ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES CENTER

FOR WATER RESOURCES MANAGEMENT

TOWARDS MANAGEMENT AND SUSTAINABLITY OF WASTEWATER REUSE: FEATURES, CHALLENGES AND OPPORTUNITIES, CASE STUDY IN ADDIS ABABA CITY

BY

TESFAYE GETACHEW

A THESIS SUBMITTED TO

CENTER FOR WATER RESOURCES MANAGEMENT

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A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE (MSC. DEGREE) IN DEVELOPMENT STUDIES, WATER RESOURCES MANAGEMENT

BY

TESFAYE GETACHEW

ADVISOR: DR. ENGIDAWORK ASSEFA

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ADDIS ABABA, ETHIOPIA

Addis Ababa University

School of Graduate Studies

This to certify that Tesfaye Getachew entitled: towards management and sustainability of wastewater reuses: features, challenges and Opportunities in case of Addis Ababa city and submitted in partial fulfillment of the requirements for degree of Masters of Science of Water Resources Management in Center of Development Studies compiles with the regulation of the university and meets the accepted standards with respect to the originality and quality.

Approved by the Examining Committee

External examiner………………………… Signature …………….. Date……………….

Internal examiner………………………… Signature …………….. Date……………….

Advisor ………………………………….. Signature …………….. Date……………….

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Table of Contents

List of Tables

List of Figures

LIST OF ACRONYMS AND ABBREVIATIONS

AAWSA: Addis Ababa Water Supply and Sewerage Authority

BOD: Biochemical Oxygen Demand

COD: Chemical Oxygen Demand

CSA: Central Statistical Agency

FGD: Focus Group Discussion

HH: House Hold

Lpcd: liters per capita per day

NBA: National Bank of Ethiopia

SD: Standard Deviation

SPSS: Statistical Package for Social Sciences

SWM: Sustainable Water Management

UN: United Nations

UNCED: United Nations Conference on Environment and Development

UNESCO: United Nations Educational Scientific and Cultural Organization

WHO: World Health organization

WMO: World Meteorological Organization

WRM: WATER RESOURCES MANAGEMENT

WWR: Wastewater Resources

ABSTRACT

The purpose of this research is to explore features, challenges and opportunities of management and sustainability of wastewater reuses in order to improve water access a reliable and adequate potable and non-potable water supply. Additionally, water resources need to be managed far more efficiently. The key objectives of this study are: to assess the total amount of water supply for various non-potable water use (toilet flushing) in Addis Ababa city; to examine the attitude/ perception of the residents to reuse recycle water for various non-potable water uses in the city and; to evaluate public acceptance in order to use recycle water for various non-potable water uses in the city. Quantitative and qualitative methods were used to collect and analyze data. The study employs descriptive statistical method and the selection of the respondents was done by using Cochran sample determination method. Questionnaires and key informant interview were prepared and distributed to legible respondents to collect data. According to the informant responses, the results demonstrated that Addis Ababa Water Supply and Sanitation Authority, it is incapable to provide adequate water for potable and non-potable uses. The results field survey demonstrated that there are perceived positive public perceptions and opinion in order to use recycle wastewater for various non-potable water uses. Based on the results of the output, it was success for Addis Ababa Water Supply and Sanitation Authority should pay attention on HHs wastewater discharge from households are sustainable source of wastewater reuses in the future and thereby it safeguards potable water supply in Addis Ababa city.

Key words: Wastewater discharge, Sustainable waste water reuses, perception of non-potable water, wastewater management.

CHAPTER ONE: INTRODUCTION

1.1. Background of the Research

Water resources have been one of the most important areas of concern during the past three decades. Moreover, since the turn of the 20th century, the utilization of freshwater for economic purposes has been challenging (Arsano, 2007).Nowadays, politically and technically the important role of treated wastewater and its reuse could play in reducing the enormous gap between the increasing water demand limited fragile water supply particularly in many arid and semi arid developing countries is well recognized. In dead for some water scarce regions including those of the Mediterranean and the Middle East, treated wastewater is becoming a common source for additional water and is already included in their master plans (Bazza, 2002). As a matter of fact, for many countries, wastewater reuse is recognized as an encouraging solution to cope with the problem of water scarcity, the big challenge many countries are now facing (Varma & Chartres, 2010). With issues of climate change, increase in urban population and increased demand for water from competing sectors, wastewater recycling is becoming an important strategy to complement the existing water resources for both developing and developed countries and there are lessons, experiences data and technology that can be shared for mutual benefit (Hamdy & Aley, 2015).

In developing countries the situation is exacerbated by rapid population growth and urbanization. As the demand for water for human use has escalated, so has the competition for water used for agriculture and industry (World Bank, 2004).

Ethiopia with a total area of 1.13 million km^2 has a total population of 73.9 million with an annual growth rate of 2.6 % (Abdella, 2018). About 61.9 million (84%) live in rural areas while 11.9 million (16%) live in urban areas. Although the country's renewable surface and ground freshwater amounts to 122 and 2.6 billion cubic meter per annum, respectively, its distribution in terms of area and season does not give adequate opportunity for the sustainable growth of the economy (MoWR, 2002). Ethiopia's economy is heavily dependent on agriculture for generating employment, income and foreign currency. Agriculture accounts for 46% of GDP and 85% of employment(Birhane, 2002).

The increase in population, where coupled with the high dependence of the economy on agriculture, contributes to increased demand and increased competition for limited water resources. This calls for efficient management of the resource (Shewaye & Adam, 1998).

Water resources are defined as the water available for human and environmental uses that can be obtained from any natural water sources under the limitations of the combination of technological feasibility, economical effectiveness, environmental security, and human acceptability (UN-Water, 2013).

In certain parts of the world, water scarcity has been and will likely become a fatal constraint to sustainable development (WHO, 2006). In some developing countries and/or regions facing water scarcity, especially those in arid and semiarid areas, sustainable development strongly depends on the availability of water resources for both society and nature, and the manner of water resource management (WHO, 2006).

Particularly, for agricultural and industrial development, water resources planners are continually looking for additional sources of water to supplement the limited resources available to their region. Several countries of the Eastern Mediterranean region, for example, where precipitation is in the range of 100-200 mm per annum, rely on a few perennial rivers and small underground aquifers that are usually located in mountainous regions (P.Edwards, 1992).

The United Nations Economic and Social Council provided a management policy to support this approach by stating that "no higher quality water, unless there is a surplus of it, should be used for a purpose that can tolerate a lower grade. Low quality waters such as wastewater, drainage water sand brackish waters should, whenever possible, considered as alternative sources for less restrictive uses(United Nation, 1958).

The big and main water resources problem in Ethiopia is the uneven spatial and temporal occurrence and distribution of water. Between 80-90% of Ethiopia's water resources is found in the four river basins namely, Abay (Blue Nile), Tekeze, Baro-Akobo, and Omo Gibe in the west and south-western part of Ethiopia where the population is no more than 30 to 40 per cent. On the other hand, the water resources available in the east and central river basins are only 10 to 20 per cent whereas the population in these basins is over 60 per cent (MoWR, 2002).

According to the AAWSA`s February 2018 performance report, the total amount of water production is about 182,135,000 m^3 per year (499,000 m^3 per day), it is decreased by 100,000m^3 per day compare to last fiscal year performance report of AAWSA from Legedadi, Diredam, Gefersa, different springs and underground sources(AAWSA, 2018).

According to the performance report, the total production classified in to revenue water and non revenue water. About 62% of the total water production is revenue water, which is about (62%*182,135,000 m^3 = 112,923,700 m^3per year). It is used for potable and non-domestic (non-potable such as construction, fire fighting, green areas, fountains, car washes, gardening etc) water uses.

On the other hand, about 38% of the revenue water (38%*112,923,700m^3= 42,911,006m^3per year); it is lost water due to leakage caused by damage of pipe lines because of construction and maintenance of infrastructures such as roads, drainages, electric lines and buildings. Therefore, this phenomenon disputes to potable and non-potable water supply systems in the study areas as well as Addis Ababa city(AAWSA, 2018).

Moreover, AAWSA harvested about 44,320 m^3per day (it is 30% of the total wastewater collected) water from domestic and non-domestic wastewater per day, which is the amount of water treated, it is 16,176,800 m^3 (about 1.62×10^{10} liters) treated water per year. About 2% of the total water is produced from non- domestic wastewater sources, which is only about 323,536 m^3 while about 98 % of the total harvested water is produced from domestic wastewater, which is about 15,853,264 m^3(AAWSA, 2018).

Therefore, the performance report of fiscal year is a basis or beginning for the researcher to focus on HHs wastewater is an alternative source of non-potable water supply, particularly, wastewater discharged from HHs is potential source of non-potable water reuses in the city is the important features of non-potable water supply for management of sustainable non-potable water reuses in the city.

Besides, the abundance of wastewater in HHs in the residential area is an opportunity for AAWSA to access wastewater from HHs as alternative source for non-potable water supply in the study areas as well as in the city, which led towards management of sustainable non-potable water reuses in Addis Ababa city.

Still AAWSA is discharging the treated (recycled) water, excess amount of recycled water in to downstream for community irrigation. It is disproportionate (excess) water for community irrigation uses or purposes. Therefore, the researcher perceived that this water is still lost water because it does not serve for the city to reduce the problem or challenge related to water supply; simply it is totally discharged in to downstream. Consequently, AAWSA is incompetent to supply water for both potable and non-potable water supply in sustainable manner in the city. So, it is the prominent challenge of AAWSA to cover the residents' water demand in the city.

1.2. Statements of the Problem

Addis Ababa city is urbanized, it plays important role for sustainable potential wastewater source in the city to improve potable and non-potable water supply in the city; thus, as a result the urbanization is an opportunity to AAWSA to access household wastewater sustainably in the city (AAWSA, 2018).

Water demand for potable and non-potable water uses, agricultural and industrial purposes is increasing rapidly in the city. So, AAWSA is incapable to provide this service sufficiently, this perpetual problems or challenges of Addis Ababa city, which it has not been competent to supply enough potable and non-potable water to its residents (AAWSA, 2018).

Pre-existing report of AAWSA, according to AAWSA performance report, Addis Ababa Water Supply and Sewerage Authority (AAWSA) can supply about 52 % of the total water demand of HHs. The remaining 48% of the total harvested water (potable water) by AAWSA is used for non- potable water uses such as construction, fire protection, green areas, fountains, car-wash, gardening, etc. This has been caused for severe water shortages in various residential areas (sub-cities) of Addis Ababa city. Therefore, the performance reports of AAWSA for various fiscal years had been pointed that Addis Ababa faces challenges related to potable and non-potable water supply to address the social and economic needs of the city's population. Moreover, the poor urban populations in the city have been suffering more due to lack of water supply for potable and non-potable water uses resulted from inefficient capacity of AAWSA (AAWSA, 2018).

Additionally, according to the interviewees in AAWSA`s wastewater treatment and reuses processing team leader, water production department team leader and water supply department team leader; there is acute shortage or scarcity of water supply in Addis Ababa city for potable and non-potable water uses. As the interviewees said AAWSA has challenges of water supply for potable and non-potable water uses due to various causes such as rapid population growth, expansion of housing investments (private and governmental sectors), establishment of new residential areas and condominium houses (in particular), construction of building in the city for various activities, establishment of public green areas, fountains and public toilets in the city at different location and public recreation areas, water for fire protection services etc.

In general, the researcher observed that AAWSA`s limited capacity and source to cover the city water demand due to the upper mentioned issues for potable and non-potable water uses as AAWSA`s gap, which have been led towards management of sustainable non-potable water reuses: features, challenges and opportunities. Thereby HHs wastewater (98% of the total wastewater source in Addis Ababa city) as alternative sustainable source of non-potable water uses. Thus, the researcher focused towards HHs wastewater used as alternative potential source of non-potable water reuses and tried to conduct this research. Thus, the researcher had been focused on management of sustainable non-potable water reuses by using wastewater as alternative potential water source for non-potable water supply(AAWSA, 2018).

Therefore, the researcher conducted this study, it is management and sustainability of wastewater reuses: features, challenges and opportunities in case of Addis Ababa city; finally, forwarded recommendation based on the output of this particular study for better water resources management in the city.

1.3. Research Questions

This study or research is tried to answers for the following questions:

1. What are the trends of the total amount of water supply and distribution in Addis Ababa city?
2. How does the attitude/perception of people to use recycle water for wastewater reuses in sustainable manner in the city affected by different factors?
3. What are challenges and opportunities to use recycle water for non-potable water uses in the city?

1.4. Objectives of the Research

1.4.1. General Objective

The main objective of this research is to explore features, challenges and opportunities of HHs wastewater as alternative source of various non-potable water uses; there by it leads towards management and sustainability of wastewater reuses for various non-potable water uses in Addis Ababa city.

1.4.2. Specific Objectives

1. To assess trends of the total amount of non-potable water supply and distribution in the city for different non-potable water uses.
2. To examine the attitude/perception of the people to use recycled water for wastewater uses in sustainable manner in the city.
3. To evaluate challenges and opportunities to use recycle water for non-potable water uses in sustainable manner in the city.

1.5. Significances of the Research

The basic significances of this research categorized in to three basic purposes; theses are to enhance and enrich knowledge of the researcher to conduct research and completion of academic courses primarily, providing information for policy makers as input and providing guide (source) document for further study related to this research for other researchers or students. In the future, the output of this study and its topic will be used to other researchers to conduct further studies in the future (opportunity) in water resources management field of study.

In addition, the significance of this research, towards management and sustainability of wastewater reuses: features, challenges and opportunities case in Addis Ababa city; it focuses on factors (drivers) that are causes of water supply shortage of Addis Ababa city for potable and non-potable water uses. These results thus contribute to the empirical study that focuses on water reuses.

Finally, the research aimed at HHs wastewater as sustainable source of non-potable water after recycling processes. Forward possible recommendation that HHs wastewater as alternative source of non-potable water supply.

1.6. Scope of the Study

1.6.1. Spatial Scope

The study was conducted in ten sub-cities of Addis Ababa. Particularly, the place where used for residential areas (condominium areas) in different ten sub-cities in Addis Ababa city.

1.6.2. Thematic Scope

The study considers management and sustainability of wastewater reuses; features, challenges and opportunities in case of Addis Ababa city related issues such as assessing the total amount of non-potable water consumption at household levels in Addis Ababa city; to assesses the attitude/perception of the people to use recycle water for non-potable water uses and examine features, challenges and opportunities for harvesting recycle water for various non-potable water uses in the city.

1.6.3. Temporal Scope

The time length of this particular research required different time phases such as collection of relevant information by data collection tools as initial stage, organization of collected data and making analysis and discussion based on the collected data and at the end forward conclusion and recommendation based on the outputs of the study starting from July 2018 to February 2020.

1.7. Limitation of the Study

During assessment and field survey, the main problem that was encountered in the course of this research was lack of adequate information due to improper documentation handling by AAWSA`s different department offices. Due to these reasons, the researcher was encountered challenge to access the necessary and relevant information easily in proposed time.

Absences of team leaders of different departments in AWWSA caused by meeting and training during data and information collection phase were the other challenge of the researcher to collect data and information according to the proposed time.

Absence of previous research related to the research topic (issue) and lack of reference books in A.A.U library and documentation rooms; it is the foremost challenge of the researcher to complete the research in the proposed time.

Finally, budget, it also worth mentioning that lack of sufficient amount of money and time had an objectionable upshot on the study. These are the foremost limitations of the research that the researcher was faced in this specific study in order to accomplish the research in the proposed time.

1.8. Organization of the Thesis

The study contains five chapters. The first chapter contains the introduction of the research including background of the study, statements of the problem, objectives and significances of the research, the research questions, scope and limitation of the research and organization of the research; the second chapter review of related literature including theories, various views of wastewater and water related issues and definitions of key terms such as domestic wastewater, sustainable water resources management and sustainable water supply and the conceptual framework as well as AAWSA`s business plan and performance report of different fiscal years; the third chapter contains materials and methods, which includes the methodology and its sub-components as well as description of the study area, and empirical formula to specify sample size of population, basic components of research design, models and packages to analyses data and tools to collect reliable data, etc; the fourth chapter includes discussion and analysis, which is based on the relevant data and information collected by different tools during survey and secondary sources; the fifth chapter includes conclusion and recommendation based on the output of the study.

CHAPTER TWO: REVIEW OFRELATED LITERATURE

2.1. Definitions of Terms

Wastewater: Wastewater contains a number of pollutants and contaminants, including plant nutrients (nitrogen, phosphorus, potassium), pathogenic microorganisms (viruses, bacteria, protozoa and helminthes), heavy metals (e.g. cadmium, chromium, copper, mercury, nickel, lead and zinc), organic pollutants (e.g. polychlorinated biphenyls, polyaromatic hydrocarbons, pesticides); and biodegradable organics (BOD, COD); and micro-pollutants (e.g. medicines, cosmetics, cleaning agents)(UN-Water, 2013).

Domestic wastewater (HHs wastewater)*:* Domestic wastewater is the water that has been used by a community and which contains all the materials added to the water during its use. It is thus composed of *human body wastes* (faeces and urine) together with the water used for flushing toilets, and *sullage*, which is the wastewater resulting from personal washing, laundry, food preparation and the cleaning of kitchen utensils(Mara, 2003).

Sustainable water resources: Water resources are defined as the water available for human and environmental uses that can be obtained from any natural water sources under the limitations of the combination of technological feasibility, economical effectiveness, environmental security, and human acceptability. This definition is in fact an extension of that of UNESCO/WMO's for sustainable water resource management and may be regarded as a definition of sustainable water resources (UNESCO/WMO, 1992).

Water reuse*:* water reuse is the use of treated wastewater for beneficial purposes that include non-potable uses such as agricultural irrigation and industrial cooling (UN-Water, 2013).

Water supply: Water supply implies human uses of water such as drinking water, water for livestock use, water for industrial use, and water for municipal use (MoWR, 2000).

***Potable water*:** Water that uses for domestic uses such as drinking, cooking, washing (UN-Water, 2013).

Non-potable water: The water that used to construction, fire protection, green areas, fountains, carwash, gardening, etc(UN-Water, 2013).

2.2. Concepts of Sustainable Water Resource Management

In certain parts of the world, water scarcity has been and will likely become a fatal constraint to sustainable development. In some developing countries and/or regions facing water scarcity, especially those in arid and semiarid areas, sustainable development strongly depends on the availability of water resources for both society and nature, and the manner of water resource management. It is necessary for these developing countries and/or regions to seek theoretical, methodological and technological support to ensure their sustainability. This problem has attracted worldwide concerns (WHO, 2006).

There are several definitions of sustainable water resources; for example, water resources can be defined as the "water available or capable of being made available, for use in sufficient quantity and quality at a location and over a period of time appropriate for an identifiable demand. Recognizing the principles of sustainable development and probable conflicts between currently available definitions and the goal of sustainable water resource management, this paper introduces new definition to water resources based on the concepts of environmental security and sustainable development. (UNESCO/WMO, 1992).

Accordingly, water resources are defined as the water available for human and environmental uses that can be obtained from any natural water sources under the limitations of the combination of technological feasibility, economical effectiveness, environmental security, and human acceptability (Hermanowicz, 2005). This definition is in fact an extension of that of (UNESCO/WMO, 1992)for sustainable water resource management and may be regarded as a definition of sustainable water resources.

2.3. Wastewater as Resources of Water Global View

Water resources have been one of the most important areas of concern during the past three decades. Moreover, since the turn of the 20th century, the utilization of freshwater for economic purposes has been challenging (Arsano, 2007).

Nowadays, politically and technically the important role of treated wastewater and its reuse could play in reducing the enormous gap between the increasing water demand limited fragile water supply particularly in many arid and semi arid developing countries is well recognized. In dead for some water scarce regions including those of the Mediterranean and the Middle East, treated wastewater is becoming a common source for additional water and is already included in their master plans (Bazza, 2002). As a matter of fact, for many countries, wastewater reuse is recognized as an encouraging solution to cope with the problem of water scarcity, the big challenge many countries are now facing (Varma & Chartres, 2010). With issues of climate change, increase in urban population and increased demand for water from competing sectors, wastewater recycling is becoming an important strategy to complement the existing water resources for both developing and developed countries and there are lessons, experiences data and technology that can be shared for mutual benefit (Hamdy & Aley, 2015).

In developing countries the situation is exacerbated by rapid population growth and urbanization. As the demand for water for human use has escalated, so has the competition for water used for agriculture and industry (World Bank, 2004).

Drinking water is usually supplied through expensive desalination systems, and more than 50 per cent of the food demand is satisfied by importation. In such situations, source substitution appears to be the most suitable alternative to satisfy less restrictive uses, thus allowing high quality waters to be used for domestic supply(Burgess, Meeker, Minton, & O'Donohue, 2015).

Agricultural use of water resources is of great importance due to the high volumes that are necessary (ISO, 2015). Irrigated agriculture will play a dominant role in the sustainability of crop production in years to come. By the year 2000, further reduction in the extent of exploitable water resources, together with competing claims for water for municipal and industrial use, will significantly reduce the availability of water for agriculture. The use of appropriate technologies for the development of alternative sources of water is, probably the single most adequate approach for solving the global problem of water shortage, together with improvements in the efficiency of water use and with adequate control to reduce water consumption(Zhang & Babovic, 2012).

2.4. Water Resources Problem in Ethiopia

Ethiopia with a total area of 1.13 million km^2 has a total population of 73.9 million with an annual growth rate of 2.6 % (Abdella, 2018). About 61.9 million (84%) live in rural areas while 11.9 million (16%) live in urban areas. Although the country’s renewable surface and ground freshwater amounts to 122 and 2.6 billion cubic meter per annum, respectively, its distribution in terms of area and season does not give adequate opportunity for the sustainable growth of the economy (MoWR, 2002). Ethiopia’s economy is heavily dependent on agriculture for generating employment, income and foreign currency. Agriculture accounts for 46% of GDP and 85% of employment(Birhane, 2002).

The increase in population, where coupled with the high dependence of the economy on agriculture, contributes to increased demand and increased competition for limited water resources. This calls for efficient management of the resource (Shewaye & Adam, 1998)

The geographical location of Ethiopia and its endowment with favorable climate provides a relatively higher amount of rainfall in the region. Much of the water, however, flows across the borders being carried away by the Trans-boundary Rivers to the neighboring countries (MoWR, 2002).

The main water resources problem in Ethiopia is the uneven spatial and temporal occurrence and distribution of rivers. Between 80-90% of Ethiopia's water resources is found in the four river basins namely, Abay (Blue Nile), Tekeze, BaroAkobo, and Omo Gibe in the west and south-western part of Ethiopia where the population is no more than 30 to 40 per cent. On the other hand, the water resources available in the east and central river basins are only 10 to 20 per cent whereas the population in these basins is over 60 per cent (MoWR, 2002).

2.5. Problem of Water Resources in Addis Ababa

Addis Ababa Water and Sewerage and Sanitation Authority was established as an autonomous body by order No 68/1971 issued on 26 February 1971 and re-established by Proclamation No 10/1995 as an autonomous Public Authority under Addis Ababa following the formation of regional states(AAWSA, 2018).Proclamation No 10/1995 defines the objectives, powers and duties of AAWSSA. The duties of AAWSSA include the supply of safe and adequate potable water and the provision of wastewater/sludge collection, treatment and disposal within the limits of the city of Addis Ababa. Accordingly, AAWSA has two main business lines which are reflected in its organizational structure:

1- Water Supply, Sewerage and

2- Sanitation.

AAWSSA is managed by a General Manager appointed by and reporting to the Board of Directors. The General Manager's responsibilities include managing and overseeing all activities within AAWSSA according to the policy guidelines of the Board of Directors. The Board of Directors formulates policy and management strategy and its duties include approving AAWSA's budget (AAWSA, 2018).

Addis Ababa is the biggest city in Ethiopia accounting for 23 per cent of the nation’s urban population. Like any other developing city, Addis Ababa faces multiple challenges that have to be addressed to provide a decent life for the people. Although considerable effort has been made to improve the provision of safe and clean water supply coverage and to address the social and economic needs of the city’s population, the poor urban people have been suffering due to lack of water. According to the report, about 63% of the households in its service area have an in-house connection (private water taps and taps in compound shared by more than two households) and use 80 to 100 liters while the remaining 37% are served by yard taps, public taps and by buying water from kiosks using between 10-30 liters per capita per day (AAWSA, 2018).

According to AAWSA`s performance report, one of the causes for the deteriorating urban environment in general and water resource management in particular, is the poor performance of the municipal administration in terms of catering to the interests, needs and priorities of the public, on one hand, and the institutional aspect which encompasses governance such as budgetary, planning, implementation, providing efficient and improved water supply and sanitation services on the other (AAWSA, 2018).

2.6. Wastewater as Water Resources

The term water supply includes water supply for human as well as animal consumption, industrial and other uses outside irrigation and hydropower (MoWR, 2002). Domestic wastewater is the water that has been used by a community and which contains all the materials added to the water during its use. It is thus composed of human body wastes (faeces and urine) together with the water used for flushing toilets, and sullage, which is the wastewater resulting from personal washing, laundry, food preparation and the cleaning of kitchen utensils(UN-Water, 2013).

Fresh wastewater is a grey turbid liquid that has an earthy but inoffensive odor. It contains large floating and suspended solids (such as faeces, rags, plastic containers, maize cobs), smaller suspended solids (such as partially disintegrated faeces, paper, vegetable peel) and very small solids in colloidal (i.e. non-settle able) suspension, as well as pollutants in true solution. It is objectionable in appearance and hazardous in content, mainly because of the number of disease-causing (‘pathogenic’) organisms it contains. In warm climates wastewater can soon lose its content of dissolved oxygen and so become ‘stale’ or ‘septic’. Septic wastewater has an offensive odor, usually of hydrogen sulphide(UN-Water, 2013).

Sullage contributes a wide variety of chemicals: detergents, soaps, fats and greases of various kinds, pesticides, anything in fact that goes down the kitchen sink, and this may include such diverse items as sour milk, vegetable peelings, tea leaves, soil particles (arising from the preparation of vegetables) and sand (used to clean cooking utensils). The number of different chemicals that are found in domestic wastewater is so vast that, even if it were possible, it would be meaningless to list them all. For this reason wastewater treatment engineers use special parameters to characterize wastewaters(UN-Water, 2013).

2.7. Wastewater Collection

Domestic wastewaters are collected in underground pipes which are called ‘sewers’. The flow in sewers is normally by gravity, with pumped mains only being used when unavoidable.

The design of conventional sewerage (the sewer system used in industrialized countries and in the central areas of many cities in developing countries) is described in several texts (Metcalf and Eddy, 1986) and is detailed in national sewerage codes. However, it is extremely expensive. A much lower cost alternative, which is suitable for use in both poor and rich areas alike, is ‘simplified’ sewerage, sometimes called ‘condominium’ sewerage(Mara, D D, Sleigh, A & Tayler, K, (2001a)) and(Council World Water, 2012).

2.8. Why treat wastewater

Untreated wastewater causes major damage to the environment and to human health. Almost always, therefore, wastewater should be treated in order to (UNESCO/WMO, 1992):

- reduce the transmission of excreta-related diseases
- reduce water pollution and the consequent damage to aquatic biota

In developing countries only a small proportion of the wastewater produced by sewered communities is treated. In Latin America, for example, less than 15 per cent of the wastewaters collected in sewered cities and towns are treated prior to discharge (Organization, Pan American Health, 2010). Often the reason for the lack of wastewater treatment is financial, but it is also due to ignorance of low-cost wastewater treatment processes and of the economic benefits of treated wastewater reuse; and also because too many decision-makers appear happy to accept the status quo: the continued discharge of untreated wastewater with its resultant damage to the environment and human health (Organization, Pan American Health, 2010).

Currently the global burden of excreta-related disease is extremely high. Over half the world’s rivers, lakes and coastal waters are seriously polluted by untreated domestic, industrial and agricultural wastewaters and they contain high numbers of faecal bacteria (Ceballos, 2003). Effective wastewater treatment needs to be recognized, therefore, as an environmental and human health imperative (Organization, Pan American Health, 2010).

2.9. Investment in Wastewater Treatment

Developing country governments and their regulatory agencies, as well as local authorities (which may be city or town councils, or specific wastewater treatment authorities, or more generally water and sewerage authorities), need to understand that domestic and other wastewaters require treatment before discharge or, preferably, re-use in agriculture and/or aquaculture. They also need to act, but first they need to decide where, when and how much to invest in wastewater treatment (Mariño, M and Boland, J, 1999). Advice on the economic analysis of investment projects is given by the World Bank (World-Bank, 2016).

Wastewater treatment for re-use in agriculture and aquaculture can be subjected to classical benefit–cost analysis using discounted cash-flow techniques to show if the present value of future additional crop yields is more than the present value of wastewater treatment. However, wastewater treatment prior to discharge to inland or coastal waters is less easy to analyze (Amerasinghe P, Bhardwaj RM, Scott C, Jella K, Marshall F , 2013)

Central government, with its national perspective, must set national environmental and environmental health priorities. It can enforce this by lending money only for wastewater treatment projects that lie within these priorities. Local authorities can then apply for a loan for a ‘priority’ wastewater treatment project. Generally, and ideally, priority projects should be dealt with on the basis of river basin catchment areas, as this is the best method of integrated water resources management, with central government deciding which river basin is (or which river basins are) to be protected first, what level of protection is needed now and how this can be developed to progressively higher levels of protection in the future (Sato T, 2013).

Wastewater treatment is needed on a truly enormous scale in developing countries, and the purpose of wastewater treatment is how it can be done at low cost, and how treated wastewaters can be profitably and safely used in agriculture and aquaculture for wastewaters are simply too valuable to waste (World-Bank, 2016).

2.10. Types of Wastewater Reuse

Water is a renewable resource within the hydrological cycle. The water recycled by natural systems provide a clean and safe resource which is then deteriorated by different levels of pollution depending on how, and to what extent, it is used. Once used, however, water can be reclaimed and used again for different beneficial uses. The quality of the once-used water and the specific type of reuse (or reuse objective) define the levels of subsequent treatment needed, as well as the associated treatment costs (Sato T, 2013).

2.10.1. Agriculture and Aquaculture

On a world-wide basis wastewater is the most widely used low-quality water, particularly for agriculture and aquaculture. This rest of this chapter concentrates on this type of reuse because of the large volumes used, the associated health risks and the environmental concerns. Other types of reuse are only discussed briefly in the following sub-sections (FAO, 2010).

2.10.2. Urban

In urban areas, reclaimed wastewater has been used mainly for non-potable applications

(Pintilie, Torres, Teodosiu, & Castells, 2016) such as:

- ✓ Irrigation of public parks, recreation centers, athletic fields, school yards and playing fields, and edges and central reservations of highways.
- ✓ Irrigation of landscaped areas surrounding public, residential, commercial and industrial buildings.
- ✓ Irrigation of golf courses.
- ✓ Ornamental landscapes and decorative water features, such as fountains, reflecting pools and waterfalls.
- ✓ Fire protection.
- ✓ Toilet and urinal flushing in commercial and industrial buildings.

The disadvantages of urban non-potable reuse are usually related to the high costs involved in the construction of dual water-distribution networks, operational difficulties and the potential risk of cross-connection. Costs, however, should be balanced with the benefits of conserving potable water and eventually of postponing, or eliminating, the need for the development of additional sources of water supply (Pintilie, Torres, Teodosiu, & Castells, 2016).

Potable urban reuse can be performed directly or indirectly. Indirect potable reuse involves allowing the reclaimed water (or, in many instances, raw wastewater) to be retained and diluted in surface or groundwater before it is collected and treated for human consumption. In many developing countries unplanned, indirect potable reuse is performed on a large scale, when cities are supplied from sources receiving substantial volumes of wastewater. Often, only conventional treatment (coagulation, flocculation, clarification, filtration and disinfection) is provided and therefore significant long-term health effects may be expected from organic and inorganic trace contaminants which remain in the water supplied (Pintilie, Torres, Teodosiu, & Castells, 2016).

Direct potable reuse takes place when the effluent from a wastewater reclamation plant is connected to a drinking-water distribution network. Treatment costs are very high because the water has to meet very stringent regulations which tend to be increasingly restrictive, both in terms of the number of variables to be monitored as well as in terms of tolerable contaminant limits (Pintilie, Torres, Teodosiu, & Castells, 2016).

2.10.3. Industry

The most common uses of reclaimed water by industry are:

- ✓ Evaporative cooling water, particularly for power stations.
- ✓ Boiler-feed water.
- ✓ Process water.
- ✓ Irrigation of grounds surrounding the industrial plant.

The use of reclaimed wastewater by industry is a potentially large market in developed as well as in developing and rapidly industrializing countries. Industrial reuse is highly cost-effective for industries where the process does not require water of potable quality and where industries are located near urban centers where secondary effluent is readily available for reuse (Pintilie, Torres, Teodosiu, & Castells, 2016).

2.10.4. Recreation and landscape enhancement

The uses of reclaimed wastewater for recreation and landscape enhancement ranges from small fountains and landscaped areas to full, water-based recreational sites for swimming, boating and fishing. As for other types of reuse, the quality of the reclaimed water for recreational uses should be determined by the degree of body contact estimated for each use. In large impoundments, however, where aesthetic appearance is considered important it may be necessary to control nutrients to avoid eutrophication (Pintilie, Torres, Teodosiu, &

Castells, 2016).

2.11. Recycle water as alternative source of non-potable water supply

Without improved water resource management, it is predicted that water shortages will affect two-thirds of humanity by 2025. One solution that has traditionally faced fierce public resistance is recycling wastewater. Successful implementation of a wastewater reuse project depends not only on its economic and environmental feasibility, but mainly on the support of the general public, who, ultimately, pays for, and might be affected by the reuse project.(Wester, Timpano, Çek, & Broad, 2016)

2.11.1. Challenges towards Recycle Water for Potable Uses

One of the earliest suggestions was the examination of demographic characteristics as predictors of recycled water acceptance. Factors include education level, age and gender. However, when viewed in synthesis, conclusions about demographic predictors of recycled water acceptance are often unclear and contradictory; there are no demographic and social influences that predict acceptance of potable reuse"(Bruvold, 1998).

Public opposition has the potential to cause wastewater reuse projects to fail, before, during, or after their execution. Reuse schemes may face public opposition resulting from a combination of prejudiced beliefs, fear, attitudes, lack of knowledge and general distrust, which, on the whole, is often not unjustified, judging by the frequent (and highly publicized) failures of wastewater treatment facilities worldwide (Nancarrow, 2009).

…in the United States, (Bruvold, 1998)showed negative correlation between support for water reuse and the degree of contact; in Australia, 97% and 96% of the public supported wastewater reuse for irrigation and for toilet flushing, respectively, but as low as 20–30% supported potable reuse (Denlay J. Dowsett B., 1994); (Crook, 2003)adds that in the United

States the public generally supports non-potable reuse, while acceptance of potable reuse is problematic(with typically less than 50% support).

The primary concerns of the public are costs and public health protection, thus uses that result in financial gains and involve minimal degree of contact with the reclaimed water are favored. It was further found that beyond the importance of the ‘‘degree of contact’’ the respondents were also affected by reasons of water conservation, environmental and health issues, and costs of treatment and distribution of water (Nancarrow, 2009).

In contrast, (Marks J, Zadoroznyj M, 2005), reviewing public acceptance of potable reuse, suggests that for this type of reuse the degree of contact is still the most dominant consideration. Some recent case studies seem to strengthen Bruvold’s point, at least for uses that do not involve direct potable reuse (i.e. drinking): (van der Hoek, 1999) report on a survey performed in Amsterdam to examine public attitude toward reuse in a big housing project that was due to start a year later. In the survey, 97% and 80% of the public supported wastewater reuse for toilet flushing and for clothes washing, respectively. Another example: (Marks, J., Cromar, N., Fallowfield, H., Oemcke, D., 2003)report that all20 residents interviewed in Adelaide, where a dual distribution system is built but not yet operational, were strongly in favor of garden irrigation and toilet flushing with the reclaimed water.

For the third category (public attitude toward reclaimed water where reuse schemes are already in place) there is only limited data: Report the results of qualitative research performed in three operational reuse(non-potable) sites (two in Florida, one in Adelaide, Australia), where 95–100% of the residents used the reclaimed water for garden watering, in the Adelaide site100% used the water for toilet flushing, and 55% and 50%used the water for car washing in Florida (one site) and Adelaide, respectively(Marks, J., Cromar, N., Fallowfield, H., Oemcke, D., 2003).

This variation in uses is mainly due to structural limitations at the various sites (e.g. in the Florida site, indoor reuse is impossible). Cost savings was signaled out as the most important benefit of water reuse, as it was chosen by 71% of the respondents. This was followed by positive effects on the environment and not wasting potable water (with 36% and 34%, respectively),25% noted the nutritional value of the reclaimed water to plants, while 20% noted satisfaction with their role in conserving water as one of the significant benefits of reusing water(Marks J, Zadoroznyj M, 2005).

In all, 85–95% of the people in the three sites stated that they had no concerns related to the reuse of wastewater effluent. The few people who raised concerns said that these were related to contact of young children with the reclaimed water (direct or indirect), stating that children like to play with water. Somewhat in contrast with the above, when asked, about 50% of the respondents thought that others may be reluctant to use reclaimed water, the suggested reasons for which were: concerns of quality (44%), issues related to costs (26%), and the rest 30%distributed between apathy, skepticism, dislike of change and other reasons.(Marks J, Zadoroznyj M, 2005).

Importance of dissemination of information to the public: According to the authors' experience it is safe to say that the majority of water sector professionals in arid and semiarid regions are in favor of reusing wastewater effluents. However, the dissemination of this concept to the public is sometimes difficult task. This is due in part to the non-homogenous nature of the population consisting of groups of different socioeconomic backgrounds, cultures and interests (Marks J, Zadoroznyj M, 2005).

2.11.2. Opportunities towards Recycle Water for Potable Uses

Global population is increasing at an alarming rate with about 7.6 billion people on the earth today and an estimated 9.8 billion by the year 2050. Humans depend on water for sustenance and for almost every endeavor. Water is used for domestic purposes, agriculture and manufacturing (Marks, J., Cromar, N., Fallowfield, H., Oemcke, D., 2003).

However, the earth's growing population is placing great pressure on the existing global water resources of which just 1/3 is fresh. Climate change has further worsened the water challenge by altering weather patterns resulting in reduced rainfall and drought in some parts of the world. According to the prevalence of strong climactic seasonal variations worsens water challenges in tropical regions. Moreover, underground water is used up more than it is being replaced (Ormerod, 2016).

The growing demand for fresh water fuelled by population increase, climate change, unsustainable disposal of waste water and developments in water technology has made researchers and world agencies such as the United Nations to seek ways of conserving existing fresh water system of which recycling is one(Ormerod, 2016).

Water resources planners are continually looking for additional sources of water to supplement the limited resources available to their region. Several countries of the Eastern Mediterranean region, for example, where precipitation is in the range of 100-200 mm per annum, rely on a few perennial rivers and small underground aquifers that are usually located in mountainous regions (Council World Water, 2012).

2.11.3. Challenges on Wastewater Treatment and Reuse

As human population continues to grow and urbanize, the challenges for securing water resources and disposing of wastewater will become increasingly more difficult. Today, wastewater is usually transported through collection sewers to a centralized WWTP at the lowest elevation of the collection system near to the point of disposal site to the environment. Because centralized WWTPs are generally arranged to route wastewater to these remote locations for treatment, water reuse in urban areas is often inhibited by the lack of dual distribution systems(Russell, S., and C. Lux , 2009).

The infrastructure costs for storing and transporting reclaimed water to the points of use are often prohibitive, which is making reuse less economically viable. Thus, decentralized wastewater management systems should be more seriously considered in the future to treat wastewater at or near the points of waste generation. Also an alternative to the conventional approach of transporting reclaimed water from a central WWTP, the concept of decentralized (satellite) treatment at upstream locations with localized reuse and/or the recovery of wastewater solids is becoming more appreciated(A.Synder, 2015).

Water reuse offers tremendous potential in augmenting already strained water resource portfolios, yet bio-solids utilization/disposal remains challenging particularly for dense urban settings. In both water reuse and bio-solids applications to land, the primary challenge remains public perception. While advanced technologies can help to lower energy footprint and to increase reliability, the obstacle of perception can be far more daunting(A.Synder, 2015).

Emerging contaminants such as pharmaceuticals and antibiotic resistant bacteria are particularly difficult to explain to the public. Both historical and more recent examples of disease spread by water (such as cholera and cryptosporidiosis, respectively) weigh heavily on public concerns over the safety of water reuse. Advanced technologies such as on-line sensors, membranes, and advanced oxidation can help ease perception; however, a better understanding of how engineered reused water compares to existing source waters can be quite persuasive. The challenge of emerging chemical constituents has become exacerbated by concerns of mixture toxicity. Exposure to chemicals does not happen discretely, but rather, chemicals exist as complex mixtures of widely variable composition. Animal testing alone cannot reasonable address the fundamental question of “is it safe?” This is particularly true for mixtures since a seemingly infinite number of computations exist (A.Synder, 2015).

Therefore, rapid biological screening assays (examine), primarily in vitro, are gaining attention as a means to quickly and comprehensively evaluate the complex mixtures of chemicals in water. High-throughput bioassays can be quite successfully used for the qualitative and quantitative identification of chemicals present in a wide array of biological endpoints relevant to public health. Since new chemicals are constantly introduced to the market and considering the innumerable amount of potential transformation products, bioassays make good sense in paving a path forward that will better help the public and regulators move forward with water reuse projects (A.Synder, 2015).

As cities continue to grow and water resources continue to become more challenged, only water reuses, desalination, and transportation outside can provide additional resources than those provided by natural deposition. Water reuse in particular has numerous advantages, yet real challenges in terms of public acceptance. Scientists have an opportunity to help move the field forward through development of more effective communication of complex data and by making sure that reused water quality is compared to that of existing urban water resources (A.Synder, 2015).

2.12. Patterns and trends of recycling water global view

The first historical evidence of water reuse for irrigation goes back to Bronze Age in Crete (Hellas) and Mohenjo-Daro (Indus valley) approximately *ca*. 5000 years ago. In the more recent history, the first large-scale projects of indirect water reuse were established during the period from 1500 to 1800 when “sewage farms” were developed as an attempt to protect public health and to control water pollution. Sewage farms were operated in most cases as disposal sites aiming to maximize the volume of wastewater applied per surface area unit rather than to recycle it efficiently for crop irrigation (A.Synder, 2015).

The first modern wastewater treatment systems appear in the mid of 19th century; however, water reuse as a planned activity started about one century ago with the use of treated effluent to irrigate Golden Gate Park in San Francisco, California. Non-potable water reuse applications have grown substantially since then, from urban landscape irrigation to irrigation of food crops, from thermoelectric cooling water to car wash facilities, and from firefighting activities to seawater intrusion barriers (A.Synder, 2015).

Emerging technologies such as on-line sensors with real-time feedback will certainly play a major role in water reuse in the near future. Advances in membrane technologies will also be critical in lowering energy needs and increasing water recovery rates. These technology advances should be prioritized comprehensively for achieving the correct water quality for the application needed. Creating ultra-high purity water for irrigation, toilet flushing, and clothing washing does not make good sense(A.Synder, 2015).

Therefore, the future will lie squarely in fit for purpose treatment and more distributed systems that can be interlinked and autonomously controlled. As the world’s population continues to grow and urbanism such research priorities will become increasing paramount. This Special Issue provides historical context and links to some of the latest developments in safe and sustainable wastewater and bio-solids management and reuses (A.Synder, 2015).

2.12.1. Social Dimensions Related to Wastewater

The focus of most wastewater related research has been on the technical aspects of the problem and improvements in terms of water quality and in minimizing environmental and health impacts, with very limited attention to its basic social and cultural sustainability dimensions. While, with increasing urbanization, wastewater treatment has moved further away from the household and its social roots for using reclaimed water for drinking made it clear that sanitation depends strongly on social habits and acceptance (Crook, 2003). Where treatment is not keeping pace with population growth, and environmental pollution is threatening public health, the social dimension of wastewater management becomes obvious. Recognizing the role of the social base for wastewater management from risk reduction to reuse can have major implications. Yet, usually, only limited information is available on the social perspective (Crook, 2003).

Wastewater management strategies have been traditionally driven by considerations of efficiency, safety, and cost-effectiveness. Even technology choices are often made by finance institutions outside the country, especially in low-income countries, often favoring “Northern” technology options. The emphasis on costs and benefits in this context would be acceptable if, in addition, other relevant factors could be included in the decision-making process by adopting a holistic methodology that includes the voices of all stakeholders and an analysis of sociological factors (Crook, 2003).

2.12.2. Social Perception and Public Acceptance

Even when wastewater is treated using advanced technologies and health risks are carefully addressed and controlled, irrespective of all scientific evidence, social perception remains the driver of the success or failure of wastewater reuse schemes. Depending on public perceptions, impressions and attitudes, the development of a wastewater scheme can be supported or constrained. Negative public perception can prevent well-planned projects from moving forward. On the other hand, positive public perception, which leads to greater acceptance, is the key element for successful implementation of wastewater recycling. Experience shows that the local communities have rejected a number of wastewater recycling projects by the governments and water boards around the world as a result of inadequate community consultation which led to negative public perception (Bruvold, 1998).

The degree of acceptance of wastewater reuse varies widely depending on the reuse purposes and is influenced by many factors, such as the degree of contact; expressions of disgust; education; risk awareness; the degree of water scarcity or availability of alternative water sources; calculated costs and benefits; trust and knowledge; issues of choice; attitudes toward the environment; economic considerations; involvement in decision-making; the source of water to be recycled; and experience with treated wastewater. Other factors that depend on the region and case include cultural, religious, educational and/or socioeconomic factors (Bruvold, 1998).

Education and the level of physical contact (potable/no potable reuse) are the most influential factors that have been frequently associated with levels of acceptance of treated wastewater. In Kuwait and Greece, for example, the willingness to accept recycled water increased with educational levels (Jeffry P. and Temple C., 1999). However, as much as education and knowledge support public acceptance, nevertheless, direct exposure to the recycled water strongly influences its acceptance (Bruvold, 1998). For example, potable use is usually rejected due to health concerns. Wastewater use in agriculture generally is preferred to potable use, but more distant uses, such as landscape irrigation, are the most preferred(Amerasinghe P, Bhardwaj RM, Scott C, Jella K, Marshall F , 2013).

Several authors have investigated the association of socio-demographic descriptors with the acceptance of treated wastewater. The (D’Angelo, 1998) indicated that the acceptability of using recycled water in agriculture is higher for no edible crops than for edible crops. For edible crops, the preference is for crops that must be peeled prior to human consumption, such as oranges and sweet corn. A relevant study reported that the public's acceptance of reuse increases as the degree of human contact with the recycled water increases, with 97% and 96% of the public supporting wastewater reuse for irrigation and for toilet flushing, respectively, whereas only 20%–30% support potable reuse (Denlay J. Dowsett B., 1994) . Another study conducted by (Friedler E. and Lahav O., 2006) to determine the attitudes of the Israeli urban public toward possible urban reuse revealed that the majority of participants supported options perceived as low contact, such as irrigation of public parks (96%), sidewalk landscaping (95%) and use in the construction industry (94%), while higher contact reuse options, such as commercial launderettes (60%), found less support. According to (Bruvold, 1998), the degree of human contact has a greater effect when people were asked about general use options, whereas when the specific use scheme was used, other factors such as health, environment, treatment, distribution and conservation had greater impact on people's perceptions. Therefore, he argues that it is essential to weigh the different objectives of the recycling options in coordination with people’s/users’ acceptability and preference and select the recycling projects which are most likely to be accepted by the community and therefore make the project implementation successful (Bruvold, 1998).

2.12.3 Socio-economic status of developing countries

(Banerjee & Duflo, 2008) examine key household and individual characteristics of different economic classes, including three of the five classes analyzed in this paper: the extreme poor, moderate poor; near poor; and the middle class in the range US$6 to US$10 per-capita (5,193

ETB to 8,655 ETB in average currently) household consumption (Note: The aggregate refers to 39 countries). They find that middle class households have far fewer members on average than poor and near poor households (Kapsos & Bourmpoula, 2013).

Middle class households have greater access to bank credit, which helps to smooth consumption in periods of income volatility and provides capital for entrepreneurial endeavors, though credit constraints still pose a barrier to widespread entrepreneurship among the middle class. At the same time, middle class households are also far more likely to have health and life insurance than the poor, which further serves to reduce vulnerability to poverty (Kapsos & Bourmpoula, 2013).

2.1. Socio Economic Status of Residents

Income per month in USD/ETB	**Socio-economic status**
Below US$ 1.25 (below 1,081.88 ETB)	Extreme working poor
US$ 1.25-US$ 2 (between 1,081.88 to 2,163.76 ETB)	Moderate working poor
US$ 2 - US$ 4(2,163.76 to 3,462 ETB)	Near poor workers
US$ 4 - US$ 13 (3,462 to 11, 251.5 ETB)	Developing middle class workers
Above US$ 13 (above 11,251.50)	≥ Developed middle class

Note: that the current currency of US$ 1 is 28.85 ETB in average (National Bank of Ethiopia, 2019).

2.13. The Existing Organizational Structure of AAWSA

The Addis Ababa Water and Sewerage Authority (AAWSA) was established as an autonomous body by order No 68/1971 issued on 26 February 1971 and re-established by Proclamation No 10/1995 as an autonomous Public Authority under Region 14 following the formation of regional states. Region 14 has since become the Addis Ababa City Government, which is one of the two independent City Administrations established by the Federal Government (AAWSA, 2018).

AAWSA is governed by the Addis Ababa City Government. The Mayor of the City of Addis Ababa is the Chairman of the Board of AAWSA. Other members of the Board include the City Manager of Addis Ababa, representatives from the City Government, other relevant organizations and two labor union representatives(AAWSA, 2018).

Proclamation No 10/1995 defines the objectives, powers and duties of AAWSA. The duties of AAWSA include the supply of safe and adequate potable water and the provision of wastewater/sludge collection, treatment and disposal within the limits of the city of Addis Ababa. Accordingly, AAWSA has two main business lines which are reflected in its organizational structure:

1- Water Supply,
2- Sewerage and Sanitation.

AAWSA is managed by a General Manager appointed by and reporting to the Board of Directors. The General Manager's responsibilities include managing and overseeing all activities within AAWSA according to the policy guidelines of the Board of Directors. The Board of Directors formulates policy and management strategy and its duties include approving AAWSA's budget(AAWSA, 2018).

The Board of Directors also appoints four Deputy General Managers (Sewerage, Water Supply, Resource Management and Project Office). There are also eight Branch Offices, Core Processes, Sub-Processes and Case Teams(AAWSA, 2018).

The total number of staff in AAWSA at the start of the Consultancy Services was 1,888, of which 1,850 were permanent employees and 38 were contract employees. It must be noted that AAWSA recently began outsourcing certain activities, such as customer meter reading(AAWSA, 2018).

The Addis Ababa City Administration recently launched a Business Process Re-engineering (BPR) undertaking all the municipal entities and sector bureaus in the City. In line with these undertaking AAWSA has also embarked in re-engineering all business and operation areas within its organization(AAWSA, 2018).

AAWSA has been providing wastewater collection, transportation and treatment services to the metropolitan since 1970's. Only 6 to 7% of the housing units enjoy the off-site disposal system and the remaining 13 to 14% of the housing units in the city do not have toilet facility at all. On-site sanitation facility users obtain sludge collection and disposal services mainly from AAWSA (67%) and private operators. The off-site disposal system has limited sewer network coverage and a conventional wastewater treatment plant serving only some parts of Kality catchment specifically Bole, Lideta, Old Airport, Central part of the City, Mekanisa and Kera areas (AAWSA, 2018).

AAWSA provides sanitation services for the city by collecting, transporting, treating and disposing the liquid wastes. At present, a total amount of waste water and sludge being collected and treated is 22, 830 m^3/day at sludge and waste water treatment plants (AAWSA, 2018).

With conventional sewer system about 21,630 m^3 (7.3% coverage) of wastewater is conveyed to the treatment plants every day. Vacuum trucks managed by AAWSA and private owners collect on average about 1,200 m^3 of sludge every day from the on-site disposal sanitation facility users (37.0% coverage). The overall waste collection coverage at city level is then around 44.3%(AAWSA, 2018).

Considering the isolated sewer networks for different condominiums, recently connected condominiums to Kality system and AAWSA's record of sewer connections there are around 51,500 domestic connections and 2,164 non domestic connections totaling to 54,089 customers connected to the sewer system at present 2011(AAWSA, 2018).

About 96% of the connections are domestic connection serving the domestic consumers, 1.8% of the connections are non domestic industrial and 2.27% of the connections are non-domestic public & institutional customers. Even though, AAWSA's has eight branches within the city administration it was not possible to obtain the distribution of sewer connections by branches (AAWSA, 2018).

Considering the ongoing construction of condominiums, upgrading of slums to high rise buildings within the built up area, real-estate development and envisaged target coverage, high growth rate is anticipated with in the planning period. Accordingly, the annual growth rate of demand for sewer connections is estimated to be around 68% at the beginning of the planning period and is expected to decline to 13% towards the end (AAWSA, 2018).

2.14. Wastewater and Sludge Generation and Projections

A - Low Scenario Case

The low scenario case considers lower growth rate like the case of the water supply. Accordingly, the total wastewater to be generated from the off-site system at the beginning of the fiscal year will be32, 241m^3/day; and 258,328 m^3/day by the end of the planning horizon exhibiting an annual increment of 4%.Considering the existing conventional sewer system capacity of 21, 630m^3/day and the capacity requirement for additional waste water system facilities to fulfill the targeted coverage is 236,698 m^3/day (AAWSA, 2018).

B - High Scenario Case

The High scenario case considers higher (2.52%) growth rate like the case of the water supply. Accordingly, the total waste water to be generated from the off-site system will be 32,472m^3/day at the beginning and 285,993m^3/day by the end of the planning horizon exhibiting an annual increment of 4.2% (AAWSA, 2018).

Considering the existing conventional sewer system capacity of 21, 630m^3/day, the capacity requirement for additional waste water system facilities to fulfill the targeted coverage is 264,363 m^3/day (AAWSA, 2018).

Projected wastewater demand

a. **Low scenario case**

Description	Units	2011	2013	2015	2017	2019	2020
Annual growth rate	%	2.10	2.10	2.10	2.10	2.10	2.10
Housing units	No.	697,815	735,116	774,489	816,058	859,948	882,807
Population using flush toilet	%	21.8	33.6	45.5	57.3	69.1	75.0
Population using flush toilet	No.	649,855	1,045,030	1,472,908	1,935,570	2,435,213	2,699,623
Population using sewer system	%	6.8	16.4	26.0	35.6	45.2	50.0
Population using sewer system	No.	202,916	509,863	842,768	1,203,296	1,593,202	1,799,749
Domestic wastewater generated	m^3/day	73,044	118,297	167,911	222,203	281,511	313,156

Table: 2.2a. Waste water demand low case scenario (AAWSA, 2018)

b. High scenario case

Description	Units	2011	2013	2015	2017	2019	2020
Annual growth rate	%	2.52	2.52	2.52	2.52	2.52	2.52
Housing units	No.	709,700	753,975	801,096	851,249	904,639	932,615
Population using flush toilet	%	21.8	33.6	45.5	57.3	69.1	75.0
Population using flush toilet	No.	206,372	522,944	871,722	1,255,191	1,676,006	1,901,298
Population using sewer system	%	6.8	16.4	26.0	35.6	45.2	50.0
Population using sewer system	No.	660,927	1,071,843	1,523,510	2,019,045	2,561,778	2,851,947
Domestic wastewater generated	m^3/day	73,336	120,132	172,461	230,817	295,732	330,826

Table: 2.2b. Waste water demand high case scenario (AAWSA, 2018)

2.12.1. Proposed Projects and Implementation Schedule

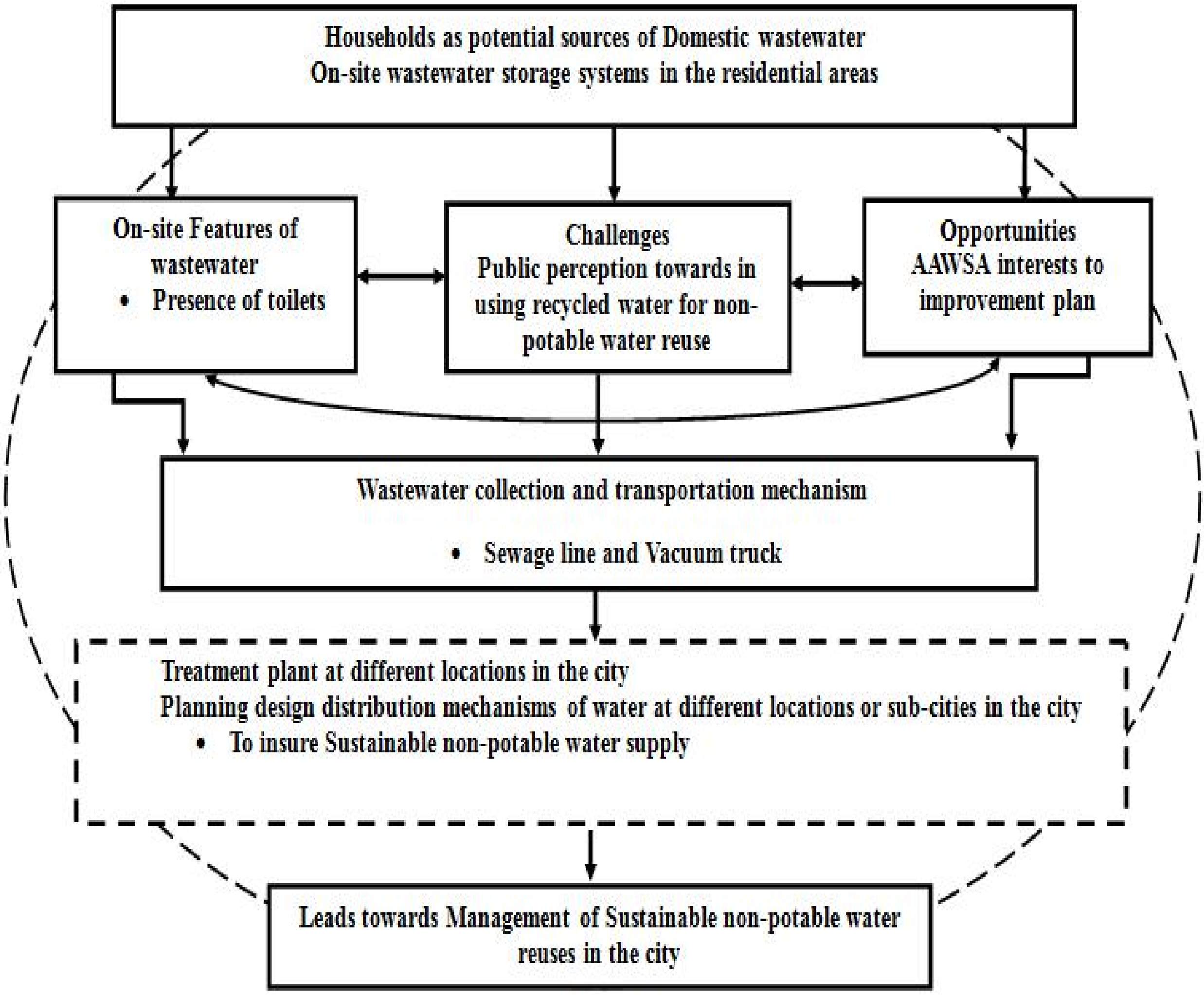
In order to satisfy the increasing demand for waste water services AAWSA has identified 8 Sewerage Service Projects. Five of the projects, sewerage service projects, are planned to increase the coverage of conventional sewer system to 50% by the year 2020. Three of the projects are dedicated for collection & treatment of sludge from the on-site sanitary facilities Wastewater demand low case scenario (AAWSA, 2018).

2.13. Conceptual Framework

The framework below conceptualizes households (residential areas) are sources of domestic wastewater and the on-site domestic wastewater storage shows the initial condition (the original stage) for planning series of activities to harvest recycled water for non-potable water uses by using wastewater as alternative sources of recycled water. Also, availability of domestic wastewater from different households and its on-site storage system realizes the sustainability of wastewater sources and its management in the study area as well as Addis Ababa city. The next stage below indicates wastewater collection modes and how wastewater is collected from the storages of different residential areas, swage lines and trucks are used to collect domestic wastewater from on-site storage and residential areas. Therefore, the wastewater is transported by swage lines and trucks to the treatment plant. At the third stage, at the treatment plant initially the sludge (feaces and solid waste) is removed by sedimentation process besides biological treatment continued and finally physic-chemical treatment have been done to harvest quality water. In the treatment plant the effluent smell and the adverse impact of photogenic organisms are removed as a result the environment is safe from pollutant. It is also healthy and conducive environment to live in. The quality water (recycled water) is harvested in the treatment plant for non-potable water reuses. Finally, the last stage indicates that the plant used to harvest quality water, which used as alternative sustainable non-potable water supply for various services in the study area as well as Addis Ababa city.

Regarding on the scope of the study, time constraint and limitation of adequate potentials of resources and institutions capacity, the researcher is unable to cover the contents of conceptual framework like wastewater treatment processes, designing and planning and distribution. Therefore, the researcher pointed these contents as research gap caused by the uppermost reasons. Thus, they are put in recommendation part for other researchers for further study.

Fig2.1- Conceptual Framework Work of the Study



CHAPTER FOUR: METHODS AND MATERIALS

3.1. Description of the Study Area

Addis Ababa lies at an average elevation of 2408 meters above sea level and located at 9°1′48″N 38°44′24″E having an average minimum temperature of 6^{o}C maximum temperature 27^{o}C(yearly average temperature is 16.5^{o}C), and average annual rainfall of 1143millimeter (Abebe, 2017).

Addis Ababa is constituted as a City Government. The city covers a total area of 530 square. It is divided into ten Sub-Cities stemming from the 2003 reforms onwards and every sub-city has its own administrative autonomy, contains that Lideta, Kirkos, Arada and Addis-Ketema represent the core or central area where as Akaki, Nifas-Silk-Lafto, Kolfe Keranio, Gulele, Yeka and Bole correspond partly to the expansion areas at their peripheries.

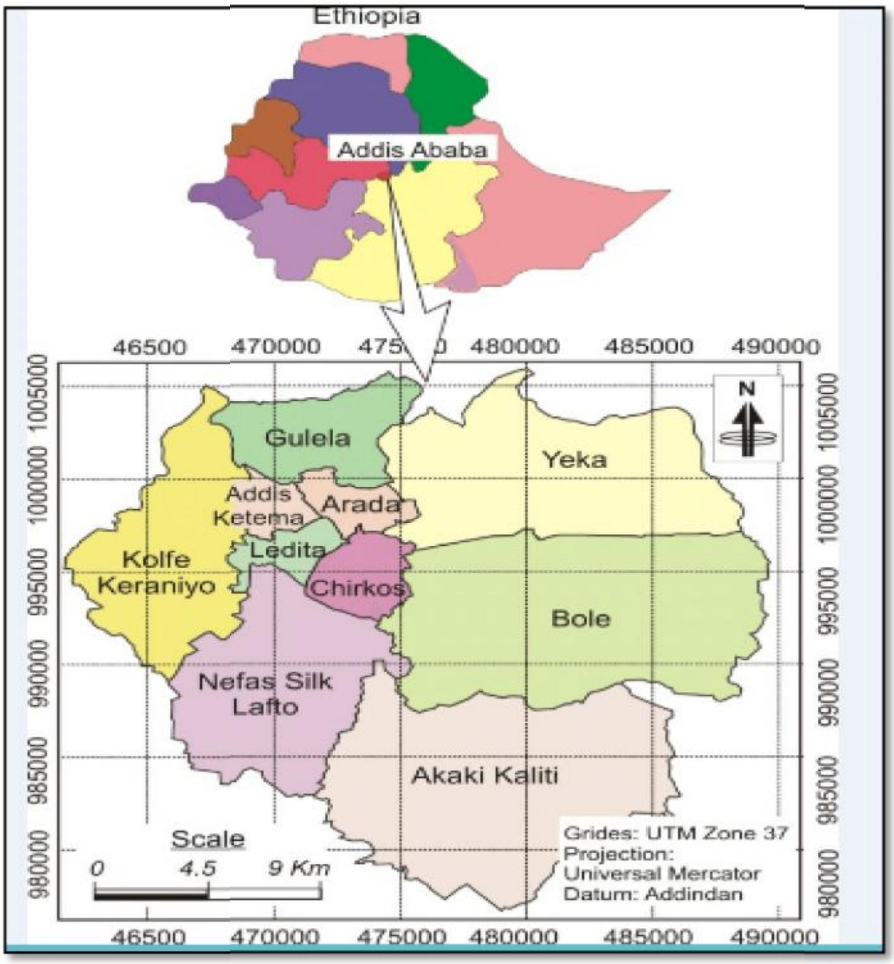


Figure: 3.1. Map of Addis Ababa city:(Berhanu, Raghuvanshi, & Suryabhagavan, 2017)

The study populations were residents predominantly head of households (HHs) or housing units from ten different sub cities in Addis Ababa city. These are 859,948 HHs, which has been taken from projection data of 2019 (CSA, 2012).

3.2. Methods and Materials

3.2.1. Research Design

The general idea of the design is one of the important situation that the research in the empirical world. On the practical level, it means connecting the research questions to data that collected during field survey. Design had been put between the research questions and data, showing how the research questions were connected to the data, and what tools and procedures to use in answering them (Punch, 2006).

In this particular research, the researcher was used cross-sectional and longitudinal study designs. In cross-sectional design, in this type of studies both the entire population or a subset thereof was selected, and from these individuals, data were collected to help answer research questions of interest. It is called cross-sectional study because the information gathered from the individual (HH) represents what was going on at only one point in time. Also the study, it was contained longitudinal study design, which was appropriate for measuring the extent of change in a phenomenon, situation, problem, attitude, and so on, but is less helpful for studying the pattern of change. To determine the pattern of change in relation to time, a longitudinal design used. Longitudinal studies were also useful in order to collect factual information on a continuing basis. Longitudinal study could be seen as a series of repetitive cross-sectional studies (Punch, 2006).

Therefore, in this particular study, the researcher was used cross-sectional and longitudinal study designs to explore feature, challenge and opportunities, which led towards management and sustainability of wastewater reuses in Addis Ababa city.

Also, the study design incorporates quantitative as well as qualitative research methods. Qualitative method used to enhance the quantitative results of the study and filled the gap where/when quantitative survey unable to fill.As a result the study was intended to describe the existing practices; descriptive statistical methods and multiple linear regression models were used for the study. Accordingly, this study had been conducted on towards management and sustainability of wastewater reuses: features, challenges and opportunities case study in

Addis Ababa city.

3.3. Sampling procedures and sample size

The HHs were selected by systematic random sampling technique, which was enabled the researcher used to collect relevant information, explore and examine the attitude (perception) of residents (people) to accept/deny recycled wastewater (domestic wastewater or toilet flush water) in order to use for various non-potable water reuses after the process of wastewater treatment and provide due attention for HHs are potential wastewater sources of non-potable water reuses in sustainable manner in the study areas as well as in the city.

Therefore, the researcher had been given due attention for this particular study, which had been focused on HHs wastewater used as potential source of non-potable water reuses, besides it used to safeguard the potable water supply of AAWSA by using recycled water for non-potable water supply for various non-potable water reuses. Finally, it had been led towards management and sustainability of wastewater reuses after assessed features, challenges and opportunities related to HHs wastewater and realized sustainable WRM in Addis Ababa city.

3.3.1. Sample Size Determination

The researcher was applied, formula to yield a representative sample for proportions which were selected for this research(Cochran, 1963).

To estimate the sample size of participants in the study, the researcher was applied the formula; Cited by (Israel, 1992):

$\mathbf{n} = \frac{Z^2}{e^2}\boldsymbol{p} \bullet \boldsymbol{q}$, where;

$n =$ Sample size required

$p =$ The estimated proportion of an attribute that was present in the population

$q = 1 - p$

$Z =$ Z- Score associated with appropriately chosen level of confidence (95%) with the table value of 1.96

$e =$ 0.05, the desired level of precision

Therefore, assume P=0.05. Accordingly, the desired level of precision 5% with 95% level of confidence the Z value equals 1.96. The estimated sample size was described by:

$$\mathbf{n} = \frac{(1.96)^2}{(0.05)^2}[\mathbf{0.5(0.5)}] \approx \mathbf{385}$$

Also, adding 5% contingency for expected non-response rate, the final sample size in the study was described as:

$$\boldsymbol{n} = \mathbf{385 + 5\%(385) = 385 + 20 = 405}$$

This estimated sample size was distributed to 10 sub cities in Addis Ababa city with prospect proportional to size taking into consideration time and resource allocation to the study. The researcher used purposive (own judgment) method as a result the household survey was conducted and it was assessed by five intervals starting from the first household as shown in (Table: 3.1.) as follow;

Table: 3.1. Sample population from ten sub-cities in Addis Ababa city

S. No.	**Sub-cities in Addis Ababa city**	**Sample HH`s in each sub city**
1	Arada	40
2	Addis Ketema	40
3	Akaki	40
4	Bole	40
5	Gulele	40
6	Kirkos	40
7	KolfeKeranio	40
8	Lideta	40
9	Nifas-Silk Lafto	40
10	Yeka	45
Total		405

3.4. Sources of Data

Both primary and secondary sources of data used to collect information (data). The primary data of the study was collected from eligible respondents (water treatment and reuse team leader, water supply team leader, production team leaders and residents of sample housesor

HHs) during field survey, observation and office visit. Whereas secondary data was collected through review of documents, books, journals, reports, websites etc. used to gather the anticipated information based on the objectives of this research.

3.5. Methods of Data Collection

3.5.1 Key Informant Interview

The semi- structured interview was used to collect data about management of sustainable non-potable water reuse: features, challenges and opportunities in Addis Ababa city from department heads of different team leaders of AAWSA as key informants; to collect primary data or information to understand the future prospects of AAWSA to enhance wastewater management as well as water supply capacity. Besides, it was used to make narration on the features, opportunities and challenges, which leads towards sustainable management of non-potable water uses in the city based on the collected information during field survey.

3.5.2 Questionnaires

A semi structured questionnaire was prepared and distributed that was useful for this particular study because it presents the views of sample population and extract reliable information about the sustainability of HHs wastewater as sustainable sources of non-potable water reuses; features, challenges and opportunities in relation to the objectives of the research. The researcher was used own judgment to select the respondents after determination of total sample size by applying Cochran formula. It was prepared purposely as tool to guide and gather relevant and reliable information or collect data based on the objectives of the research.

3.6. Methods of Data Analysis

Quantitative data to be obtained through survey questionnaire were entered into computer for analysis using Statistical Packages for Social Science (SPSS-21) software and excel to make analysis on quantitative data.

Accordingly, the data were edited, coded, and cleaned. Some consistency checks were verified by running descriptive statistics that used to verify the output by using frequencies tables and the mean values of variables such as demographic variables. Also, regression model to predict cause and effects relationship among variables such as degree of contact expression of disgust, risk awareness, access of choice, economic consideration(Bruvold, 1998), which are relevant to describe public perception, attitude in order to change public attitude towards management and sustainability of wastewater reuse in Addis Ababa city. The analysis part had been done by using descriptive analysis.

Narration made because data were collected by semi-structured interview from different department team leaders in AAWSA. Finally, the researcher was assorted them (qualitative and quantitative analysis) together and made discussion accordingly the collected data to accomplish the research successfully as per the objectives of the research.

3.6.1. Descriptive Analysis

Descriptive statistics for the statistical significance of the dummy/discrete variables were tested and checked.

3.6.2. Models Specification

Regression model was applied to describe the predictors/determinants of public perceptions such as such as degree of contact expression of disgust, risk awareness, access of choice, economic consideration (Bruvold, 1998), which were led towards public attitude change in order to use recycle wastewater for various non-potable reuses. Finally, demonstrate their relationship by using regression (by plotting P-P graph and plotting scattered plot graph).

Descriptive statistics, it used to demonstrate relationship among different variables (dependent and independent variables) like public perception to use recycle water for various non-potable water reuses in terms of demographic variables like age, sex, education, income level and religion of residents.

The form of the model that is thought to relate the response variables like age, sex, religion, education and income to the set of predictor variables can be specified initially by the researches in this particular study based on objectives and subjective judgments. The hypothesized model can then be either confirmed or refuted by the analysis of the collected data to describe the perception or acceptance of community to use recycled water for various non-potable water reuses.

Therefore, the researcher had been used multiple regression models. The model employed one dependent variable and five independent variables (Gujrati, 2004).

The ***multiple regression model***: ***Y= 0 + 1X1 + 2X2 + …+ kXk + U,*** where

β_0: is the intercept

β_1: is the parameter associated with ***X_1*** (measures the change in *y* with respect to ***X_1***, holding other factors fixed)

β_2: is the parameter associated with ***X_2*** (measures the change in ***Y***with respect to ***X_2***, holding other factors fixed) and so on…

β_1, **β_2**, …, **β_k**: are often referred to as slope parameters,

U: is the disturbance term (error term). It contains factors other than the ***X_1***, ***X_2,…,X_k*** affecting ***Y*** (Gujrati, 2004).

3.6.3. Variables in the Study

To examine the people perception towards recycle wastewater for various non-potable water reuses and demographic characteristics (like age, sex, income, education and religion of residents), the researcher was reviewed literature in depth; one of the earliest suggestions was the examination of demographic characteristics as predictors of recycled water acceptance. In addition the researcher gave due attention on religion of the residents or peoples as variables to gather detail information to verify their effect on perceptions of people on recycle water uses and confirm the people in order to use recycle water for non-potable water uses and insure sustainability of wastewater as potential source of non-potable water (recycled water). Currently, degree of contact expression of disgust, risk awareness, access of choice, economic consideration (Bruvold, 1998) are important variables to determine the public perception towards non-potable water reuses in sustainable manner in the study areas as well as in Addis Ababa city.

3.7. Ethical Consideration

The research was conducted upon securing ethical approval. Official letter from the College of Development studies, Centre for Water Resources Management, Addis Ababa University was provided by AAU to the researcher to request different data from CSA, AAWSA and Housing Agency and to whom they might be concerned. After the permission received then the study was conducted, by consent the participants (HHs) through notifying the objectives of the study, data to be gathered from them should be kept confidential and important for the study and participation based on their willingness.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Demographic and Socioeconomic Characteristics

A total of 405 questionnaires were distributed to collect sample survey data for this study in Addis Ababa city. The number of respondents for this particular study were selected from ten different sub cities; Addis ketema sub city 40 HHs, Arada sub city 40 HHs, Akaki sub city 40 HHs, Bole sub city 40 HHs, Gulele sub city 40 HHs, Lideta sub city 40HHs, Lafto Nifas Silk subcity40 HHs, Kirkos sub city 40 HHs, Kolfe Keranio sub city HHs and Yeka sub city 45HHs as shown in (Table: 3.1.).

Table: 4.1belowcontained demographic data of the respondents such as sex, age classes, family size, religion, marital status, educational status and income level of the respondents in the study areas. These demographic data were played important role in order to depict their impact on features, challenges and opportunities of wastewater reuses for various non-potable water uses. Therefore, which led towards management and sustainability of wastewater reuses for various non-potable water uses in the study areas as well as in the city?

The results in (Table: 4.1) indicated that the age interval of the respondents; 6.9% were grouped (31 to 40), 53.8 % were grouped (41 to 50), 33.8 % were grouped (51 to 60) and 5.4 % were grouped older than 60 years old. In general, these results indicated that 87.6 % of the respondents were grouped in the second age category. Thus, the respondents are permanent settlers in the study areas. This could have positive implications in terms of availability of HHs wastewater discharge as potential source of recycle water.

About 74 % of the respondents were married. Thus, this result could have implication for that the respondents are regular residents in the study areas as a result the respondents have sustainable contribution of HHs wastewater. Therefore, the marital statuses of the respondents were realized that the respondents are regular residents in the study areas as a result it insures the residents as sustainable potential source of wastewater in the study areas as well as in the city.

Table: 4.1. Demographic Characteristics of Respondents

Demographic Characteristics	Frequency	Percentage	Mean	Std. Deviation
Gender				
Female	242	59.8 %	.40	.491
Male	163	40.2 %		
Age				
31 – 40	28	6.9 %	3.3778	.69510
41 – 50	218	53.8 %		
51 – 60	137	33.8 %		
Older Than 60	22	5.4 %		
Marital Status				
Single	30	7.4 %	6.1877	.67071
Married	299	73.8 %		
Divorced	46	11.4 %		
Widowed	30	7.4 %		
Religion				
Christian	221	54.6 %	3.4543	.49852
Muslim	184	45.4 %		
Educational Status				
Unable To Write And Read	9	2.2 %	5.2123	1.27207
Completed In Primary School	15	3.7 %		
Completed In Secondary School	15	3.7 %		
Completed In Preparatory School	26	6.4 %		
College Diploma /TVET	159	39.3 %		
Bsc. /Bed.	139	34.3 %		
MSc. /MA.	42	10.4 %		
Income level per month				
Below 1000	1	.2%	6.748	1.6031
1001-1500	3	.7%		
1501- 2000	5	1.2%		
2001-2500	23	5.7%		
2501- 3000	26	6.4%		
3001-3500	162	40.0%		
3501-4000	52	12.8%		
4001-4500	44	10.9%		
4501-5000	89	22.0%		

(Source: Field survey 2019)

So, the respondents could be important features to access sustainable wastewater in the study areas. Consequently, it leads towards management and sustainability of wastewater reuses for various non-potable water uses in Addis Ababa city.

As shown in (Table: 4.1.), the educational level of respondents, out of the surveyed HHs, 2.2 % respondents were could not able to read and write, 3.7 % respondents were completed primary school, 3.7 % respondents were completed secondary school, 6.4 % were respondents completed preparatory school and 39.3 % respondents were completed college diploma/TVET BSc. / Bed and MSc. /MA programs. In general, about13.8 % of the respondents was enrolled primary, secondary and preparatory schools and about 81 % of the respondents were enrolled in college (TVET) and higher education levels or programs. Therefore, the results revealed that education status of respondents is the other important feature to create awareness on the respondents and to build positive attitude on respondents in order to use recycle water for various non-potable reuses in sustainable manner.

As shown in (Table: 4.1), about 85 % of the total respondents were contained family size of 5,6,7,8 and 9 family members respectively. “7” is the more frequent (mode) of family size in sample populations. About 13.1 %of the sample populations (HHs) were contained family members 3, 4, 10 and 11 respectively. They are also, additional potential sources of HHs wastewater, in order to generate/produce wastewater as potential sources. In addition, the results in (Summary Table: I. in appendix IV.) indicated that the mean (average) family size of the respondents in the study areas is about “6.83 $\cong$ 7”. Therefore, the results indicated that the family size has significant role to generate adequate wastewater from individual HH (HHs) in the study areas. Also, it is proportional to water demand (consumption) and wastewater production in the residential areas from different HHs. Thus, family size is the significant feature of wastewater production from different HHs in the study areas. Consequently, it leads towards management and sustainability of wastewater reuses in the city.

4.2. Economic Status of Respondents

The results were illustrated that (see table 4.1) 85.7 % of the respondents’ income per month were grouped 3001- 5000 ETB. According to (Kapsos & Bourmpoula, 2013) document, about85.7 % of the respondents are economically at near poor and developing middle income status. Therefore, economic status of the respondents is a major challenge for management and sustainability of wastewater reuses in the study areas as well as in Addis Ababa city.

4.3. Non-potable Water Use Trends of Respondents

In this particular research, non-potable water use trends of respondents related to water supply for non-potable water uses, the type of toilets and their uses in the HHs around the study areas, toilet services by respondents, consumption of toilet by respondents per day, amount of water consumption for toilet service per use, the amount of HHs wastewater discharge from the HH (HHs) in relation to/in terms the average family size of HHs, the storage of HHs wastewater discharge in the study areas and mechanisms to remove wastewater discharge from individual HH (by septic tank or pipe).

4.3.1. Types of Water Supply in the Study Areas

As shown in (Table: 4.2.), about 86.4 % respondents were used tap water in private owned, about 5.7 % of the respondents were used tap water in share, about 4.2 % of the respondents were used public tap water and about 3.7 % of the respondents were used rivers and springs.

Table: 4.2. Types of water supply in the residential areas

Types of water supply for HHs in the study areas	Frequency	Percent
Tap water use in private owned	350	86.4
Tap water use in share	23	5.7
Public tap	17	4.2
River and springs	15	3.7
Total	405	100.0

(Source: Field survey 2019)

In general, about 96.3 % of the respondents were used tap water use in private owned, tap water in share and public tap. The results indicated that 96.3 % of the respondents were used tap water for various potable and non-potable water uses in the study areas. Therefore, this finding were depicted that tap is sustainable water supply for various non-potable water uses in the study areas. So, this result could have negative implication on adequate water supply for potable and non-potable water uses in the study areas. This could lead to focus on HHs wastewater as alternative source for non-potable water supply in the study area. Consequently, it leads towards management and sustainability of wastewater reuses in the study areas as well as in the city.

4.3.2. Types of toilet used by HHs

As shown in (Table: 4.3.) about 7.7 % of the respondents were used pit-hole, about 90.6 % of the respondents were used flush toilet, about 1.7 % of respondents were used open defecation. In general, about 90.6 % of the respondents were used flush toilet in their households.

Table: 4.3. Types of toilets

Types of toilets used by households	Frequency	Percent
Pit-hole	31	7.7
Flush toilet	367	90.6
Open defecation	7	1.7
Total	405	100.0

(Source: Field survey 2019)

90.6 % of the respondents were used flush toilet for excretion/ cleaning purpose in their households. Thus, the result indicated that HHs wastewater discharge were stored in septic tank. This could have positive implication for sustainable wastewater storage in the study areas. Therefore, wastewater is abundant source of recycle water in the study areas. Consequently, the availability of toilet and septic tank in the study areas are important features in order to store wastewater discharge from HHs in the study areas as well as in the city in sustainable manner. This insures that the availability of potential wastewater as source of recycle water, which safeguards as guarantee to harvest recycle water for various non-potable water reuses in the study areas. Therefore, it leads towards management of sustainable non-potable water reuses for better wastewater in the city.

4.2.3. Toilet services for HHs

Residential areas (HHs), compounds, and work places provide toilet services for people in private and shares. Recently, flush toilets are accessible in HHs caused by the paradigm shift of housing types from public houses to condominium buildings (apartment buildings) in Addis Ababa city.

Table: 4.4. Use of toilets at different areas

Uses of toilets at different areas	Frequency	Percent
Toilet in home	370	91.4
Communal toilet	19	4.7
Toilet at work place	16	4.0
Total	405	100.0

(Source: Field survey 2019)

As shown in (Table: 4.4.), 91.4 % of the respondents were accessed toilet services in home, 4.7 % of the respondents were accessed toilet services communal/share toilet in the compound and other 4 % of the respondents were accessed toilet services at working places. In general, the result illustrated that about 96.1 % of the respondents were accessed toilet services in the study areas. Thus, about 96.1 % of the respondents were accessed toilet services in their residential areas or houses as a result there is adequate HHs wastewater discharge in the study areas, which used as sustainable potential source to produce/harvest recycle water for various non-potable water uses in the city. Consequently, the HHs have positive attribute of HHs wastewater discharge in order to improve non-potable water supply in the city.

4.3.3. Consumption of toilet per day (Toilet service)

As shown in (Table: 4.5.), 86.7 % of the respondents were used toilet twice per day in their HH, 8.7% of the respondents were used toilet three times per day in their HH and 4.4 % of the respondents were used toilet for times and above per day in their HH.

Table: 4.5. Consumption of toilet by respondents per day in the study areas

Consumption of toilet per day in the study areas	Frequency	Percent
Twice	351	86.7
Three times	36	8.9
Four times and above	18	4.4
Total	405	100.0

(Source: Field survey 2019)

In general, 86.7 % of the respondents were used toilet twice per day in their HH at the study areas. This result illustrated that 86.7 % of the respondents could have significant contribution to generate ample HHs wastewater discharge from their HHs. Thus, these results could have positive implications for management of sustainable wastewater reuses in the study areas as well as in the city.

4.3.4. Amount of water consumption per use

As shown in (Table: 4.6.), 4 % of the respondents were used 1 liter of tap water per use for toilet flush, 3.2 % of the respondents were used 2 liters of tap water per use for toilet flush, 87.9 % of the respondents were used 3 liters of tap water per use for toilet flush and 4.9 % of the respondents were used 4 liters and more amount of tap water per use for toilet flush.

Table: 4.6. Amount of water consumed per use for toilet service

Amount of Water Consumed Per use	Frequency	Percent
1 lit.	16	4.0
2 lit.	13	3.2
3 lit.	356	87.9
4 lit and above	20	4.9
Total	405	100.0

(Source: Field survey 2019)

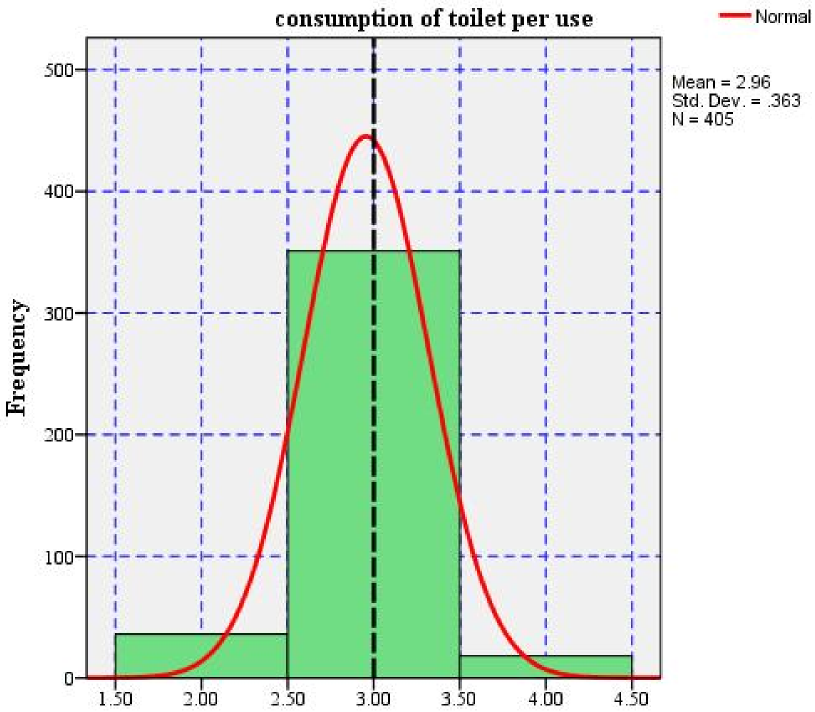
In general, 87.9 % of respondents were consumed 3 liters of water per use for toilet flush and 12.1 % of the respondents were consumed 1 liter, 2 liters and 4 liters and above tap water for toilet flush. These results could have implications on the abundance of HHs wastewater discharge in the study areas as important feature/ attribute of potential source of recycle water.

More specifically, as shown in (Graph: 4.1.) mean/average amount of water consumption for toilet service per individual per use is 2.96 liters of tap water for the total respondents(total sample population, N= 405 in the study areas).

In addition, the result in (Graph: 4.2.) illustrated that the average time/frequency of toilet uses by an individual from each HH per day is 2.01. So, the average amount of tap water consumed by an individual (wastewater produced per individual) in a particular day from each HH is 2.96*2.01= 5.9496 liters of wastewater per individual per day in the study areas.

Also, as shown in (Appendix IV: Summary Table: I.), the mean family size of the respondents or HHs in the study areas is"6.83 $\cong$ 7", about seven family members per HH.

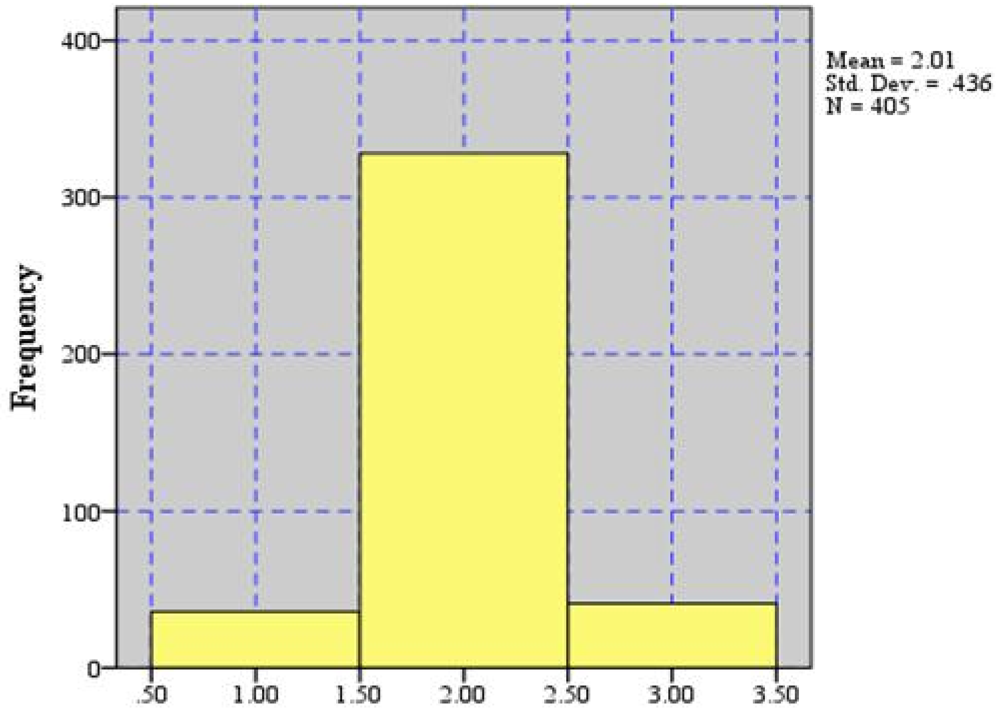
Graph: 4.1. Amount of water consumption for toilet per use



Therefore, the total amount of potential wastewater produced from individual HH is calculated by (it is the product of the average family size of individual HH and the average amount of wastewater produced by a person per day); 6.83*5.9496= 40.6358 liters (approximately 41 liters) of wastewater is produced per HH per day. So, the total amount of wastewater produced in the city per day, it is the amount of wastewater in average produced from an individual HH per day multiplied by the number of proposed HHs in the city; that is 40.6358 liters per HH*859,948 HHs (the number of HHs proposed in 2019) = 34,944,647.42 liters per day (approximately 34,944,647 liters of wastewater is produced per day), which is about 34,945 cubic meter HHs wastewater produced per day in the city from the total HHs.

In general, the total amount of HHs wastewater generated in the city per fiscal year is 34,945 m^3per day*365.25 days = 12,763,661.25 m^3 (about twelve million and seven hundred sixty three thousands and six hundred sixty one cubic meter) per year in 2019. Therefore, 12,763,661.25m^3wastewater is generated from all HHs in the city. Therefore, this result illustrated that HHs wastewater is sustainable potential source of recycle water which is used for various non-potable water uses. Consequently, it leads towards management and sustainability of wastewater reuses.

Graph: 4.2. The frequency require for toilet uses per day



4.3.5. Storage of wastewater discharge in the residential areas

As shown in (Table: 4.7.), 96.8 % of the respondents were stored HHs wastewater discharge inside septic tank in the compound and 3.2 % of the respondents were stored HHs wastewater discharge inside pit hole around the compound in the study areas. As a result, the survey result illustrated that 96.8 % of the respondents are used septic tank as permanent HHs wastewater discharge in the study areas. This could have positive implications on the occurrence of HHs wastewater discharge as important feature to access adequate HHs wastewater as potential source of recycle water in the study areas as well as in the city. Consequently, septic tank that is used to store HHs wastewater discharge could have positive contribution for management of sustainable wastewater reuses in the city.

Table: 4.7. Storage of wastewater discharge

Storage of HHs wastewater in the study areas	Frequency	Percent
Septic tank	392	96.8
Pit- Hole	13	3.2
Total	405	100.0

(Source: Field survey 2019)

Consequently, presence of reliable storage (Septic tank) of HHs wastewater discharge is an important attribute/ feature of sustainable source of recycle water for various non-potable water uses. Therefore, it could lead towards management and sustainability of wastewater reuses in the study areas as well as Addis Ababa city.

4.3.6. Removal of wastewater from residential areas

As shown in (Table: 4.8.), 3.7 % of the respondents were replied that HHs wastewater discharge removed by swage lines, 93.8 % of the respondents were replied that HHs wastewater removed by vacuum truck, 2.5 % of the respondents were replied that HHs wastewater discharge removed by bucket or pail.

The results illustrated that HHs wastewater discharge is removed by swage line and vacuum truck. This could have positive implication on sustainable HHs wastewater discharge removal mechanisms. Consequently, reliable wastewater discharge removal mechanism is important feature sustainable HHs wastewater management in the study areas as well as in Addis Ababa city.

Table: 4.8. Removal of wastewater discharge from the study areas

Removal of wastewater discharge from households	Frequency	Percent
Swage line	15	3.7
Truck	380	93.8
Bucket or Pail	10	2.5
Total	405	100.0

(Source: Field survey 2019)

4.3.7. Water use trends of respondents

As shown in (Table: 4.2.), about 96.3 % of the respondents were used tap water in private owned, tap water in share and public tap. This result illustrated that 96.3 % of the respondents were used tap water (source of water supply) for various potable and non-potable water uses in the study areas. As the survey result revealed that tap is the major water supply means of various potable and non-potable water uses. This result could have negative implication on adequate water supply for various potable and non-potable water uses. So, shortage of adequate water supply is the prominent challenges of HHs to access/right to use sufficient amount of water for their daily uses in the study areas. This inadequate water supply for various potable and non-potable water uses, it is fundamental cause to change non-potable water uses pattern. So, it could lead to focus towards HHs wastewater discharge as alternative source of recycle water for various non-potable water supplies in the study areas as well as in the city.

In general, about 90.6 % of the respondents were used flush toilet (Table: 4.3.).97 % (96.8 %) of the respondents were stored HHS wastewater discharge in septic tank inside the compound (Table: 4.7.). These results illustrated that the availability of flush toilet and septic tank as sustainable HHs wastewater discharge storage in the study areas are causes to change patterns and trends of water consumption for various non-potable water uses.

The amount of water consumed by respondents in the study areas is also another cause to change the water consumption trend of respondents for toilet uses in home. About 4 % of the respondents were used 1 liter of tap water per use, 3.2 % of the respondents were used 2 liters of tap water per use, 87.9 % of the respondents were used 3 liters of tap water per use and 4.9 % of the respondents were used 4 liters and more amount of tap water per use for toilet services in the study areas (Table: 4.6.).So, this result illustrated that the amount of tap water demand for toilet consumption per individual per day is used to produce wastewater discharge from individual HH in the study areas in sustainable manner.

4.3.8. Consequences

96.3 % of the respondents were used tap water for various potable and non-potable water uses in the study areas (Table: 4.2.). Therefore, this result depicted that tap is sustainable supply for various non-potable water uses in the study areas. So, it could lead to focus on HHs wastewater discharge as alternative source for non-potable water supply and reuses in the study areas as well as Addis Ababa city. Consequently, the availability of HHs wastewater discharge in the study areas is abundant source of recycle water and it is important features of sustainable recycle water various non-potable water uses. So, it could lead to towards sustainable management of non-potable water reuses in the study areas as well as Addis Ababa city.

90.6 % of the respondents were used flush toilet (Table: 4.3.).Thus, the result illustrated that there is adequate HHs wastewater discharge in the study areas. 96.8 % of respondents were used septic tank for HHs wastewater discharge (Table: 4.7.). These results illustrated that availability of toilet and septic tank in the study areas are important features in order to store wastewater discharge from HHs in the study areas as well as in the city. Consequently, it could lead towards management of sustainable non-potable water reuses for better HHs wastewater discharge management in sustainable manner in the study areas as well as in Addis Ababa city.

91.4 % of the respondents were got toilet services in home, 4.7 % of the respondents were got toilet services communal toilet in the compound and other 4 % of the respondents were got toilet services at working places(Table: 4.4.). In general, about 96 % (96.1 %) of the respondents were accessed toilet services in home. This result illustrated that toilet in the residential areas (houses) abundant source of recycle water, which used various non-potable water uses. So, HHs is important feature of adequate wastewater discharge in the study areas. Consequently, there is sustainable and adequate wastewater potential source of recycle water that is significant for various non-potable water uses.

86.7 % of the respondents were replied that their toilet consumption per day is twice, 8.7 % of the respondents were replied that their toilet consumption per day is three times and 4.4 % of the respondents were replied that their toilet consumption per day four times and above (Table: 4.6.). 4 % of the respondents were used 1 liter of tap water per use, 3.2 % of the respondents were used 2 liters of tap water per use, 87.9 % of the respondents were used 3 liters of tap water per use and 4.9 % of the respondents were used 4 liters and more amount of tap water per use for toilet services in the study areas. Consequently, these results illustrated that the amount of water consumption per use per day and the number of toilet services required by respondents could change non-potable water use trend and pattern of the population in the study areas.

Therefore, there is sustainable wastewater source in the study areas. So, it points that toilet is important feature to produce domestic wastewater (wastewater discharge from HHs) and it insures that enduring storage of HHs wastewater in the study areas. Accordingly, it leads towards management and sustainability of wastewater reuses.

More specifically, the mean consumption or service of tap water per individual per use for toilet service was 2.96 liters of tap water for the total respondents or total samples N= 405 in the study areas (Graph: 4.1.). In addition, (Graph: 4.2.) illustrated that the average time of toilet uses or event to consume toilet by an individual from each HH per day is 2.01. Therefore, the average amount of wastewater produced per individual in a particular day from individual HH is 2.96*2.01= 5.9496 liters of wastewater per individual per day in the study areas.

The mean family sizes of the respondents or HHs in the study areas were "6.83 $\cong$ 7", about seven members per HH in the study areas (Appendix IV: Summary Table: I.).

Therefore, the total amount of potential wastewater produced from individual HH is calculated by (it is the product of the average family size of individual HH and the average amount of wastewater produced by a person per day) 6.83*5.9496= 40.6358 liters (approximately 41 liters) of HHs wastewater discharge is produced/generated per HH in the study areas per day in the study areas in average. Also, the total amount of HHs wastewater discharge produced/generated in the city per day, it is the amount of wastewater in average produced from an individual HH per day multiplied by the number of proposed HHs in the city; that is 40.6358 liters per HH*859,948 HHs (the number of HHs proposed in 2019) = 34,944,647.42 liters per day (approximately 34,944,647 liters of waste water is produced per day), which is about 34,945 cubic meter HHs wastewater produced per day in the city from the total HHs.

In general, the total amount of HHs wastewater produced in the city per fiscal year is 34,945 m^3*365.25 = 12,763,661.25 m^3 (about twelve million and seven hundred sixty three thousands and six hundred sixty one cubic meter) per year in 2019.Therefore, 12,763,661.25m^3 wastewater is sustainably produced from all HHs in the city. Consequently, this result could have implication in order to change trends and patterns of non-potable water uses in the study areas as well as Addis Ababa city. So, it leads towards management and sustainability of wastewater reuses for various non-potable uses in the study areas as well as in the city.

4.4. Perception of community for the use of recycle water

In this section, the study includes the opinion of community towards non-potable water reuses and its management, public view on non-potable water, public perception and public acceptance to use recycle water for various non-potable water uses and determinants of public perception on recycle water for non-potable water reuses.

4.4.1. Opinions of community on non-potable water uses and management

Successful implementation of wastewater reuse project depends not only on its economic and environmental feasibility, but mainly on the support of the general public, who, ultimately, pays for, and might be affected by the reuse project (Bruvold, 1998).

Table: 4.9. Opinion of respondents to use wastewater as source of non-potable water uses

Opinion of Respondents on Recycled Water	Frequency	Percent
Strictly disagree	20	4.9
Agree to use moderately	346	85.4
Strongly agree to use	39	9.6
Total	405	100.0

(Source: Field survey 2019)

As shown in (Table: 4.9.), about 4.9 % out of the total respondents were strictly disagree to use HHs wastewater as source of non-potable water uses, about 85.4 % respondents out of the total respondents were agree to use HHs wastewater as source of non-potable water reuses moderately and 9.6 % of the respondents out of the total respondents were strongly agree to use HHs wastewater as source of non-potable water. In general, about 95 % of the total respondents were agreeing to reuse HHs wastewater discharge as source of non-potable water uses.

Therefore, this result illustrated that about 95 % of the respondents' were accepted in order to use HHs wastewater discharge as potential source of non-potable water reuses. This result could have the respondents possess positive opinion towards management of sustainable non-potable water reuses. Consequently, it could lead towards management and sustainability of wastewater reuses.

4.4.2. People view on recycle water for non-potable water uses

Public opposition has the potential to cause wastewater reuse, before, during, or after their execution. Public opposition resulting from a combination of prejudiced beliefs, fear, attitudes, lack of knowledge and general distrust, which, on the whole, is often not unjustified, judging by the frequent failures of wastewater treatment facilities worldwide (Nancarrow, 2009).

Table: 4.10. Attitude change in use of recycled water for non-potable water reuses

Change in Public Attitude to use Recycle Water	Frequency	Percent
Yes	345	**85.2**
No	60	14.8
Total	405	100.0

(Source: Field survey 2019)

85.2 % of the respondents were replied “Yes”, the respondents were changed their attitude in order to use recycle water for various non-potable water uses and 14.8 % of the respondents were disagreed to change their attitude to use recycle water (Table: 4.10.).So, this result illustrated that 85.2 % of the respondents were accepted recycle water as source of non-potable water uses. Consequently, this result could have positive implication on management and sustainability of wastewater reuses in the city.

4.4.3. Determinants of the Perception of Respondents for using Recycle Water

The focus of most wastewater related researches have been on the technical aspects of the projects and improvements; but also, water quality and minimizing environmental and health impacts, with very limited attention to its basic social and cultural sustainability dimensions. While, with increasing urbanization, wastewater treatment has moved further away from the household and its social roots for using reclaimed water depends strongly on social habits and acceptance (Crook, 2003).

The degree of acceptance of wastewater reuse varies widely depending on the reuse purposes and is influenced by many factors, such as the degree of contact; expressions of disgust; education; risk awareness; the degree of water scarcity or availability of alternative water sources; calculated costs and benefits; trust and knowledge; issues of choice; attitudes toward the environment; economic considerations; involvement in decision-making; the source of water to be recycled; and experience with treated wastewater. Other factors that depend on the region and case include cultural, religious, educational and/or socioeconomic factors (Bruvold, 1998).

However, the results of different studies had been illustrated various factors, which could be affected the public perception and acceptance to reject/accept HHs wastewater discharge as potential source of various non-potable water uses. Regarding on the scope and limitation of the study, the researcher was pay attention on socio demographic (social biography) factors such as age, sex, income and education.

Table: 4.11a. Perception of respondents towards recycle water Vs respondents' biography

Model		Beta In	T	Sig.	Partial Correlation
1	Age	.277[c]	4.838	.000	.234
	Sex	.031[c]	1.735	.084	.086
	Education level	.344[c]	7.464	.000	.348
	Income level	.184[c]	3.430	.001	.168
2	Age	.172[d]	3.017	.003	.149
	Sex	.025[d]	1.448	.148	.072
	Income level	.103[d]	1.981	.048	.098
3	Sex	.023[e]	1.363	.174	.068
	Income level	.063[e]	1.170	.243	.058

a. Dependent Variable: Perception of community towards recycled water

b. Linear Regression through the Origin

c. Predictors in the Model: Religion

d. Predictors in the Model: Religion, Education level

e. Predictors in the Model: Religion, Education level, Age

Notice; Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). It is computed by SPSS.

(Source: Field survey 2019)

As shown in (Table: 4.11a.), the predictors such as age (P = 0.000 < P = 0.050), education level (P = 0.000 < P = 0.050) therefore, education was an important factor and features in order to create public acceptance and awareness to utilize recycle water for various non-potable water uses in the study areas as well as in Addis Ababa city. The results could have positive implication on the predictors to change public perception towards recycle water as source of non-potable water uses. Consequently, the result could lead public attitude change towards sustainable use of recycle water for various non-potable water consumptions. As shown in (Table: 4.11a.), the income level of respondents, income level (P = 0.001< P = 0.050)was the other significant factor, which necessitate the respondents in order to explore/search additional water supply sources for their daily water demand. Therefore, these respondents were pushed for using recycle water for various non-potable water uses in sustainable manner in the study areas as well as the city. So, income of respondents one of significant factor to create public acceptance and positive public perception towards for use of recycled water for their daily various non-potable uses water demand.

While sex (P = 0.084) > P = 0.050) is insignificant determinant of public perception towards in use of recycled water for various non-potable uses in the first section of (Table: 4.11a).Also, the predictors such as age (P = 0.003< P = 0.050), income level (P = 0.048) < P = 0.050) are significant determinants while sex (P = 0.148) > P = 0.050) is insignificant determinant the second section of (Table: 4.11a).

Therefore, education, age, religion and income level are significant determinants of people perception for using recycle water for various non-potable water uses in the study areas as well as in the city in sustainable manner. Consequently, these determinants lead towards positive public perceptions and public acceptance to use recycle water for various non-potable water uses as a result it leads towards management and sustainability of wastewater reuses.

Figure: 4.1 illustrated that normal P-P plot of standardized regression residual (with value R^2 linear = 0.817), describes about the relationship between expected cumulative probability and observed cumulative probability to demonstrate the impact of predictors (education level, age and income level of respondents) on people perception to use recycle water as source of non-potable water uses. The graph demonstrated that expected cumulative probability is directly proportional to the observed cumulative probability (see the red line in Graph: 4.1). Thus, the results implied that education level, sex, age and income level of respondents are significant determinants of perception of people to use recycle water as source of various non-potable water uses in the city.

As shown in (Table: 4.11b), Source of water supply in the residential areas, source of water for non-potable uses, consumption of toilet per day or degree of contact, amount of water consumption per day for toilet use and public attitude in use of recycle water for non-potable water uses are other factors, which were affected public perceptions in use of recycle water as source of non-potable water uses supply.

Graph: 4.3. Public perceptions of community towards recycle water vs predictors

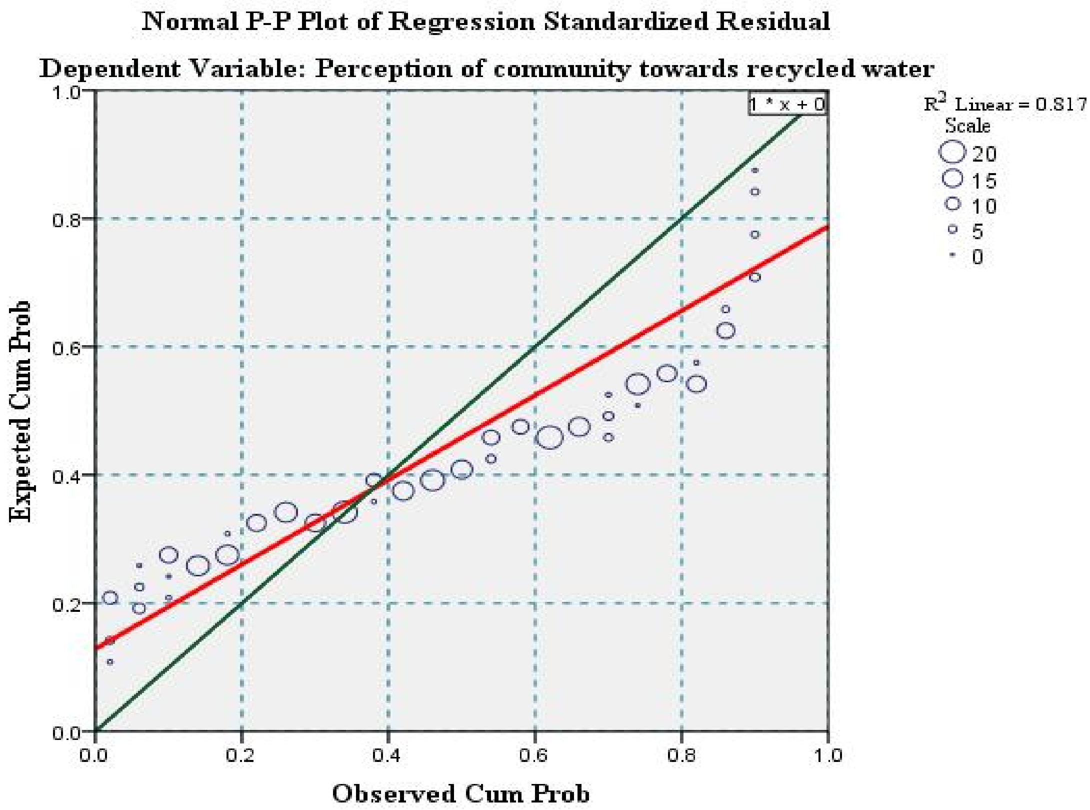


Table: 4.11b Determinants of public perception towards recycle water (ANOVA[a,b])

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	471.970	1	471.970	5443.253	.000[c]
	Residual	35.030	404	.087		
	Total	507.000[d]	405			
2	Regression	474.071	2	237.036	2900.987	.000[e]
	Residual	32.929	403	.082		
	Total	507.000[d]	405			
3	Regression	474.534	3	158.178	1958.602	.000[f]
	Residual	32.466	402	.081		
	Total	507.000[d]	405			

a. Dependent Variable: Perception of community towards recycle water

b. Linear Regression through the Origin

c. Predictors: Access of choice

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: Access of choice, Source of water supply

f. Predictors: Access of choice, Source of water supply , Degree of contact to use toilet

Notice; Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). It is computed by SPSS.

(Source: Field survey 2019)

The result illustrated that of the regression rows or values (Table: 4.11b) access of water supply choice (P = 0.000< P= 0.050), source of water supply (P = 0.000) < P = 0.050) and degree of contact to use toilet (P = 0.000) < P = 0.050)are significant determinants of public perceptions to use recycle water for various non-potable water uses. These results illustrated that positive implications towards public acceptance to use recycle water as sustainable source of wastewater reuses in the study areas as well as Addis Ababa city. Consequently, access of recycle water could be important in order to fulfill their necessities of respondents related to non-potable water consumptions. Therefore, these phenomena lead towards sustainable management and sustainability of wastewater reuses in the study areas as well as in Addis Ababa city.

The degree of acceptance of wastewater reuse varies widely depending on the reuse purposes and is influenced by many factors, such as the degree of contact; expressions of disgust; education; risk awareness; the degree of water scarcity or availability of alternative water sources; calculated costs and benefits; trust and knowledge; issues of choice; attitudes toward the environment; economic considerations; involvement in decision-making; the source of water to be recycled; and experience with treated wastewater. Other factors that depend on the region and case include cultural, religious, educational and/or socioeconomic factors (Bruvold, 1998).Sources of water supply, expression of disgust, use of toilet in the HHs, degree of contact to use toilet/water and involvement in decision making were considered as predictors of public acceptance, which were determined factors of public acceptance in order to consume recycled HHs wastewater for various non-potable water uses.

The results illustrated that sources of water supply ($P = 0.000 < P= 0.050$), expression of disgust ($P = 0.002 < P= 0.050$), use of toilet in the HHs ($P = 0.014 < P= 0.050$), degree of contact to use toilet/water ($P = 0.000 < P= 0.050$) were significant factors of the public acceptance of recycle water reuses for various non-potable water demand. So, the results could have positive contribution for management of sustainable non-potable water reuses in the study areas as well as Addis Ababa city (Table 4:.11c).

Table: 4.11c Public perception towards recycled water in terms of different predictors (Coefficients[a,b])

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	Access of choice	.547	.007	.965	73.778	.000	.532	.561
2	Access of choice	.492	.013	.867	37.636	.000	.466	.517
	Source of water supply	.091	.018	.117	5.071	.000	.056	.126
3	Access of choice	.382	.048	.673	7.989	.000	.288	.475
	Source of water supply	.069	.020	.089	3.447	.001	.030	.109
	Degree of contact to use toilet	.083	.035	.220	2.394	.017	.015	.151

a. Dependent Variable: Perception of community towards recycled water

b. Linear Regression through the Origin

Notice; Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). It is computed by SPSS.

(Source: Field survey 2019)

4.5. Challenges and opportunities in using recycle water

Challenges and opportunities in using recycled water associated with public perception and public oppositions towards for using recycled water for various non-potable water uses in the study areas as well as in Addis Ababa city.

Particularly, public opposition resulting from a combination of prejudiced beliefs, fear, attitudes, lack of knowledge and general distrust, which, on the whole, is often not unjustified, judging by the frequent failures of wastewater treatment facilities worldwide (Nancarrow, 2009).

4.5.1. Challenges in using recycle water in the study areas

About 5 % of the respondents were agreed in order to use HHs wastewater discharge as potential source of wastewater reuses (Table: 4.9). The result illustrated that the respondents were rejected recycle water for various non-potable water uses in the city.

About, 14.8 % of the respondents were opposed recycle water as alternative water supply choice for wastewater reuses (Table: 4.10). So, the result could have negative implications on management and sustainability of wastewater reuses in the study areas as well as Addis Ababa city. Thus, this result could be considered as a prominent challenge encountered in use of recycle water for non-potable water uses related to public attitude towards in use of recycle water.

4.5.2. Opportunities in using Recycle water

95 % of the respondents were agreed in order to use HHs wastewater discharge as potential source of recycle water (Table: 4.9.). In addition, as shown in (Table: 4.10.), 91.6 % of the respondents were replied agree to use recycle water for various non-potable water uses. This result demonstrated that the respondents were possessed positive perceptions towards recycle water in order to use recycle water for various non-potable water reuses. Consequently, these results depicted that public acceptance in order to use recycle water for various non-potable water uses is an important opportunity in use of recycle water for non-potable water uses.

4.5.3. Challenges and Opportunities in using recycle water at institution level

4.5.3.1.The Existing organizational Structure of AAWSA

AAWSA is governed by the Addis Ababa City Government. The Mayor of the City of Addis Ababa is the Chairman of the Board of AAWSA. Other members of the Board include the City Manager of Addis Ababa, representatives from the City Government, other relevant organizations and two labor union representatives.

Proclamation No 10/1995 defines the objectives, powers and duties of AAWSA. The duties of AAWSA include the supply of safe and adequate potable water and the provision of wastewater/sludge collection, treatment and disposal within the limits of the city of Addis Ababa.

AAWSA is managed by a General Manager appointed by and reporting to the Board of Directors. The General Manager's responsibilities include managing and overseeing all activities within AAWSA according to the policy guidelines of the Board of Directors. The Board of Directors formulates policy and management strategy and its duties include approving AAWSA's budget.

The Board of Directors also appoints four Deputy General Managers (Sewerage, Water Supply, Resource Management and Project Office). There are also eight Branch Offices, Core Processes, Sub-Processes and Case Teams.

The total number of staff in AAWSA at the start of the Consultancy Services was 1,888, of which 1,850 were permanent employees and 38 were contract employees. It must be noted that AAWSA recently began outsourcing certain activities, such as customer meter reading.

Most of the staff are semi-skilled and trained on the job with satisfactory experience. Out of the total of 1,888 employees 276 are professionals with first degree qualification or higher.

4.5.3.2. Interviewees Responses on Existing Organizational and Structure

According to the interviewees in AAWSA, it has been providing wastewater collection, transportation and treatment services to the metropolitan since 1970’s. Only 6 to 7% of the housing units enjoy the off-site disposal system and the remaining 13 to 14% of the housing units in the city do not have toilet facility at all. On-site sanitation facility users obtain sludge collection and disposal services mainly from AAWSA (67%) and private operators. The off-site disposal system has limited sewer network coverage and a conventional wastewater treatment plant serving only some parts of Kality catchment specifically Bole, Lideta, Old Airport, Central part of the City, Mekanisa and Kera areas.

AAWSA provides sanitation services for the city by collecting, transporting, treating and disposing the liquid wastes. At present, a total amount of waste water and sludge being collected and treated is 22, 830 m^3/day at sludge and waste water treatment plants. With conventional sewer system about 21,630 m^3 (7.3% coverage) of wastewater is conveyed to the treatment plants every day. Vacuum trucks managed by AAWSA and private owners collect on average about 1,200 m^3 of sludge every day from the on-site disposal sanitation facility users (37.0% coverage). The overall waste collection coverage at city level is then around 44.3%.

According to the team leader of water treatment processing and reuse department, population growth, urbanization, perception of the people to use recycle water, limited infrastructure costs for storing and transporting wastewater from sub stations and residential areas to treatment plants in order to provide adequate service for users, disposing solid waste from wastewater are challenges for appropriate treatment of AAWSA to treat wastewater at the treatment plants.

Considering the isolated sewer networks for different condominiums, recently connected condominiums to Kality system and AAWSA's record of sewer connections there are around 51,500 domestic connections and 2,164 non domestic connections totaling to 54,089 customers connected to the sewer system at present 2011.

About 96% of the connections are domestic connection serving the domestic consumers, 1.8% of the connections are non domestic industrial and 2.27% of the connections are non-domestic public & institutional customers. Even though, AAWSA's has eight branches within the city administration it was not possible to obtain the distribution of sewer connections by branches.

Currently, AAWSA proposed business plan in order to establish new treatment plant and expansion of old treatment and disposal stations at different sub-cities in Addis Ababa city. It is one important opportunity to provide improved services in the study areas as well as in the city.

At municipal level, AAWSA as a utility company is not supposed to be directly concerned by the regulation scheme to be organized at the municipal administration. Even though residential areas are potential source of wastewater at community level, due to the negative perceptions of the community in using recycled water; the community does not participate as stakeholder to separate solid waste and wastewater in their residential areas. In addition, the community has lack of protecting the conventional sewer from solid wastes or solid waste materials. Usually, the HHs disposed solid waste and wastewater discharge from HHs through tubes from their houses together simultaneously. These are challenges in using recycled water for non-potable reuses.

Residential areas are abundant potential sources of wastewater. In addition, the population growth in the city, up grading and expanding public toilets, expansion of new in-built areas and increase in housing units due to up grading and construction of condominium blocks are opportunities to possess potential wastewater source and for using recycled water for AAWSA to harvest recycled water for various non-potable water reuses in the study areas as well as Addis Ababa city.

The expansion of housing project or condominium areas, construction of new in- built areas, upgrading slum areas, public green space, establishment of parks and fountains in the different sub cities, establishment of new water storage at different sub cities for fighting fire or fire protection and positive perception of the population to use recycle water at community level are opportunities in using recycled water for non-potable water reuses.

4.5.4. Opportunities and future prospects

95 % of the total populations were agreed to use HHs wastewater as source of non-potable water reuses (Table: 4.10.). This result implied that public acceptance to reuses recycle water for various non-potable water uses is an opportunity to AAWSA in order to have alternative source of non-potable water uses there by it safeguards the potable water supply in the residential areas as well as in Addis Ababa city. So, the result could lead towards management of sustainable wastewater reuses in Addis Ababa city.

In addition, there is sustainable storage of wastewater in the study areas, which is used to store wastewater discharge from individual HH in the study areas (Table: 4.7.). This result could be important feature in order to store HHs wastewater discharge in the study areas. Consequently, the results lead towards management of sustainable wastewater reuses in sustainable manner in the city.

Hence, the public acceptance in uses of recycle water for various wastewater reuses is an opportunity in order to possess, access alternative sustainable source of non-potable water supply. Also, the abundance of toilets and wastewater storages in the study areas is important feature in order to move towards management of sustainable non-potable water reuses in the city. Further, it has future prospects towards sustainable management of wastewater reuses in the study areas and Addis Ababa city.

Even though residential areas are potential source of wastewater at community level, due to the negative perceptions of the community in using recycled water; the community does not participate as stakeholder to separate solid waste and wastewater in their residential areas. In addition, the community has lack of protecting the conventional sewer from solid wastes or solid waste materials. Usually, the HHs disposed solid waste and wastewater discharge from HHs through tubes from their houses together simultaneously. These are challenges in using recycled water for non-potable reuses.

Residential areas are abundant potential sources of wastewater. In addition, the population growth in the city, up grading and expanding public toilets, expansion of new in-built areas and increase in housing units due to up grading and construction of condominium blocks are opportunities to possess potential wastewater source and for using recycled water for AAWSA to harvest recycled water for various non-potable water reuses in the study areas as well as Addis Ababa city.

Currently, AAWSA proposed business plan in order to establish new treatment plant and expansion of old treatment and disposal stations at different sub-cities in Addis Ababa city. It is one important opportunity to provide improved services in the study areas as well as in the city.

Wastewater Treatment and processing mechanism, planning and design for storage of recycled water and distribution forwarded as research gap of this particular study due to the scope and limitation of the study. Thus, there is a need for further study by other researchers in the future.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Conclusions

There were a number of issues relating to management and sustainability of wastewater reuses: features, challenges and opportunities in the study areas of Addis Ababa city. The result of issues rose in the study was perceived that there is a need to develop a holistic approach towards management and sustainability of wastewater reuses in Addis Ababa city.

Management and sustainability of wastewater reuses: features, challenges and opportunities in the city; it has impacts upon many issues social, economic and environmental phenomena; besides, trend and consequences of wastewater reuses in terms of non-potable water supply, sources of non-potable water uses, storage of HHs wastewater in the residential areas; challenges related to social attitude towards in use of recycle water for various non-potable water and public perception, public acceptance. Finally, examine change in public attitude towards in use of recycle wastewater; improve public perception for better management of sustainable wastewater reuses in Addis Ababa city and introduce future prospects in uses of recycle water for various wastewater reuses. Thus, issues need to be taken into account at all stages related to the existing situations in the study.

About 81% of the respondents were enrolled in college (TVET) and higher education levels or programs. It is a need to change public attitude towards to use recycled water for various non-potable water reuses. It is the prominent opportunity that the respondents in order to invite them as stakeholder for management of non-potable water reuses in the study areas as well as Addis Ababa city.

About 88% of the respondents were in the age group interval of 41 – 60; this result illustrated that the respondents were categorized in to secondary age category. So, the respondents are regular residents in the study areas. As a result, there is need to access water supply for various water uses. Also, HHs is important feature/ attributes in order to generate HHs wastewater discharge as potential source of recycle water in the study areas as well as Addis Ababa.

About 74 % of the respondents are married (coupled). Thus, this implies that the respondents are regular residents in the study areas. It creates an essential situation in order to contribution HHs wastewater discharge as potential source of recycle water in the city.
About 85 % of the respondents were contained family size of 5,6,7,8 and 9 family members respectively. “7” is the more frequent (mode) or the mean value of family size in sample populations. It is a need in order to generate/produce HHs wastewater as potential source of recycle water in the study areas.

About 95 % of the total populations are monthly waged by government organizations and NGOs. It is a need for populations are live in the study areas as important feature or feature for adequate HHs wastewater as potential source of non-potable water supply in the study areas.

About 96.3 % of the respondents were used tap water for various potable and non-potable water uses in the study areas. Therefore, this finding depicted that tap is sustainable water supply for various non-potable water uses. In addition, it is pointed that there is inefficient/scarcity of water supply for potable and non-potable water supply in the study areas.

About96.5 % of the respondents were replied “No” other sources for non-potable water uses in the study areas. This result were depicted that there is no other/alternative sources of water supply for non-potable water uses in the study areas as well as Addis Ababa city.

About 90.6 % of the respondents were sustainably used flush toilet. Thus, the availability of flush toilet (HHs wastewater) as sustainable potential source of non-potable water reuses in the study areas is causes to change patterns and trends of water consumption of the respondents in order for various non-potable water uses in the study areas as well as in the city.

In addition, about 96 % of the population used toilet (access toilet service) in their residential areas or houses as a result there is adequate HHs wastewater in the study areas as well as in the city, which used as sustainable potential source to produce non-potable water for various uses.

About 87.9 % of the respondents were used 3 liters of tap water per use for toilet services in the study areas. So, this result claimed that the amount of tap water demand for toilet consumption or service is used to produce wastewater from individual HH in the study areas as well as in the city.

About 97 % of wastewater was stored in septic tank in the compound the remaining 3 % of the wastewater was stored in dry pit hole inside the compound or in the study areas. Thus, septic tank used as sustainable storage of wastewater in the study areas is important feature to insure sustainable availability of HHs wastewater storage in the study areas as well as in the city.

About 95 % of the respondents have acceptance to use HHs wastewater as potential source of non-potable water reuses. It is a need to possess positive public perception and public acceptance towards management of sustainable non-potable water reuses and it is considered as an opportunity towards management of sustainable non-potable water reuses in the study areas as well as in the city.

5.2. Recommendations

Management of sustainable non-potable water reuses: features, challenges and opportunities could be effective in terms of the objectives of this particular study. The following recommendations should be considered.

- Socio- demographic and economic characteristics of the respondents are important factors/ determinants of sustainable HHs wastewater management and management of sustainable non-potable water reuses in the city. thus, these are important features of sustainable various non-potable reuses in the study areas as well as Addis Ababa city as a result social- demographic and economic factors should be required due attention to insure sustainable various non-potable water reuses in Addis Ababa city.
  - About 96.3 % of the respondents were used tap water for various potable and non-potable water uses in the study areas. In addition, it is pointed that there is inefficient/scarcity of water supply for potable and non-potable water supply in the study areas as well as in the city. Therefore, there should be a need to pay attention

for alternative source of non-potable water supply in the study areas as well as the city.

- About, 96.5 % of the respondents were replied “No” other sources for non-potable water uses in the study areas as well as the city. This result were depicted that there is no other/alternative sources of water supply for non-potable water uses in the study areas as well as Addis Ababa city. There should be a need to focus on HHs wastewater as important feature of alternative water supply in order to access water for various non-potable water uses in the study areas.
- About 90.6 % of the respondents were used flush toilet. Thus, the availability of flush toilet (HHs wastewater) as alternative potential source of non-potable water uses in the study areas. Thus, there should be due attention to pay causes to change patterns and trends of water consumption of respondents for searching other source of water supply to access improved water supply for sustainable non-potable water uses in the study areas as well as Addis Ababa city.
- About 87.9 % of the respondents were used 3 liters of tap water per use for toilet services in the study areas. So, this result claimed that the amount of tap water demand for toilet consumption or service is used to produce wastewater from individual HH in the study areas as well as in the city in sustainable manner. There should be additional non-potable water supply in order to give improved non-potable water supply in the study areas as well as Addis Ababa city in sustainable manner.
- About 97 % of wastewater was stored in septic tank in the compound the remaining 3 % of the wastewater was stored in dry pit hole inside the compound or in the study areas. Thus, septic tank used as sustainable storage of wastewater in the study areas is important feature to insure sustainable availability of HHs wastewater storage in the study areas as well as in the city. There should be a need to pay attention on available adequate HHs wastewater potential in the study areas and the city, which led towards management of sustainable non-potable water reuses.
- It is the need for that education, age, religion and income level are significant determinants of people perception for using recycled water for various non-potable water uses. These determinants/factors are need to describe positive people

perceptions to use recycle water for non-potable water reuses as a result it should be led towards management of sustainable non-potable water reuses in the study areas as well as in the city.

- AAWSA proposed business plan in order to establish new treatment plant and expansion of old treatment and disposal stations at different sub-cities in Addis Ababa city. It is one important opportunity to provide improved services in the study areas as well as in the city.
- Wastewater Treatment and processing mechanism, planning and design for storage of recycled water and distribution forwarded as research gap of this particular study due to the scope and limitation of the study. Thus, there is a need for further study by other researchers in the future.

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APPENDICES

Appendix I:

Questionnaires to be Filled by Sample Households

Dear respondents;

This questionnaire is prepared (designed) to collect data for the purpose to explore the features, opportunities and challenges towards management and sustainability of wastewater reuses for non-potable water uses in case of Addis Ababa city. To achieve this purpose your response to the questions presented below has a great value. Thus, kindly you are requested to read and give response for them clearly and genuinely.

General instruction

1. Please circle or "X" mark on your choice that appropriately represents your responses in multiple choice questions.
2. To the questions with alternatives that do not match to your response, please write your appropriate response on the space provided.

Part I. Demographic characteristics of HHs

1- Name of respondent___________________________
2- Enumeration city______________________________
3- Date of enumeration___________________________
4- Sub city___________________
5- Woreda___________________
6- House no._________________
7- Age______________________
8- Sex
   1- Male ☐   2- Female ☐
9- Family size_________________
10- Marital status
   1- Single ☐
   2- Married ☐

3- Divorced
4- Widowed

11- Religion

1- Christian 2- Muslim 3- Others

12- Education level

1- uneducated (unable to write and read)
2- Completed primary school
3- Completed secondary school
4- Completed preparatory school
5- College diploma/ level in TVET program
6- BSc./BA. higher education level
7- MSc./ MA. higher education level and above

13- Current occupation

1- Government
2- NGO
3- Hired in private organization
4- Private owned
5- Daily laborer
6- Any other

14- Residents income level per month (ETB)

1- Below 1000
2- 1001- 1500
3- 1501- 2000
4- 2001- 2500
5- 2501- 3000
6- 3001- 3500
7- 3501- 4000
8- 4001- 4500
9- 4501- 5000
10- Above 5000

Part II. Patterns and trends of non-potable water uses

1- What are sources of water in your residence area/compound?

1- Tap in private ☐ 2- Tap in share ☐

3- Public tap ☐ 4- River and springs ☐

5- Other sources ☐

2- Do you have any other sources of water supply for non-potable water use?

1- Yes ☐ 2- No ☐

3- If your answer is "Yes" for question 2 mention your water supply on the provided space

____

____.

4- If your answer is "No" for question 2 mention your water supply on the provided space

____

____.

5- What is your opinion if you use domestic wastewater or toilet as source of non-potable water use?

1- Strictly disagree to use ☐
2- Agree to use moderately ☐
3- Strongly agree to use ☐
4- Any other opinion to use ☐

6- If your answer is "choice 1" for question 5 put your suggestion /reason on the provided space

____

____.

7- If your answer is "choice 3" for question 5 put your suggestion /reason on the provided space

____

____.

8- If your answer is "choice 4" for question 5 put your suggestion/ reason on the provided space

____

____.

9- Where do you use toilet?

1- Home 2- Communal toilet in the compound 3- Work place

10- What type of toilet do you use?

1- Pit- hole 2- Flush toilet 3- Open defecation

11- How many times do you use toilet per day?

1- Once 2- twice 3- three times 4- four times and above

12- Do you have adequate water for toilet use in your HH?

1- Yes 2- No

13- If your answer is choice "12", how many liters (in average) of water do you consume when do you use toilet?

1- 1lit 2- 2lit 3- 3lit 4- 4lit and above

14- Where do you store wastewater discharged from your HH?

1- In septic tank 2- Hole 3- Open space near the compound

15- How do you remove the wastewater as your wastewater storage full?

1- Swage line 2- Truck 3- Bucket or Pail

16- If your response is choice "2" for question 15, which agency provides this service in your locality or residential area?

1- AAWSA at sub city level 2- Private agencies 3- Laborers 4- Your-self

17- How long do you use to remove wastewater from your HH successively?

1- 1 to 6 months 2- 7 to 12 months 3- 12 months and above

18- Does AAWSA provide removal of wastewater service in your locality or residential area adequately for effective wastewater management in sustainable manner?

1- Yes 2- No

Part III. Public perceptions towards in using recycle water

19- What is your opinion if you use domestic wastewater or toilet waste as source of non-potable water use?

1- Strictly disagree to use ☐

2- Agree to use moderately ☐

3- Strongly agree to use ☐

4- Any other opinion to use ☐

20- If your answer is "choice 1" for question 19 put your suggestion /reason on the provided space

____

____.

21- If your answer is "choice 3" for question 19 put your suggestion /reason on the provided space

____

____.

22- If your answer is "choice 4" for question 19 put your suggestion/ reason on the provided space

____

____.

23- How do you accept/ perceive the quality of recycle water if you use the recycle water for non-potable water uses such as gardening, washing car, construction, etc?

1- Not agree to use the recycle water due to its quality

2- Agree to use the recycle water due to its quality

24- If your answer is "choice 1" for question 23 put your suggestion/ reason related to your perception/ acceptance to use recycle water for non-potable water use on the provided space

____

____.

25- If your answer is "choice 2" for question 23 put your suggestion/ reason related to your perception/ acceptance to use recycle water for non-potable water use on the provided space

____

____.

26- Do you have you made any changes on your attitude or perception in order to use recycle water for non-potable use?

1- Yes 2- No

27- If your answer is "choice 1" for question 26 put your suggestion/ reason that causes to change your perception/ acceptance to use recycle water

____

____.

28- If your answer is "choice 2" for question 26 put your suggestion/ reason that causes to change your perception/ acceptance to use recycle water

____

____.

29- Does the community have training to make any changes on their attitude or perception in order to use recycle water for non-potable use?

1- Yes 2- No

30- If your answer is "choice 1" for question 29, who provides the training?

1- The health office/administer ☐
2- The Woreda AAWSA office ☐
3- Any other body ☐

31- What is your future attitude to use recycle water for non-potable use in sustainable manner?

1- Willing to use it ☐ 2- not willing to use it ☐

Part IV. Factors affecting the use of recycling water

32- What affects the community to use recycle water for non-potable uses?

1- Economic status of the community ☐
2- Education status of the community ☐
3- Social acceptance ☐
4- Availability of water resource ☐
5- Policy of the country ☐

Appendix II:

Interview Prepared for key informants (Team Leaders) of Different Departments in AAWSA.

Interview prepared for the purpose to collect information in order to explore the role of AAWSA as institution on features, opportunities and challenges towards sustainable management of recycle water for non-potable uses in case of Addis Ababa city. To achieve this purpose your response in the interview has a great value. Thus, kindly you are requested to provide responses for all questions that are attached here below clearly and genuinely.

I. General Information of the Interviewee;

1. Name of the interviewee_________________________
2. Department_________________________________
3. Years of service______________________________

II. Questions related to wastewater collection and water recycled

1- When did AAWSA establish?

2- How long does AAWSA have to collect domestic wastewater from HHs in the city?

3- Does HHs wastewater use as alternative sources of non-potable water for sustainable wastewater management?

4- Does AAWSA have adequate capacity to collect HHs wastewater from HHs of Addis Ababa city?

5- What types of methods AAWSA use to collect domestic wastewater from HHs of Addis Ababa city?

6- What types of domestic wastewater treatment does AAWSA use?

7- Does the recycle water is safe for non-potable uses?

8- If you have any suggestion related to waste water collection and water recycle water please write the role of AAWSA in the provided space;

____

____

____

Appendix III: Summary Tables

Summary table: I. statistical data of demographic characteristics of respondents in the study areas

		Id.	Sub city	Age	Sex	Family size	Marital status	Religion	Ed. Level	Current occupation	Income level
N	Valid	405	405	405	405	405	405	405	405	405	405
	Missing	0	0	0	0	0	0	0	0	0	0
Mean			5.5556	3.3778	.40	6.83	6.1877	3.4543	5.2123	1.560	6.7481
Median			6.0000	3.0000	.00	7.00	6.0000	3.0000	5.0000	1.000	6.0000
Std. Deviation			2.90101	.69510	.491	1.902	.67071	.49852	1.27207	1.1896	1.60315
Variance			8.416	.483	.241	3.619	.450	.249	1.618	1.415	2.570
Range			9.00	3.00	1	11	3.00	1.00	6.00	4.0	8.00
Minimum			1.00	2.00	0	1	5.00	3.00	1.00	1.0	1.00
Maximum			10.00	5.00	1	12	8.00	4.00	7.00	5.0	9.00

Source: computed from HHs survey data 2018/19

Summary table: II. Statistical data related to water consumption, types of toilets, public perception to use recycled water for non-potable reuses and wastewater disposal

	Source of water supply in the resident area	Source of water for non-potable uses	Opinion of respondents to use domestic waste water as source of non-potable water	Use of toilet in the residential area	Consumption of toilet per day	Types of toilet	Availability of adequate water for toilet use	Amount of water consumed per day for toilet use	Store wastewater discharged	Removed wastewater from HHs	Waste water removal agency	Time to remove waste water	Perception of community for recycle water	Attitude change in use of recycle water for non-potable uses	Factors to the respondents to use recycle waste water
Mean	1.2519	1.9654	2.0469	1.1259	2.9556	1.9407	2.0000	2.9383	1.0321	1.9877	1.2691	2.0123	1.0840	1.1481	1.4741
Std. Deviation	.70414	.18291	.37925	.43537	.36288	.30090	.00000	.48609	.17648	.24845	.57520	.43640	.27766	.35569	.95308
Variance	.496	.033	.144	.190	.132	.091	.000	.236	.031	.062	.331	.190	.077	.127	.908
Range	3.00	1.00	2.00	2.00	2.00	2.00	.00	3.00	1.00	2.00	2.00	2.00	1.00	1.00	4.00
Minimum	1.00	1.00	1.00	1.00	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Maximum	4.00	2.00	3.00	3.00	4.00	3.00	2.00	4.00	2.00	3.00	3.00	3.00	2.00	2.00	5.00

Source: computed from HHs survey data 2018/19