FACTORS INFLUENCING SUSTAINABILITY OF WATER SUPPLY PROJECTS FOR RURAL COMMUNITIES IN ARID AND SEMI ARID LANDS, A CASE OF GARBATULA SUB COUNTYINISIOLO COUNTY, KENYA

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DECLARATION

This research project report is my original work and has not been presented for the awardof a degree in any other university.

Signedé é é é é é é é é é é é Date é é é é é é é é é é é é é é é é

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This research project report has been submitted for examination with my approval as the university supervisor.

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DEDICATION

I dedicate this research project to my parents, Michael G. Olela and Lilian A. Olela, my brothers Cyril Oluoch and George Ochieng, my sisters Carol Olela and Laura Olela, my work and study colleagues all who encouragedme through mentorship and guidance on work ï study balance.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASALs	Arid and Semi-Arid Lands
CDF	Constituency Development Fund
CIDP	County Integrated Development Plan
CSO	Civil Society Organizations
CP	Community Participation
ICT	Information Communication Technology
NGO	Non-Governmental Organizations
O&M	Operations and Maintenance
SDG	Sustainable Development Goal
SPSS	Statistical Package for the Social Sciences
UN	United Nation
UNICEF	United Nation Children's Fund
WASREB	Water Services and Regulatory Board
WASH	Water Sanitation and Hygiene
WHO	World Health Organization

ABSTRACT

Access to water is key in promoting resilience and livelihoods in arid and semi-arid lands. Sustainable management of water supply projects would ensure water for drinking, domestic, livestock and other productive uses is enhanced to support inhabitantôs livelihoods. The government and civil society organizations have implemented many projects worth millions of investments but still facing sustainability challenges over a period. The study objectives were to evaluate the choice of technology influence on sustainability, to determine the level at which socio-economic factors influence sustainability, to evaluate influence of socio cultural factors on sustainability, to identify influence of water tariffs on sustainability and finally to determine the influence of specialized training of service teams on sustainability of water supplies projects for rural communities in Arid and Semi-Arid Lands. The researchwas guided by four capital modeltheory. The research adopted a descriptive research methodologyto collect quantitative and qualitative data froma sample size of 384from a target population of 32, 226 served by 17 boreholes, focus group discussions with threewater management committees and threekey informants. Simple random samplingtechnique was used to select respondents who are water supplies projects beneficiaries. Datawas collected using well-structured questionnaires, interview schedules and focus group discussion guides. Thedata was cleaned of errors, verified and coded. Using statistical package for social sciences (SPSS version 21), descriptive and inferential statistics was used to analyze quantitative data while qualitative data was analyzed thematically, and the findings presented.The study findings show that there is a positive relationship between sustainability of water supply projects and choice of technology, socio-economic factors, socio-cultural factors, water tariffs and specialized training of service teams. The significance values for relationship between sustainability of water supply projects and choice of technology, socio-economic factors, socio cultural factors, water tariffs and specialized training on technical knowledge and skills influence of magnitude 0.000, 0.004, 0.006, 0.000 and 0.001 with water tariffs and choice of technology being the most significant factors. Training, availability of spare parts and water abstraction technology were prerequisite towards sustainability resulting to reliable access to water dur to minimal breakdowns. There was lack of involvement and participation in water supply development process including tariff setting with household consumption a major factor to consider in tariff setting. Socio-cultural factors were found not to influence sustainability of water supply projects. Researcher recommends selection of appropriate technologies such as solar powered systems in place of generators to reduce costs of regular maintenance due to lack of trained technicians, Training of service team and water committees technical and management of water supply projects and advocacy for local entrepreneurs to become stockiest of spare parts required for existing systems. Finally, water supply projects conduct life cycle cost analysis to help in setting tariffs able to raise operations and maintenance. Further study is recommended on factors influencing sustainability of water supply projects for rural communities in Arid and Semi-Arid lands.

CHAPTER ONE
INTRODUCTION

1.1 Background to the study

844 million people that still lacked clean drinking water in 2015. They either used improvised sources with water collection times beyond 30 minutes (limited services), some used unprotected wells and springs (unimproved sources), or fetch water straight from surface water sources according tothe Progress on drinking water, sanitation and hygiene report (WHO, 2017).According to the report 127 million of 2.1 billion population still used basic amenities, 263 million used limited services, 423 million used unimproved sources while 59 million used surface water. This means that millions of people still have no access to water from safe water systems which is defined as being available when necessary and free from fecalmatter and chemical contaminations.

Many initiatives have been made to reduce the gap of water scarcity by large investments in water supply infrastructure among other interventions in the water sector. Gains have been made in the water provision since the year 2015 where 91% of the worldôs population were able to access water from an improved source of drinking water compared to 76% in the year 1990 (UN, The Millennium Development Goals Report, 2015). Despite these gains, what can governments, public society organizations, the private sector players and the community do to reduce the chances of fall back? Are there systems in place to ensure sustainability of the investments already made?

Investments in the water sector has focused on economic value of time and cost savings through improved water systems which would enable people to use the saved time and costs in other productive activities which in turn boosts the chances of sustainably managing the systems. An improved water supply is defined as a system which provides water reliably, of potable quality, and of sufficient quantity to meet basic household needs like drinking, bathing, cooking, and washing around the house (Cook, 2017)

According to Abrams (2018) defines sustainability as ñwhether or not something continues to work over timeò. He further elaborated that it is the test of sustainability is whether water continues to be abstracted at the same rate and quality as when the supply system was

designed, continue to function and be used as planned, and whether environmental quality continues to improve. In his writings, he identified key factors that influence sustainability including availability of money for recurring expenses and occasional repair, acceptance from users of the service, adequacy of service providers, appropriate design and quality of works.

The sustainability of the commissioned projects are enhanced by ensuring that only projects prioritized by the beneficiaries are implemented, building the capacity of the beneficiaries and enhancing project ownership. Project implementers ensure that a management and sustainable operations concept is established to ensure projects continues to meet the needs of the recipients over time. This is through key stakeholderôs involvement from project preparation phase.(Irrigation, 2016)

Isiolo Countyis located in Kenyaôs lower eastern region is categorized as an ASALregion (ASALs). It is to the north of Marsabit County, west of Laikipia and Samburu Counties, south east of Garissa County,North East of Wajir County and south of Kitui and Tana River Counties. The County is 25,605 square kilometers in size and a population of 143,294 according to the 2009 census. It is divided into ten wards all within 3 sub Counties including Isiolo,Garbatula and Mertiand is broken down into sixmanagerial divisions namely Central, Sericho, Garbatula, Merti, Oldonyiro and Kinna. Merti and Garbatula have a larger rural population and drier parts of the County.

1.2 Statement of the problem

According to the Joint Monitoring Plan report by UNICEF and WHO, 2017, by 2015, out of three people living in the rural areas, only one is using safely managed drinking water services (1.9 billion). That means still many rural populations are still not getting safely managed water systems. It was also reported that 263 million persons spent more than 30 minutes per round trip to fetch water from an improved source in 2015 (constituting a limited drinking water service) (UNICEF, 2017). However, since water use generally needsa lot ofinfrastructural investment and management systems, tenure concerns not only access the rights to water, but the capability to set up water related technologies as well, and relationships with other users who shared certain water sources.

According to Isiolo County National Drought Management Authority EWS Bulletins for the last 3 years, water sources have been boreholes, sand dams, rivers and shallow wells which have and still are faced with frequent breakdowns with common recommendation of repairs of the broken pumps, water storage tanks, hand pumps, generators etc. The most affected areas includeDrought Reserve Boreholes in Garbatula and Merti sub Counties which serve livestock from other Isiolo and neighboring counties(NDMA, 2017). These challenges affect sustainability of water infrastructure which are key to livestock which is the economic backbone of the County.

Funds received by Isiolo County Government from the National Government over the past three years have increased from Ksh. 21.4 billion in financial year 2013/14 to Ksh. 31.8 billion in financial year 2014/15, andKSh33.55 billion in financial year 2015/16(Irrigation, 2016). In the draft Mid Term Plan for 2018-2022 for the water sector,a key lesson learnt included unsustainable water projects operating with a reliance on fuel due to high costs of power despite several projects in the rural area being developed with fuel powered systems(Devolution, 2018).

From the County Water Points Database 2016, Garbatula Sub County had documented 14known out of 38known boreholes that are in major centers in the County are non-operational. This is only for boreholes recorded in the database excluding those that have not been document by the County government as at the time of the study. Drilling of new boreholes has continued with non-operational boreholes being abandoned or revived at high costs. The value for money in these investments is not realized when the WASH assets are not sustainable. It is therefore necessary to find a solution to ensure existing and new borehole projects are sustainable through appropriate planning, management, operations and maintenance.

1.3 Purpose of the study

The main aim of thisresearch is to investigate factors that influencethe sustainability of projects that focus on water supplyfor rural communities in theASALin Kenya with emphasis in Garbatula Sub County ofIsiolo County.

1.4 Specific objectives of the study

1. To evaluateinfluence of choice of technology onsustainability of water supply projects for rural communities in Garbatula Sub County,
2. To determine the level to whichsocio-economic factors affect sustainability of water supply projects for rural communities in Garbatula Sub County,
3. To evaluate the influence of socio-cultural factors on sustainability of water supply projects for rural communities in Garbatula Sub County.
4. To identify the influence of water tariffs on sustainability of water supply projects for rural communities in Garbatula Sub County.
5. To determine the influence of specialized training ofservice teams on sustainability of water supply projects for rural communities in Garbatula Sub County.

1.5 Research Questions

The research questions of the study were as follows:

1. What is the influence of choice of technology on sustainability of water supply projects for rural communities in Garbatula Sub County?
2. In what ways do socio economic factors influence sustainability of water supply projects for rural communities in Garbatula Sub County?
3. In what ways do socio cultural factors influence sustainability of water supply projects for rural communities in Garbatula Sub County?
4. Is there influence of water tariffs on sustainability of water supply projects for rural communities in Garbatula Sub County
5. What is the influence of specialized training of service teams on sustainability of water supply projects for rural communities in Garbatula Sub County?

1.6Significance and Justification of the study

The research will be beneficial to the rural management committees and the Isiolo County Government, Ministry of Water, Energy, Environment and Climate Change in finding solutions towards sustainable rural water management. The study seeks to fill in the gaps of information on sustainability challenges in Garbatula Sub County and further the findings can be used to inform on water related policies in semi-arid and arid regions. It was also give researchers opportunity for further studies in enriching the gaps.

The research element is useful towards enriching existing knowledge on factors that influence sustainability of water supplies to help in decision making towards the realization of Goal six and seven of the SDGs. In reference to SDG goal 6, by the year 2030, the world should achieve universal and equitable access to safe and affordable drinking water for all, improved water quality by reducing pollution, substantially increased water-use efficiency across all sectors and ensure sustainable withdrawals and support and strengthen the participation of local communities in improving water and sanitation management (Nations, 2018). In reference to goal 7, the world should ensure universal access to affordable, reliable and modern energy services, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support (UN, Sustainable Development Goals, 17 goals to transform the World, 2018)

Water Act 2016 provides the County government with legislative powers to form water service providers whose mandate according to the regulatory board is to ensure provision of adequate water to people. In the same act, there is a provision of water service trust fund to ensure water management of community level initiatives for sustainable management of water resources(WASREB, 2018). According to the constitution of Kenya, every citizen has a right to access safe and clean water in adequate quantities. Under the fourth schedule on functions of the national and county governments, the constitution also gives the national governments the mandate to protect the environment and natural resources with a view of establishing a durable and sustainable system of development including water protection, securing residual water, hydraulic engineering and safety of dams among other natural resources and the county public works and services to provide water and sanitation services(Law, 2018).

The study would contribute to future development of customized policies in the water sector to improve on sustainability of water projects by both Government and Civil society organizations. The findings would also contribute to increasing knowledge on the best possible approaches by water departments, planners, community water managements among other rural management models including establishment of rural water companies. The study

was also give scholars and researchers in the field an opportunity to evaluate gaps and improve on the academic knowledge in the water sector.

1.6 Delimitations of the Study

The research was conducted inGarbatula Sub County, Isiolo County. The sub county is majorly inhabited by Boranaand Somali Community who rely on pastoralism as source of livelihoods and are of Islam religion. The community rely heavily on improved water sources (boreholes)provided by the government and civil society organizations to improve water access to the communities and livestock migrating to the grazing areas from other different parts of the county and neighboringcounties including Marsabit, Wajir, Garissa and Meru and Tana River. It has 38 documented boreholes, 62 water pans, 63 shallow wells, 18 springs around Kinna along Meru county border and Ewaso Nyiro on the east side of the Sub County. The study was focus on community managed boreholes in centres within the Sub County because they offer permanent and reliable water sources throughout the year. The boreholes water supply projects are named in the Appendix 8.Interviews targeted projects beneficiaries, management committees and County Government staff in the study.

1.7 Limitations of the Study

The researcher faced challenges with accessing some regions via roads that had been affected by floodingõs during the March and May 2018 rains. The rains continued to early June 2018. Data collection had to be postponed and pushed ahead to July 2018. There was use of alternative routes to the target areas. The study is likely to face challenges in the area where majority of the population do not know English and Kiswahili in some cases thereby requiring the presence of a translator. A local research assistant was therefore engaged to collect data, majority of the inhabitants being origin of Borana and Somali communities.

1.8 Assumptions of the Study

During data collection, the researcherõsassumption was that the sampled population was a true representation of the study population and that return rate of questionnaires would behigh to provide a true and honest representation of the area of research. The researchwas also assumed that respondents werehonest in theiranswers tothe questions asked during interviews.

1.9Definition of Significant terms used in the study

As per this study, the following terms adopted these definitions:

Abstraction technology ï Refers to all equipmentôs and machinery operated by electricity, diesel or petrol used through scientific knowledge for the purposes of pumping water from a source e.g. solar system, Diesel generators and hand pumps.

Arid lands – Lands having little or no rain therefore less vegetation during dry seasons preventing growth and development of both plants and animal

Breakdown ï Refers to all failures that causes a system not to operate as expected

Choice of technology –infrastructure chosen for use in abstracting water from its source

Community: People with common socio-cultural characteristics living in the similar environmental setting and have a common interest in a given initiative (project)was be perceived as a group.

Community management structure ï A locally formed structure with the sole responsibility of operating and maintaining water facilities and addressing water issues in the community e.g. water management committee.

Community participation - this indicates that men, women, girls and boys perceive that they actively participate in all aspects of water infrastructural development, with specificemphasis on provision of free labour locally available materials, decision making, project implementation, planning, evaluation and monitoring.

Cost Recoveryï means a process of recovering all the expenses linked to construction / setting up of a water system, service or programme.

Improved sources–Water sources that have been installed with infrastructure to support in abstraction and supply to points of collections such as kiosks

Pastoral culture – Refers to the way pastoralists manage resources and organized

Project – Is a set of complex activities entailing planning and financing to meet specific objectives, within a specific time, scope, budget constraints and resources with expected returns.

Semi-arid lands – Lands receiving of precipitation below the normal but not as low as arid lands

Reliable water supply - it is a source that provides water all year round, during the dry and wet season.

Rural water supply ï This refers to a water supply system managed at the community level

Socio-cultural – This refers to the traditional beliefs and ways of doing things

Socio-economic – This refers to how the economy defines the interaction of people within the society

SpecializedTraining – Denotes a process of acquiring knowledge, skills and competence as a result of teaching from vocational institutions, apprenticeship and or teaching on specific abilities and knowledge

Sustainability: The continuing ability of a project to meet the needs of its community and embraces the concept of doing this beyond the time of donor agency involvement (adopted from Brinkerhoff and Goldsmith, 1992).

Technology ï Refers to tools and machines that define the methods of ground water abstraction, source of power facilitating the abstraction that is accepted and able to be adopted and operated by the community.

Unimproved sources – water sources (mostly surface water such as rivers, dams, pans) that do not have any mechanized systems for fetching water

Water Supply – Refers to Water Supply infrastructure the comprises of a borehole, submersible pump, draw pipes, solar or genset pumping system, water storage tank (either masonry, elevated steel tank or plastic tanks), pipeline distribution to communal water points (such as water kiosks/stand pipes)

Water tariffs – Refers to amount of money charged for water paid by consumers buying water

Water supply system ï Refers to all physical infrastructure constructed forextraction, storage, supply, distribution and treatment of water for human and livestock use.

1.10Summary

This chapter deals with the background of the study, the statement of the problem and the objectives that guided the study of factors influencing water supply sustainability projects for rural communities inASAL lands. Rural communities tend to be dependent on government subsidies in operating and maintaining their boreholes because of misuse of funds to do repairs and pay salaries for those managing the boreholes which have frequent breakdowns because of poor handling and servicing.

CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

The literature review of this research wasdone through five major themes including choice of technology, socio-economic factors, socio-cultural factors, specialized training and water tariffs as elements influencing water supply sustainability projects in ASAL, a case of Garbatula Sub County in Isiolo County. This chapter provides a conceptual framework under which the variables relationships are graphically presented. Finally, last section presents research gaps within the study area and a summary literature.

2.1.1 Concept of sustainability of rural water supply projects

According to Virjee and Gaskin (2004) paper presented in a conference for sustainability of energy, water and environment systems, ñSustainability is defined as that which meets the needs of the present without compromising the ability of future generations to their ownò quoted from (WCED, 1987). Sustainability of water supply projects is influenced by environmental quality, financial management and institutional capacity. In developing countries there should be guiding principles to which these projects should be implemented to meet the user needs namely water should be managed as an economic good as well as a social good, women should play a key role in management of water and a holistic approached employed. The two stated that cost recovery is crucial for sustainability through user payments intended to meet costs of operations and maintenanceò (Afgan, Bogdan, & Duic, 2004).

According to Ashley, Blackwood and Jowitt (2004) sustainability factors focus on economic, environmental, social and technical aspects. They further elaborated indicators for each factor where life cycle costs, willingness to pay, affordability and financial risk exposure were identified under economic factor; resource utilization, service provision, environmental impact were identified under environmental factors, impact on risks to human health, acceptability of stakeholders, participation ad responsibility, public awareness and social inclusion were identified under social factors and finally performance of the system, reliability, durability, flexibility and adaptability indicators were identified under technical factors (Ashley, Blackwood, & Jowitt, 2004).

A study in Tanzania identified that many latent and manifest conflicts over water. The availability of water during the dry season is diminishing, because of erosive land use-patterns, poor management, population increase, and the rising number of commercial and small-holder irrigation systems. Conflicts vary from possible legal disputes over incompatible desires from different of users, to issues relating to vandalism and even violence. Thesedisagreements are seldom straightforward, but administration problems and disputes over water are mostly symptoms of uncertainties over ównershipô of the water (Huggins, 2000)

From previous studies by researchers and scholars, there is still a gap in defining a practical standardized sustainability index to guarantee sustainability of water projects in rural semi-arid and arid regions that would guide donors, governments and the community themselves in implementing sustainable water projects. By practically implementing findings of these studies, governments and water sector stakeholders can confidently implement water projects putting in place measures to ensure these factors are in play to increase chances of continues water provision. Many scholars have done tremendous studies and research of the same to define sustainability using major factors that influence sustainability.

It is the mandate of both local communities and institutions to work on achieving sustainable development goal (SDG) 6.1.1 which is to ensurethat the population consuming safely managed drinking water services. To realize this goal, we must identify what measures that need to be in place to not only improve safe water provision but ensure they are able to serve future generations.

Sustainability has been loosely defined as the summation of man-made and natural resources remains constant for the predictable future, so that the well-being of future generations does not deteriorate(Tom Kuhlman, 2010). Sustainability in the context of water and sanitation has also been defined as the provision of services which continue to work overtime and endure changes for a long duration of time. In his book he also noted that sustainability requires one to consider non-technical aspects of technology, social implications, and constraints in the economy and environment.(Abraham & Sheldon, 2006)

Looking at sustainability factors and possible indicators, Martin, 2012, in his study, categorized sustainability of water supplies into place, performance and persons. He defined

place as the relationship between water supply management with its environment and cultural location. To further expound on this identified environment indicators such as water availability, water quality, changes in aquifer, water wastage and water pollution. He defined permanence as institutional aspects and planning ability to solve problems and local capacity to improve the management. Lastly, by personal involvement in management, accountability, community participation through meetings and public audience, sustainability can be achieved even in times of scarcity and unequal access to water. In his study, participation in this case was viewed in terms of attitudes and values that would motivate individuals to get involved in the overall management of a water system (Iribarnegaray & Seghezzo, 2012).

Governments and water sector stakeholders have worked hard in ensuring improvement in institutional capacities through policies and guiding frameworks for sustainable service delivery. There is need to move beyond infrastructure development to ensuring water service providers receive capacity building with a focus on governance, technical capacity and equipping with information. It has become a challenge financing rural water supply projects since these projects cannot recover costs, capital maintenance, cost of operations and maintenance yet they collect revenues from the sale of water. Rural schemes may require cost recovery in this line of thought. The government is usually called to fix broken parts or replace infrastructure without considering Life Cost Cycle approach (The World Bank, 2017).

According to Montgomery, Bartaram and Elimelech 2009, identified three factors to consider planning for sustainability of water projects which include effective societal demand, cost recovery, local financing and dynamic operation and maintenance. Effective community demand is achieved through participation and involvement in planning. However, this has faced challenges such as limited incentives, choice of technology and limited awareness. Local financing and cost recovery is linked to local borrowing and savings, community-based subsidies which is faced with lack of transparency and accountability. Dynamic operations and maintenance was identified to face challenges such as isolation of rural communities and unmotivated local technicians who are not well incentivized (Montgomery, 2009).

Sustainability factors have been looked in different perspectives with different scholars and researchers looking at different variables that would guarantee sustain water systems.

According to Moriarty, 2013, community participation, ownership, willingness and ability to carry out operation and maintenance defines sustainability (Moriarty & Butterworth, 2013). However, he also highlighted that these factors come with assumptions to have a holistic thinking around sustainability including willingness for communities to manage the technical systems which according to Harvey and Reed, 2006, found to be cultural ideologies of rural communities.

According to MacDonald, Alan; Davies, Jeffrey; Calow, Roger; Chilton, John (2005) research on development of ground water, indicate that the expenses of new water projects seem to rise in with relation to the cost of construction per unit of water supplied. This increase is as a result of the increasing remoteness of sources where the water is being tapped, and the need for a more complex supply system. Therefore, it may prove to be more effective in terms of the expenses in the thereafter to invest in training and policy measures which would create more efficient and equitable water distribution. ASAL with minimal chances for underground exploitation, thereby necessitating a mixture of surface water systems such as earth dams, protected water pans, sub-surface dams, sand dams and rainwater harvesting structures. These may not be expensive even though the remoteness of some areas leads to high transport costs for materials. Arid areas also require acomprehensive strategic planning of water resource development since the effects of water availability on the nomadic movements and settlements (MacDonald, Davies, Calow, & Chilton, 2005).

2.1.2 The context of rural water supply projects

Rural water supplies projects are those investments that are made in the areas regarded as rural to provide communities with cleans, reliable and safe water. Water for drinking, domestic, livestock and other productive uses such as small-scale irrigation. The main objective of these water supply projects to provide potable water on a continuous basis guaranteeing sustainability such as security of supply across rainy and dry seasons, it is important if health and wider alleviation of poverty benefits that are to be sustained and met. Each Country has water supply targets based on surveys and evaluations covering their desired regions, coverage and financing among other guidelines in water provision as in the Sustainable Development Goal 6 (MacDonald, Davies, Calow, & Chilton, 2005)

Community management model has been the most preferred method of rural water supplies management in most developing countries. This is because of the low expenditure incurred by governments in further operations and maintenance. This approach is where communities participate in the process of development of water supply projects, taking ownership of the systems and are expected to have the total role and responsibilities of village level operations and maintenance (Paul Hutchings, 2017)**.** However, this approach may not be the best option due to the different dynamics involved in management which require experienced persons both in Knowledge and skills in structured and organized management.

The main aspect of the community administration model is a Water Point Team, which is usually a group of 6 - 10 villagers appointed or assigned by their community tobe responsible for the water points, such as boreholes, sand dams, water pan or a gravity fed water supply. The committee has a formal structure, with a constitution and officials including a chairperson, secretary and treasurer. Its responsibilities are both managerial through records keeping, book keeping of sales from water point, operations and maintenance. In some instances, villagers contribute regular monthly or per litre jerrycan while at times they contribute in kind through fuel subsidy or shoats. The government is responsible for only training of the committee on management, operations and maintenance and handover to them with expectations of sustained management of the system.(Chowns, 2015).

2.2Choice of technology and sustainability of rural water supply projectsfor rural communities in the ASAL

Choice of technology is important in ensuring sustainability. Technology choice may have impact on its adoption, cost of capital, operations and maintenance such as major parts replacement. When designing or planning, there is need to do wider consultations including community in the identification of the technology to be used especially in the rural water supplies. The choice of technology is influenced by the characteristics of the water source, users, demand, and availability of spare parts, cost of operations and the consumersô ability to pay for service delivery. The choice of technology alone does not render sustainability without other factors (Kwena, 2015).

In a study in Ghana, it was discovered that factors accountable for the non-functioning of wells as at the time of the study ranged from extremely low returns, inability to raise

moniesto purchase spare parts, to poor access to spare parts. The nonfunctional boreholes could not be repaired because the spare parts necessary were outdated and no longer manufactured that. This therefore meant that it is difficult to obtain. The non- functional and abandoned boreholes were community owned(Fielmua, 2011) .

Operation and maintenance cuts across tariffs and technology. This is because the adopted technology must have available parts or spare for replaced. Due to lack of availability of spare parts rural societieslack the capability to sustain their water systems. Pipelines dug over long kilometers face detection challenges which would be solved if there were technological solutions to address this challenge. Therefore, rural communities in most cases repair using old pipes from previous maintenance works that have been carried out. The maintenance is also done on a reactive basis. This would further lead to loss of revenues through loss of water leading to unstained systems. (Reed, 2004)

According to a study conducted by Mamburi, 2014, found out that most interruptions forty-five(44.8%) of water supply in Kinna division in Isiolo were because of generator failures attributed to poor operations and maintenance by the rural water management committees and in some instances lack of technicians or skills transfer. The study findings also indicated that spare parts are not locally available within the locality therefore would mean no stockiest or vendors in that line. He also found there was a need to train local technicians on operation and maintenance. From the findings frequency of breakdowns is high which would amount to higher operations and maintenance costs(Mamburi, 2018).

In a study conducted by Adaka, (2017), indicated seventy one percent (71%) of the rural community water points in Merti sub County, Isiolo, were unable to operate the technology used without relying on external assistance. In his study rural water points were operating on mostly diesel generators with two water points operating on solar system. He found out of high breakdowns of diesel powered generators and high reliance on external support for spare parts and replacements. In his study over sixty percent of project beneficiaries and ninety percent water management committees preferred solar powered technologies citing minimal cost of operations and maintenance but with an expectation of major replacement after a long duration (Adaka, 2017) .

Folifac and Gaskin (2011) in their research state that the provision of potable water supply services contains costs that are incurred during the design, construction and operational phases of any water supply system. They further argue that the degree of these costs is specific to the utility and would mostly rely in part on the type of technology applied and management practices.

ICT is a key factor in ensuring sustainability despite the low adoption. To promote service delivery in a timely manner, reduce waiting and improve accountability, ICT innovations in the water sector has been promoted such as m*Maji* which has been piloted and found to inform management on water availability, price and quality. Accurate data helps make informed decision on water use and WASH asset or infrastructure maintenance. These technologies also include billing systems which would ensure accountability and improve on revenue collection. Other examples include digitized water meter readers which improve meter reading unlike the manual way which at times are inaccurate thus leading to discrepancies in billing. These technologies allow for better management through monitoring of functionality such as the Sweetsense .inc borehole sensors piloted in northern counties which help reduce response time in borehole repairs, use of *mWater* piloted in Niger which helps at water quality testing, MPESA which has improved billing in Kenya, *Majivoice* a complaint mechanism aimed at receiving feedback critical to management, *Jisomee Miita* piloted in 2014 by Nairobi water. These tools have advantages and disadvantages but has shown great potential of assisting in management of Water Infrastructure and service delivery (Ndaw, 2015).

2.3 Socio-economic factors and sustainability of rural water supply projects for rural communities in ASAL

According to Tadasse, 2013, linked sustainability of rural water supply system to cost sharing through consumersô payment for services delivered to them. He also highlighted service providers and consumers are expected to assess the costs of operations and maintenance when setting consumers fees. Through this process, funds from consumers who are the community are expected to be utilized for major replacements. He therefore identified cost sharing as one alternative for projects to mobilize funds (Abebe Tadesse, 2013). However, water service providers are faced with a major challenge involving capital maintenance. This is the repair, replacements of parts and rehabilitation as water assets life

span deteriorates with frequent use. Maintenance may be reactive in response to failure or proactive (Richard M. Ashley, 2004). It is therefore essential to look at the socio-economicaspects involving the sustainability when it comes to raising funds by service providers.

In a study in Ethiopia, a relationship between community contribution and participation was identified one of socio economic factors that play a role in ensuring sustainability. In this study, findings indicated that functional rural water points had a direct relationship to those communities (47.5%) who contributed to the water project all in cash, labor and local materials which had resulted to felt ownership. 21.2% of those communities who only contributed cash and labor during construction did not have most of their water points working(Beyene, 2012).

Nkeita, 2009, noted that Rural dwellers are unlikely to access piped water in their dwelling or homes and the public outdoor tap respectively compared to boreholes. Therefore, looking at Public spending on water infrastructure had a significant correlation to the public outdoor taps and protected wells being that outdoor tap and protected well are majorly donor funded and not directly related to the central government expenditures. This would suggest the sustainability of these two sources of water should donors relocate (Nketiah-Amponsah, Aidam, & Senadza, 2009).

According to a study by Nketial et al, 2009, found distance and time cost as a factor sourcing for water behavior. It was found the longer the distance to a given source of drinking water, the lesser the demand for same. This outcome was similar as quoted in their paper by Persson (2003) who found that time cost is akey determinant of household selection of drinking water-source while taste proxied by income had ambiguous effect. However, the relationship between demand and supply is important for sustainability in aspect of spending involved during demand which would help generate revenues in turn ensuring availability of funds for maintenance (Nketiah-Amponsah, Aidam, & Senadza, 2009).

According to Koskei et al. (2013) study on household economic characteristics and access to improved water systems, they established that the career of the family head had a considerable influence on the type of water source used by household. They claimed that the household expense (proxy of household welfare) is an important factor that would drive

households to depend on not improved sources hence the need of authorities to consider poorer households when executing strategies for reliable and safe water supplies (Koskei et al, 2013). This proves a possibility of that purchasing power of households could be connected to affordability of services such as water. Thus, a likelihood that households with no reliable sources of income are likely to use water from unimproved source leading to low utilization of improved water systems.

Another aspect to look at is the household size/population in relation to demand. The amount of water used per household is mainly determined by the number of people in it. Families with bigger population would use more water compared to smaller families. What this would imply is that large households would need to source for more water, even if it is from different sources so as to meet their daily water demand. More so household size has been found to be the most important factor affecting water consumption(Kithinji, 2015)

In a study by Kithinji, 2015, communities in Imenti South, Meru, alternative sources of water for cooking, washing clothes, cleaning the house, washing their bodies and domestic farming was rain water. It was explained that households who had constructed houses with iron sheet roofing with gutters and did not have household connections preferred harvesting rain water during wet seasons thus did not use water from alternative sources. This therefore affected the water sourcing behavior by households. During the dry seasons they would seek alternative sources. Therefore,this trend could be linked to revenue generation from water points in the dry and wet seasons. Those with storage tanks for rain harvesting would have enough water even at the onset of dry seasons affecting demand at the major water sources(Kithinji, 2015).

2.4Water Tariffs and sustainability of rural water supply projects for rural communities in ASAL

In Kenya and Tanzania, rural water tariffs consumption islower when compared to those in the urban areas, notwithstanding the higher costs of implementation, running and maintenance. In some of the rural water systems water is provided for free despite incurring running and maintenance costs. As a result, most of them are currently unsustainable since there is the unavailability of resources for repairs. Water tariffs need toproject on the cost of

the water supply system, as well as allow for repairs and the development of new amenities when increased demands by the populations.(Huggins, 2000)

There is a need, however, to ensure the provision andaccess of safe water to the poor. According to Huggins, there is need to raise awareness and encouraging everyone to pay for water and giving the choice of accepting small amount of water to every individual at subsidized rate. There is debate in both Kenya and Tanzania as to whether charges should be set by associations ofthe local consumers of water, or by the government through WSREB. The voice of poor people in the community might not be represented properly when setting the prices which may lead water being priced beyond their reach. Nevertheless, while setting ófriendlyô tariffs there is a risk that a nationwide tariff may not be sensitive enough to local variations in financial power(Huggins, 2000)

In a report by Mansoor, 2008, it was found that a flat rate payment method is suitable for systems with minimal operations and maintenance, but the overall collection is not enough to meet the long-term costs of replacements of parts or whole system. A flat rate therefore would suit a gravity-fed system which has minimal running and maintenance. It was observed that, at sites where a flat rate was payable irrespective of usage, there was more transparency and easy accountability, since each household paid the same amount and the number of households was known. However, it was noted that there is need to charge reasonable charges when it comes to motorized systems which have higher operations and maintenance costs therefore the fee needs to be suited for such costs for sustainability to be maintained.(Mansoor Ali, 2008)

According to in a study in Kenya, indicated the positive correlation between water tariff paid by community and sustainability. It is against this backdrop that respondents in the study agreed that the tariff was important to raise revenues for maintenance of the water systems. It was however important to note the willingness to pay and the tariff setting that needs to consider the financial capacity of the community and the capital cost of the water system(Mwangangi P. M., 2016).

A key factor in tariff setting is cost recovery plans can be used to set tariffs. This is to ensure long term plans of operations and maintenance which was in turn ensure sustainability.It is a reality the water sector must address to effectively implement self-sustaining water systems.

By ensuring this is done, water service providers would ensure accountability and provide desirable services to ensure communities comply to the cost recovery plans. While setting tariff factors including metered connections are key. Metered connections could be at community tap, water kiosks and or individual connections to households and institutions. Payment per consumption is key to ensuring appropriate revenue collection a cost recovery measure. Cost of meters could be subsidized through longitudinal fees included in the billing system to customers with meters(The World Bank, 2010).

2.5 Socio-cultural factors and sustainability of rural water supply projects for rural communities in ASAL

According to Barbara, 2012, culture is a way of life by communities who share social relationships, common beliefs and values through a common knowledge integrated in their customary or traditional laws and spiritual values. These practices vary from one community to another in across the world. These cultures play key role in how communities manage their resources and resolve issues. These cultures also have an impact on the general environment under which they live. Community based natural resource management has been widespread in rural parts of Africa where governments must consider the role of communities in managing natural resources especially water points. In this regard, local customary or indigenous institutions play a key role in the management and sustainability of these water points.

The present social structures have demonstrated their capability to organize and encouragepeople into fulfilling the institutionsô aims, and proofindicates that building upon prevailinglaws, customs and authority structures is successful as compared to attempting to impose new unclear structures to the communities. In some parts of Tanzania, ñ*kualika"*labor (agricultural work-sharing involving a local group that farms each memberôs farm, in rotation), forms the basis for other institutions, such as water groups(Huggins, 2000). Most of these groups consisted of extended family and close neighbors usually bound in a systematic way. The structures have local methods of resolving conflict and managing resources such as land and water therefore the need to consider these structures. In Tanzania, some village-level indigenous systems have been so successful at dealing with local conflicts that the state courts have been moved to another area due to lack of demand (Huggins, 2000).

According to Bancy (2005), thirty six percent of water sources in Isiolo were found not to be operating in Isiolo County during dry season. During the study fifty percent people rely on boreholes and thirty-fourhave institutionalized community management thus issues to do with empowerment and mobilization to improve governance using the community managed model. The Borana in Isiolo have a tradition of utilizing their water sources mostly during dry season unlike wet season which they look for alternative sources for their livestock (Mati, 2005).

Customary laws that are being practiced in some communities have proven their ability to maintain equitable use of water and long-term services (Arsano, 2007). In his study of the Borana community which is a pastoralist community living in the southern parts of Ethiopia along the Kenya borders, show that the traditional law of Boranaôs deep wells has distinctive features of ownership, user access, management and custodianship. In this study it was found out that access to all watering points are free and to all water resources property of community. However, contribution towards the maintenance of wells is done through labor and cattle. During new systems and rehabilitation, labor and other resources are provided by users in their capacity and supervised by Abba Herega(Homann, 2005)

The Somali traditional practices hold that water from the streams and naturally captured ponds are accessible to anybody and have the right of access to the common territory of the incumbent community. Man-made ponds are only accessible tomembers who took part in its establishment. *Birka subterranean silos* for rain water harvesting stored for use during dry season are used by a family or extended family(Arsano, 2007) .

In a similar study of the Borana community, the administration unit is known as *Gedaa* whose leadership also involves water system management. *Gedaa* has a general assembly oversees enactment of water systems management rules. *Konfi* (regarded as father of water) manages wells on behalf of the community. To access water, formal requests are made through him and taken note by a well council. According to their traditions, well maintenance involve daily removal of dung, seasonal removal of sediments deposits after flood season and extension of the depth of well following depletion of groundwater table (Behailu, Pietila, & Katko, 2016). It is the responsibility of the community to carry out well operations and maintenance to ensure participation, involvement and ownership.

To further support the importance of involvement ad participation, Kenâichi (2016), identified communities that feel they own a hand pump installed at a shallow well are more likely to look after it. He also noted community structures are key to ensuring proper management of water projects to achieve sustainability(Nakagami, Setiawan, & Indra, 2016). In conclusion, any community-based project, must provide a lot of consideration to the socio-cultural facets in any project during before and after the implementation.(Oino, Towett, & Luvega, 2015)

2.6 Specialized Training and sustainability of rural water supply projects for rural communities in ASAL

In the context of water sector, water systems require institutions to keep them functioning from inception to the future. These systems require maintenance which could be mostly preventive through regular maintenance example hand pumps was require grease for moving parts, fuel and change of oil for generators etc. Gravity systems may also require sediments removal from storage tanks, repair of taps and busted pipes. Importantly is also to keep water free of contamination. Rural water systems being shared by different families and their extended families, these inputs for maintenance must be handled by a management structure whose role was also be involved in collection of revenues from the systems to recover the cost of services provided(Sarah & Katz, 2005)

In a study on user satisfaction and sustainability in Nepal, found out that rural villages face challenges with water management institutions which have weak managerial skills while those in areas considered centers face insufficient pressure head in the water supplies. It was in this regard that the study indicated the need to strengthen these institutions through capacity building (education) on holistic water management systems to ensure sustainability (Bhandari & Grant, 2007).

According to a study conducted by Habtamu in Woreda in Ethiopia, 2012, found out that twenty-nine of respondents in functional water points had received training on water schemes management while those in non-functional water points had not received training. This showed a significant relationship between training and functionality of the water which would have some influence on the sustainability of those water points (Beyene, 2012)

Mwangangi, 2010, found that sustainability of water systems relies not only on technology, infrastructure or assets involved but also alternative methods of ensuring safe provision of clean water. In the rural communities, modern methods of water treatment are in low supply due to either unavailability of the treatment chemicals or lack of stockiest within the rural areas, therefore low-cost technologies such as born, and char have been promoted. Therefore, trainings are required on use which would result to reduction cost of transport to urban areas for purchase and cost of buying treatment chemicals which may be slightly higher than the cost of born and char.

In his study he identified there is lack of transfer of skills when old committee members leave office. This led to a management skills gap to the new members who came into office. Lack of these skills would render management to face challenges and result to poor management if no new trainings are conducted. It was therefore recommended knowledge and skills transfer to not only new members but all those involved in the water governance of the specific water points (Mwangangi & Wanyoike, 2010)

According to Kwena, 2015, the sustainability of rural water supplies is relative to the quality of the managementsô skills of the WASH committees. The large number of associates of water management committee with basic and college level education has improvedthe capacity of water management committees in the development and utilization management, operation and maintenance skills necessary for enhancement sustainability. In findings from his study in Kajiado, water committees comprised of higher education levels and abilities had better interaction with their consumers thus increasing participation of the stakeholders involved. These category of water committees could make informed decisions and share information using information technologies such as mobile phones.

The study showed evidence of increased participation by men in water collection due to education and awareness. Traditionally women and girls have been known to do these duties thus menôs participation would help increase gender mainstreaming in roles played in the society. Project planners should therefore bank on this trend by reinforcement gender mainstreaming programming approaches since it has significant implications for enhancing the imminent sustainability of rural water supplies (Kwena, 2015)

According to findings in a study by Wanyoike, 2016, in Kitui, Kenya, through training creation of awareness is important in ensuring sustainability of boreholes. He also acknowledged the need to have indigenouslabor for the piping systems to the closest points and then sell to the community to raise income that was meet the costs of maintenance. From his study, he recommended the need for community frequent trainings, organizing *barazas* and holding discussionswith the local administration, churches, clinics and learning institutions the importance of sustainability of borehole and other water projects which serve them. With good leadership and accountability, water management committees would increase chances of sustainability of water projects. (Mwangangi & Wanyoike, 2016)

According to Kithoka in his study in Kitui, Kenya, training of community water management committees needs to be done across management, operations, maintenance and resource mobilization. Eighty-threepercent of respondents reported water supplies were operated by untrained technicians therefore need to have them trained. A significant number of respondents reported technicians also lacked skills in maintenance and lacked the tools and equipment to use to conduct the Operations and Maintenance. Eighty one percent had no training on how to mobilize for resources leading to challenges in replacing major parts that were of high costs since they heavily relied on revenues from the water sales (Kithoka, 2014)

With reference to a study conducted by Adaka, 2017, in Merti, Isiolo, it was eminent that water management committee lack skills to operate and maintain their water supplies to ensure sustainability. These inadequate skills resulted to sole reliance on external assistance. During his study he identified water committees had plumbers, electricians, meter readers and top officials from chairpersons, secretaries and treasurers. However, over fifty five percent respondents and water committees agreed there is need for training of the management personnel to help improve service delivery (Adaka, 2017)

2.7Theoretical framework

The research study was guided by four-capital model theory to explain the concept sustainability and the components to explore for an in-depth understanding.According to Paul Ekins, 2008, in their article of the four-capital model, explain that sustainable development according to the World Commission on Environment and Development (1987) as that, that meets the essentials of the present without necessarily compromising the future

generationsôcapability to meet their needs. They elaborated this involved the socio-economic development that allows future generations to ability to ensure well-being. They expressed the four-capital model as a concept where assets provide continuity of goods and services that helps in human health. (Ekins, Dresner, & Dahlström, 2008)

Four capitals in their analysis explained the concept has gone beyond quantity of human labor with a shift of focus to quality, natural resources and environment, organization of labor which ensures economic process ad continuity of well-being.

According to Erik, 1997, the four-capital model is related to manufacturing, human, social and natural capital to the process of production and the generation of human welfare. Examples of the four capital models include manufacturing capital such as machines, tools, which are used to produce other goods and services, natural capital which include components of nature such as energy, water, timber directly or indirectly linked to the well-being of humans; Human capital which refers to the health, well-being and productive potential of an individual. This is the aspect of motivation and skills of an individual towards ensuring productive output on the responsibilities bestowed upon him or her. It is through this theory that wellbeing associated to good health is linked to improved opportunities encouraging economic growth through a productive workforce.

Lastly is Social capital which explainsthe social networks that support associations, civic organization to address common problems are important towards ensuring a conducive environment that promote political stability, social justice among other social factors important towards ensuring sustainability of water supplies in this context(Ekins, Dresner, & Dahlström, 2008).

Therefore, sustainability can be considered through the analysis of the four capital models which if put together creates an opportunity for sustainability of any development including water supplies systems.

2.8Conceptual framework

Marilla, 2010, ascertains thata conceptual framework as an interconnected set of ideas or theories about how a specific phenomenon functions or is linked to its parts. It provides a foundation for understanding the causal or relational patterns of related activities, ideas, events, observations, knowledge, concepts, interpretations and other components of experience (Svinicki, 2010).

The conceptual framework below shows the relationship of the variables in the study. Independent variables include choice of technology, socio-economic factors, socio-cultural factors, water tariffs and training while the dependent variable depicted in Figure 2.1 below is water supply sustainability projects for rural communities in ASAL areas showing how theyplay a key role in guaranteeing sustainability. In the study, the researcher wasexplored indicators under each independent variable to investigate the relationship or the extent to which they influence sustainability. The intervening variable is the attitude of the community while moderating variable weather conditions.

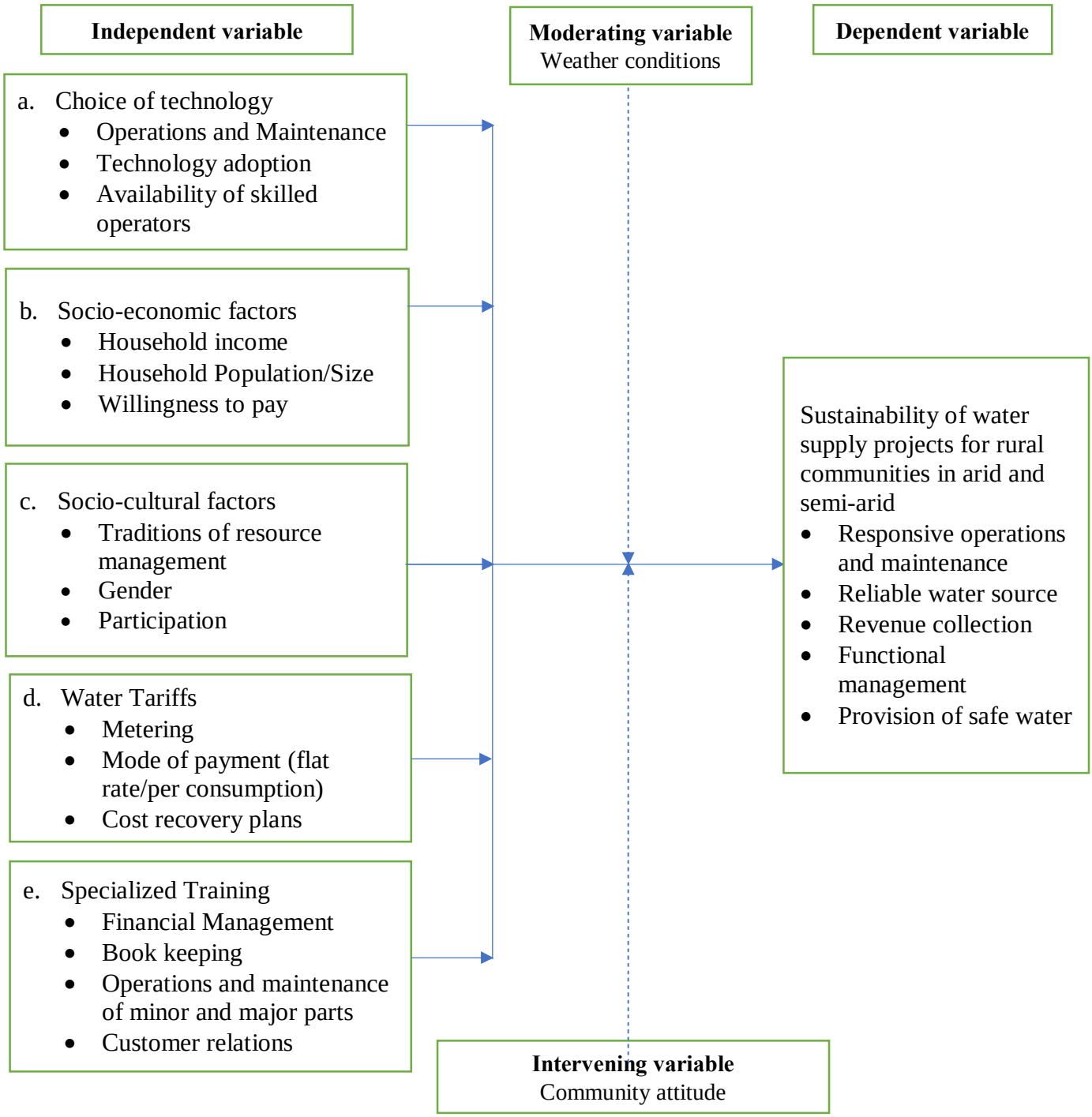

Figure 1: Conceptual framework. Source (Ashley, Blackwood, & Jowitt, 2004)

2.9Knowledge gaps in the area of study

The reviewed empirical and theoretical literature enabled the study to identify thefollowing research gaps as summarized in the tabular form.

Table 2.1: Research gaps

Objective	Variable	Source of literature	Findings	Knowledge gap
To assess identification of technology influence on sustainability of rural water supply projects in ASAL lands, a case of Garbatula Sub County, Isiolo County, Kenya	Choice of technology	(Kwena, 2015) (Fielmua, 2011) (Reed, 2004) (Adaka, 2017)	• When designing consider user characteristics, demand, availability of spare parts, cost of operation and pay services • Spare parts outdated and no longer manufactured • O&M linked to tariff and tech - if tech solutions were available pipeline detections would take place. reactive solution of maintenance lead to loss of revenue through loss of water • Preferred solar in Merti Sub County	Involvement of community at technological design phase has not been well explored.
To determine to what extent, socio-economic factors influence water supply sustainability projects in rural ASAL lands, a case of Garbatula Sub County, Isiolo County, Kenya	Socio-economic factors	(Abebe Tadesse, 2013) (Beyene, 2012) (Nketiah-Amponsah, Aidam, & Senadza, 2009) (Koskei et al, 2013)	• Cost sharing for projects to be sustainable. Need of service providers to assess cost of O&M • Linked sustainability to community contribution through cash, labor and local materials • Public spending in rural areas is minimal as most donor funded projects take place in the rural areas • Distance and time cost influence water service seeking behavior which in turn influence utilization water	How culture affect management of water resources has not been adequately explored.

		(Kithinji, 2015)	supplies • Found a link between household occupation influencing the source of water used by household where households with better occupation are likely to use improved water systems compared to the rest. This way they can afford water services leading to generation of revenues for sustainability of water supply • The more household size, the higher demand for water thus likelihood to rely on water source	
To assess influence of socio cultural factors on water supply sustainability projects in rural ASAL lands, a case of Garbatula Sub County, Isiolo County, Kenya	Socio-cultural factors	(Behailu, Pietila, & Katko, 2016) (Huggins, 2000) (Mati, 2005) (Homann, 2005)	• Traditions influence access and management of water supplies • Traditional methods of resource management cannot be ignored by development projects • Women still bear burden to roles of water management at household level and not at community level • Current social structures have proved their capability to organize and motivate people to fulfil the aims of those institutions that build upon prevailing customs, laws. The local methods of conflict resolution and management of resources such as land and water are important • Borana study in Isiolo	This type of research has never been done in Garbatula Sub County

			revealed the they have a tradition of utilizing their water sources mostly during dry season unlike wet season they look for alternative sources for their livestock • Borana community have traditions that guide participation in wells maintenance and management	
To establish the impact of water tariffs on water supply sustainability projects in rural ASAL lands, a case of Garbatula Sub County, Isiolo County, Kenya.	Water Tariff	(Huggins, 2000) (Mansoor Ali, 2008) (Mwangangi P. M., 2016)	• Some rural water systems provide water for free despite incurring running costs leading to unsustainability with no money to do operations and maintenance. Water charges can be subsidized to ensure the poor access water but also save for repairs. • Flat rate payment method is not suitable for systems with major operations and maintenance. • Willingness to pay influences sustainability because consumers help generate money for O&M. Cost recovery plans are therefore necessary for self-sustaining water supplies which are affected through metering and payment of water per consumption unlike the flat rate which is usually set by the community at the minimum despite	No such study has been done in Garbatula Sub County

			consuming more water.	
To determine the influence of training on operations and maintenance teams in water supply projects in rural ASAL lands, a case of Garbatula Sub County, Isiolo County, Kenya.	Specialized Training	(Bhandari & Grant, 2007) (Beyene, 2012) (Mwangangi P. M., 2016) (Kwena, 2015)	• Challenges facing water management committee usually are managerial skills • Water schemes where training has been done perform better in functionality compared to those whose management committees have not received training • Training on low cost water treatment to ensure safe delivery of water. Transfer of skills by old committee are necessary through refresher trainings or apprentice to ensure sustain water supply management • More involvement because of education and awareness which is enhanced through trainings and advocacy	No such study has been done in Garbatula Sub County

2.9.1 Summary of Chapter Two

From the literature review, it is therefore important to conclude that factors influencing sustainability of rural water supplies in rural semi-arid and arid areas including appropriate management practices, tariffs in line with cost recovery to ensure charges of water can sustain projects through minor and major repairs, increase involvement in the strategy and implementation of projects which would increase ownership(The World Bank, 2017). From related studies in the literature, it also important to take note of the socio-economic factors such as income, population size which influence demand affecting utilization of these projects. It also important to note that infrastructure (hardware) alone cannot ensure sustainability but all other factors (software) such as training, awareness and sensitization etc. have to be in play for water supplies to be self-sustaining(Abebe Tadesse, 2013). From the literature review, there is still need to conduct further research to address the gaps identified towards addressing sustainability challenges as most projects are designed with the community not being engaged at some levels e.g. the choice of technology(Adaka, 2017).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the research methodology applied by the researcher to carry out the research. They include the research design, targeted populations, size and sampling techniques applied, instruments for data collection, research instruments validity as well as the reliability, ethical considerations to be employed in the study, operational definition of variables.

3.2 Research Design

Research design technique provides a framework through which the researcher gathers and presents data. This study employed a descriptive research methodology.

According to Mugenda, 2003, descriptive survey design focuses objectives formulation, data collection tools design, data collection, data processing, analysis and reporting of findings. A descriptive survey involvesissuing out the questionnaires in person, via mail and telephone. This research design method was used because the method provides an opportunity to obtain in depth information from quite a large sample of respondents. By employing this research design, both quantitative and qualitative data was collected from a section of the community members at household level, members of water management committees and key informants from Sub County Water officer and Ward Administrator.

3.3 Target Population

This researchwasconducted in Garbatula Sub County in Isiolo County with a population of 43,118(KNBS, 2010) with a 2018 population projection of 13,401. The study focused on the three wards within the sub county namely Kinna, Garbatula and Sericho.

Table 3.1: The study target population

Constituency	Sub-county	Area (Km^2)	Ward	Total Ward Population (2009)	Projected Ward Population (2018)
Isiolo South	Garba Tulla	9,819	Kinna	14,618	16,191
			Garba Tulla	16,401	18,166
			Sericho	12,099	13,401
Total				**43,118**	**47,758**

Source:*Kenya National Bureau of Statistics*(KNBS, 2010)*; CIDP 2018-2022*(County, 2018)

The Sub County has 17 main boreholes that have been reliably serving a population estimated 32,226. 10 operate on diesel generators that experience frequent breakdowns because of poor servicing and replacement of parts and use of dirty fuel. The 17 boreholes are the main water sources for the settlements (centers) in Garbatula Sub County. Itôs from this population that a representative sample was drawn and administered questionnaires. These boreholes operate under community management.

3.4 Sample size and sampling Technique

The sample size and sampling procedure that was be used in the study are as discussed below:

3.4.1 Sample size

The methodology for determining the sample size of the study borrows from previous studies, published formulas and census for small populations. According to Mugenda and Mugenda 2003, a quality research must be characterized by affordability in terms of finances, time sensitive and enough human resource. Sample sizes should not be too large or too small to be within the confidence levels of a study outcome. The sample size for the study therefore was calculated using Fishers formula given by:

$$n = \frac{Z^2 pq}{d^2}$$

Where: n = the desired sample size (if the target population is greater than 10000).

Z = the standard normal deviation at the required confidence interval

p= Proportion in the target population with characteristics being used and q=1-p

d= the level of statistical significance set

According to Mugenda and Mugenda, 2003, fifty percent of the estimate number of the target population presumed to have characteristics of interest is not given.

If the p is not known in advance 50% should be used.

P=0.5, q=1-p=1-0.5=0.5, d=5%

Z=1.96 at 95% confidence interval, $n=1.96^2 x 0.5 x 0.5/0.05^2=384$

The water projects serve a population of 32,226

Table 3.2: Proportional sample allocation

	Abstraction point name	**LOCATION**				**Water Body**		**Proportional allocation**
No		**Village/ Community**	**Location**	**Ward**	**Sub county**		**Total No.of People**	
1	Boji borehole 1	Boji	Garbatula North	Garbatula	Garbatula	B/H	2,400	29
2	Taiboto borehole	Garbatula	Garbatula North	Garbatula	Garbatula	B/H	600	7
3	Eskot (Skot) Borehole	Eskot trading centre	Garbatula North	Garbatula	Garbatula	B/H	1,750	21
4	Malka Daka Borehole	Malka daka	Malka daka	Garbatula	Garbatula	B/H	3215	38
5	Mata Gari Tinga borehole	Near Garbatula town	Garbatula North	Garbatula	Garbatula	B/H	1200	14
6	Sister Waliyana borehole	Garbatula town	Garbatula North	Garbatula	Garbatula	B/H	1500	18
7	Garfasa borehole	Gafarsa	Garfasa	Garbatula	Garbatula	B/H	2947	35
8	Much'uro borehole	Muchuro trading centre	Garfasa	Garbatula	Garbatula	B/H	660	8
9	Belgesh Borehole	Belgesh Area/Garfasa location	Garfasa	Garbatula	Garbatula	B/H	336	4
10	Range Water borehole/ Gawasco	Near Garbatula town	Garbatula North	Garbatula	Garbatula	B/H	1150	14
11	Kula Mawe Borehole	Kulamawe	Kulamawe	Kinna	Garbatula	B/H	3093	37
12	Jilo Dima Borehole	Kinna town	Kinna	Kinna	Garbatula	B/H	2,400	29

13	Duse/Bibi Borehole	Moliti and kinna	Bibi	Kinna	Garbatula	B/H	1,218	15
14	Rapsu Borehole	Rapsu	Rapsu	Kinna	Garbatula	B/H	1,278	15
15	Ell Iresaboru Gotu Borehole	Iresa boru trading center	Iresa Boru location	Sericho	Garbatula	B/H	2,690	32
16	Bisan Sericho Borehole	Sericho town	Sericho	Sericho	Garbatula	B/H	5,064	60
17	Kombola Borehole	Kombola	Kombola village	Garbatula	Garbatula	B/H	725	9
							32,226	**384**

3.4.2 Sampling Technique

A sample of 384 was required for this study. Using convenience sampling, conducted one focus groups discussion of 8participants each was conducted. Key informants included Sub County Water Officer and Kinna Ward administrators were interviewed. The study was employ simple random sampling technique to identify 344 respondents.

3.5 Research instruments

In this study, the instruments of research that was be used to collect include questionnaires and interview schedules to collect primary data. The questionnaire and key informant interview guides was used for households, Focused group discussions and specific informant interviews. The key informants wereKinna Ward administrator and Garbatula Sub County Officers. The questionnaire comprised of sections consisting of questions on demographic characteristics, choice of technology, socio economic factors, socio cultural factors, tariff and specialized training.

3.5.1 Pilot testing of instruments

Mugenda and Mugenda, 2003 point that a pilot study containing a sample representing 10% (38) of the total sample with homogeneous characteristics is encouraged. Pilot testing of the research instruments gives the researcher an opportunity to refine tweak the tool further. During pilot tests, efficiency and flow of the questions in the questionnaires

wasfine-tuned to get better responses. This pilot study was done in Garba Tula where beneficiaries of Attir and Maendeleo villages, Ngaremara Ward in Isiolo Sub County. St. Waliyana borehole, Garbatula town. One water officers in the headquarters was take part in the Key informant interviews. As a result, the questionnaire was fine-tuned by editing questions to make sense to respondent and better understanding when administered.

3.5.2 Validity of the instrument

According to Mugenda and Mugenda, 2003, validity defines the accuracy of data collected or to be collected in a study or data collections. An important aspect of validity is content validity which is defined as the ability of research instrument giving adequate results with characteristics to be measured. The results were given to supervisors and specialists within the University of Nairobi to cross check the format, relevance, reliability and content to ensure research instrument collects appropriate data. Upon this cross checking, the final research instrument was reviewed. Key informant interview guide and schedules were used to triangulate information collected from households.

3.5.3 Reliability of the instrument

Reliability is a measure of the extentat which a research instrument produces consistent results or data after several trials(Mugenda & Mugenda, 2003). This was realized during pilot testing and analysis upon completion of data collection. Split half test is one-way reliability was assessed. During reliability testing, the coefficient should be between 0.00 (no reliability) and +1.00 (positive reliability). The test was conducted for Pearson Moment Product Coefficient was determined and the results used to determine Correlation Coefficient that was found to be 0.879 which was within the acceptable margin.

3.6 Data collection Procedures

Researcher seeked for a permission to conduct research following receipt of introductory letter. The researcher employed three research assistants who was be trained on the data collection procedures, communication skills and ethical considerations. The research assistants were engaged in the study for 13 days due to challenges with access roads. Garbatula town was set as the meeting place and collection point for all questionnaires.

3.7 Data analysis Techniques

Upon completion of data collection, questionnaires were checked for errors and data was be entered in Statistical Package for Social Scientists (SPSS V.21) software for it to be cleaned. After cleaning, data was coded where responses were put in categories and numbers to allow for analysis. Qualitative and quantitative techniques of data analysis from SPSS V.21 software wasused and presented in percentages, means, frequenciesand standard deviations. During analysis both descriptive and inferential statistics which included frequency tables and cross tabulation was be executed. The software wasused because of its flexibility and most commonly used.

3.8 Ethical considerations

Ethical considerations are those guiding norms that govern human conduct to behave in the appropriate and accepted ways. It is the responsibility of the researcher to ensure these norms are not violated especially those that regards the dignity of respondents taking part in the study. In this regard, identities of the respondents not revealed to persons outside the research. The ethical considerations that was guide the research include voluntary or willingness to take part in the study, informed consent, confidentiality, guarantee protection of information and privacy. The researcher and research assistants explained the objectives of the study and provide room for respondents to willingly and consent to the study. The study was also considered the fact that the area under study is Muslims dominated and therefore was not interfere with the prayers between noon and two pm.

3.9 Operational definitions of variables

Table 3.3: Operational definition of variables

Research Objective	Variable	Indicators	Measurement	Scale of Measurement	Data Collection method	Data Analysis
Factors influencing water supply sustainability projects for rural communities in ASAL lands.	**Dependent:** Sustainability of rural water supplies projects in ASALlands	• Responsive operations and maintenance • Reliable water source • Functional water supplies • Revenue collection • Functional management • Provision of safe water	• Efficient management • Ability to carry out operations and maintenance • Ability to operate technologies installed in the system • Appropriate book keeping • Saving of funds to meet O&M costs • Reliable water provision • Appropriate Knowledge and skills	Nominal Ordinal Interval and ratio scale	Structured questionnaire and interview guides	Descriptive statistics and inferential statistics (correlation and regression)
To evaluate the choice of technology influence on sustainability of a rural water supply project in areas ASAL lands.	**Independent:** Choice of technology	• Type of technology • Participation in technology selection • Operations and Major maintenance • Skills required to operated	• Type of pump installed e.g. Diesel genset, Solar Pump, handpump • Availability of parts • Number of skills technicians • Frequency of breakdowns	Nominal Ordinal	Structured questionnaires and interview guides	Descriptive statistics (frequencies, percentages and cross tabulation) and correlation
To determine the level to which socio-economic factors	**Independent:** Socio-	• Community economic activities	• Households income • Household size and water demand	Nominal	Structured questionnaires and interview	Descriptive statistics (frequencies,

influence sustainability in a rural water supply in rural ASAL lands.	economy factors	• Market trends	• Education • Water as an economic or social	Ordinal	schedules	percentages and cross tabulation) and correlation
To evaluate influence of socio cultural factors on sustainability of water provision to rural communities in rural ASAL lands.	**Independent:** Socio-culturalfactors	• Cultural practices in resources management • Gender balance in water issues	• Gender involvement in management • Level of community participation • Traditions in resource management • Perception about water	Nominal	Structured questionnaires and interview schedules	Descriptive statistics
To identify the impact of water tariffs on water supply sustainability projects in rural ASAL lands.	**Independent:** Water tariffs	• Water tariff set against cost of expenditure	• Life cycle cost analysis documentation • Type of tariff • Metering • Billing system	Nominal Ordinal	Structured questionnaires and interview schedules	Descriptive statistics and correlation
To determine the impact of specialized training on technical knowledge and skills on sustainability in rural semi-arid and arid areas.	**Independent:** Area of training	• Quality and content of training	• Governance • Financial management • Operations and maintenance • Customer satisfaction	Ordinal Ratio	Structured questionnaires and interview schedules	Descriptive statistics

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter entails the data analysis, the presentation and the interpretation of results. This research aimed at establishing the factors affecting the water supply sustainability projects for rural communities in ASAL lands in Kenya with focus in Garbatula Sub County of Isiolo County. Present data was collected by through. This chapter begins by giving the demographic profile of the respondents.

4.2 The response rate

Three hundred and eighty-four questionnaires were issued to target sampled population who are the project beneficiaries. The response rate is indicated in table 4.1 below.

Table 4.1: Response rate

Ward		**Position in the water management committee**						**Tot**
		Member	Sec	Chair	Vice Chair	Vice treasurer	Community member	
Garbatula	n	13	2	1	0	0	88	104
	%	40.6%	3.8%	50.0%	0.0%	0.0%	40.0%	33.8 %
Garbatula - Adele	n	0	6	0	0	0	0	6
	%	0.0%	11.5%	0.0%	0.0%	0.0%	0.0%	1.9%
Garbatula - Biliqi	n	3	13	0	0	0	0	16
	%	9.4%	25.0%	0.0%	0.0%	0.0%	0.0%	5.2%
Garbatula - Gubatu	n	3	10	0	0	0	0	13
	%	9.4%	19.2%	0.0%	0.0%	0.0%	0.0%	4.2%
Garbatula - Machesa	n	0	7	0	0	0	0	7
	%	0.0%	13.5%	0.0%	0.0%	0.0%	0.0%	2.3%
Garbatula - Mulanda	n	2	6	0	0	0	0	8
	%	6.3%	11.5%	0.0%	0.0%	0.0%	0.0%	2.6%
Garbatula - Mwangaza	n	5	0	0	0	0	0	5
	%	15.6%	0.0%	0.0%	0.0%	0.0%	0.0%	1.6%
Garbatula - Slaughter	n	0	4	0	0	0	0	4
	%	0.0%	7.7%	0.0%	0.0%	0.0%	0.0%	1.3%
Garbatula	n	0	2	0	0	0	0	2

- Tank	%	0.0%	3.8%	0.0%	0.0%	0.0%	0.0%	0.6%
Garbatula - Walda	n	1	1	0	0	0	0	2
	%	3.1%	1.9%	0.0%	0.0%	0.0%	0.0%	0.6%
Garbatula-Barrier koropo	n	0	0	0	0	0	3	3
	%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	1.0%
Garbatula-Kiwanjani village	n	0	0	0	0	0	4	4
	%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	1.3%
Garbatula-Matagari	n	1	0	0	0	0	14	15
	%	3.1%	0.0%	0.0%	0.0%	0.0%	6.4%	4.9%
Garbatula-Qampe town	n	0	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%
Garbatula-St Waliyana	n	0	0	0	0	0	13	13
	%	0.0%	0.0%	0.0%	0.0%	0.0%	5.9%	4.2%
Garbatula-town centre	n	0	0	0	0	0	4	4
	%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	1.3%
Garbatula-Wanyama village	n	0	0	0	0	0	2	2
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	0.6%
Kinna	n	1	1	1	0	1	39	43
	%	3.1%	1.9%	50.0%	0.0%	100.0%	17.7%	14.0 %
Kinna-Jabal Nur village	n	0	0	0	0	0	6	6
	%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	1.9%
Kinna-Kulamawe	n	0	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%
Kinna-Shauri yako village	n	0	0	0	0	0	25	25
	%	0.0%	0.0%	0.0%	0.0%	0.0%	11.4%	8.1%
Kinna-Tawi village	n	0	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.3%
Sericho	n	3	0	0	1	0	19	23
	%	9.4%	0.0%	0.0%	100.0%	0.0%	8.6%	7.5%
Tot	n	32	52	2	1	1	220	308
	%	100.0%	100.0%	100.0 %	100.0%	100.0%	100.0%	100. 0%

From the findings in Table 4.1, the total number of questionnaires dully filled was 308 representing 80.2% response rate. Furthermore, 71.4% (n=220) were community members, 16.9% (n=52) were secretaries, 10.4% were just ordinary members of the committee, 0.6% (n=2) were chairpersons while 0.3% (n=1) were either vice chairperson or treasurer. It can be deduced that there is minimal participation of the local residents in the management of the water supply in the region. It is important to note that some missing data in the variables were excluded in the analysis.

4.3 Demographic profile

Demographic characteristics were analyzed based on gender, age and the level of education. The tables below present the findings of the demographic characters:

Table 4.2: Gender of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	150	48.6	48.6	48.6
	Male	158	51.4	51.4	100.0
	Total	**308**	**100.0**	**100.0**	

The results in Table 4.1 3 shows that 51% (n=158) were males while 49% (n=150) were females. The findings suggest that there is a good gender balance in the sampled population and would suggest possible balance involvement in the water supply projects in Garbatula Sub County of Isiolo County.

Table 4.3: Ages of the respondents by the position in the management committee

		Position in the water management committee						Tot
		Member	Sec	Chair	Vice Chair	Vice treasurer	Community member	
18-25	n	0	2	0	1	0	15	18
	%	0.0%	3.8%	0.0%	100.0%	0.0%	6.8%	5.9%
26-35	n	11	19	0	0	1	70	101
	%	34.4%	36.5%	0.0%	0.0%	100.0%	32.0%	32.9%
36-45	n	10	13	1	0	0	85	109
	%	31.3%	25.0%	50.0%	0.0%	0.0%	38.8%	35.5%
46-55	n	9	10	0	0	0	26	45
	%	28.1%	19.2%	0.0%	0.0%	0.0%	11.9%	14.7%
55	n	2	8	1	0	0	23	34

and over	%	6.3%	15.4%	50.0%	0.0%	0.0%	10.5%	11.1%
Tot	n	32	52	2	1	1	219	307
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0 %

The results in Table 4.2 show that most of the respondents are aged between 36 and 45 years representing 35.5% (n=109). Of these, majority (77.98%, n=85) are community members. Furthermore, the results show that 34.4%(n=11) committee members, 36.5% (n=19) secretaries are aged between 26 and 35 of whom majority are community members representing 32.0% of the total community members (n=219). The results indicate that majority of the residents of Garbatula Sub-County involved in the water supply management and sustainability are the youths and the middle-aged people.

Table 4.4: The highest level of education attained by position in the committee

Position		**The highest level of education attained**					**Tot**
		None	Primary	Secondary	Tertiary	College/ University	
Member	n	14	9	7	1	0	**31**
	%	45.2%	29.0%	22.6%	3.2%	0.0%	**100.0%**
Secretary	n	25	12	11	0	2	**50**
	%	50.0%	24.0%	22.0%	0.0%	4.0%	**100.0%**
Chair	n	0	1	1	0	0	**2**
	%	0.0%	50.0%	50.0%	0.0%	0.0%	**100.0%**
Vice Chair	n	0	0	1	0	0	**1**
	%	0.0%	0.0%	100.0%	0.0%	0.0%	**100.0%**
Vice treasurer	n	0	1	0	0	0	**1**
	%	0.0%	100.0%	0.0%	0.0%	0.0%	**100.0%**
Community member	n	92	77	42	4	5	**220**
	%	41.8%	35.0%	19.1%	1.8%	2.3%	**100.0%**
Tot	**n**	**131**	**100**	**62**	**5**	**7**	**305**
	%	**43.0%**	**32.8%**	**20.3%**	**1.6%**	**2.3%**	**100.0%**

The study findings in Table 4.3 show that 43.0% (n=131) of the respondents had no formal education, 32.8% (n=100) had primary level of education, 20.3% (n=62) had

secondary education while only 1.6% (n=5) and 2.3% (n=7) had tertiary and college and/or university education respectively. The high number of residents with no formal education can be attributed to the nomadic nature of the residents in search of pasture and water for the livestock. Therefore,the respondents would provide valid and consistent information about sustainability of water supplies in their locality.

4.4 Functionality of water source and use

The study sought to evaluate the main source of water used by respondents, its functionality and reasons for functionality

Table 4.5:The main source of drinking water

Source	Frequency	Percent
Piped water into the dwelling place	65	21.1
Borehole	219	71.1
Protected Shallow Well	1	0.3
Unprotected Shallow Well	12	3.9
Water Pan	11	3.6
Total	**308**	**100.0**

The results in Table 4.5 show that 71.3% (n=219) of the respondents use boreholes as their main source of drinking water, 65 representing 21.1% indicated that they get drinking water from piped water into their respective dwelling place while 3.9% (n=12) showed that they get drinking water from unprotected shallow wells.

Table 4.6: Water source functional or non-functional

Response	Frequency	Percent
Functional	268	87.3
Non-Functional	39	12.7
Total	**307**	**100.0**

The study findings in Table 4.6 shows that most of the water sources are functional as represented by87.3%(n=268) of the respondents who affirmed. However, minority of the respondents indicated that the water sources are not functional (12.7%, n=39). The functionality of the water sources reveals that water is treated as a very important resource by the community.

Table 4.7: Reasons for non-functionality

Reasons	Frequency	Percent
Pump broken	8	20.5
Solar System not working	6	15.4
Generator mechanical issues	17	43.6
Lack of fuel	1	2.6
Dried because of dry weather	6	15.4
Damaged by flooding	1	2.6
Total	**39**	**100.0**

Of those who reported that their water sources are non-functional in Table 4.6, the results in Table 4.7 show that 43.6% (n=17) showed that the non-functionality of the water sources is due to mechanical issues originating from the generator, 20.5% (n=8) indicated that it was due to broken pumps while 15.4% (n=6) reported that the non-functionality of the water sources is due to either solar system not working or the water sources dried due to weather.

4.5 Choice of technology

The study sought to evaluate influence of choice of technology on sustainability of water supply projects for rural communities in Garbatula Sub County. The study focused on the type of technology used for abstraction, participation in technology, factors to consider when selecting a technology, frequency of breakdown, duration of repair, responsible for repairs and costs.The findings are presented through tables below:

Table 4.8:Most common technologies used for abstraction of water

Technology	Frequency	Percent
Generator powered	154	50.0
Solar Powered	129	41.9
Hand pump	14	4.5
Buckets	11	3.6
Total	**308**	**100.0**

According to the study findings in Table 4.8, the majority of the respondents (50.0%, n=154) posited that they use generator powered for water abstraction and 41.9% (n=129) use solar powered.

Table 4.9: Participation in technology selection

	Frequency	Percent
Yes	15	6.1
No	230	93.9
Total	**245**	**100.0**

The research findings in Table 4.9 shows that most respondents from the study do not take part in the selection of the technology used in water abstraction. This represented 93.9% (n=230) of the respondents.

Table 4.10: Issues to consider when selecting technology

The issues to consider	Frequency	Percent
Type of water point (surface, borehole, shallow well etc.)	39	15.9
Water yield	2	0.8
Depth of aquifer	2	0.8
Durability	4	1.6
Ease of operations and maintenance	10	4.1
Donôt know	188	76.4
Availability of parts	1	0.4
Total	**246**	**100.0**

The conclusions in Table 4.10 show that most of the respondents indicated that they didnôt know about the choice of technology used in water abstraction (76.4%, n=188) and therefore didnôt know about the issues to consider when selecting a technology. Furthermore, the findings indicate that 15.9% (n=39) of the respondents posited that the type of water point should be an issue to be considered when selecting the appropriate technology.

Table 4.11: Breakdown of water supply

	Frequency	Percent
Yes	187	60.7
No	121	39.3
Total	**308**	**100.0**

The findings in Table 4.11 indicate that 60.7% (n=187) of the respondents had their water supply broken leading to water interruption while 39.3% (n=121) of the respondent indicated that they have never had water supply broken down or interrupted.

Table 4.12: The causes of water breakages

Problems	**Frequency**	**Percent**
Broken parts	15	9.3
Pump not operational	16	9.9
Busted/Leaking pipes	96	59.3
Damaged solar system	3	1.9
Mechanical problem with generator	32	19.8
Total	**162**	**100.0**

The breakage in water supply is mainly caused by busted/leaking pipes as shown by most of the respondent in Table 4.12 representing 59.3 % (n=96). The findings also suggest that mechanical problems with the generator is another problem that causes water interruption as shown by 19.8% (n=32) of the respondents.

Table 4.13: Duration taken to repair breakdowns

	Frequency	Percent
Yes	118	63.1
No	69	36.9
Total	**187**	**100.0**

The findings in Table 4.13 show that when there are breakdowns in the water supply, it takes considerably longer time before they are repaired. This is supported by 63.1% (n=119) of the respondents.

Table 4.14: The reasons why repair takes long

Reasons	Frequency	Percent
Lack of spare parts	35	29.4
Lack of specialized technician	55	46.2
No funds for repair	15	12.6
I donôt know	14	11.8
Total	**119**	**100.0**

According to the study findings in Table 4.14, the respondents cited various reasons as to which it takes long for the broken supply system to be repaired. The most common reason is lack of spare parts (29.4%, n=35) and lack of specialized technician (46.2%, n=55).

Table 4.15: Repair and replacement of the water supply systems

Who repairs the broken water supply systems	Frequency	Percent
Paid local untrained technician	101	40.2
Paid local trained technician on operations and maintenance	12	4.8
Paid technician from outside the ward	69	27.5
Ministry of Water, Energy, Environment and Natural Resources	59	23.5
CDF	1	0.4
NGOs	3	1.2
Unpaid Well-wishers/Volunteers	6	2.4
Total	**251**	**100.0**

According to the study findings in Table 4.15, most of the respondents (40.2%, n=101) indicated that untrained local technicians are the ones who repair or replace the parts of the water supply system during breakdowns, 27.5% (n=69) showed that the paid technician from outside the ward do repair or replacement for the breakdowns of the water system while 23.5% (n=59) indicated that ministry of water, energy, environment and natural resources is responsible for the repair and replacement of the water systems upon breakdown.

Table 4.16: Payment of the broken water supply system

	Frequency	Percent
Water management committee with revenues collected	229	74.4
Water management committee through haram bees	4	1.3
Ministry of Water, Energy, Environment and Natural Resources	56	18.2
CDF	6	1.9
NGOs	3	1.0
Well wishers	10	3.2
Total	**308**	**100.0**

According to findings in Table 4.16, 74.4% (n=229) showed that the repairs and replacement of the broken water systems are paid by water management committee with revenues collected. Furthermore, 18.2% (n=56) showed that the payment is made by ministry of water, energy, environment and natural Resources.

Table 4.17: Spare parts shops availability

	Frequency	Percent
Yes	9	2.9
No	299	97.1
Total	**308**	**100.0**

The respondents were asked if there are shops within the area that stocks the spare parts for water supply systems and from the study findings in the Table 4.17, majority of the respondents (97.8%, n=308) indicated that there are no shops within the area that stock spare parts for water supplies systems in the area. This is could be the reason as to why the repairs and or replacement take too long to be affected as earlier reported in the study.

Table 4.18: Affordability of the spare parts

	Frequency	Percent
Yes	20	6.5
No	16	5.2
Don't know	272	88.3
Total	**308**	**100.0**

According to the study findings in Table 4.18, most of the respondents could not tell whether the spare parts are affordable or not. This represented 88.3% (n=272) of the respondents. However, 6.5% (n=20) agreed that the spare parts area affordable while 5.2% (n=16) disagreed that the spare parts are affordable.

Table 4.19: Revenue generated sufficient for repair

	Frequency	Percent
Yes	199	80.9
No	47	19.1
Total	246	100.0

The findings in Table 4.19 shows that most of the respondents (80.9%, n=199) believe that the revenue raised from the water supply is enough to sustain system repairs and replacement while 19.1% (n=47) showed that the revenue is not enough for the repair.

Table 4.20: Reasons why the revenue collected is not sufficient

	Frequency	**Percent**
Revenue collected not sufficient	7	15.9
Major parts and replacements expensive	21	47.7
Revenue collected is mismanaged	4	9.1
Tariff too low	9	20.5
Unwillingness to pay for water by some consumers	2	4.5
Donq know	1	2.3
Total	**44**	**100.0**

According to the study findings in Table 4.20, those who indicated that the revenue is not sufficient cited that major parts and replacements of the water systems are expensive (47.7%, n=21) and that the tariffs are too low (20.5%, n=9) to sustain the repair.

4.6Socio-economic factors influencing sustainability

The study sought to establish the influence of socio-economic factors on sustainability of water supply projects for rural communities in Garbatula Sub County, Isiolo. The focus was on household size and demand for water, payment for water, trend of payment, willingness to pay and reasons for nonpayment and payment.

Table 4.21: Water collected for domestic use by households

Amount of water used	Frequency	Percent
40 litres (2 jerry cans)	3	1.2
60 litres (3 jerry cans)	13	5.2
80 litres (4 jerry cans)	57	22.7
More	178	70.9
Total	**251**	**100.0**

The study findings in Table 4.21 show that most of the respondents use more than 80 litres (4 jerry cans) representing 70.9% (n=178) of the respondents. The study also reveals that 22.7% (n=57) of the respondents use 60 litres of water while minority of the respondents (1.2%, n=3) use 40 litres of water.

Table 4.22: Payment for water

	Frequency	**Percent**
Yes	261	83.7
No	47	15.3
Total	**308**	**100.0**

The study findings in Table 4.22 reveal that, 83.7% (n=261) of the respondents pay for the water they use while 15.3% (n=47) do not make any form of payment towards the water they use for domestic purposes.

Table 4.23: Ways of payment

	Frequency	Percent
Per 10 litre jerrycan	80	30.2
Per Month	115	43.4
Per consumption (Metered connection) per month	8	3.0
Per number of jerrycans (no limit to capacity)	62	23.4
Total	**265**	**100.0**

The study findings in Table 4.23reveals that a majority of the respondents (43.4%, n=115) pay for water monthly while 30.2% (n=80) pay per 10 litre jerrycan. The results also show that 23.4% (n=62) pay per the number of jerrycans they use.

Table 4.24: The amount of payment

	Median	Min	Max
If yes how much do you pay per 10 litre jerrycan of water	1.0	0.0	5.0
How much do you pay per month?	400.0	100.0	4000.0
On average how much do you pay per consumption per month?	400.0	50.0	3500.0

The study findings in Table 4.24reveal that the respondent make an average of Ksh 1.0 as a payment per 10 litre jerrycan of water. On a monthly basis, the respondents make an average of payment of Ksh 400 per consumption per month.

Table 4.25: Trend of payment

	Frequency	Percent
Consistent	106	37.6
Regular	156	55.3
Occasional	20	7.1
Total	**282**	**100.0**

The study findings in Table 4.25 reveal that the respondents are consistent and or regularly pay for the water as accounted for by 37.6%(n=106) and 55.3% (n=156) respectively of the respondents.

Table 4.26: Willingness to pay for water by other consumers

	Frequency	Percent
Yes	218	70.8
No	90	29.2
Total	**308**	**100.0**

It is shown in Table 4.26 that 70.8% (n=218) of the respondents are willingness to pay for thewater by other consumers while 29.2% (n=90) are unwillingness to pay for water by other consumers.

Table 4.27: Reasons for willingness to pay

	Frequency	Percent
Good water provision services	103	51.5
Need to generate revenue for repairs and maintenance	24	12.0
Affordability of water	32	16.0
Reliability of water	41	20.5
Total	**200**	**100.0**

According to the study findings in Table 4.27, of those who are willingness to pay, 51.5% (n=103) indicated that they are willingness to pay if there are good water provision services and 20.5% (n=41) are unwillingness to pay more if there is reliability of water supply.

Table 4.28: Demotivation of willingness to pay

	Frequency	Percent
Already it's expensive due to high tariffs	16	8.7
Alternative source available (river) for other uses but not drinking	8	4.4
Breakdowns take too long to be repaired	10	5.5
Committee management	1	0.5
Delay of elevated tank in our village.	6	3.3
Due to poor supply of water	1	0.5
Each household need individual connection	3	1.6

Insufficient supply of water	10	5.5
Lack of water at the kiosk	13	7.1
Mismanagement of funds	10	5.5
No committee in place	2	1.1
No diesel used	1	0.5
No village representative in water office	5	2.7
Poor delivery of water	15	8.2
Poor management and longer repairing period	12	6.6
Rationing and mode of delivery tampers with quality	12	6.6
Refusal at the water point	5	2.7
Repair and maintenance process	1	0.5
Sharing of one water point with livestock	19	10.4
Some people fetch from the river which is free	3	1.6
The waterpoint is far from the household	5	2.7
They need individual connection	17	9.3
water is not enough, no supply storage tank	4	2.2
Water management committee are corrupt	1	0.5
Water treatment is not done. They say borehole water is clean, but delivery process contaminates the water	3	1.6
Total	**183**	**100.0**

The study findings in Table 4.28 show the reasons that demotivates the residentsô willingness to pay for water supply. Most respondents (9.3%, n=17) indicated that they are not willingness to pay due to the fact that they need individual water connections. 8.7% (n=16) indicated that they are not willingness to pay since water is very expensive due to high tariffs. 8.2% (n=15) cited poor delivery of water while 6.6% (n=12) mentioned management and longer repairing period.

Table 4.29: Reasons for not paying for water

	Frequency	Percent
Water is provided for free at the Water kiosk	6	42.9
We fetch at sources not under management (Surface water river)	8	57.1
Total	**14**	**100.0**

The study findings in Table 4.29 show that 57.1% (n=8) of the respondents are not paying for water because they fetch water from sources and not under management (Surface water river) while 42.9% (n=6) are not paying since water is provided for free at the Water kiosk.

Table 4.30: Source of income

	Frequency	Percent
Sale of livestock	143	46.7
Business	83	27.1
No source	25	8.2
Employed as casual	33	10.8
Employed in government	21	6.9
Employed in an NGO	1	0.3
Total	**306**	**100.0**

The chief source of revenue in the area is proceeds from the sales of livestock as indicated by 46.7% (n=143) of the respondents in Table 4.32. The results reveal that 6.9% (n=21) are employed by the government and hence get their income from the salaries they earn.

4.4 Socio-cultural factors influencing sustainability

The study sought to evaluate socio-cultural factors influencing sustainability of water supply projects for rural communities in arid and semi-arid lands, a case of Garbatula Sub County. The researcher therefore studied participation, positive and negative traditions that may influence sustainability of the water supply projects, beliefs associated with water and gender participation through decision making.

Table 4.31:Participation in the development processes

	Frequency	Percent
Yes	55	22.1
No	194	77.9
Total	**249**	**100.0**

According to study findings in Table 4.31 most of respondents (77.9%, n=194) have never participated in the development processes of the water project while 55% have participated in water supply development. This means that majority of the residents could have little say in the development process of water projects and supply in the area.

Table 4.32: Type of participation in the development processes

	Frequency	**Percent**
Cash	2	1.0
Unpaid labor contribution	22	11.4
Paid labor	37	19.2
Contribution of unpaid local materials	2	1.0
No contribution	3	1.6
No participation	127	65.8
Total	**193**	**100.0**

The study findings in Table 4.32, indicate that during the project development majority of the respondents (65.8%, n=127) never had any form of participation while 19.2% (n=37) participated through paid labour. 11.4% (n=22) contributed unpaid labour.

Table 4.33: Decision making among participants in the development process

	Frequency	Percent
Men only	80	26.3
Men and women	222	73.0
Men and children	1	0.3
Men, Women and Children	1	0.3
Total	**304**	**100.0**

The study findings in Table 4.33 show that during the decision making about water in the community, both men and women are equally involved as reported by 73.0% (n=222) of the respondents. However, it is important to note 26.3% (n=80) mentioned men only as important decision makers.

Table 4.34: Traditions that positively influence management of water supplies

	Frequency	Percent
Communal collective responsibility to provide protection of water points	3	1.7%
Don't know	134	75.7%
Paying of fines to elders for none compliance to protection of source	4	2.3%
Protection of available water sources	27	15.3%
Other reasons	9	6.7%
Total	**177**	**100.0%**

The study findings in Table 4.34 shows that most of the respondents representing 75.7% (n=134) donâ t know of existence of traditions that positively influence management of water supply while 15.3% (n=27) indicated that protection of available water sources is a tradition that positively influence management of water supply. The findings suggest that communitymembers are simply not aware of practices that can improve water supply and sustainability. Thus, there is need for creating awareness on good practices that can positively sustain water supply in the area.

Table 4.35: Tradition that negatively influence management of water supplies

	Frequency	Percent
Don't know	69	37.7%
Gender biasness in decision making	1	0.5%
In older times	2	1.1%
Low participation of women	1	0.5%
Not aware of any	98	53.6%
Selection of committee on tribe or clans	11	6.0%
Water is life any person refusing with water is cursed	1	0.5%
Total	**183**	**100.0%**

The study findings in Table 4.35 shows that most of the respondents (53.6%, n=98) are not aware of any traditions that negatively influence management of water supplies while 37.7% (n=69) indicated that they completely donôt know if there are traditions that negatively affect water supply management. It is imperative to note that 6.0% (n=11) of the respondents reported that selection of committee based on tribe and clan negatively influence the water supply management.

Table 4.36: Beliefs associated with water supplies and their sustainability

	Frequency	Percent
Condemning of people who poison water	2	0.9%
Donôt know	68	31.9%
Mismanagement of water supplies and revenue collection	11	5.2%
None	101	47.4%
Protection of water source	1	0.5%
Selection of committees based on tribe and clan	3	1.4%
They do not maintain the water point properly	14	6.6%
They do not talk to us about water problems	3	1.4%
Water should not be for sale	10	4.7%
Total	**213**	**100.0%**

In responding to the beliefs associated with water supplies and their sustainability, 68 respondents representing 31.9% indicated that they donôt know if there are beliefs , 101

respondents representing 47.4% reported that none existed, 14 respondents representing 6.6% indicated that lack of proper maintenance of water points are such beliefs while 11 respondents representing 5.2% indicated that mismanagement of water supplies and revenue collection is a belief associated with water supplies and their sustainability.

4.5 Water tariffs as a factor influencing sustainability

The study sought to identify the influence of water tariff on sustainability of water supply projects for rural communities in in Garbatula Sub County, Isiolo. The study focused on the awareness of the respondents on Life Cycle Cost Analysis, participation in tariff setting, who is involved in the process, payment for water and water tariff against operation and maintenance

Table 4.37:Life Cycle Cost Analysis

	Frequency	Percent
Yes	43	13.8
No	268	86.2
Total	**311**	**100.0**

From the findings in Table 4.37, most of the respondents (86.2%, n=268) indicated that they have never heard of life cycle cost analysis.

Table 4.38: Participation in tariff setting process

	Frequency	**Percent**
Yes	47	19.3
No	197	80.7
Total	**244**	**100.0**

The study findings in Table 4.38 show that most of the respondents (80.7%, n=197) have never participated in tariff setting process. Further to this, 72.8% (n=211) of the respondents indicated that community income should be major factor to be considered when setting water tariffs. On average, the community members pay Ksh 510 as water tariffs per month.

Table 4.39: Tariff setting process

	Frequency	Percent
Community	22	7.6
Water management committee	172	59.3
County government	15	5.2
National government	4	1.4
Community and water management committee	77	26.6
Total	**290**	**100.0**

The findings in table 4.39 show that water management committee sets the tariffs as reported by 59.3% (n=172) of the respondents while 26.6% indicated that community and water management committee is responsible for setting the tariffs.

Table 4.40: Factors to be considered in tariff setting process

	Frequency	Percent
Community income	211	72.8
Repairs and maintenance	71	24.5
Payments of salaries	7	2.4
For use by water management committee to purchase office items	1	0.3
Total	**290**	**100.0**

The findings in Table 4.40indicate that 72.8% percent of the respondents believe that the community income should be considered in tariff setting while 24.5% are of the opinion that repairs, and maintenance should be a factor when setting tariffs.

Table 4.41: Payment for water

Size	Median	Min	Max
10 litre jerrycan	1.0	1.0	5.0
20 litre jerrycan	2.0	1.0	1000.0
Per month	400.0	50.0	3500.0
Average per consumption (metered)	**511.8**	**60.0**	**1240.0**

The results in Table 4.41 show that for 10 litre jerrycan, the residentsaveragely pay Ksh 1.0 up to the maximum of Ksh 5.0. On monthly average the resident pays approximately Ksh 400.0 while those with meters pay an average of Ksh 511.80.

Table 4.42: Current tariff and repair and maintenance

	Frequency	**Percent**
No, non-consistent payment of water with poor management	89	29.4
Yes, because revenue is collected from each household	135	44.6
Yes, because no major breakdowns occur	58	19.1
Yes, no diesels required	21	6.9
Total	**303**	**100**

The study findings in Table 4.42 shows that majority of the resident (44.6%, n=135) agreed that the current tariffs are sufficient for repairs and maintenance since revenue is collected from each household. However, 29.4% of the respondent disagreed that it is not enough due to non-consistent payment of water tariffs with poor management.

Table 4.43: Willingness to pay more if services improved

	Frequency	**Percent**
Yes	187	61.7
No	116	38.3
Total	**303**	**100.0**

The study findings in Table 4.43 show that most of the respondents (61.7%, n=187) are willingness to pay more if water services were improved through access, safety and reliability while 38.3% (n=116) of the respondents indicated that community they are not willingness to pay more even if there is improvement in the water supply services.

4.6 Specialized training of service teams

The study sought to evaluate specialized training of service teams and how it influences sustainability of water supply projects for rural communities in Garbatula Sub County, Isiolo. The area of focus was whether respondents and service teams have received training, nature of training, impact of training on attitude towards management of water supply projects and applicability of the training content.

Table 4.44: Receiving specialized training on water management

	Frequency	Percent
Yes	28	9.1
No	279	90.9
Total	**307**	**100.0**

It is clear from the research findings in Table 4.44 thatmost of the community members have not received any specialized training on water management as represented by 90.9% (n=279) of the respondents. However, only about 9.1% (n=28) of the respondents have received specialized training.

Table 4.45: Nature of training

	Frequency	**Percent**
Operations and Maintenance	10	41.7
Records and book keeping	1	4.2
Water management training	1	4.2
Water treatment	12	50.0
Total	**24**	**100.0**

The study findings in Table 4.45 shows that of the respondents that have received training, the training was mainly on water treatment and operations and maintenance as represented by 50.0% (n=12) and 41.7% (n=10) respectively.

Table 4.46: Training on attitude and involvement in the water management

	Frequency	**Percent**
Always treating water	1	9.1
Avoiding drinking bad water	1	9.1
Hygiene and sanitation	1	9.1
knowhow to treat water	1	9.1
knowledge on causes of diarrhea	2	18.2
None	2	18.2
To monitor revenue collection	1	9.1
water treatment and storage	1	9.1

Water treatment for safe water drinking	1	9.1
Total	**11**	**100.0**

The study findings in Table 4.46show that 18.2% (n=2) of the respondents learnt about the causes of diarrhea after undergoing the training. 9.1% of the respondents learnt about water treatment and hygiene.

Table 4.47:Value of training and applicability to the community

Training or education	**Mean**
Tariff	3.56
Management	4.29
Operations and maintenance	4.25
Revenues savings	4.11
Book keeping	4.81
Customer involvement	4.53
Feedback mechanism and reporting	3.21

The study also sought to establish the aspects of training or education which were of value and applicable to the community. The respondents were required to give their level of agreement on the degree to which aspects of training or education were of value and applicable to the sustainability of water supply. The responses were rated on a five-point Likert scale where: 1 - Strongly Disagree 2 - Disagree 3 - Neutral 4- Agree and 5- Strongly Agree. The mean was generated thereafter and showed in Table 4.48. The study findings in Table 4.47 shows that most of the respondents agreed that rural water supply sustainability depends on factors controlled by the project like; management (mean=4.29), operations and maintenance (mean=4.25), revenues savings (mean=4.11), book keeping (4.81) and customer involvement (4.53). However, tariffs and feedback mechanism and reporting are not of great value and applicability to the community.

Table 4.48: Education and training affect community ownership of water projects

	Frequency	Percent
To a very great extent	153	96.8
To no extent	1	0.6
To a little extent	2	1.3
To a very little extent	2	1.3
Total	158	100.0

In order to further establish the rate of satisfaction of water service parameters on the sustainability of the water supply, the respondents needed to indicate the extent to which they are satisfied with certain key parameters of water supply. The responses were rated on a five-point Likert scale where: 1 = very dissatisfied, 2 = dissatisfied, 3 = neither satisfied nor dissatisfied, 4 = satisfied and 5 = very satisfied. The mean was generated and illustrated in Table 4.48.

4.7 Satisfaction of water service parameters

To establish the degree to which education and training affect community ownership of water projects, the report required the respondents to indicate their level of agreement on the extent to which education and training affect community ownership of water projects in their respective divisions. According to the findings in Table 4.48, majority of the respondents (96.8%, n=153) indicated that education and training affect community ownership of water projects to a very great extent while 1.3% indicated that education and training affect community ownership of water projects to a very little extent. This depicts that through majority of the water projects in the county were professionally managed to ensure the sustainability of the project.

Table 4.49: Satisfaction of water service parameters

Parameters	Mean
Management	3.189
Quality	3.801
Tariff	3.142
Reliability	3.317
Complaints handling	3.382

According to the results in Table 4.49, most of the respondents were neither satisfied nor dissatisfied with the parameters of water supply and sustainability that included; management (mean=3.189), quality of services (mean=3.801), tariffs associated with water supply services (mean=3.142), reliability of water supply services (mean=3.317) and complaint handling (mean=3.382), respectively.

4.8 Regression and correlational analysis

The researcher used a linear regression model to establish the level of significance of the relationship between the independent variables; choice of technology, socio-economic factors, socio-cultural factors, water tariff and specialized training and the dependent variable which was sustainability of water supply projects for rural communities in Garbatula Sub County. The researcher used Statistical Package for Social Sciences (SPSS) to enter, clean, code and compute the measurements of the linear regression.

To study the effect of choice of technology, socio-economic factors, socio cultural factors, water tariffs and specialized training on technical knowledge and skills on sustainability of water supply projects, a multiple regression analysis was carried out. The results are represented as shown below;

Table 4.50: Model summary

Model	R	R square	Adjusted R square	Std. error of the estimate
1	.998[a]	0.995	0.995	0.047320175782655
a. predictors: (constant), specialized training on technical knowledge and skills, choice of technology, socio-economic factors, water tariffs, socio cultural factors				

The study results in Table 4.50 show the model summary and overall fitting statistics. Both the adjusted R^2 and R^2 of the model is 0.995. This means that the regression explains 99.5% of the variation in the data.

Table 4.51: Analysis of Variance (ANOVA)

Model		Sum of Squares	df	Mean Square	F	P-value
1	Regression	11.827	5	2.365	1056.331	.000[b]
	Residual	0.054	302	0.002		
	Total	11.880	307			
a. Dependent Variable: Sustainability of water supply projects						
b. Predictors: (Constant), Specialized training on technical knowledge and skills, Choice of technology, Socio-economic factors, Water tariffs, Socio cultural factors						

The study findings in Table 4.51 shows the analysis of variance which has the null hypothesis that there is no linear relationship between the variables in the regression model, that is, $R^2 = 0$. Since p-value<0.05, the level of significance, we conclude that there is a linear relationship between the dependent variable (sustainability of water supply projects) and the predictor variables (specialized training on technical knowledge and skills, choice of technology, socio-economic factors, water tariffs, socio cultural factors).

Table 4.52: Regression results

Model		Unstandardized Coefficients		t	P-value
		B	Std. Error		
1	(Constant)	0.839	0.072	0.541	0.004
	Choice of technology	0.041	0.021	0.053	0.008
	Socio-economic factors	0.023	0.022	1.044	0.017
	Socio cultural factors	0.339	0.145	2.342	0.028
	Water tariffs	1.209	0.019	51.903	0.000
	Specialized training on technical knowledge and skills	0.331	0.149	2.220	0.036
a. Dependent Variable: Sustainability of water supply projects					

The study findings in Table 4.52 give the regression coefficients, the constant and the significance of all the coefficients and the constant of the model. We establish that our linear regression analysis estimates the linear regression model to be:

Sustainability of water supply projects = 0.839+0.041choice of technology+0.023socio-economic factors+0.339socio cultural factors+1.209water tariffs+0.331specialized training on technical knowledge and skills.

The above model indicates that there is a positive relationship between the predictor variables and the dependent variables. This implies that a unit change in the predictor variables there a positive change in the sustainability of water supply projects by the coefficients of the predictor variables as given in the Table 4.52. In our linear regression analysis, the test, tests the null hypothesis that the coefficients are all 0. The t-test finds that both intercept and variables are significant ($p < 0.05$) and thus we might say that they are different from zero.

Table 4.53: Correlation analysis

	Sustainability of water supply projects	Choice of technology	Socio-economic factors	Socio cultural factors	Water tariffs	Specialized training on technical knowledge and skills
Sustainability of water supply projects (r), p-value (2-tailed)	1					
Choice of technology (r), p-value (2-tailed)	0.677 0.000	1				
Socio-economic factors (r), p-value (2-tailed)	0.514 0.004	0.578 0.001	1			
Socio cultural factors (r), p-value (2-tailed)	0.309 0.006	0.274 0.043	0.506 0.004	1		
Water tariffs (r), p-value (2-tailed)	0.997 0.000	0.685 0.000	0.535 0.002	0.304 0.003	1	
Specialized training on technical knowledge and skills (r), p-value (2-tailed)	0.316 0.001	0.287 0.025	0.534 0.002	0.996 0.000	0.314 0.001	1

To quantify the strength of the relationship between the variables, we used Karl Pearsonôs coefficient of correlation. The Pearson correlation coefficient is a measure of the strength of a linear association between two variables and is denoted by *r*. The Pearson correlation coefficient, *r*, takes a range of values from +1 to -1. A value of 0 indicates that there is no association between the two variables. A value greater than 0 indicates a positive association, that is, as the value of one variable increases so does the value of the other variable. A value less than 0 indicates a negative association, that is, as the value of one variable increases the value of the other variable decreases.

The study findings in Table 4.53 show that there is a positive relationship between sustainability of water supply projects and choice of technology, socio-economic factors, socio cultural factors, water tariffs and specialized training on technical knowledge and skills influence of magnitude 0.677, 0.541, 0.309, 0.997 and 0.316, respectively. The positive relationship indicates that there is a correlation between the factors influencing sustainability and sustainability of water supply projects with water tariffs having the highest value and specialized training on technical knowledge and skills having the lowest correlation value. The study findings further indicate that, all the factors had a significant p-value ($p<0.05$) at 95% confidence level. The significance values for relationship between sustainability of water supply projects and choice of technology, socio-economic factors, socio cultural factors, water tariffs and specialized training on technical knowledge and skills influence of magnitude 0.000, 0.004, 0.006, 0.000 and 0.001, respectively. This implies that water tariffs and choice of technology were the most significant factor, followed by specialized training on technical knowledge and skills, socio-economic factors and socio-cultural factors, respectively.

4.9 Key informants on the water management committees

From the key informantsô perspectives, there are only three active members including chairman and two other members. Furthermore, the gender composition of the committee includes five males and four females. It was further indicated by the key informants that committee contributes in monitoring of water rationing patterns and then convene meetings for contribution towards the water supplies in the area. In addition, it was indicated that the general community assist in the management of water supply through occasional meetings with the county office that collect fuel and distribute to water points.

On the training of the committee, the key informants indicated that the members of the committees have been trained but mainly on general good water management practices that include basic plumbing works and book and record keeping methods. The key informants reaffirmed that the training is quite important as it enhances smooth operations of the water systems.

It was indicated that the committee charges for water supply but occasionally. This is because the existing committee is weak and whenever the committee runs out of money to operate, the members call for contributions from the community to enable it to meet its financial obligations. The water tariffs are collected on monthly basis though the less fortunate groups are exempted from paying for water. Furthermore, it was indicated that the money collected from the fees and or tariffs is used for paying the watchmen and those tasked with the maintenance of the water systems.

It was indicated by the key informants that the revenue collected is not enough to do major repairs and replacement on the water systems. They argued that the payments are made through contributions and so there is no systematic revenue collection method in place. In addition, the committee only collects money for basic repairs such as pipe bursts and replacement while the county does major services such as generator servicing. On the technology used in water abstraction and availability of spare parts for the water supply projectsô equipment, the key informants indicated that the solar and generator power work well if properly managed since most spare parts are not locally available. Nonetheless, with the solar power, the community would be spared on spending on fuel.

It was indicated by the key informants that the main problem facing water management committee is the conflict among the committee members and the use of politics when it comes to the management of the water points. On the other hand, the main problem facing communities in the area with regards to water, payment and involvement in the management to ensure sustainability is the unwillingness to pay for the water as they believe that water should be free. Furthermore, since there are alternative sources like a nearby spring, they donôt want to pay for water. However, whenever an issue arises, meetings are called to solve.

It was also indicated that there are no feedback mechanisms for the communities to raise concerns on water issues and they only communicate to the area MCA or discuss among the committee to solve the issues whenever they arise. The key informantsôcontribution to the water supplies in the area is through proposal writing for support for additional boreholes and also doing basic repairs and maintenance.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

Based on the study findings in line with the study objective, conclusion and recommendations are drawn and presented in this chapter. The research sought to establish the factors influencing the water supply sustainability projects for rural communities in ASAL lands in Kenya with focus in Garbatula Sub County of Isiolo County.

5.2 Summary of Key findings

The study was conducted in Garbatula Sub County to establish factors influencing sustainability of water supply projects for rural communities in Arid and Semi-Arid Lands. The key findings of the study have been summarized according to the five variables of the study namely choice of technology, socio-economic factors, socio-cultural factors, water tariffs and specialized training and how they influence sustainability of water supply projects for rural communities in ASAL.

The total number of questionnaires dully filled was 308 representing 80.2% response rate. Furthermore, 71.4% (n=220) were community members, 16.9% (n=52) were secretaries, 10.4% were just ordinary members of the committee, 0.6% (n=2) were chairpersons while 0.3% (n=1) were either vice chairperson or treasurer. The results also showed that 51% (n=158) respondents were males while 49% (n=150) respondents were females.

5.2.1 Choice of technology influence on sustainability of water supply projects for rural communities in Garbatula Sub County

The study was to evaluate influence of choice of technology on sustainability of water supply projects for rural communities in ASAL. The study revealed that majority of the respondents (50.0%, n=154) use generator powered systems while 41.9% (n=129) use solar powered systems for water abstraction. Other abstraction methods are handpumps used by 4.5% (n=14) respondents while buckets are used by 3.6% (n=11) respondents. It was found majority 93.9% (n=230) of the respondents do not take part in technology selection.

Most of the respondents indicated that they didnôt know about the choice of technology used in water abstraction (76.4%, n=188) and therefore didnôt know about the issues to consider when selecting a technology. However, 15.9% (n=39) of the respondents posited that the type of water point should be an issue to be considered when selecting the appropriate technology.

Findings indicate that 60.7% (n=187) of the respondents had their water supply broken leading to water interruption while 39.3% (n=121) indicated they never had their system breakdown. The breakdowns were found to be mainly caused by busted/leaking pipes as mentioned by 59.3 % (n=96) of the respondents. Mechanical problems with the generator was another major problem that caused water interruption as highlighted by 19.8% (n=32) of the respondents. It was found that 63.1% (n=119) of the respondents reported it took longer for breakdowns to be addressed because of lack of spare parts (29.4%, n=35) and lack of specialized technician (46.2%, n=55).

Most of the respondents (40.2%, n=101) indicated that untrained local technicians are the ones who repair or replace the parts of the water supply system during breakdowns. 27.5% (n=69) showed that the paid technician from outside the ward do repair or replacement for the breakdowns of the water system while 23.5% (n=59) reported the County Government is responsible for the repairs of the breakdowns.

Majority of the respondents 74.4% (n=229) showed that the repairs and replacement of the broken water systems are paid by water management committee with revenues collected while 18.2% (n=56) indicated the Ministry of Water, Energy, Environment and Natural Resources paid for the repairs. 97.8%, n=308) indicated that there are no shops within the area that stock spare parts for water supplies systems in the area. However, 88.3% (n=272) could not tell the weather spares are affordable or not. 80.9% (n=199) of respondents believe that the revenue raised from the water supply is enough to sustain system repairs and replacement while 19.1% (n=47) showed that the revenue is not enough for the repair. Out of the respondents who mentioned the revenue is not sufficient, 47.7% (n=21) reported major parts and replacements expensive.

5.2.2 Socio-economic factors influence on sustainability of water supply projects for rural communities in Garbtula Sub County

70.9% (n=178) of the respondents use more than 80 litres (4 jerry cans) while 22.7% (n=57) use 60 litres. 82.1%, n=206) was then require more than 100 litres of water for domestic use. Since there appears to be high demand for water, majority of the respondents (62.5%, n=155) use water the water points more due to the demand for extra water.

83.7% (n=261) of the respondents pay for the water they use while 15.3% (n=47) do not make any form of payment. 57.1% (n=8) of the respondents are not paying for water because they fetch water from sources and not under management (Surface water river) while 42.9% (n=6) are not paying since water is provided for free at the Water kiosk. 9.3%, n=17) of the respondents indicated that they are not willingness to pay due to the fact that they need individual water connections. 8.7% (n=16) indicated that they are not willingness to pay since water is very expensive due to high tariffs. 6.6% (n=12) respondents reported poor management and longer repairing period as demotivating factor towards payment for water.

Majority of the respondents (43.4%, n=115) pay for water monthly while 30.2% (n=80) pay per 10 litre jerrycan. The results also show that 23.4% (n=62) pay per the number of jerrycans they use. Findings revealed that the respondent make an average of Ksh 1.0 as a payment per 10 litre jerrycan of water. On a monthly basis, the respondents make an average of payment of Ksh 400 per consumption per month. However, 70.8% (n=218) of the respondents are willingness to pay for the water while 29.2% (n=90) are unwillingness to pay for water by other consumers. For those willingness to pay water (51.5% (n=103) indicated that they are willingness to pay if there are good water provision services.

The main source of revenue in the area is proceeds from the sales of livestock as indicated by 46.7% (n=143) of the respondents.

5.2.3 Socio-cultural factors influence on sustainability of water supply projects for rural communities in Garbatula Sub County

According to study findings most of the respondents (77.9%, n=194) had never taken part in the process of the development of the water project. Asked if there is any type of participation 65.8% (n=127) never had any form of participation while 19.2% (n=37) participated through paid labour and 11.4% (n=22) had participated through unpaid labour. Majority of the respondents (73.0% (n=222) reported men and women make important decisions regarding the development process while 26.3% (n=80) indicated men only make such important decisions.

The study found that most of the respondents representing 75.7% (n=134) donâ t know of existence of traditions that positively influence management of water supply while 15.3% (n=27) indicated that protection of available water sources is a tradition that positively influence management of water supply. It was also found that (53.6%, n=98) are not aware of any traditions that negatively influence management of water supplies while 37.7% (n=69) indicated that they completely donâ t know if there are traditions that negatively affect water supply management. It is imperative to note that 6.0% (n=11) of the respondents reported that selection of committee based on tribe and clan negatively influence the water supply management. 68 respondents representing 31.9% indicated that they donâ t know if there are beliefs and 101 respondents representing 47.4% reported that none existed.

5.2.4 Water tariffs and sustainability of water supply projects for rural communities in Garbatula Sub County

The study found 86.2% (n=268) of the respondents indicated that they have never heard of life cycle cost analysis while 13.8% (n=43). Findings also showed that most of the respondents (80.7%, n=197) have never participated in tariff setting process. Further to this, 72.8% (n=211) of the respondents indicated that community income should be major factor to be considered when setting water tariffs. On average, the community members pay Ksh 510 as water tariffs per month.

The findings showed that water management committee sets the tariffs as reported by 59.3% (n=172) of the respondents while 26.6% indicated that community and water management committee is responsible for setting the tariffs.

Asked what factors to consider when setting tariffs, 72.8% (n=211) of the respondents believe that the community income is a major factor followed by repairs and maintenance as reported by 24.5% (n=71) respondents. Findings of the study found that respondents pay Ksh. 1 for 10 litre jerrycan, Ksh. 2 to a maximum of Ksh. 5 for 20 litre jerrycan. On monthly average the resident pays approximately Ksh 400 while those with meters pay an average of Ksh 512.

The study findings show that majority of the resident (44.6%, n=135) agreed that the current tariffs are sufficient for repairs and maintenance since revenue is collected from each household. However, 29.4% of the respondent disagreed that it is not enough due to non-consistent payment of water tariffs and poor management.

The study revealed that most of the respondents (61.7%, n=187) are willing to pay more if water services were improved through access, safety and reliability while 38.3% (n=116) of the respondents indicated that community they are not willingness to pay more even if there is improvement in the water supply services.

5.2.5 Specialized training of service teams influence on sustainability of water supply projects for rural communities in Garbatula Sub County

Most of the community members have not received any specialized training on water management as represented by 90.9% (n=279) of the respondents. However, only about 9.1% (n=28) of the respondents have received specialized training. Respondents that have received training was mainly on water treatment and operations and maintenance as represented by 50.0% (n=12) and 41.7% (n=10) respectively. The study findings show that 18.2% (n=2) of the respondents learnt about the causes of diarrhea after undergoing the training while 9.1% of the respondents learnt about water treatment and hygiene.

Majority of the respondents agreed that rural water supply sustainability depends on factors controlled by the project like; management (mean=4.29), operations and maintenance (mean=4.25), revenues savings (mean=4.11), book keeping (4.81) and

customer involvement (4.53). However, tariffs and feedback mechanism and reporting are not of great value and applicability to the community.

During Key informantsô interviews, it was reported the members of the committees which form part of the operations and maintenance (service teams) have been trained but mainly on general good water management practices that include basic plumbing works and book and record keeping methods. The service teams do not have adequate training and equipmentôs. The key informants reaffirmed that the training is quite important as it enhances smooth operations of the water systems. It was also reported by key informant that the remuneration of the technicians, plumbers is a challenge when committees donôt manage funds well thus may shy from offering services.

According to the findings, majority of the respondents (96.8%, n=153) indicated that education and training affect community ownership of water projects to a very great extent while 1.3% indicated that education and training affect community ownership of water projects to a very little extent.

According to the results of the study, most of the respondents were neither satisfied nor dissatisfied with the parameters of water supply and sustainability that included; management (mean=3.189), quality of services (mean=3.801), tariffs associated with water supply services (mean=3.142), reliability of water supply services (mean=3.317) and complaint handling (mean=3.382), respectively.

5.3 Discussion of key findings

The discussion of the findings of the study have been discussed according to the five variables of the study namely choice of technology, socio-economic factors, socio-cultural factors, water tariffing and specialized training and how they influence sustainability of water supply projects for rural communities in Arid and Semi-Arid Lands.

5.3.1 Choice of technology influence on sustainability of water supply projects for rural communities Garbatula Sub County

The first objective of the study was to evaluate the choice of technology influence on sustainability of water supply project for rural communities in Arid and Semi-Arid Lands in Garbatula Sub County. This was investigated with a focus on the type of technology,

participation in technology selection, frequency of breakdowns, duration of repairs and maintenance, availability of skilled technicians and availability of funds for operations and maintenance.

The study revealed that the main technology for water abstraction is powered through generators followed secondly by solar powered technologies in Garbatula Sub County. Ninety four percent of the water supply projects beneficiaries do not take part in the selection of the technologies used with an explanation that it is the County Government and development organization who implement the projects chose the technologies. It also revealed that majority of the community, 76.4% of respondents did not have knowledge on issues to consider when selecting technologies.

It was reported majority of the breakdowns are caused by leaking/busted pipes followed by generator mechanical issues. Findings established that it took longer for repairs to be done due to the fact that there were lack of spares parts shops and untrained local technicians. This was supported by explanation that the beneficiaries would source for skilled trained technicians from outside the area/ward or sub county.

It was also important to note that responsibility of the repairs and maintenance was done by water management committee where as in some instances 23.5% respondents reported it was the County Government addressed repairs of breakdowns. The above findings are in line with observations made by Reed, 2004, that adopted technologies must have available spare parts to aid in replacements and lack of available spare parts in the rural societies resulted to lack of capability to sustain water systems. He also observed that pipeline dug over long kilometers faced challenges with detection thus dalayed response further leading to loss of revenues through loss of water in turn unsustained systems.

Findings from studies conducted by Adaka, 2017 and Mamburi ,2014, in Isiolo County, reiterates that breakdowns are due to poor operations and maintence espcially on the generator powered systems which require regular oil change as was reported by key information (Sub County water officer).

5.3.2 Socio-economic factors influence on sustainability of water supply projects for rural communities in Garbatula Sub County

Findings indicate that majority of respondents pay for water while also consuming 80 litres of water for domestic use. There appears to be high demand for water given majority would still want more than 100 litres. Over eighty percent pay for water while the rest do not make any form of payment. The reasons behind nonpayment was because water was free at the kiosk, water is available through surface rivers and sixteen mentioned the price of water is too high. 6.6% (n=12) respondents reported poor management and longer repairing period as demotivating factor towards payment for water.

Majority of respondents pay water an average of ksh. 400 per month while a significant few pay per 10 litre jerrycan. There is willingness from the respondents to pay more should there be good water services. It was found respondents in the study area rely mainly on sale of livestock as their major source of income.

The relationship between demand and supply is important for sustainability in aspect of spending involved during demand which would help generate revenues in turn ensuring availability of funds for maintenance (Nketiah-Amponsah, Aidam, & Senadza, 2009), from the findings there was no significant relationship between water demand as respondents not willingness to pay for water still consumed 80 litres and would still want more water

5.3.3 Socio-cultural factors influence on sustainability of water supply projects for rural communities in Garbatula Sub County

The was no significant relationship between cultural factors and sustainability of water supply projects for rural communities in ASAL. However, it is important to note that men still were regarded as important decision makers in water supply projects despite women involvement. The study found there no positive or negative cultural practices that respondents were aware or not aware that could be sufficiently and directly linked to sustainability of water supply projects. It was noted that selection of water management committee members was based on tribe and clan which could have a negative connotation as reported by six percent of the respondents.

Other findings involved beliefs that water should not be for sale attributed by 4.7% of the respondents. It could also be noted that protection of available water sources was key as a social practice as reported by 15.3% of the respondents.

The findings echoed observations by Beneye (2012) that women participation was still low in the development of water supply projects where important decisions are made.

5.3.4 Water tariffs influence on sustainability of water supply projects for rural communities in Garbatula Sub County

The study found out that over 80 percent of the respondents do not take part in tariff setting despite reporting itôs the responsibility of the community together with the water management committee to set the tariffs. Majority indicated community income as major factor to consider in tariff setting followed by repairs and maintenance. On average respondents pay Ksh. 1 per 10 litre jerrycan, between Ksh. 2 ï Ksh. 5 per 20 litre jerrycan and average of Ksh. 510 per month for metered connection while flat rate at Ksh. 400 per month. Forty four percent of respondents agreed current tariff was sufficient, however the rest reported it was not enough for repairs and maintenance due to non-consistent payments and poor management.

187 respondents were found to be willingness to pay more water if the services were improved with regards to access, safety and reliability. The rest of the respondents indicated not willingness to pay more even if there were any improvements in the water supply services.

The findings are in line with Huggins, 2000, observation that people might not be represented during water tariff setting which may lead to prices being too high for the poor. He noted there is need to raise awareness and encouraging everyone to pay for water and giving the choice of accepting small amount of water to every individual at subsidized rate which could ensure income that could be used to sustain water supply systems(Huggins, 2000). He also observed water tariffs need to project on the cost of the water supply system, as well as allow for repairs and the development of new amenities when the areas experienced increased demands by the population. The findings also concur with findings from a study conducted in Kitui by Mwangangi, 2016, that

willingness to pay and tariff setting needs to consider financial capacity of communities. (Mwangangi P. M., 2016).

5.3.5 Specialized training of service teams influence on sustainability of water supply projects for rural communities in Garbatula Sub County

The study established many beneficiaries have not undergone specialized training. This could be linked to the fact that repairs are majorly done by untrained local technicians. However, it is important to note that only 9.1% (n=43) of respondents have undergone training with some undergoing training on water treatment and operations and maintenance. Respondents could also attribute importance of training to learning about causes of diarrhea, water treatment and hygiene. Majority of the respondents agreed that rural water supply sustainability depends on two main factors such as book keeping (4.81) and customer involvement (4.53). It was important to note that tariffs and feedback mechanism and reporting is not of great value and applicability to the community.

During Key informantsô interviews, it was reported the members of the committees which form part of the operations and maintenance (service teams) have been trained but mainly on general good water management practices that include basic plumbing works and book and record keeping methods. The service teams do not have adequate training and equipmentôs. The key informants reaffirmed that the training is quite important as it enhances smooth operations of the water systems. It was also reported by key informant that the remuneration of the technicians, plumbers is a challenge when committees donôt manage funds well thus may shy from offering services.

According to a study in Woreda in Ethiopia, 2012, there was found to be a relationship between training and functionality of water systems that would have some influence on their sustainability (Beyene, 2012). This finding supports findings of delayed response to repairs by untrained local technicians. Due to weak managerial skills of water management committees as observed by Bhandari and Grant, 2007, they recommended institutional strengthening through capacity building (education) on holistic water management systems to ensure sustainability.

5.4 Conclusion

Water plays a significant role in the daily lives of every individuals. It is the most important basic need of life and no living organism can do without.Thus, it can be regarded as the basic unit needed in life. Itôs uses range from drinking, cooking and washing. This explains the importance of the resource and hence the need for its sustainability especially in ASALareas of Kenya where the main economic activity is nomadic cattle rearing.

The study has revealed that most of the residents of Garbatula Sub County of Isiolo County lack formal education. This can be attributed to the nomadic nature of the residents in search of pasture for their livestock. The study further revealed that community members constitute the biggest proportion of water management committee. It can be deduced that this is due to encouragement of local involvement of the local residents in the management of the water supply in the region so that they are involved in the water sustainability programmes. It can also be deduced that most of the residents are conversant with water supply projects in the area. The research has also established that the main source of drinking water is borehole of which most of them are functional. However, the other water sources that are non-functional arise from mechanical issues originating from the generator.

The study has established the main technology used water abstraction is the use of powered generators followed by solar powered technology. However, the residents indicated that they do not take part in the selection of the technology used in water abstraction. In addition, it is the water stakeholders that are involved in management and running of the operation of the rural community-based water projects. It has also been revealed that most of the residents didnôt know about the choice of technology used in water and therefore didnôt know about the issues to consider when selecting a technology. In addition, the findings indicate that the residentsô respondents had their water supply broken leading to water interruption. The breakage in water supply is mainly caused by busted/leaking pipes. The findings also show that when such breakage occur in the water supply, it takes considerably longer time before they are repaired. The respondents cited

various reasons as to which it takes long for the broken supply system to be repaired. The most common reason is lack of spare parts and lack of specialized technician.

The study has revealed that untrained local technicians are the ones who repair or replace the parts of the water supply system during breakdowns with little responsibility from indicated that ministry of water, energy, environment and natural resources. Furthermore, the study has shown that the repairs and replacement of the broken water systems are paid by water management committee with revenues collected. However, the biggest impediment to repairs and replacement is the lack of shops within the area that stock spare parts for water supplies systems in the area. This is could be the reason as to why the repairs and or replacement take too long to be affected as earlier reported in the study. In addition, the residents believe that the revenue raised from the water supply is enough to sustain system repairs and replacement. However, it was also found that in some instances, the residentsô highlighted misuse of revenues collected thus unwillingness to pay.

On the socio-economic factors affecting water sustainability, the study has established that the demand of water is high and most of the residents use the water points more due to the demand for extra water to meet their needs. The residents do pay for the water they use which is mostly done on a monthly basis in which the payment is consistent and or regular. The study has also revealed that the residents are willingness to pay for water by other consumers if there are good water provision services as well as reliability. It has been established that the chief source of income in the area is proceeds from the sales of livestock. This explains the main economic activity in the area.

The study has revealed that residents have never taken part in the processes of development of the water project. This means that the residents have little say in the development process of water projects and supply in the area. Furthermore, during the project development the residents have never had any form of participation. It is important to note that during the decision making about water in the community, both men and women are equally involved as reported. The study has also revealed that the residents are not ware or simply donôt know of existence of traditions that positively influence management of water supply. However, it is established that protection of

available water sources is a tradition that can positively influence management of water supply. The findings suggest that community members are simply not aware of practices that can improve water supply and sustainability. Thus, there is need for creating awareness on good practices that can positively sustain water supply in the area. On the other hand, the study has established that the residents believe that selection of committee based on tribe and clan negatively influence the water supply management.

The study reveals that the residents have never heard of life cycle cost analysis and hence have never participated in tariff setting process since it is set mainly by the water management committee. Further to this, the study has established that community income should be major factor to be considered when setting water tariffs. On average, the community members pay Ksh 510 as water tariffs per month. It is clear from the study findings that majority of the community members have not received any specialized training on water management. However, the few residents that have received specialized training, were mainly on water treatment and operations and maintenance.

5.5 Recommendations

Water supply sustainability is a critical project that ensures that there is continuity in supply of water. Various actors need therefore to come together to develop a proper policy aimed at efficient operations of water supply. In view of this, the recommendations below are made: -

1. The training of residents on water sustainability and maintenance of water sources should be reinforced. As per the study findings, most of the residents have no formal education. This implies that the professionals are needed to help the community learn essentials of water source maintenance. Furthermore, training may never be conducive for the residents due to lack of formal education. It is thus recommended that the policy makers should come up with a friendly water sustainability and maintenance curriculum and affordable fees to encourage adequate training of the residents.
2. With the establishment that the biggest challenges facing water supply projects is frequent breakdown such as pipe bursts and generator with longer down times, there

is need to promote alternative systems such as solar systems, training of local technicians on both current technologies that are easy to operate and maintain.

3. It is also recommended for government to promote spare parts stockiest or private sector engage on Private Public Partnerships models that may involve provision of spare parts among other services to reduce on mechanical or technical challenges that could be faced by service teams or management committees.
4. County government to conduct life cycle cost analysis to help in setting realistic tariffs from which revenues can be collected would help raise money for major or expensive parts. This would help in awareness raising link between cost of establishing a water infrastructure and cost of both minor and major replacements.

5.6 Future research

Based on the findings of this research, there are areas that are worth looking into for future research to enhance smooth and efficient water supply. There is need for further study of choice of technology, socio-cultural, socio-economic, water tariffs and specialized education factors influencing sustainability of water supply projects for rural communities in arid and semi-arid lands.

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Appendix 1: Letter of Transmittal of Research Instruments

Emmanuel Steve Olela

P.O Box 103,

Oyugis, Kenya.

Mobile No: +254716091713

Email: stevee.olela@gmail.com

Dear Sir/Madam,

RE: REQUEST FOR YOUR PARTICIPATION IN M.A RESEARCH PROJECT

I am a student at the University of Nairobi pursuing Master of Arts Degree in Project Planning and Management. As a pre-requisite of the coursework, I would like to conduct a research project to investigate factors influencing water supply sustainability projects for rural communities in ASAL lands in Garbatula Sub County, Isiolo County.

You have been selected to participate in this study and your voluntary participation was be highly appreciated. During this time, I would like to seek your honest answers and opinion for questions in the questionnaire (s). The information you provide was be used for academic research purposes but may also inform the County Government in planning future projects. Your identity and Information was be highly confidential.

In case of any information or clarifications, please contact the researcher on telephone number 0716091713.

Thank you.

Yours sincerely,

Emmanuel Steve Olela

L50/87029/2016

Appendix 2: Household Questionnaire

Questionnaire number: ____ Date: _____

The purpose of this interview is to collect data on a Research to determine the factors influencing sustainability of semi-arid and arid rural water supplies. The interview was comply to research principles including ensuring confidentiality and anonymity of respondents.

Name of County:		Name of Sub County	
Name of Ward:		Name of borehole:	
Name of Interviewee (Optional)		Date:	

Section A: Background information of respondent

Please answer the following questions by ticking √ or **X** on the boxes and circle on response choices provided below

1. Respondents name (Optional): _____
2. Age bracket of respondent

   ☐18-25 ☐26-35 ☐36-45 ☐46-55 ☐55 and above

3. What is you sex

   ☐Male ☐Female

4. What is your highest level of education
   a. None
   b. Primary
   c. Secondary
   d. Tertiary
   e. College/University
5. What is your position in the water management committee?
   a. Member
   b. Secretary

c. Chairperson
d. Vice Chairperson
e. Treasurer
f. Vice treasurer

6. For how long have you stayed in this area?
    a. 0 - 3 months
    b. 1 - 3 years
    c. 3 - 5 years
    d. More than 5 years
7. How many family members do you live with?

    _____

8. What is your **main** source of drinking water
    a. Piped water into the dwelling place.
    b. Borehole
    c. Protected Shallow Well
    d. Unprotected Shallow Well
    e. Protected Spring
    f. Unprotected Spring
    g. Rainwater Collection
    h. Water Pan
9. Is your nearest water source functional or non-functional?
    a. Functional
    b. Non-functional
    c. Abandoned
10. If nonfunctional or abandoned, what could be the reason?
    a. Water quality
    b. Pump broken
    c. Solar System not working
    d. Generator mechanical issues
    e. Lack of fuel
    f. Community moved to another location

g. Dried because of dry weather
h. Damaged by flooding

Section B: Choice of technology

11. What is the most common technologies used for abstraction of water for community members to use?
    a. Generator powered
    b. Solar Powered
    c. Hand pump
    d. Buckets
12. Did you take part in the selection of the technology?
    a. Yes
    b. No
13. Do you know issues to consider when selecting a technology?
    a. Type of water point (surface, borehole, shallow well etc.)
    b. Water yield
    c. Depth of aquifer
    d. Durability
    e. Ease of operations and maintenance
    f. Donôt know
    g. Availability of parts
14. In the last 3-6 months have your water supply broken down or water supply interrupted?
    a. Yes
    b. No
15. If Yes, what was the problem
    a. Broken parts
    b. Pump not operational
    c. Busted/Leaking pipes
    d. Lack of water at the water scheme
    e. Damaged solar system
    f. Mechanical problem with generator

16. In your own opinion, do you felt it took less or longer time to repair?
    a. Yes
    b. No
17. If yes to above, what was the reason?
    a. Lack of spare parts
    b. Lack of specialized technician
    c. No funds for repair
    d. I donôt know
18. Who repairs or replacements of parts of the water supply systems during breakdowns?
    a. Paid local untrained technician
    b. Paid local trained technician on operations and maintenance
    c. Paid technician from outside the ward
    d. Ministry of Water, Energy, Environment and Natural Resources
    e. CDF
    f. NGOs
    g. Unpaid Well-wishers/Volunteers
19. Who pays for the repair works?
    a. Water management committee with revenues collected
    b. Water management committee through haram bees
    c. Ministry of Water, Energy, Environment and Natural Resources
    d. CDF
    e. NGOs
    f. Well wishers
20. Are there shops within the area that stock spare parts for water supplies systems in the area?
    a. Yes
    b. No
21. How affordable are the spare parts?
    a. Yes
    b. No

c. Donôt know

22. In your own opinion, is the revenue you are paying enough to sustain system repairs and replacement?
    a. Yes
    b. No
23. If No, why so?
    a. Revenue collected not sufficient
    b. Major parts and replacements expensive
    c. Revenue collected is mismanaged
    d. Tariff too low
    e. Unwillingness to pay for water by some consumers
    f. Donôt know

Section C: Socio-economic factors influencing sustainability

24. How much water does your household collect for domestic use? (do not include water for watering animals or gardens) (20litre is standard jerry can)
    a. 20 litres (1 jerry can)
    b. 40 litres (2 jerry cans)
    c. 60 litres (3 jerry cans)
    d. 80 litres (4 jerry cans)
    e. More
25. How much water would your household need more if you had access to more water?
    a. 40 litres (2 jerry cans)
    b. 60 litres (3 jerry cans)
    c. 80 litres (4 jerry cans)
    d. 100 litres (5 jerry cans)
    e. more
26. Due to the demand for extra water, do you use the water point more?
    a. Yes
    b. No
27. Do you pay for water?

a. Yes
b. No

28. How do you pay for water

a. Per 10 litre jerrycan
b. Per Month
c. Per consumption (Metered connection) per month
d. Per number of jerrycans (no limit to capacity)

29. If yes how much do you pay per 10 litre jerrycan of water

_____

30. How much do you pay per month?

_____

30. On average how much do you pay per consumption per month?

_____

31. What is the trend of payment?

a. Consistent
b. Regular
c. Occasional

32. Is there willingness to pay for water by other consumers?

a. Yes
b. No

33. What drives the willingness to pay (multiple choices)?

a. Good water provision services
b. Need to generate revenue for repairs and maintenance
c. Affordability of water
d. Reliability of water

34. What demotivates the willingness to pay?

_____

35. If No in **27** above, what are the reasons for not paying for water?

a. Water is provided for free at the Water kiosk
b. Water is free at standpipe
c. We fetch at sources not under management (Surface water river)

36. What is the source of income for the household?

a. Sale of livestock
b. Business
c. No source
d. Employed as casual labor
e. Employed in Government
f. Employed in an NGO

Section D: Socio-cultural factors influencing sustainability

37. Have you participated in the development processes of the water project?

a. Yes
b. No

38. What type of participation did you have during the project development?

a. Cash
b. Unpaid labor contribution
c. Paid labor
d. Contribution of unpaid local materials
e. Contribution of paid local materials
f. No contribution
g. No participation

39. Who participates in mostly makes important decisions about water in this community

a. Men only
b. Men and women
c. Men and children

d. Women and Children
e. Men, Women and Children

40. Is there any culture or traditions that positively influence management of water supplies? To what extent.

41. Is there any culture of tradition that negatively influence management of water supplies? To what extent?

42. What are the beliefs associated with water supplies and their sustainability?

Section E: Water tariffs as a factor influencing sustainability

43. Have you ever heard of Life Cycle Cost Analysis?

a. Yes
b. No

44. Have you ever participated in tariff setting process?

a. Yes
b. No

45. Who sets the tariff?

a. Community
b. Water management committee
c. County Government
d. National Government
e. Community and Water management committee

46. In your own opinion, what factors should be considered when setting a tariff?

a. Community income
b. Repairs and maintenance
c. Payment of salaries
d. For use by water management committee to purchase office items

47. How much do you pay for water per

a. 10 litre jerrycan_____

b. 20 litre jerrycan_____

c. Per month_____

d. Average per consumption (metered)_____

48. In your own opinion, is the current tariff sufficient for repairs and maintenance? Why

49. Are you was to pay more if water services were improved through access, safety and reliability?

Section F: Specialized training

50. Have you received any specialized training on water management (if Yes,) What was the nature of training (If No, skip)

51. Did the training influence your attitude and involvement in the water management? If Yes, How? (If No, skip)

52. Did the training make you feel ownership of the water supply? If Yes How? If No, skip)

53. Which aspects of training or education have been of value to you in a scale of 1-5

	1	2	3	4	5
Water quality					
Water treatment					
Mode of delivery					
Tariff					
Management					
Operations and maintenance					
Revenues savings					
Book keeping					
Customer involvement					

Feedback mechanism and reporting					

54. To what extent does education and training affect community ownership of water projects in your division?
    a. To a very great extent
    b. To no extent
    c. To a little extent
    d. To a very little extent

55. How can you rate your satisfaction of the following water service parameters?

1=Very dissatisfied, 2=dissatisfied, 3=neither satisfied nor dissatisfied, 4= satisfied, 5=very satisfied

Category	**1**	**2**	**3**	**4**	**5**
Management					
Quality					
Tariff					
Reliability					
Complaints handling					

Appendix 3: Focus Group Guide Interviews: Water Management committees

County		**Sub County**	
Ward		**Village**	
FGD NO.		**No. of Participants**	

1. How many members are actively involved in the water management committee?
2. What is the gender composition of the committee?
3. What do the committee contribute in general to the water supplies in the area?
4. Do the general community assist in the management of the water supplies? If so, how are they involved?
5. Have members of this committee been trained? If Yes? What was the nature of training?
6. In your own opinion, why is the training of members of the water management committee important?
7. Do you charge for water? If so, what tariff do you charge for consumers of water?
8. If NO above, why?
9. What is the method of collection of water fee?
10. How do you use the money you collect?
11. Do you think the revenues collected are enough to do major repairs and replacement? Why?
12. What is your opinion on technology used in water abstraction and the availability of spare parts for the water supply projects in this area?
13. What are the main problems facing water management committee?
14. What are the main problems facing communities in this area with regards to water, payment for water and involvement in the management to ensure sustainability? ***Probe and check for attitudes, opinions, breakdowns, income etc.***
15. Are there feedback mechanisms for the communities to raise concerns on water issues in place? How are the decisions communicated?
16. What was your/community contribution to water supplies in this area?

Participants List

S/N	Name	Title	Gender	Village name	Tell
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

Appendix 4: Key Informant Interview – Ward Administrator

Name of Interviewee: _____

Position: _____

Contacts: _____

1. Both National Government, County Government and Civil Society Organizations have invested a lot in the water supplies in this County. What is your opinion on the water supplies sustainability in Sericho Ward?
2. Do communities participate or involved in the development of these water supplies in Sericho (If Yes, why, If No, why?)
3. What are the major challenges facing water supplies in your Sericho Sub County
4. Are water management committees trained? What is the nature of training?
5. Do the trainings influence sustainability of these water points?
6. What type of technologies have been used in Sericho Water Supplies?
7. Who is responsible for choosing these technologies?
8. What is considered when choosing a technology?
9. Who does operations and maintenance of the water supplies in Sericho?
10. Do consumers of water pay for water in the rural water supplies?
11. In your own opinion, is the tariff charged by water management committee sufficient for major repairs and replacement?
12. What can be done to improve on revenue collection to be sufficient?
13. What is the attitude of the community towards paying for water in Sericho?
14. Do the community have knowledge and skills on Operations and Maintenance?
15. Is there a role culture plays in the rural water supplies management in the area?
16. Are there policies, laws, regulations that guide rural water supplies management now that Water services is a devolved function?
17. In your own opinion, what are the success factors that need to be considered to ensure rural water supplies are self-sustaining?
18. How can sustainability be achieved for the rural water companies?

Appendix 5: Key Informant Interview – Garbatula Sub County Water Officer

Name of Interviewee: _____

Position: _____

Contacts: _____

1. Both National Government, County Government and Civil Society Organizations have invested a lot in the water supplies in this County. What is your opinion on the water supplies sustainability in Sericho Ward?
2. Do communities participate or involved in the development of these water supplies in Sericho (If Yes, why, If No, why?)
3. What are the major challenges facing water supplies in your Sericho Sub County
4. Are water management committees trained? What is the nature of training?
5. Do the trainings influence sustainability of these water points?
6. What type of technologies have been used in Sericho Water Supplies?
7. Who is responsible for choosing these technologies?
8. What is considered when choosing a technology?
9. Who does operations and maintenance of the water supplies in Sericho?
10. Do consumers of water pay for water in the rural water supplies?
11. In your own opinion, is the tariff charged by water management committee sufficient for major repairs and replacement?
12. What can be done to improve on revenue collection to be sufficient?
13. What is the attitude of the community towards paying for water in Sericho?
14. Do the community have knowledge and skills on Operations and Maintenance?
15. Is there a role culture plays in the rural water supplies management in the area?
16. Are there policies, laws, regulations that guide rural water supplies management now that Water services is a devolved function?
17. In your own opinion, what are the success factors that need to be considered to ensure rural water supplies are self-sustaining?
18. How can sustainability be achieved for the rural water companies?

Appendix 6: Key Informant Interview – County Water Engineer

Name of Interviewee: _____

Position: _____

Contacts: _____

1. Both National Government, County Government and Civil Society Organizations have invested a lot in the water supplies in this County. What is your opinion on the water supplies sustainability in Sericho Ward?
2. Do communities participate or involved in the development of these water supplies in Sericho (If Yes, why, If No, why?)
3. What are the major challenges facing water supplies in your Sericho Sub County
4. Are water management committees trained? What is the nature of training?
5. Do the specialized trainings influence sustainability of these water points?
6. What type of technologies have been used in Sericho Water Supplies?
7. Who is responsible for choosing these technologies?
8. What is considered when choosing a technology?
9. Who does operations and maintenance of the water supplies in Sericho?
10. Do consumers of water pay for water in the rural water supplies?
11. In your own opinion, is the tariff charged by water management committee sufficient for major repairs and replacement?
12. What can be done to improve on revenue collection to be sufficient?
13. What is the attitude of the community towards paying for water in Sericho?
14. Do the community have knowledge and skills on Operations and Maintenance?
15. Is there a role culture plays in the rural water supplies management in the area?
16. Are there policies, laws, regulations that guide rural water supplies management now that Water services is a devolved function?
17. In your own opinion, what are the success factors that need to be considered to ensure rural water supplies are self-sustaining?
18. How can sustainability be achieved for the rural water companies?

Appendix 7: List of Water Points – Boreholes in Garbatula Sub County

		UMT Coordinates		LOCATION			Population			Current Operation Status	Management	Abstraction type
		GPS location					Rates (m3/day); people-0.02, cattle-0.0175, shoats, 0.0035, camels-0.0335, donkeys-0.0175					
No	**Abstraction point name**	Latitude	Longitude	**Village/ Community**	**Ward**	**Sub county**	**No. of HH**	**Total No.of People**	**Total No. of Livestock**			
1	Boji borehole 2	0.570 8033 56	38.339 15615	Boji	Gar batu la	Gar batu la	50	30 0	1,60 0	Operational	Community	diesel genset
2	Boji borehole 1	0.570 8033 56	38.339 15615	Boji	Gar batu la	Gar batu la	400	2,4 00	19,0 00	Operational	Community	diesel genset
3	Taiboto borehole	0.569 6073 98	38.444 54039	Garb atula	Gar batu la	Gar batu la	200	60 0		Operational	LMD	no extraction
4	Eskot (Skot) Borehol	0.129 9753 3	38.496 09138	in skot tradin	Gar batu la	Gar batu la	292	1,7 50	0	Non-operation	Community	solar pump

	e			g centre						al		
5	Malka Daka Borehole	0.82812551 1	38.50659619	in Malka daka	Garbatula	Garbatula		3215		Operational with frequent breakdowns	Community	diesel genset
6	Mata Gari Tinga borehole	0.52750870 5	38.50714605	in Garbatula town	Garbatula	Garbatula		1200		Operational		diesel genset
7	Sister Waliyana borehole	0.53815588 6	38.51655366	in Garbatula town	Garbatula	Garbatula	200	1500		Operational	Community	mains electric
8	Garba Tulla Hospital borehole	0.53517253 2	38.51897515	in Garbatula town	Garbatula	Garbatula	Hospital (15 bed capacity and HHs (30)	500		operational	Institutional	solar
9	Garfasa borehole	0.94224282 8	38.59487202	in Gafarsa town	Garbatula	Garbatula	400	2947		Operational	Community	solar pump
10	Bubisa borehole	0.93544627 9	38.59896609	in Garbatula town	Garbatula	Garbatula		0		Operational	Community	solar pump

11	Much'uro borehole	0.96208890 3	38.6202708	in Much uro tradin g centre	Gar batu la	Gar batu la	110	660	14,800	Oper ation al	Com munit y	diese l gense t
12	Benane Borehole	0.50364646 4	38.6630811	in Bena ne tradin g cente r	Seri cho	Gar batu la		250		Oper ation al	Com munit y	diese l
13	Belgesh Borehole	0.83481606 87	38.72861364	in Belge sh Area/ Garfa sa locati on	Gar batu la	Gar batu la		336	2,740	Oper ation al	Com munit y	diese l gense t
14	Range Water borehole/Gawasco	0.54248683	38.47797236	in Garb atula town	Gar batu la	Gar batu la		1150		Oper ation al		no extra ction
15	Yaqbarsadi	0.57257691	38.08011077	Kula mawe	Kin na	Gar batu la	0	120		Oper ation al	Com munit y	Diese l
16	Shauri Yako Borehole	0.56933135 9	38.19427658	in Kula mawe town	Kin na	Gar batu la		0		Non-oper ation al	Com munit y	Diese l
17	Livestock Holding Ground Borehole	0.33555279 7	38.19878163	in Kinn a town	Kin na	Gar batu la		0		Non-oper ation al		NUL L
18	Kula Mawe Borehole	0.56984445 2	38.19901807	in Kula mawe town	Kin na	Gar batu la	700	3093	4000 cattle,	Oper ation al		Diese l (List er)

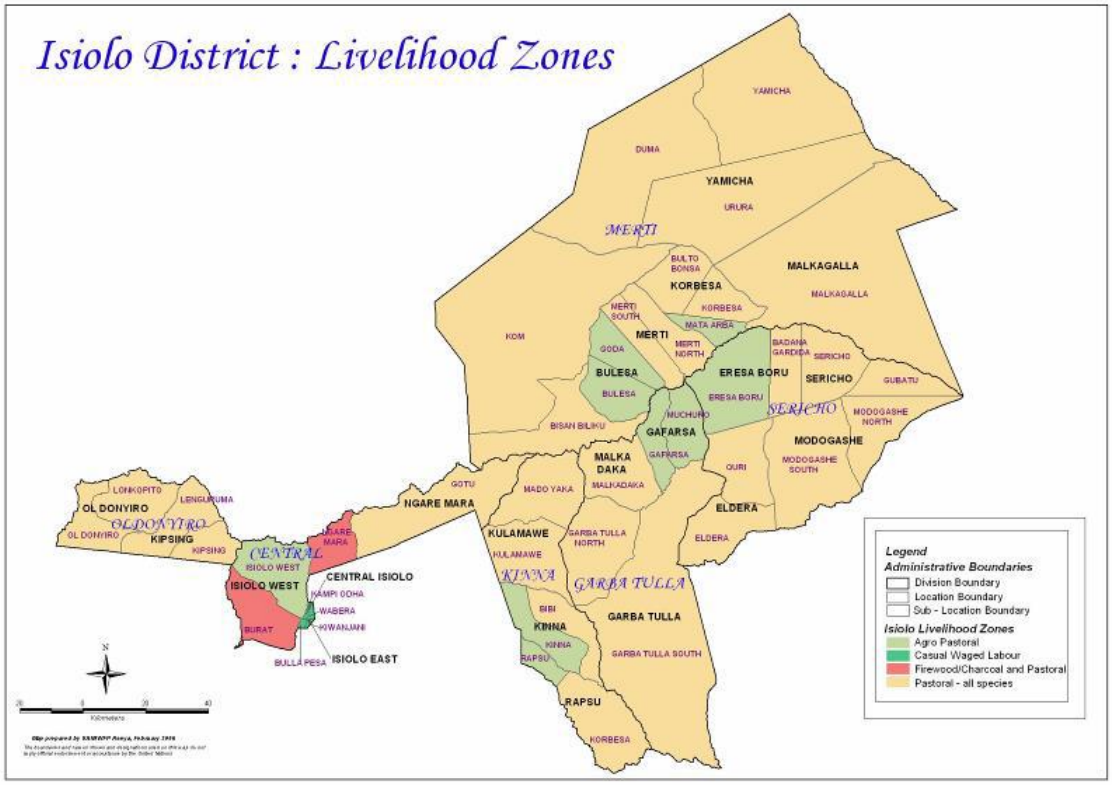
									2000 other			
19	Kubiaro Borehole (In Sec Schools	0.5723075 1	38.20614656	Next to kulamawe town	Kinna	Garbatula	0	0		Non-operational		diesel
20	Mosque Borehole	0.31822252 96	38.20857767	in Kinna town	Kinna	Garbatula	200	1,200		Non-operational	Institutional	NULL
21	Jilo Dima Borehole	0.31975115	38.21318908	in Kinna town	Kinna	Garbatula		2,400		Operational	Community	Electricity
22	Bibi Borehole	0.36396845	38.2283274	between Molliti and kinna	Kinna	Garbatula	300	1,218	3,250	Operational	Community	Diesel/solar
23	Rapsu Borehole	0.25853435 1	38.24256327	in Rapsu	Kinna	Garbatula		1,278		operational	Community	NULL
24	Ell Iresaboru Gotu Borehole	1.06587835 4	38.74130693	in Iresaboru trading center	Sericho	Garbatula	250	2,690		Operational	Community	diesel genset
25	Kobbe Bulti Loni borehole	1.99568228 2	38.88294601	in Badha Galan Waso	Sericho	Garbatula	0	0		Non-operational	Community	diesel genset
26	Danti Borehole	1.18432495 3	38.98628137	in Badha Galan Waso	Sericho	Garbatula	0	0		Non-operational	Community	diesel genset
2	Ell	1.126	39.055	in	Seri	Gar	0	0		Non-	Com	diese

7	Biliqi Borehole	034077	93799	Biliqi trading center	cho	batula				operational	munity	l genset
28	Ell Daaba Borehole	1.17723129 6	39.10805762	in Badha Galan Waso	Sericho	Garbatula	0	0		Non-operational	Community	diesel genset
29	Bisan Sericho Borehole			in Sericho town	Sericho	Garbatula		5,064		Operational	Community	genset
30	Kombola Borehole	00o, 58', 28.999'	038O,38',35.561"	Kombola	Garbatula	Garbatula	150	725		Operational	Community	Diesel Gensets
31	Kula Mawe 1 new B/H (C-9641)	00o, 34', 94.443'	038O,11',36.075"	Kula mawe	Kinna	Garbatula		0		Not yet equipped	Community	Diesel Gensets
32	Kula Mawe AP post (SA-66)			Kula mawe	Kinna	Garbatula		50	14,600	Operational	Community	diesel genrators
33	Malkadaka B/H (World Vision)	00o, 52', 31.634'	038O,29',2.141"	Malkadaka	Garbatula	Garbatula	650	3,215	3,250	Operational	Community	diesel generators
34	Malkadaka Old B/H C-4475)	00o, 52', 23.198'	038O,28',56.156"	Maldaka	Garbatula	Garbatula		0		Operational	Community	diesel generators
35	Alfallah Garbatula B/H	0.539122	38.208271	Alfallah	Garbatula	Garbatula		0		Non-operational	institutional	diesel genset
36	Gababa	0.697979	39.136114	Gababa	Sericho	Garbatula	0	0		Non-operational	Community	

37	Hioole (Hilole)	1.019873	39.106572		Sericho	Garbatula	0	0		Non-operational	Community	
38	Modogashe - Moliti			Molliti	Sericho	Garbatula		0		Non-operational	non	

Source:*Department of Water Database (2016), Ministry of Water, Energy, Environment and Natural Resources and Water Resource Authority, Isiolo County.*

Appendix 8: Map of livelihood zones in Isiolo



Source: *Isiolo Map. Source - Isiolo County CIDP 2013-2017 (pg3)*

Appendix 9: Isiolo County Population and Population projections

Constituency	Wards	Total Ward Population (2009)	Projection Ward Population (2018)	Projection Ward Population (2020)	Projection Ward Population (2022)
	Wabera	17,431	19,307	19,679	20,065
	Bulla Pesa	22,722	25,167	25,652	26,156
	Chari	4781	5,296	5,398	5,504
	Cherab	15,560	17,235	17,567	17,911
	Ngare Mara	5,520	6,114	6,232	6,354
	Burat	18,774	20,795	21,195	21,611
	Oldonyiro	15,388	17,044	17,372	17,714
Isiolo North	**Sub Total**	**100,176**	**110,957**	**113,095**	**115,315**
	Garbatula	16,401	18,166	18,516	18,880
	Kinna	14,618	16,191	16,503	16,827
	Sericho	12,099	13,401	13,659	13,927
Isiolo South	**Sub Total**	**43,118**	**47,759**	**48,678**	**49,634**
	Grand Total	**143,294**	**158,716**	**161,773**	**164,949**

Source: *Final Isiolo County 2018-2022 CIDP*