOs, Academic Institutions, private sector sanitary suppliers and donors. Efforts are made in the areas such as policy and strategy formulation, planning, coordination, infrastructure provision, monitoring and evaluation. Urban wastewater management activity in the country in a planned manner is limited to Addis Ababa and few other cities (Temesgen, 2018).

Table4.4- Participation of private organization in wastewater treatment

private organization participation	Frequency	Valid Percent	Cumulative Percent
No	138	100.0	100.0

Source: *From own field survey, in 2019*

4.3.2 Wastewater Treatment Facilities

According to the table (4.7) below the luck of sewerage line in the city is one of the main factors to reach the waste at central level. Deteriorations of sewer line and luck of regular repair and maintenance is also an obstacle to wastewater disposal systems.

Table4- factors of effective wastewater disposal from source up to central

The main factors of effective wastewater disposal from source up to central	Frequency	Valid Percent	Cumulative Percent
Luck of disposal sewerage line	91	65.9	65.9
Deterioration of sewerage line	22	15.9	81.9
I don't know	25	18.1	100.0
Total	138	100.0	

Source: *From own field survey, in 2019*

The city has expanded extensively over the past decade due to the foundation of new expansion areas where real estate is mushrooming. The massive public projects in the construction of condominium houses put additional pressure both on sewerage services.The main parameter required for the sewer collection system is the quantity of wastewater to be transported. About 80% of the water actually provided to the users with in-house sanitary facilities discharged into the sewers. The population connected to the sewer network discharge about 45 grams BOD/day per person as a pollution load including the pollution load from non-domestic connections. The average wet sludge volumes were 0.35m^3/person/year for septic tanks and 0.10m^3/person/year for dry pit latrines.

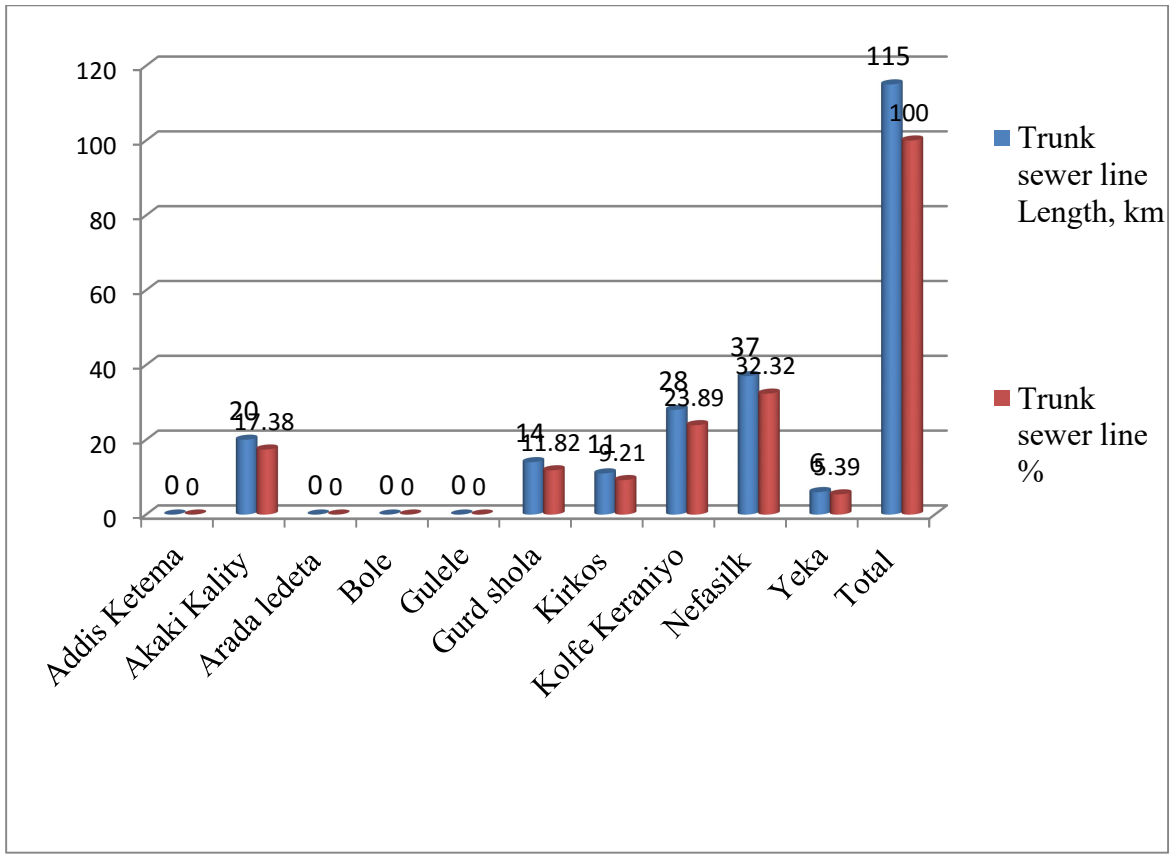

Figure 4- Summary of sewer network under new boundary

Source: *From analysis of AAWSA report, 2018/9*

4.3.3 Sewerage coverage based on customer number

The collected data indicated that AAWSA has about 86,535 mixed customers as of 2009 EC related to the sewerage service as depicted below and this resulted to the population coverage percentage of about 86,535*5.4=467,289 population using the heads of 5.4 (obtained from the household survey) persons per connection. This portion of population 467,289 is averagely about 12.46 % or is 13.94% of CSA 2016 with a household size of 4.2 (3,353,004) population of the city. The summary of the sewerage connection in the existing branch boundary areas is depicted.

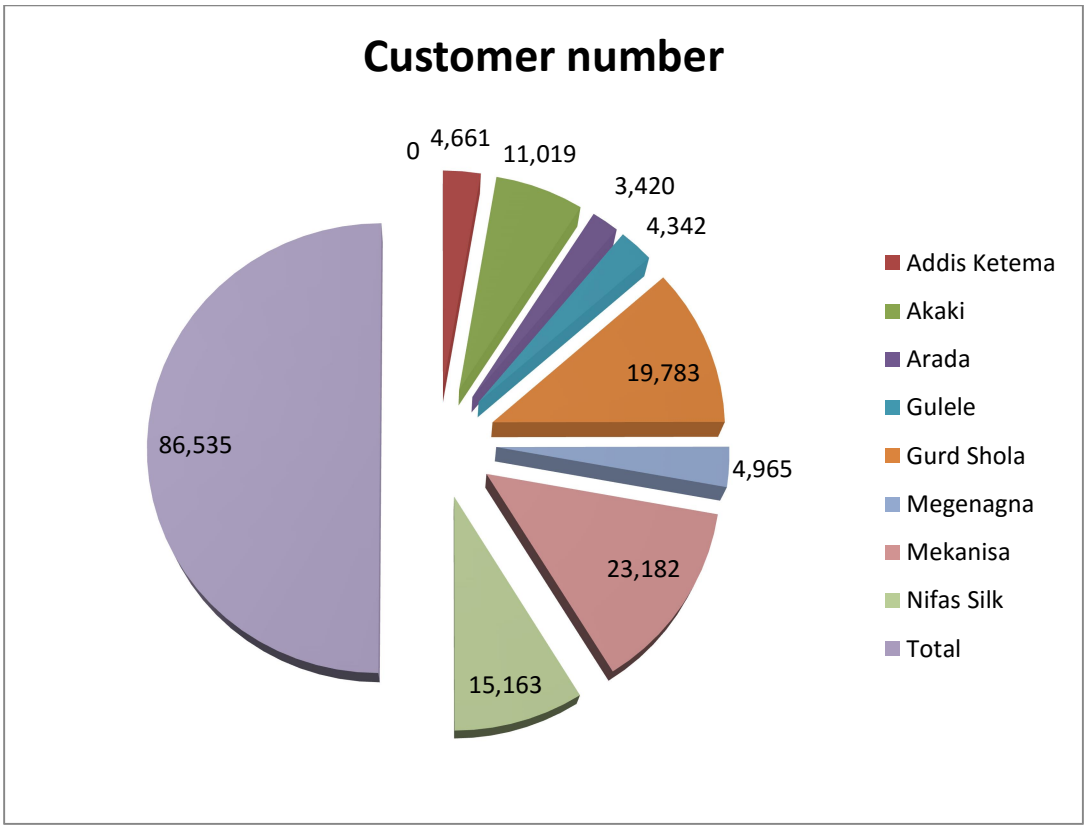

Figure 4- Breakdown of the sewerage customer services by existing branch office level
Source: *From analysis of AAWSA report, 2018/9*

4.3.4 Toilets coverage and Services in the city

Figure (4.11) below present's overview of the type of sanitary services and facilities available in Addis Ababa according to the 2007 census, 14.3% of the housing units had no toilet facility and 51% of the households use private and shared pit latrines.

The 2014 Ethiopia Mini Demographic and Health Survey (EMDHS) and (CSA) in Ethiopia in 2014 showed that only 4.5% Percentage of the population with access to flush toilet, ventilated improved pit latrine, traditional pit latrine with a slab, or composting toilet and does not share this facility with other households (Temesgen , Mekuriaw Manderso;, 2018).

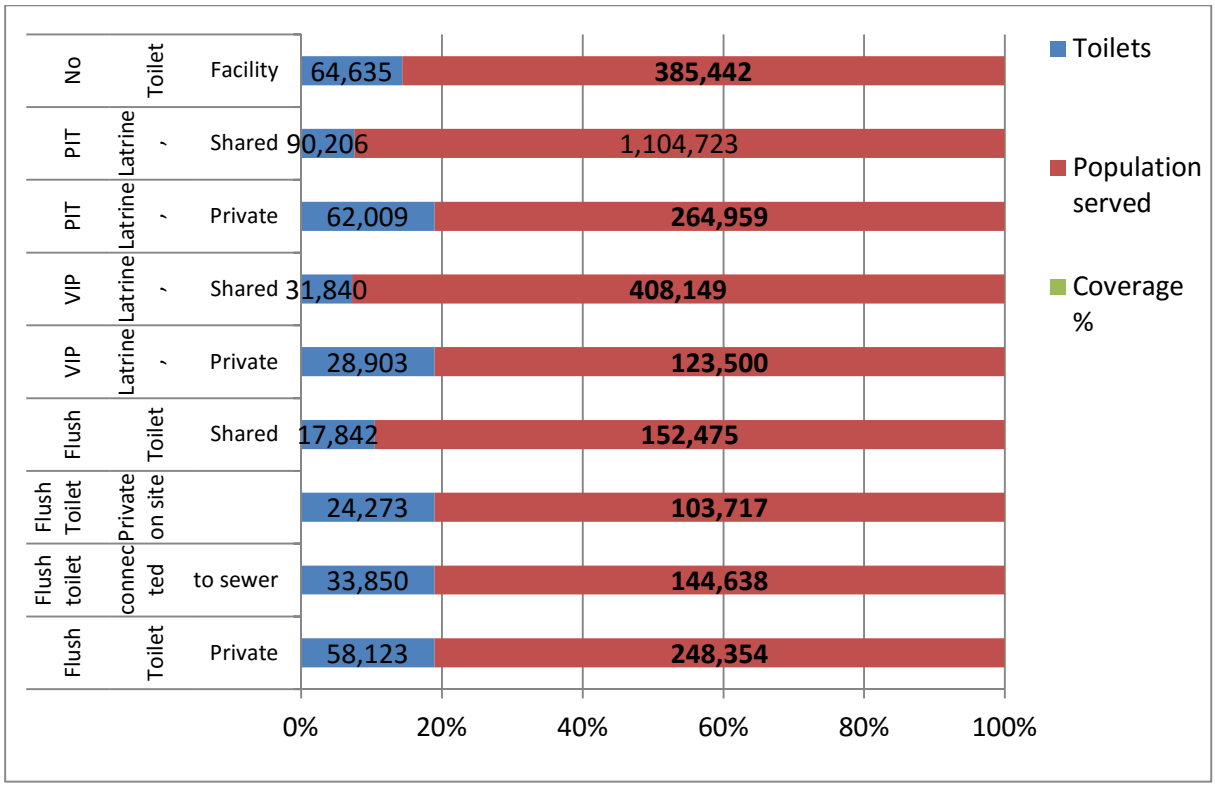

Figure 4- Toilets coverage in Addis Ababa city

Source: *From analysis of AAWSA report, 2018/9*

As per the World Bank Definitions Access to improved sanitation facilities refers to the share of the population with at least adequate excreta disposal facilities (private or shared, but not public) that can effectively prevent human, animal, and insect contact with excreta. Suitable facilities range from simple but protected pit latrines to flush toilets with sewerage. To be effective, all facilities correctly constructed and properly maintained. Improved Sanitation facilities include: connection to a public sewer, connection to septic system, Pour-flush latrine and Simple pit latrine Ventilated improved pit latrine.

On the other hand sanitation facilities considered as not improved include:-Service or bucket latrines (where excreta are manually removed), Public latrines with an open pit and plastic bags usage and open dumping.

Sanitation services strongly determine the quantities and quality of domestic wastes that will be produced, their nature (fluid or solid).

Septic tanks and pit latrines are low-cost technologies that allow construction, repair, and operation by local communities or homeowners and effectively reduce public health problems

related to wastewater but households that collects wastewater from toilets, showers, sinks, and other household utilities through a pipe, solids settle on the bottom. In a pit latrine, the solids settle but the liquid seeps directly into the soil and river.

The liquid flows out of the septic tank into a drainage field or overflows into a drainage system. The required effluent disposal area depends on flow rate and local soil infiltration. The effects of these flows on the quality of the groundwater must be considered. Accumulating solids have to be periodically removed from the tank. In properly designed septic tanks with soil absorption of the liquid flows, the soil will remove the remaining BOD, suspended solids, bacteria, and viruses from the effluent.

4.3.5 Wastewater Governance

As shown in the table (4.8) arbitrarily wastewater disposal in the study area is very high. Around 47.1% of respondents disposed arbitrarily, 10.5% and 22.5%recycled the wastewater onsite from the source and disposed as open defecation respectively.Management of emptying the toilet is one of the commonest challenges at household as well as at institutional levels. This is mainly due to financial constraints, shortage of vacuum truck service, lack of awareness and limited attention. The study examined the practices of emptying the toilet, frequency, access to the service

Table 4-household adopt Wastewater managements practices in Addis Ababa

Domestic Wastewater managements	Frequency	Valid Percent	Cumulative Percent
On site recycling	15	10.9	10.9
Open defecation	31	22.5	33.3
Arbitrarily disposals	65	47.1	80.4
Connected to centralized sewerage system	27	19.6	100.0
Total	138	100.0	

Source: *From own field survey, in 2019*

Based on the field study wastewater related governance problems is very extreme (41.3%), and it is serous (26.1%) agenda for government and other concerned body in Addis Ababa as shown in table 4.9).

Table 4- wastewater management processes related governance problems in Addis Ababa

Governance Problems	Frequency	Valid Percent	Cumulative Percent
Yes extremely	57	41.3	41.3
Yes seriously	36	26.1	67.4
Yes Adversely	24	17.4	84.8
Yes moderately	16	11.6	96.4
Yes but normal	3	2.2	98.6
I don't know	2	1.4	100.0
Total	138	100.0	

Source: *From own field survey, in 2019.*

The odor of the reclaimed water is the main problems the downstream society in Kality treatment catchment area. Complain of peoples, odors of reclaim water (67.40%).colors (21.7%), safety and price also sources of complains for the reclaimed water.

Wastewater (effluent) is not flow and stay long time cause to create offensive odder and the community easy to catch with common cold and the cause of disease of those as thematic patients(Temesgen, 2018)

Table4- knowledge of respondent about reclaimed water

The complains about reclaim water	Frequency	Valid Percent	Cumulative Percent
Odors of the reclaimed water	93	67.4	67.4
Colors of the reclaimed water	30	21.7	89.1
Safety of the reclaimed water	8	5.8	94.9
Price of the reclaimed water	1	.7	95.7
I don't know	6	4.3	100.0
Total	138	100.0	

Source: *From own field survey, in 2019.*

The results of the survey were concluded and Seen from this table; it is obvious that the concept of reclamation did not get enough public awareness. Similar as the situation of Kaliti case, 18.1 % of respondents didn't know about the definition of "reclamation". Just one of the respondents knows it, but unfortunately, they had now ideas about the situation of reclamation system in Kaliti WWTP. According to the table, among these 81.9% knows what the reclaimed water is.

Moreover, the rest of them who don't know the definition of reclamation water can only express a few of opinions about their using experience.

Therefore, the investigation for public acceptance met a big obstacle. This phenomenon can be explained by three possibilities: The citizens do not have right to choose the source of water. In other words, they just can use the water from pipe. So they do not care about the characteristics of water. Currently, the most popular usage of reclaimed water is for landscaping, people do not have direct contact with the water. Therefore, they are not aware of the existence of reclaimed water.

Table4-Respondents understanding about reclaimed water

Understanding about reclaimed water	Frequency	Valid Percent	Cumulative Percent
No	25	18.1	18.1
Yes	113	81.9	100.0
Total	138	100.0	

Source: *From own field survey, in 2019.*

The water which release from the treatment plant is not much used by the people as explained in the table below. From release treated wastewater by Kaliti wastewater treatment plant, only 21% of water used by the respondents.

Table4- customers of reclaimed water

using the reclaimed water know	Frequency	Valid Percent	Cumulative Percent
No	109	79.0	79.0
Yes	29	21.0	100.0
Total	138	100.0	

Source: *From own field survey, in 2019.*

On the other hand, surveys for end users (the citizens who use the reclaimed water produced by Kaliti outside reclamation process) was also carried out to check whether the public awareness or/and public acceptance is good enough. Therefore, within the scope of the pipe system of Kaliti Wastewater Treatment plant, two groups of dwellers from two residential areas were chosen to generalize the result from all units in the operational population. The survey was carried out in the nearby residential areas which are using the reclaimed water generated by Kaliti Wastewater

Treatment Plant: Kaliti residential area and end user residence residential area. Above 77.5% the respondent doesn't satisfied by the reclaimed water and only15.9% accepts even for irrigation as shown in table (4.5).

The reclamation process within Kaliti wastewater treatment plant was under construction which can be depicted shortly like this: After primary and secondary treatment for municipal wastewater, part of the effluent is under further treatment in order to reach the standards for reclaimed water. The water is for in-plant reuse afterwards, such as device washing, car washing and landscaping in a slight manner. It undergoes the advanced treatment in order to reach the standards for the urban reclamation water. Afterwards, part of this water is used as second municipal water resource and mostly the other is for landscaping or agricultural irrigation otherwise they discharges in to Akaki river.

Table4-the purpose of reclaimed water

Importance of reclaimed water	Frequency	Valid Percent	Cumulative Percent
Landscaping	4	2.9	2.9
Industry cooling water	1	.7	3.6
Urban Agriculture irrigation	90	65.2	68.8
I Don't know	43	31.2	100.0
Total	138	100.0	

Source: *From own field survey, in 2019.*

4.4 Kaliti Wastewater Treatment Plant Influents Design Data

4.4.1.1 Effluent Quality

The required effluent quality for irrigation is presented

Table 4- Treated Effluent Characteristics

Effluent Quality Standard For Irrigation			**Monthly av. KWWTP Laboratory Result**	
Parameter	**Unit**	**Value**	**Value**	**% from the standard**
COD	mg/l	100	202	49.5%
BOD	mg/l	35	133	26.3%
TSS	mg/l	35	66	53%
Helminthes	#eggs/l	1 *	No data	
E. coli	E. coli/l	10^5	No data	
Source :WHO guideline,2012			**Source:** *Kaliti WWTP laboratory results*	

The overall removal efficiencies of the treatment plant (i.e. comparison between standard treatment system) were 35-133 for BOD (26.3% efficiency), 100-202 for COD (49.5% efficiency), 66 for TSS (53% efficiency) and also there is not recorded data on Helminthes and E. coli. Based on this analysis the Kaliti wastewater treatment plant discharges the effluents difficult to reuse for irrigation.

The relevant criteria are much more stringent than the related recommended guidelines for wastewater reuse published by the World Health Organization but comparable to the related guidelines published by the U.S. Environmental Protection Agency (EPA). Table (4.15) summarizes the typical reclaimed municipal wastewater quality standards for municipal uses.

Table 4- Reclaimed water quality criteria for urban use (1) (mg/L unless specified otherwise

Item	Toilet flushing	Car washing and road flushing	Monthly av. KWWTP Laboratory Result		
			value	% from the standard	
				Toilet	Carwash
Turbidity	≤10	≤5	No data	-	-
TDS	≤1200	≤1000	No data	-	-
SS	≤10	≤5	52	19.2	9.6
Color (units)	≤30	≤30	No data	-	-
PH	6.5-9.0	5.0-9.0	7.17	b/n the range	b/n the range
BOD5	≤10	≤10	133	7.5	7.5
COD	≤50	≤50	202	24.7	24.7
NH4-N	≤20	≤10	30	66.6	33.33
Chloride	≤350	≤300	No data	-	-
Fe	≤0.4	≤0.4	No data	-	-
Mn	≤0.1	≤0.1	No data	-	-
Chlorine residual	≤0.2	≤0.2	No data	-	-
Source: *WHO guideline,2012*			**Source:** *Kaliti WWTP laboratory result*		

In the wastewater reuse planning, the user of the reclaimed water include industry, grass irrigation, toilet flushing. Different water quality of reclaimed water should be met for different uses. However, with a view of the management, in the wastewater reuse planning of Kaliti, all

the reclaimed water from municipal reclaimed water factory would be secondary treatment plus flocculating settling. If higher water quality were needed, the appropriate treatment should be implemented by the corresponding major users.

The efficiency analysis of the treatment plants resulted in removal efficiencies of 7.5% for BOD5 (for toilet and carwash purpose) 24.7% for COD (for toilet and carwash purpose), 19.2%, and 9.6 for SS (for toilet) and for carwash respectively. Similarly, for NH4-NtheKalityiwastewater treatment plant monthly removal efficiencies for toilet and carwash 66.66% and 33.33% respectively. In overall result as shown in table 4.16 and 4.17 the treated wastewater in Kaliti wastewater treatment plant is not fulfills the standards when compare with the who standard.

Quality management system is used to develop efficient and effective, high quality and appropriate laboratory services to satisfy the need of customer, the laboratory must plan the activities and perform the analysis. And the data generated from the laboratory must be quality control. Then Quality Management system is established in the laboratory but not in this way in Kality treatment plant.

Municipal activities, agriculture, and rapid urbanization led to increased nitrogen and phosphorus discharge to the water system. More often, the effluents from municipal wastewater treatment plant failed to meet the national standard for effluent quality (Wahyu, 2018).

4.5 Economic Factor of Wastewater Management

Wastewater management is capital intensive for both investments and operation and maintenance costs. It tends to be two or three times more expensive than the costs of abstracting, treating and distributing tap water. In the Netherlands, Germany and other European countries, for example, water agencies spend more money on treating wastewater than on all other water-related activities. Thus financing wastewater infrastructure can be a difficult issue and in fact only a few countries in the world manage to cover all costs (construction, operation and maintenance) directly from their customers through user charges. Even in countries where labor and materials are cheap, cost is high and can be prohibitive, and households prefer not to use scarce income to address wastewater problems (Hophmayer, 2017).

In Kaliti catchment, the Kaliti Wastewater treatment plant rehabilitation and expansion project (having 100,000 m^3/day capacity and serving 2 million users) was intended to carry out 60% of the construction work In this project it is planned to complete the construction of the 50% outstanding works for Kaliti Wastewater treatment plant Expansion and Rehabilitation Project by the year ending 2019 at the cost of Birr 800 million. Chefe WWTP Phase I having the capacity of 12,500 m3/day and has been completed in year 2017 at the cost of Birr10.5 million. Akaki Catchment Sewerage Construction Project, for Chefe WWTP Phase II capacity 12,500 m^3/day the design document is prepared but construction is not yet started to date and it require at the cost of Birr 555.14 million.

The cost for South, Akaki WWTP is Birr 934.78 million. Realize the construction of South Akaki Wastewater treatment plant having the daily capacity of 60,000m^3/day in the year ending 2025 at the cost of Birr 934.78 million. Realize the construction of Eastern Catchment Phase II Wastewater treatment plant having the treatment capacity of 80 000 m^3/day in the year ending 2030 at the cost of Birr1.25 Billion.

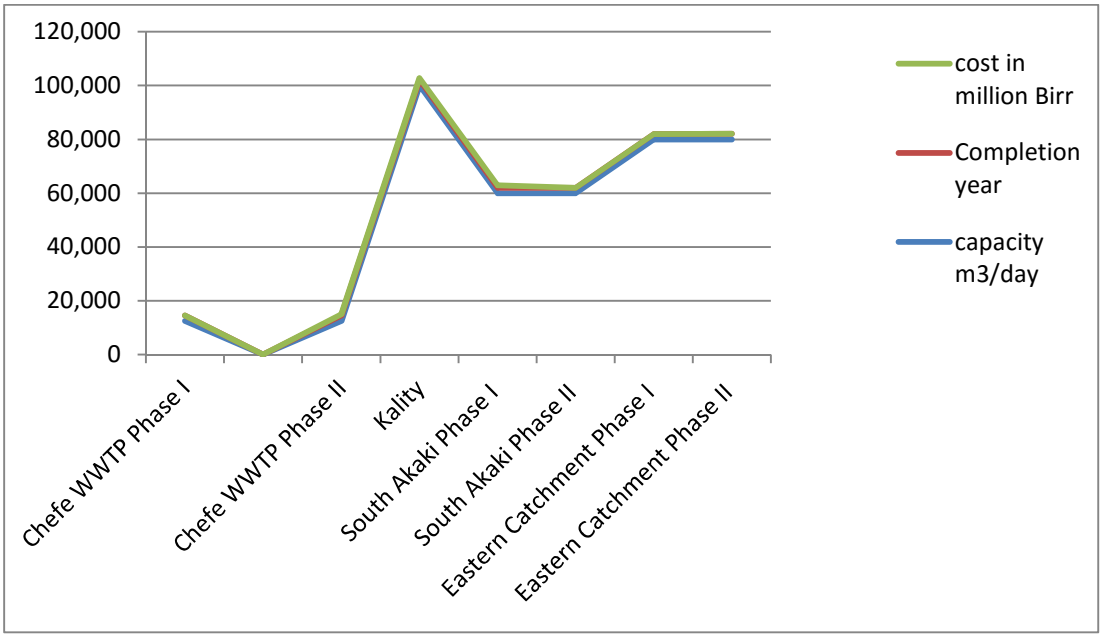

Figure 4- Wastewater treatment facilities (cost)

Source: *Analysis of AAWSA report, 2018*

4.6 Environmental factor Wastewater Management

In Addis Ababa as shown in Figure (4.11) presents an overview of the type of sanitary services and facilities present in Addis Ababa according to the 2007 census. 14.3% of the housing units had no toilet facility and 51% of the households use private and shared pit latrines.

In Ethiopia, the sanitation facility coverage gap remains unacceptably large and collection and emptying mechanisms are one of the challenges. The management of liquid waste at household level is very poor. About half of the households handle grey water (household liquid waste) by openly discharging into any accessible public properties, such as streets, drainage lines and nearby open space. Sewer line application is not that much familiar in the country (Temesgen, 2018).

This habit of open field disposal of liquid waste is one of the main causes of soil and water contamination and consequently a cause of many communicable diseases. Improper wastewater management is considered one of the challenging environmental problems in Addis Ababa. The wastewater generated from different area increased significantly due to rapid population growth and fast urbanization, change in lifestyles and consumption patterns. Major problem associated with wastewater management are poor collection rates, open dumping, and improper recycling that pose environmental damages**.** Improper management of household wastewater has various impacts on environment. The result of the study shown as, the impacts of improper household wastewater management are observed and these impacts are grouped into health problem, water and air pollution.

4.6.1.1 River Pollution in Downstream Areas

Improper management of household wastewater and effluent has great impacts on the quality of water. Hence, the finding of the study indicates in the study area, effluent wastewater is directly discharged to the river, which pollutes the water. The river and stream which were found in the city are used as washing cloth and bathing for those low income communities lived near and around the river and streams. Results from field observation shows people of different communities released their wastewater directly to the Akaki River. This river was also used as irrigation, washing cloth and recreational purpose. Downstream of the treatment plant area is mainly occupied by vegetable gardens and grasses. The local community is growing vegetables

(mainly cabbage) in these areas. The Little Akaki River seems to be more polluted than the water being released from the treatment plant. Interviewed people in downstream areas stated that the river water is much polluted and they are not interested to use it even for irrigation compared with the effluents from the treatment plant.

Much of the open ground which was considered as command area in the irrigation feasibility document is now occupied by many houses. There are many mud houses along the right bank of the Little Akaki River. The vegetable gardens along the course of the river are owned by the residents of these areas. The course of the little Akaki River is highly vegetated. This becomes important habitat for birds and animals. Some of the trees (eucalyptus) are owned by local residents. The presence of the treatment plant has favored the growth of different activity like urban agriculture improvement.

4.6.1.2 Impact of the treatment plant and sewer line development

Impacts arise due to the interaction of the project with the environment and the society. The interaction of the project can come from the project location and from the various activities of the project in the different phases. The receptors are the physical and the biological environments and the society.

4.6.2 Socio-economic impacts

The environmental problems associated with a consequence of the number of people producing wastewaters, and the high concentration; On the other hand, the large concentrations of people would appear to offer greater opportunities for centralized approaches to the provision of infrastructure and services, which may actually reduce the per capita cost of service provision. However, the population densities and the latter's distances from existing centralized wastewater disposal systems, often means that economies of scale do not exist, so that Kaliti centralized systems for wastewater collection and disposal require disproportionately large investments which are unaffordable to the government.

The conventional wisdom has been that centralized systems are easier to plan and manage than decentralized systems. There is some truth in this argument when municipal administrative systems are centralized. However, experience shows that centralized systems have been particularly poor at reaching urban areas, particularly those that fall outside municipal

boundaries and have not been responsive to local needs and resources. It has also been argued that they express power relationships within which service to the urban poor is always given a low priority (Aliyu, 2010).

Household wastewater is the principal vector by which a large number of communicable diseases are transmitted and spread in urban areas. According to Sisay (2017) study, 94.4% of city households source of wastewater were gray water, 16.6% of the population have no access to toilets and 23.3% those have access to toilet but not empting in truck who disposed their wastewater either or both in open space, in river and drainage channels. As a result, it creates environmental problems. In relation to these, according to Akaki Kaliti Werda-7 Health office Annual Report the mostly occurred top diseases were: upper respiratory disease and diarrhea 35% and 9.8% respectively, which are resulted from, the households were discharging there wastewater in to the environment without any treating mechanisms. Therefore, these methods of wastewater management have a negative consequence on health status of the community in the sub city and it also has health cost, needs additional cost and reduce the productivity of the community. A losing of a working day to health problems related to poor household wastewater management has an economic cost, which brings a reduction of household income and the productivity of local and national economy and conflicts between neighborhoods due to improper disposal of waste water in the study area.

4.7 Wastewater Management Opportunities

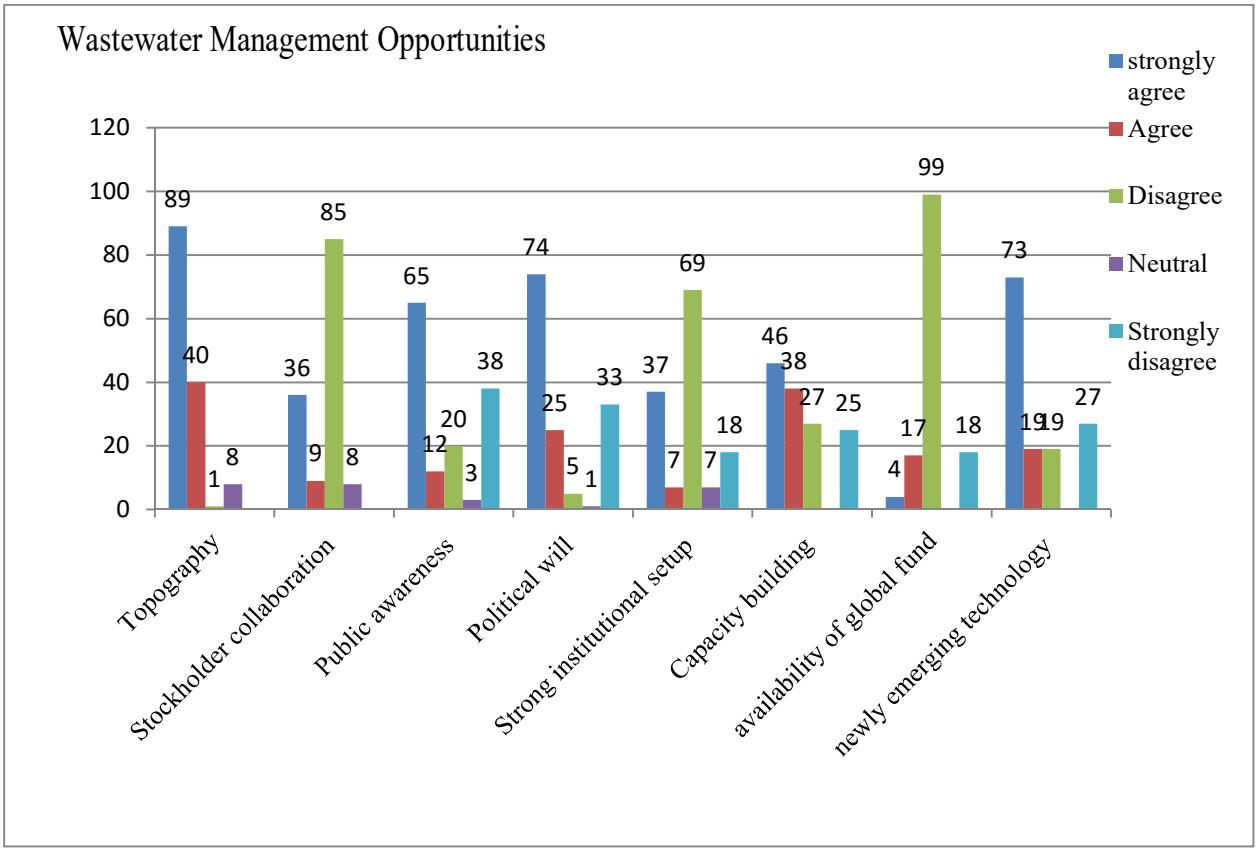

Figure 4- Wastewater management opportunities

Source: From own field survey, in 2019.

4.7.1 Topography

The topographic orientation of Addis Ababa is sloped and the Kaliti catchment centralized wastewater collection system is through gravities. There is not pump requirements for sewerage system, so it is very important for reducing wastewater collection systems. According to Ali & Eyasu (2017) Gravity sewers are preferred because of their lower operation and maintenance costs compared to pumped systems. Gravity wastewater collection becomes economically feasible and population densities in the study area are 200 to 300 persons per hectare.

4.7.2 Stakeholder Collaboration

There are a number of stakeholders with direct and indirect roles and responsibilities in urban wastewater management. In the study area Ministry of Water Irrigation And Electricity Develop policies, regulations and strategy in related with wastewater management, Plan and conduct Capacity building and cascading the training package to different Stakeholders, Arrange a joint

review meeting and workshops at city administration level on wastewater management, Coordination of planning, implementation and M&E in UWWM system.

The health sector has also an important role to play in promoting sanitation. Creating demand and changing behaviors' are both areas where the health sector has a strong track record and recognized comparative advantage. However, there is a lack of consensus regarding institutional roles and responsibilities for sanitation in the countries, and the degree of health sector involvement in promoting safe sanitation varies significantly in the study area. Improved collaboration between water and health sectors is very keys to improving sanitation -related health outcomes. It shows that health systems have a critical role to play in promoting sanitation but that existing health sector involvement is frequently. It makes a series of recommendations for health sector stakeholders interested in accelerating progress on sanitation and securing related health gains.

The Environment Protection Authority (EPA) is Develop guidance documents providing information on specific aspects of best practice in relation to onsite wastewater treatment and also the metropolitan city of Addis Ababa has set structured wastewater management system. As the respondent explanation these stakeholder collaborations is initiatives but still it requires strong relationships.

4.7.3 Political Goodwill of Government

Political climate has created high priority is assigned to all the aspects of sustainable urban wastewater management, including the allocation of Sufficient domestic resources (recycled wastewater resource) and community mobilization.

Wastewater control and management is typically one of the responsibilities of the government: national, regional and local. Governments undertake to do this by establishing appropriate organizations and launching program. National government sets wastewater management policy, regulation, planning, monitoring and partly financing. The City administration/ Local governments also typically implement local plans and finance and own wastewater infrastructure. However, wastewater management is complicated and requires managerial and technical high capabilities. Thus, it strains the already stretched technical and managerial competence of many governmental agencies and poses real obstacle and capacities to address the wastewater management issue is very often inadequate, professionals often lack the expertise

regarding the impacts of pollution and the tools to address it; institutional mechanisms are limited only in AAWSA; and managerial, technical and financial know-how is commonly poorly developed to set up and run effective wastewater management.

4.7.4 Institutional arrangement

As the explanation of AAWSA employees Ministry of Water Irrigation and Electricity Build institutional arrangement at the Ministry, Regional Bureau and city level; establish a Wastewater Management Directorate the MOWIE level for effective, coordination and administration of the urban wastewater management system, this strategy and the MoH strategy for integrated Urban Sanitation and Hygiene continue to complement each other to serve Addis Ababa cities for implementation of sanitation and hygiene practices.

4.7.5 Capacity building

Capacity development as one element of strategic framework to improve its service and transform itself to a more commercially oriented and customer focused utility. Some strategic approach is required to achieve sustainable capacity development. In the study area the capacity development intervention areas by AAWSA include, staff training and development, experience sharing, external professional service, performance contracts, developing operational manuals and guidelines in line with the business processes as outlined in BPR, benchmarking as a tool improving performance, developing well-defined mission statements and internalize in the organization's culture and facilities and infrastructure. Hire additional programmers and system analysts for ICT department. Provide staff with training and other capacity building measures. There are other opportunities which enhance the smooth implementation of plans which could treatment efficiently the progress of plan, project and program. Accordingly, for the implementation of GTP2 on sustainable development of wastewater management , it is important to consider the opportunities which could create favorable environment for accelerated implementation of the plan, projects and programs like political leaders are aware of the targets of the sub-sector and the implementation strategy thus play key role in coordinating, monitoring and evaluating the implementation, harmonization of intervention among all stakeholders or partners of the sector is undergoing well which would be improving the synergetic effect for the implementation by reducing negative impacts of disintegrated interventions and the effort government's undergoing to strengthen the domestic financial resource mobilization capacity

reduce the effect of unpredictability of external financing thus accelerating implementation of the treatment plan.

4.7.6 Emerging Technology

In successful and performing Sewage Authorities, most information is available for a large part of the staff and there are tools (such as Intranet system or others for in-house communication). However the information communication system in the study area is much localized: in AAWSA even the Branches have no access to the customers and wastewater databases and the information collected by the branches (such as the treated wastewater) are transferred to the headquarters semi manually. It seems that the ICT is designed and developed for the head quarter only and not for the whole this is not the best condition to share information and motivate the staff and community. There is no information data bank especially on population density (number of people per head), produced wastewater volume (in cubic meters per household per day); and cultural considerations need to assess in the planning of wastewater management As a result, AAWSA to make a review and assessment of this situation and: to analyze the possibility to extend the IT coverage to all of the AAWSA's premises in the city of Addis Ababa.

4.7.7 Availability of Fund

As shown in figure 4.13 the availability of funds for wastewater treatment and management is very low. The capital fund account only managed by project office in to AAWSA's overall finance and implement once the AAWSA financial statements are up to date. National government work in securing finance in the form of loan and grants from different banks and financing institution to support the current and future wastewater management projects and programs; where loans are part are of specific fund, cities and towns shall contribute portion of the project cost as matching fund through their annual capital budget fiscal plan, and manual and guidelines shall be prepared and distributed to help select eligible cities and towns for immediate loan and grant funds support.

4.8 Sustainable wastewater management

Sustainability, as a concept, aims at maintaining economic wellbeing, protection of the environment, prudent use of natural resources, and equitable social progress. It also involves the

need to design systems assuring that the use of natural resources would not lead to diminished quality of life in the future (Andrea, 2017).

Based on table 4.16, increased sustainability of wastewater collection and transport to the central treatment plant and, with potential for vast improvements in energy efficiency and resource recovery potential of decentralized urban wastewater is a key system. On the other hand Source control, separation is important.

Table 4- sustainable types of wastewater management

Eco Friendly and Sustainable Types of Wastewater Management	Frequency	Valid Percent	Cumulative Percent
By treating wastewater centrally	12	8.7	8.7
By treating wastewater domestically	71	51.4	60.1
By re use and recycle	52	37.7	97.8
I don't know	3	2.2	100.0
Total	138	100.0	

Source: From own field survey, in 2019.

Lack of proper collection and treatment of municipal wastewater have been creating harmful effects to the environment including pollution of ground and surface water resources and damage on ecosystems. Contaminants of concern those are present in wastewater include pathogens (microorganisms), nutrients, heavy metals, suspended solids, biological oxygen demand (BOD), and oil and grease. Elevated BOD in raw effluent reduces dissolved oxygen levels in receiving waters and adversely affects survival of many organisms. Oil contained in untreated wastewater also smother benthic organisms and clog respiratory structures, as well as polluting commercial species, smothering and inhibiting the growth of invertebrates in downstream. Therefore, implementation of the proposed sewer line construction project to transfer domestic wastewater to the treatment site would solve the existing environmental pollution problem.

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CHAPTER FIVE

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusions

The findings of this research work indicates that the main source and burden of the Addis Ababa city‘s municipal wastewaters is primarily linked with domestic source, making them the main focal area for prioritizing the wastewater management strategy. Despite the practice of wastewater management the progress when compared with the degree of urbanization and population pressure is very limited. Wastewater management tasks become more complex, and the quantity has also increased from time to time. Addis Ababa city administration is also working to increase the efficiency of wastewater collection, treatment and disposal or discharge practices. Although the burden of managing the municipality‘s wastewater is on the city administration, recent involvement of private sectors seems encouraging. In fact, lack of awareness, financial capacity and enforcement mechanisms are some of the challenges facing the city administration.

Wastewater can be reused for different purposes which may also demand different treatment processes before reuse. Reuse of wastewater can be in different sectors which are; agriculture, industry, residential and urban purposes but it is not in Addis Ababa city. The Kaliti WWTP is currently used UASB & TF Technology, Design capacity 100, 000 m^3/d, and Current capacity 47,500 m^3/d to serve an equivalent population of 400,000 people. Due to this fact the treatment plant capacity is the most challenges in wastewater treatment at a central level. The capacity of government, societal attitudinal change, and technology and man power are the major factors of efficient and effective wastewater managements respectively.

With these connections about 12 % sewerage service coverage has been reached for the city of Addis Ababa, during field study majority of the respondents not accepted the treated wastewater purity but few of them understand how much the treated wastewater level of purity. There no Participation of private organization in wastewater treatment. Addis Ababa has not improved sewers coverage as compared to other middle income cities. Weak and poor implementation and enforcement of existing policies and legislation is due mainly to lack of political will, expertise, adequate funding, sectors and institutional coordination in relation to water and wastewater

management. Ecological data and knowledge is lacking to clarify the linkages between environment and wastewater especially related to urban agriculture.

Relevant policy, legislation and institutional frameworks are not well harmonized in the context of local, regional and national requirements. The capacity of government, societal attitudinal change, and technology and man power are the major factors of efficient and effective wastewater managements respectively. The luck of sewerage line in the city is one of the main factors to reach the waste at central level. Deteriorations of sewer line and luck of regular repair and maintenance is also an obstacle to wastewater disposal systems. The treated water is not fulfills the standards when compare with the standards. The survey was carried out in the nearby residential areas which are using the reclaimed water generated by Kaliti Wastewater Treatment Plant: Kaliti residential area and end user residence residential area. Most of the respondents weren't satisfied by the reclaimed water only few of them accepts even for irrigation. As a result wastewater management in Addis Ababa has been faced these challenges and need to improve it.

5.2 Recommendations

Effective management of wastewater resources is a core issue for the provision of reliable and safe recycled grey water supplies. By recognizing the reality of key wastewater resources management practices and technical capabilities emerged from the study, alternative options can be identified to propose effective management instruments and better institutional arrangements to address the problems of untreated wastewater effect in Addis Ababa. The following recommendations should be considered in improving the wastewater management systems in Akaki -Kaliti sub city:

1. The city administration should focus on both centralized and decentralized wastewater management technologies and increase the capacity of the private sector participating in wastewater management hierarchy. Institutional capacity building must also be considered. The legal frameworks must also be put in place along with effective enforcement mechanisms to implement the existing pertinent laws and policies. Penalties should be practiced on those who do not obey the laws. Enhancement of the participation and role of NGOs, private sector and communities must also put in place.
2. Information data bank is needed especially on population density (number of people per head); Produced wastewater volume (in cubic meters per household per day); and cultural considerations need to assess in the planning of wastewater management.
3. The origin of wastewater is water consumption that is; increase in level of water consumption results to large quantities of wastewater generated requiring huge investment in collection and treatment infrastructure. Therefore should be develop sustainable management strategies for both water and wastewater management; with minimal withdrawal from and reduced recharge to the environment.
4. Treatment plant capacity is the most challenges in wastewater treatment at a central level, incremental treatment plant capacity and expansion of treatment plant in the city administration should be considered.
5. Wastewater release reduction should be achieved, there are options that can be adopted and these are; no use, wastewater reuse and wastewater recycling and environmental management strategies adoption.

6. Wastewater reuse is one of the wastewater management strategies. However in Addis Ababa only 21% reuse their wastewater whereas 79% don‘t. According to field study, majority of household users (for farm) reuse their wastewater as compared to business people employed. Wastewater is reused for flashing toilets, controlling dust, carwash, landscaping industrial cooling and cleaning houses but only apply in irrigation (small farm). In addition, wastewater can be channeled to dry areas for irrigation; this is because, nitrates and phosphorus present in wastewater is essential for growth of crops. However, there should be needed policy and legislation in place that gives regulatory and control on the quality of wastewater to be used for agricultural purposes.
7. Payment of wastewater management initiative is essential to realizing wastewater management as funds are required to run the projects that should be developed.
8. Effective and effective treatment is not available, other options that should be consider improve microbial water quality, such as storage reservoirs to partially treat wastewater or water abstraction from surface waters some distance from wastewater discharges where dilution has already taken place.
9. There should be appropriate policy and institutional framework in place with the mandate of ensuring that the owners of any premises whether temporary or permanent, residential or industrial is connected to wastewater collection system to ensure that the wastewater generated is safely channeled to Wastewater treatment plant site in a sustainable manner.

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Appendix

Addis Ababa University

Colleges of Development Study

Department of Water Resource Management

Interview Questionnaire

Introduction

My name is ShewangizawAmare, a graduate student from Addis Ababa University pursuing MSc Degree in Water Resources Management studies. I am carrying out a research entitled "Investigating the Challenges and Opportunities of Centralized Domestic Wastewater Management in Kaliti Catchment, the Case of Akaki-Kaliti subcity Addis Ababa,"a case study on reducing wastewater release into the environment in Addis Ababa City. I am requesting for your contribution in answering some questions.

I will be grateful if you could spare your valuable time to give me information, your views and comments. Information provided by you will be for academic purposes only and will be confidential.

Thank you in advance!

Part one: General Background of the Respondent

1.1 Full Name_____ (Not obligatory)

1.2 Age _____

1.3 Sex: 1. Male ☐ 2. Female ☐

1.4 Occupation _____

1.5 Religion/Believes _____

1.6 Address: Sub-city_____ Wired_____ House no. ____

1.7 Family size: 1. Males _____ 2. Female_____3. Total _____

1.8 Level of Education

Pre-school	☐	Secondary (preparatory)	☐
Primary school	☐	College (diploma)	☐
Secondary School	☐	Bachelor degree	☐
Master's degree and above			☐

1.9. Level of monthly income

Below 2000 ☐ 6000 ☐

2001-6000 ☐ above 10000 ☐

Part Two: wastewater management Issue

For AAWSA and Treatment plant

1. Which are the main challenges of wastewater treatment at a central level? Rank it.

☐ a) Treatment plant capacity

☐ b) The nature of wastewater

☐ c) Treatment cost

☐ d) Treatment water cost recovery

☐ e) Technical skills

☐ f) Government focus

g) If other----------

2. Which are the main factors to manage wastewater effectively and efficiently? Rank it.

☐ a) Attitudinal changes of society

☐ b) Government capacity

☐ c) Technology

☐ d) Manpower

☐ e) Ways of wastewater disposal (distribution)

f) If you have additional idea----------

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3. The following statements are challenges of wastewater management Addis Ababa city. Please indicate your judgment from the following options using √ or × the space provided in front of each statement. Each choice is identified by number ranged from 1 up to 5.

Note: - ☐strongly agree = 1 ☐Agree =2☐Disagree =3 ☐Neutral =4 ☐Strongly disagree =5

Challenges of Household Wastewater Management Systems	1	2	3	4	5
Shortage of Household Wastewater Related Infrastructures					

Lack of Coordination between Institutions					
Inadequate Participation of Stakeholders					
Lack of Awareness and Sense of Ownership on the Community					
Strategies to Improve Household Wastewater Management					

4. Is the society well understood about treated water purity? (purity acceptance)
    a) Yes
    b) No
    c) If Other----------
    ----
5. Do you know any concerned body to manage this waste water in Addis Ababa?
    a) Yes
    b) No
    c) If you say yes what is it(Name of organization) ----------
6. Based on your understanding is there any private organization participate in wastewater management practices?
    a) Yes
    b) No
    c) If yes, write the Name of private organization ----------
    ----
    ----
    d) If you have other additional related idea ----------
    ----
7. What are the main factors of effective wastewater disposal from source up to central? Rank it.
    ☐ a) Absence of disposal sewerage line
    ☐ b) Deterioration of sewerage line
    ☐ c) If you have other----------

    ----
8. Which one domestically Wastewater managements practices household adopt in Addis Ababa?

a) On site recycling
b) Open defecation
c) Arbitrarily disposals
d) Incorporate in to ground water
e) Connected to centralized sewerage system
f) If other----------

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9. Is their governance problems related to wastewater management practice in Addis Ababa?
    a) Yes extremely
    b) Yes seriously
    c) Yes Adversely
    d) Yes moderately
    e) Yes but normal
    f) If you have more ----------

    ---
10. In your opinion what types of wastewater management ecofriendly and sustainable?
    a) By treating wastewater centrally
    b) By treating wastewater domestically
    c) By re use and recycle
    d) If other----------

Part Three: Technical Issues

For Treatment plant

1. Which technology do you choose for wastewater treatment?

---

2. Which technology do you choose for reclamation part?

---

3. What is the process for this system (flow-charts)?

---

4. What is the function of each part?

---

5. What is the performance of this system?

   The designed capacity (m3/d) …….

   The occupied area (m2): ……..

Indicators	**The quality of the influent wastewater**	**The quality of the effluent reclaimed water**
COD (mg/l)		
BOD5 (mg/l)		
SS (mg/L)		
PH		
Pathogen		

6. What kind of standards does the effluent reclaimed water comply with?

---

7. What's the scope of the pipe system of the effluent reclaimed water? ----------

---

---

8. 9. How to operate this system?

---

a) Automatic and just need periodically maintenance
b) Need technical operators and periodically maintenance
c) Can be operated by normal workers and need periodically maintenance

9. How often do you maintain the system? ----------

---

10. How many times per year does a system failure occur? ……failures/year
11. Which parts of the wastewater management system failed/was out of order? ----------

---

What was the problem? ----------

When and how often does it happen? ----------

How did you solve it and who did it? ----------

Part of the system	**Problem**	**When? (Date)**	**Often? (t/m /y)**	**Solution**	**Solved**

12. When the sanitation system fails, what is the average down time in hours? ……hours/failure

Part Four: Economic Issues

For Treatment plant

1. What about the cost?

   The investment: …….

   The operation expense: ……

2. Do you think there are any opportunities to extend the market?

   a) Yes (go to question 3)

   b) No (the end)

3. Which kind of difficulty will be encountered?

   .....

   .....

   .....

   .....

4. How to solve it?

   ……

   …….....

   .....

Part Five: Social Issues

For AAWSA and the operators in treatment plant

1. What do you think about the working condition of this system?

   ……

   …….

2. Did you get any complaints from the customers?

   a) Yes (go to question 3)

   b) No (go to question 4)

3. What are the complaints about? (Multiple choices possible)

   a) Odors of the reclaimed water

   b) Colors of the reclaimed water

   c) Safety of the reclaimed water

   d) Price of the reclaimed water

   e) Others…….

4. What is the chance that you could come into direct contact with untreated or partially treated water (in percentages)?

   ---

5. Have you suffered some kind of illness due to the wastewater management system?

   a) Yes,

   It's about: ……

   .....

   b) No

6. What kind of benefits of the waste water management system do you experience?

   ……

   …….

7. What kind of drawbacks of the waste water management system do you experience?

   ……

8. Do you have any recommendation for this system?

   a) Yes. ……..

   b. No

For the end users or Household

1. Do you know what the reclaimed water is?

a) Yes. (Go to question 2)

b) No

2. Do you know you are using the reclaimed water now?

a) Yes

b) No

3. How do you think about the reclamation system you are using?

a) Good enough……

b) Acceptable

c) No opinions

d) Not satisfied

Because……..

……..

4. Do you have any recommendations for future improvements?

a) Yes

……..

……..

b) No

5. What is the reclaimed water used for? (Multiple choices possible)

a) Toilet water
b) Landscaping
c) Fire-fighting water
d) Car-washing water
e) Industry cooling water
f) Urban Agriculture irrigation
g) Others----------

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5. The statements which are stated below are concerning opportunities of wastewater Addis Ababa city. Please indicate your judgment from the following options using √ or × the space provided in front of each statement. Each choice is identified by number ranged from 1 up to 5.

Note: - □strongly agree = 1 □Agree =2□Disagree =3 □Neutral =4 □Strongly disagree =5

Variable	1	2	3	4	5
Topography					
Stockholder collaboration at different level and Following integrated approach					
Public awareness both wastewater as a resource					
Political will for wastewater management					
Strong institutional setup to handle wastewater and its management					
Staff Capacity building Active Monitoring and evaluation system,					
Give attention to wastewater treatment projects and availability of global fund					
The existence of newly emerging technology (water save, management)					

Part Six: Environmental Issue

Questionnaire for the physical observation and interview based data collection about the wastewater treatment plant under study

1) Screen-cleaning, maintenance and screenings management issues
2) Whether the treatment plant operates continuously-day and night (hours/day)
3) Sludge removal rates from primary/secondary clarifiers (per day/per week)
4) Whether flow meters are installed in the system
5) The issues of proper operation, volume and adequacy of sludge drying beds
6) Whether there is good housekeeping in the treatment plant area
7) Whether the system is covered (drains, tanks etc.) to prevent it from negative consequences of the environment such as wind current, rainfall etc.

Appendix 3

Photo of Kality treatment plant

Source: picture taken by the researcher during field survey on 11/12/2014.