ECONOMIC VALUATION OF CONSUMPTIVE WATER USE SERVICE: A CASE STUDY OF MOUNT MARSABIT WATERSHED ECOSYSTEM, KENYA

BY

BUBICHA MOHAMED JALDESA

C50/5303/2017

A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF ARTS IN BIODIVERSITY AND NATURAL RESOURCE MANAGEMENT IN THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES AT THE UNIVERSITY OF NAIROBI

OCTOBER 2019

DECLARATION

I, Bubicha Mohamed Jaldesa, declare that this is my original work and has not been submitted for examination to any other learning institution.

______________________________ ______________________________

Bubicha Mohamed Jaldesa **Date**

C50/5303/2017

This project report has been submitted for examination with our approval as the university supervisors;

______________________________ ______________________________

Prof. Francis Mwaura **Date**

Associate Professor

Department of Geography and Environmental Studies,

University of Nairobi

______________________________ ______________________________

Dr Parita Shah **Date**

Lecturer,

Department of Geography and Environmental Studies,

University of Nairobi

DEDICATION

This project is dedicated to my late father and my elder sister who took my late father's place and taught me that the best of knowledge is the one learnt for its own sake. It is also dedicated to my mother, sisters, nephews and nieces for their prayers and support.

And to Asha Hirsi who taught me that even the largest task can be accomplished if it is done one step at a time.

This is ours.

ACKNOWLEDGEMENT

I would like to express my gratitude to my university supervisors, Professor Francis Mwaura and Dr. Parita Shah, they have been the ideal supervisors. Their sage advice, insightful statements, and patient persuasion encouraged the writing of this project report in untold ways. Guidance and steadfast support of the supervisors in this work was greatly needed and deeply appreciated. I would also like to thank the authority of the University for providing me with a good environment and facilities to complete this project report.

I am indebted to the National Drought Management Authority (NDMA) for their support during the field work, my sincere thanks extended to Marsabit County Department of Economic Planning and specifically Mr. Qalicha Malicha the Assistant Director planning for his insights to my fieldwork. I appreciate the contribution of my friends for their prayers, encouragement and for being available to assist in many ways throughout this journey. Finally, an honorable mention goes to my family for their commitment to see me prosper in life. Without the help of the particular persons mentioned above, I would have faced many difficulties while doing this work.

To all of you I say, May Allah (SWA) remember you in all your doings.

ABBREVIATIONS AND ACRONYMS

AGREF	Agricultural Research Foundation
ASL	Above Sea Level
CBD	Convention on Biological Diversity
CIDP	County Integrated Development Plan
CoP	Conference of Parties
CVM	Contingent Valuation Method
FGD	Focus Group Discussion
GoK	Government of Kenya
GPS	Global Positioning System
HPM	Hedonic Pricing Method
KALRO	Kenya Agricultural and Livestock Research Organization
KNBS	Kenya National Bureau of Statistics
KWS	Kenya Wildlife Service
MEA	Millennium Ecosystem Assessment
MoALF	Ministry of Agriculture Livestock and Fisheries
MPM	Market Price Method
NBSAP	National Biodiversity Strategies and Action Plans
NDMA	National Drought Management Authority
NWSB	Northern Water Service Board
PWA	Point of Water Access
SPSS	Statistical Packages for Social Sciences
TCM	Travel Cost Method
TEV	Total Economic Value
WRMA	Water Resources Management Authority
WTA	Willingness to Accept
WTP	Willingness to Pay

ABSTRACT

Mount Marsabit ecosystem is a significant dry-land water tower supporting vast sets of ecosystem goods and services. The study sought to document watershed ecosystem service beneficiaries and their characteristics and mapping of the water points within the ecosystem. Local communities are dependent on the benefits from the ecosystem for their well-being, there has been an increased demand for its use humans and livestock. Further, the ecosystem supports wildlife. These contributions are not adequately catered in policy and management; as a result the ecosystem is degraded. The general objective of the study was to determine the economic value of the consumptive use services provided by Mount Marsabit watershed ecosystem. The estimation of monetary value was undertaken through the market price method (MPM) using market price of water in the area. Both primary and secondary data was analysed. 158 MPM questionnaires were administered at the point of water access in central, Karare and Sagante/Jaldesa wards. The questionnaires were coded and analysed to generate summary descriptive statistics. From the study, it was established that different water sources exist in the ecosystem including water pans, shallow wells, boreholes, springs and crater lakes. Key types of consumptive watershed service beneficiaries in the ecosystem include domestic water users, livestock keepers, commercial water users, conservationists, tourism operators and small scale farmers. Water pans and boreholes provided water for livestock use while shallow wells and springs are used for domestic water supply. Water abstraction was high in springs and least in shallow wells. Daily water abstraction by humans for domestic use and livestock watering was nearly 1,784,616 litres/day. Some consumers got water for free while others bought it, the average consumer price was Ksh 5 ($0.05) per 20 litre jerry can. The estimated annual monetary value of the consumptive service was Ksh 58,285,026 or $582,035. Sagante zone of Mt. Marsabit was hydrologically productive with higher values estimated, at Ksh 30,477,943. The estimated value could be higher than the value calculated since much has not been done to tap surface run off from the rainfall intercepted by the forest ecosystem. Values of dry water points were not considered in the study. The study depicts critical role played by the ecosystem in water supply and by extension the betterment of locals' livelihood. Findings from the study could be used to inform decision-making at County and national levels management plans for green growth, and international thinking on environment and sustainable development issues. The study recommends further economic studies of the ecosystem conducted using Total Economic Valuation framework.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE: INTRODUCTION

1.0 Background of the Study

Most ecosystems across the globe provide various goods like food, water, energy and medicines for human wellbeing. They also contribute to services such as climate regulation, biogeochemical cycling and biodiversity support. Further, cultural, spiritual and recreational services are important functions associated with ecosystems (Porras *et al.,* 2008). Forest watershed ecosystems on highlands are vital for rural areas and cities as sources of water supply which is a necessity to all countries of the globe. Such ecosystems function as hydrological powerhouses with their ability to intercept rain, serving as spring and stream discharge (Mwaura *et al.,* 2016*).*

Watershed ecosystems drain water to a common outlet. They tend to be the point source of the ecosystem functions, basin's water, and biodiversity. According to Luck *et al.* (2009), watershed is area of land that separates and feeds water flowing beneath it from different sources forming network of rivers and streams draining it into oceans, seas and basins. Watersheds form major water sources for human and animal livelihood in different ecosystems. People in the deserts, savannah, mountains, and other geographical locations rely heavily on watersheds for water consumption, recreation, and even commercial activities. From an ecological point of view, watersheds is river basins varying in size, biophysical, and in the characterisation (Luck *et al.*, 2009).

According to United States Geological Survey (USGS), 71% of the earth is water covered out of which 97.5% is salty and only 2.5% of it is fresh. Less than 1% of the world's fresh water is available for human consumption as much of it is locked up in polar icecaps and glaciers. The United nations-Water Energy Health Agriculture and Biodiversity framework (UN-WEHAB) (2002) strongly links fresh water resources and forest ecosystems. Forests are termed as key in water resources supply. Further, Forests also play crucial role in water and soil conservation, regulation of water flow and control of watershed erosion and floods (Kipkoech *et al.,* 2011). However, when the vegetation cover is tempered with greatly, water conservation roles are decreased and this would consequently lower the quality and quantity of water flowing downstream from the watershed.

Ecosystems such as wetlands, forests and grasslands are critical players in the global water cycle, hence the need for their proper management. Valuation of resources plays a significant role in ecosystem management and protection. In as much as it is not easily captured at all times, natural resources are valuable assets for both the present and the coming generation. Highland forest ecosystems are highly valued across the globe with its necessity of clean water provisioning for human well-being. A third of the world's largest cities including Tokyo, Mumbai, New York, Sydney, Melbourne and Bogota rely on forest watersheds for their drinking water (Dudley & Stolton, 2003). According to Paterson *et al*. (2015), in South Africa, the Cape and Drakensberg mountain forest ecosystem are the two main sources of water for Cape Town, Johannesburg and Durban; this illustrates how crucial highland forest watersheds are to human well-being.

In Kenya, water is an essential commodity to homesteads in both urban and rural areas, population found in those areas have their water and sanitation companies depending on forest watershed for their water supply (Nairobi City County, 2014). In Nairobi, the capital city of Kenya, approximately 0.5 million cubic meters of water is supplied on a daily basis, most of these waters originate from the mountain ecosystem Nairobi City County, (2014), over 100 bottled water companies also depend on various watershed across the country. Proper management of forest watershed ecosystems is therefore of importance to enhance sustainable water supply services which are critical as millions of people all over the world depend on water (Mwaura *et al.,* 2016).

High altitude forests like Mt. Marsabit in Kenya are key water catchments and sources that supply water for use in local households, pastoralism and wildlife conservation (Jillo, 2013). Mt. Marsabit ecosystem has economic and biological connections providing invaluable services whose disturbance will greatly impoverish the people depending on them. According to the Agricultural Research Foundation report (2002), Mount Marsabit ecosystem proves its importance in water provisioning services for the surrounding lowland drylands and desert in addition to the wildlife. It harbours crater lakes and streams whose recharge not only comes from rainfall but also mist condensate on bryophyte plants. Mt. Marsabit ecosystem’s service provision is on the brink of loss due to unsustainable use of the ecosystem (Government of Kenya, 2011, Muchura *et al., 2014*). One of the reasons for this is the lack of awareness on the economic value of the ecosystem watershed service.

Ecosystem economic valuation is an attempt to assign monetary values to the services provided by ecosystem regardless of market price availability or not. However, valuation requires division of the services according to their accessibility mode to the beneficiaries, which are categorised as direct and indirect services. Direct use requires beneficiaries' interaction with the ecosystems directly to enjoy the services, among the services are, water use, fuel wood, wild fruits, fishing and hunting categorized under the consumptive services and game watching, photography and worship under non-consumptive. Indirect service are services which are not tangible e.g. climate regulation, air quality moderation etc. Consumptive values of direct services presentation requires use of resource market price in place which helps in value generation (MEA, 2005).

Escalation of ecosystem service valuation is greatly contributing to the area of conservation globally. According to European Environment Agency, (2006) ecosystem valuation is crucial, mostly in matters conservation for both the current and future generation. Wide range of methods are used to infer values on ecosystems. Among the methods used in different studies globally are (Contingent Valuation Method-CVM eliciting values directly from beneficiaries and Travel Cost Method-TCM, hedonic pricing, which deduce price indirectly). MPM provides simplest valuation approach of estimating the consumptive values (Lovett & Noel, 2008).

Regardless of resource market price availability or not, valuation of the goods and services provided by the environmental resources is an important management requirement. Despite this, ecosystem valuation has been disregarded in many parts of the world including Kenya, where a countable number of valuation has been undertaken around the country. Valuing of ecosystems is an essential aspect of conservation as it informs the policymakers and enlightens the general public that the environment is not 'free of charge' even if there may be no typical market for its services. However, the general public, policy specialists and politicians are still not conversant with the values of an ecosystem; this in return hinders the conservation of environmental resources (De Groot *at al*., 2002, MEA 2005). Valuation signals the scarcity of resources by measuring the rate at which the human population is utilising ecological assets, and depending on them to their benefit (Mwaura & Muhata, 2009). Beyond ecosystem valuation, payment for ecosystem services through taxes and fines are among other instruments that can help in ecosystem conservation financing (Porras, 2013). However, ecosystem valuation has proven to be sufficient in informing policy and management decision making.

1.1 Statement of the Research Problem

Forest ecosystem forms a crucial part of global water cycle. Further, communities living around them rely on the exploitation of forest ecosystem for their livelihood. Healthy mountain forests play a vital role in the provision of watershed services among them water use, making them amongst the highly productive ecosystems on earth. Since all fresh water depends on the functionality of ecosystems, proper management is significant in achieving sustainable development. However, these areas are currently facing severe threats from population growth and climate change (Brauman *et al*., 2007). Most of these threats are linked to over exploitation and or over abstraction of ecosystem goods thereby causing many watersheds to diminish over time (Mwaura & Muhata, 2009).

Mount Marsabit is a significant dry-land water tower supporting a larger population of people, livestock and wildlife through water supply. The ecosystem is of crucial importance to the wellbeing of the local communities and there has been an increased demand for its use as a source of water for domestic purpose, livestock watering and irrigation farming. According to Government of Kenya's report, (2011), close to 140,000 people, hundreds of thousands of livestock and wildlife are dependent on the water from the forest. The services that this relatively small ecosystem provides are invaluable and upon its erosion, tens of thousands of people depending on it will become seriously impoverished (Government of Kenya, 2011).

Dry-land areas are likely to be affected by extreme effect of climate change as a result of high dependency on livestock which is prone to negative impacts of climate change and misuse. In Marsabit Forest, fuel wood abstraction stands at 16,382 tonnes per year. Encroachment into the forest for settlement and agricultural activities has also increased over the years resulting in tremendous declines in ecosystem services (Marsabit County Government, 2013). Continued unsustainable use of this ecosystem can damage its ability to full-fill essential functions. Therefore, it is necessary to help clearly define, identify and assess the costs and benefits of various watershed services to help guide the policymakers formulate and implement proper laws and strategic management of conservation activities harmonised with clear evidence-based policy objectives at the County level (MEA, 2005; Mwaura & Muhata, 2009).

Despite their importance, dry-land forest ecosystems are neglected in implementation of existing policies; this is as a result of inadequate information on the socio-economic contribution and the values it has to the local communities in dry-land areas, (Kipkoech, 2015). This could be attributed to the geographic position of the areas and inaccessibility due to poor infrastructure making data collection difficult. Since Marsabit Forest sustains the socio-economic well-being of local communities, it is essential that it is managed and conserved as a national and local economic and livelihood treasure. If such a measure is not taken into consideration, negative impacts like occurrence of water conflicts, deterioration of local livelihoods, pastoralism and reduction of wildlife based tourism will be felt. In the long run this is likely to hinder and hold back the socio-economic ambitions of local communities.

This study aimed to carry out economic valuation of the consumptive watershed services of Mount Marsabit ecosystem to provide crucial information for policy makers and resource managers through understanding the value of dry land water towers in economic development, social welfare and wealth generation. This information will enable formulation of informed policies, attract investment and help facilitate sustainable utilization of the watershed ecosystem. Further, the study will give a head start to the general public to have a more enlightened view of the importance of their natural assets leading to improved respect for their natural capital. The Market Price Method (MPM) was used to infer values through consideration of the prevailing water abstraction levels and water sale prices at each site identified around the ecosystem. Pricing was associated with the cost value of the resource in the market.

1.2 Research Questions

The following were the research questions adequately addressed by the study:

i. Who are the beneficiaries of Mount Marsabit consumptive watershed services?
ii. What is the economic value of consumptive watershed services in the Mount Marsabit ecosystem?
iii. Which are the key points of consumptive watershed service use in Mount Marsabit?

1.3 Objectives of the Study

1.3.1 General Objectives

To determine the economic value of the consumptive water use services provided by Mount Marsabit watershed ecosystem.

1.3.2 Specific Objectives

The specific objectives of the study were to:

1. Mapping of the key water points within the watershed ecosystem showing spatial distribution of the source types.
2. Document the key types of consumptive watershed service beneficiaries in Mount Marsabit
3. Estimate the beneficiaries' economic value of consumptive water use service in Mount Marsabit watershed ecosystem.

1.4 Justification of the Study

Conceived as Agenda 21 tool, the Convention on Biological Diversity (CBD) was signed at the 1992 Rio Earth Summit; devoted to promote sustainable development. In 2010, the Conference of Parties, (CoP) 10 of the CBD adopted the Aichi Biodiversity Targets, as part of the global Strategic Plan for Biodiversity Management, 2011-2020 with the key goal of bridging gap in biodiversity loss to enhance its service provision to the society. Target one requires that by 2020, society should be aware of the values of biodiversity while Target Two aims at the integration of those values in national development plans including County Integrated Development Plans, (CIDP). This study attempted to value mount Marsabit ecosystem in adherence to Aichi Target 2 in order to inform the policy makers in making right decisions on biodiversity conservation.

Mount Marsabit is the only water catchment found within the drier area of Northern Kenya, forming a vast area stretching from the foot of the mountain to the Chalbi Desert in the west, as far as the Milgis basin to the south and beyond Shura to the east (Government of Kenya, 2011). The ecosystem has a massive potential towards environmental sustainability and social-economic development of the region. Further, it has significantly contributed to the wellbeing of people living around with respect to water supply, (Government of Kenya, 2011). The thick tropical forest covering the mountain serves as a crucial hydrologic base which serves as natural hubs for water recharge through which spring and river discharge are maintained, forming a dry land water tower for the larger region. Water supply is the key consumptive service of the ecosystem hence the need of proper management through valuation.

Mount Marsabit ecosystem has been under pressure of degradation through encroachment, illegal logging, firewood harvesting and charcoal burning (Government of Kenya, 2011). Further, with extreme climatic conditions in the region, pastoral communities are pushed into a sedentary way of life which accelerates degradation through overgrazing in the areas where people have settled. Consequently, this has led to some of the springs and lakes in the watershed drying up indicating a decline in water recharge capacity, among them; Lake Areedo, Mugur, Ndonyo, Ltirim, Choop and Tumalanteyu springs in Karare; Source spring in Sagante, Lake Sokorte, Choopa and Bakuli stream in Central zone. This situation can be linked to a poor understanding of the linkage between the watershed ecosystem services and society livelihoods including the economic value of the ecosystem. Failure by the local authorities including county government to manage the resources sustainably has led to degradation of the natural woodlands, bush lands and wooded grasslands in the area.

The valuation process of the watershed ecosystem is critical in identifying the watershed services and the consumptive value. Analysis of benefit distribution and valuation of watershed services helps to equitably apportion the cost of conservation among the stakeholders, and policy makers will make informed decision to the good of the ecosystem.

This study was intended to provide insight on the economic values of the consumptive benefits of the watershed ecosystem, the need was associated with the huge danger facing the ecosystem in recent times. Through the demonstration of the consumptive benefits values of Mount Marsabit watershed service, the findings of the study will inform policymakers of the value of the dryland water tower; which will further guide them on setting proper laws and regulations for the management of conservation of the area as a valuable asset. Upon knowing their values, the general public will also earn respect for biodiversity (Kipkoech *et al., 2011*). The study area is justified since it is the only water tower for the dry-lands of Marsabit. Finally, the study will contribute to scarce literature on economic valuation in Kenya and particularly consumptive watershed service of dry-land water towers offering adequate results that may facilitate overseeing authorities for proper ecosystem planning and management.

1.5 Scope and Limitations of the Study

1.5.1 Scope

The study focused on estimating economic value of the consumptive water use service using market price method. Non-consumptive and indirect use values of the ecosystem not considered water production and supply for people and livestock considered as the direct benefit service of the watershed ecosystem. The study area forms a vast dry-land watershed ecosystem which includes the Marsabit National Park and reserve covering 2000km^2 and 150km^2 respectively (Government of Kenya, 1989,2002, 2011). However, the study focused on Marsabit Sub-County consisting of three wards (Marsabit Central, Sagante/Jaldesa and Karare ward respectively). Both rural and urban areas to bring about socio-economic characteristics of the population.

1.5.2 Limitations of the Study

The challenges encountered included security issues during the fieldwork, warring communities fighting over point of water supply. Water points being the key areas of research, data collection was greatly affected, due to this the study could not achieve the entire sample size selected. However, the achieved sample size is deemed sufficient for the study, hired security personnel played a great role overcoming the challenge. Additionally, the study was subject to financial and time constraint. Distance between water points was another major challenge encountered.

Respondents mostly livestock keepers were reserved in giving out information regarding their activities and benefits in the forest reserve fearing victimization. However, the water point's managers and elders helped in getting helpful information required to complete the research.

1.6: Operational Definitions

Consumptive watershed ecosystem service - These are services obtained through direct extraction from ecosystems e.g. Water for use on crops, consumed by humans or livestock.

Direct Use - These are the economic or social value of the goods or benefits derived from the services provided by an ecosystem and used directly by the consumers/beneficiaries e.g. harvesting goods.

Ecosystem-this involves living organisms, non-living organisms and their physical environment, interacting as a system. Examples of the ecosystem include forest and coastal ecosystems.

Ecosystem services-These are the benefits that we humans obtain from ecosystems. e.g. cultural services such as spiritual, recreational and cultural benefits; regulating services such as flood and disease control; provisioning services such as food and water; and supporting services, like nutrient cycling, which preserve the conditions for life on Earth.

Economic valuation-Assigning monetary value to ecosystem benefits (i.e. the services provided by an ecosystem) that are usually not taken into account in financial valuation.

Indirect Use -These are benefits typically derived from practical services that the environment offer to support present production and consumption. For instance, this involves ecological utilities like the recycling of nutrients natural and filtration of polluted water.

Market price method-This is a method of ecosystem valuation using prices of goods and services as used in the commercial market to help obtain the value of service an ecosystem provides.

Watershed ecosystem – This is a distinct forested area which operates a unit with a high rainfall interception and water recharge capacity that operates like a centre of water discharge through springs, streams and rivers.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This research reviews the literature on economic valuation of watershed ecosystem services. This review aims to establish the existing knowledge regarding the economic valuation of watershed ecosystem services; this was necessary to screen the research ideas and identify the existing scientific research gaps. The theoretical section highlights on economic valuation concepts including possible techniques which can be applied in the study. Empirical literature reviews studies undertaken in the area under study.

2.1 Theoretical Review

2.1.1 Resource Economic Valuation

Economic valuation is the aspect of putting a monetary value on natural resources. The conduction of an economic valuation tends to encourage wise use and decision making on the environment in relation to the conservation of forests, water catchments, among other ecosystems (Perez-Verdin *et al*., 2016). In their analysis, Small, *et al.*(2017) outlines that, valuation helps in the determination of people's preferences and their willingness to pay (WTP) for specific benefits that accrue from the conservation of the resource in question, for example, the aspect of keeping a watershed catchment or a forest ecosystem intact to enjoy their services.

Resource valuation helps in the incorporation of environmental concerns and linking them to a cost-benefit analysis. Moreover, the economic resource valuation is essential in the construction of environmental measures for national incomes that are adjustable (Vartolomei, 2012). This means that a monetary evaluation of environmental value is done and the welfare effects of the resource estimated. It also forms a basis for legal claims for damages done to natural resources in case of hazardous spills and other forms of pollutions to environmental resources.

Watershed ecosystems in most places provides water supply points for different users, but human activities have contributed immensely to the scarcity and pollution of such benefits. Studies have established that such ecosystems are valuable and their valuation becomes an important aspect of sustainable management. In connection with conservation, watersheds form a significant part of the ecosystem resources that ensure human survival (Van Wilgen *et al.,* 2017). The monetary valuation of environmental resources helps one to establish the value and uses it has for humanity and the consequences that its destruction can cause.

Resource valuation is also a tool used to gauge how much worse off the residents of a given area endowed with a natural resource can be if conservation of the resource is not done. It is a question of determining the true value of having a resource availed to the citizens and its positive impacts on the surrounding environments economically and health-wise (Vartolomei, 2012). The monetary value that the resource can fetch to the residents regarding supporting their economic activities and natural survival is calculated, and value regarding significance put on it (Safriel, 2011).

The choice to destroy or conserve an ecosystem all depend on the value that is assessed on the resources in question. Preservation of environmental resources for the current and future generations is prudent, but the decisions on how to go about it depend on the valuation process (Perez-Verdin *et al*., 2016). Economic valuations assists in the formulation of policies to create awareness and value of ecosystems, determine benefits of the resource, and also provides incentives for protection of such areas through payment for ecosystem services (PES) framework.

One may wonder why the valuation of nature and its resources is important. The main reason is that everyone can observe that the critical ecosystems, which are worth a lot of money are deteriorating and the resources meant to be shared by everyone are getting depleted. According to Safriel (2011), the quantification of economic value that a resource fetches to the government and the people that depend on it provides useful evidence that can support policies meant to protect and conserve a vulnerable resource.

2.1.2 Factors Compelling Economic Valuation of Natural Resources

The attribution of economic value to a natural resource, such as a watershed, is driven by the myriads of factors. A market economy characterised by demand, price, supply, and quantity attributes play an important part in ensuring resource valuation is done. The economics of environmental protection requires the understanding of market economics where one has to determine the most viable economic activity the resource will support based on the demand and benefits to the public (Van Wilgen *et al*., 2017).

The demand for consumptive benefits is the guiding factor in the valuation of most natural resources including ecosystems. The price of the resource also determines the willingness of the residents to pay for the conservation of the resource as compared to its demand. The quantity of the resource being supplied has to be enough to sustain the population in a regulated manner while ensuring economic gains are being attained (Safriel, 2011). The high conservation of natural resources assures sustenance of economic activities, and thus economists can gauge the value such a resource fetches the people and what detriments it could fetch economically if the resources were destroyed.

External effects are the other driving factors for the valuation of natural resources. In the normal market, demand and supply determine the pricing of goods and service. The pricing could be interpreted as a valuation process regarding the monetary value that the service or product fetches the buyer or seller. However, such aspects as biodiversity, forests, watersheds, mountains cannot be attached to some monetary pricing without proper valuation (Tao *et al.*, 2012). These are non-priced goods that can only be attributed economic value to them based on their significance to those around them.

According to Vartolomei (2012) the concept of externalities' puts a value on non-priced goods such as natural resources and values them depending on the demand for their services. Externalities can be defined as the side effects which cannot be reflected in market prices that an activity fetches leading to consequences for another activity. The generation of an external benefit translates to a positive externality while the generation of an external cost leads to a negative externality during a market transaction. In his view, Safriel (2011) outlines that a simpler understanding of externalities is the aspect of making an economic decision that causes costs or benefits to stakeholders rather than the decision maker. For example, if a decision leads to the pollution of a watershed or the atmosphere, it is an externality.

2.1.3 Functions and Attributes of Watershed Components

Water is an important commodity for the survival of both plants and animals, human beings included. The term "watershed" can be defined as a drainage system area within the land that collects water from a river(s) or streams. The surface water collected comes from specific land topographies such as valley, hills, mountains, and forests among other characteristics. Water may flow into a watershed from the surface or via underground from a stream or river (Bunse, *et al.*, 2015). However, the unique role of a forested ecosystem is its ability to connect with the water cycle through precipitation interception as a natural source of water supply. The activities on land tend to interact with natural hydrological cycle within watersheds leading to supply of nutritional sources for both terrestrial and aquatic animals. On the other hand, people utilise these environments for agricultural purposes, travel from one place to the other, and even have clean drinking water among other uses (Safriel, 2011).

Watersheds form an essential natural resource that needs to be protected, conserved, utilised and valued for human uses. This is because watersheds form productive systems for human activities. Watersheds sustain life in various ways, such as sustenance of human health (Bunse, *et al.,* 2015). For example, the conserved water is used for drinking; it is also used as a source of food through agriculture and fishing activities. Moreover, they contribute to regulating climatic impacts through cooling the air and seeing to it that greenhouse gas emissions are absorbed.

Bunse, *et al.* (2015) outlines that when it comes to hydrological function; watersheds ecosystems are known to conserve water by channeling and draining it to a place where they are collected for future use. For example, watersheds can be used to arrest flood water and conserve it for use during the dry season. From an ecological point of view, watersheds support rivers, lakes, streams, and groundwater regarding their conservation. It also forms a home for aquatic and wild animals (Vartolomei, 2012).

Looking into economic health for watersheds, they are used to generate electricity for use by people in their homes as well as the running of factories. Secondly, the water is used in commercial and subsistence farming thus the formation of a self-sustaining economy. Thirdly, they can also be used for recreational activities such as canoeing, fishing, and surfing leading to domestic and international tourism activities that fetch the government a lot of money. Also, in Africa and other countries where pastoralism is a common practice, watersheds provide water for herders by providing water for their animals (De Groot *et al*., 2002).

2.1.4 Concepts used in Environmental Economic Valuation

The ability to quantify benefits that ecosystem fetches to human beings and quantifying it on monetary value and the ability to use it as a justification for its expenditures is referred to as economic valuation. The economic valuation of environmental resources uses myriads of concepts that vary depending on the desired results. In the absence of specific markets, two broad classes of environmental economic valuation exist; Revealed Preference (behavioural) methods and Stated Preference (Attitudinal) methods (Vartolomei, 2012). Natural experiments are used in revealed preference methods in the estimation of the demand function that an environmental resource fetches. Consumer choices are observed in the estimation of the relationship that exists between quantity and price. Researchers aim at evaluating and determining the exogenous differences that exist between the quantity of goods and available environmental prices.

Value estimation relies on statistical models that are used in the randomised quasi-experiment methods. The observation of choices made by agents in the market lead to economists having a professional bias towards Revealed Preference, this is because what people say they would do end up being different (Bunse, *et al.*, 2015). However, as long as the environmental resource is well-described, the use of revealed preference valuation technique tends to have an appealing virtue and tends to be viable in assigning a value to environmental resources. One setback is that the conduction of the survey is quite complex for researchers but still implementable (Small, *et al.*, 2017).

Stated Preference or Market-Based techniques rely heavily on the law of demand in resource valuation, that is, the determination of market value for natural resources. However, as the sophistication on the measurement of these techniques increases, natural resource valuators use the appraisal method, market price approach, and resource replacement costing, as State Preference approaches in resource valuation (De Groot *et al*., 2002). In market price approaches, the provision of environmental goods and services are compared to the consequent rise in costs. The method uses direct observation of agents in the market. Alternative provision cost, mitigation costs, and opportunity costs tend to be evaluated. However, the method is limited to non-value uses since the prices paid by customers are from a mere expression of willingness to pay and not from the laws of demand (Small, *et al.*, 2017).

2.1.5 Reasons for Resource Valuation

Ecosystems provides wide range of services, they are termed life supporting enhancing human life through service provision either directly or indirectly. In many countries, the scale of production, the presence of externalities, and the non-rivalry nature of the quasi-public has prompted the need for economic valuation of watersheds. The valuation enables the optimal provision of hydrological services from watersheds. The aspect of externalities outlines that the provision of benefits for the use of watersheds to the quasi-public cannot be deviated to compensate the providers (Small, *et al.*, 2017). Quasi-public refers to the difficulty in excluding any person from using water from the watersheds for various uses.

Resource valuation is an expression of recognition by humans that non-human things have worth or value that give them some satisfaction either directly or indirectly. The feeling that resources are worth preserving can be described as intrinsic value bestowed upon that non-human resource. Valuation tends to instill both intrinsic and instrumental values on resources. Intrinsic value is expressed as the desire by a section of human beings to ensure the continued existence of natural resources, environment, and individual species; this creates existence value which is an anthropocentric and utilitarian concept (Safriel, 2011). Therefore, valuation has a utilitarian motive which involves means towards the results desired for human welfare. From a deontological view, the intrinsic value of resources outlines that they have a right to exist.

Valuation is carried out to determine the importance of environmental consequences on the economic activities conducted in those environments as well as the dependence of human beings and animals on the same resources. It is, therefore, an empirical accounting of value fetched by natural resources and environmental amenities and the benefits they fetch in comparison to costs incurred in their preservation, conservation, and protection (Safriel, 2011). Based on Hausarbeit (2013), the use of benefit-cost analysis accosts monetary value to natural resources based on the benefits they fetch to the society in comparison to the costs incurred while protecting and conserving them. It is used to make informed decisions based on the willingness to pay (WTP) for benefits as well as the willingness to accept (WTA) costs. Valuation is done to determine the choices and decisions that people make about ecosystems.

Economic valuation of watershed services is an important aspect in determining the protection of water catchment areas. Marketed and non-marketed resource values influence the valuation of the watersheds. Demand and supply in the market determine the valuation process for watersheds while non-marketed valuation is based on consumer preferences and behaviour (Perez-Verdin *et al.,* 2016). In Mexico, the detriments of failing to recognise values of resources has led to degradation, depletion, and overexploitation of forest resources and an eventual social welfare loss. Forests form the main protective areas for watersheds and deforestation has affected water levels in these water catchment areas of Mexico. Economic valuation of the Mexican watersheds based on the hydrological services offered by the ecosystem was undertaken by Perez-Verdin et al, (2016) using CVM with the results to help guide decision makers to improve conditions of water management.

2.1.6 Economic Valuation Techniques

Economists dealing with environmental and natural resources have devised different valuation methods and approaches that estimate benefits that preservation of ecological goods and services fetch as well as the damages they pose if polluted or threatened in any other way to humans, plants, and even marine life (Safriel, 2011). Benefit-cost analysis is one valuation method that helps in outlining the benefits and implications of failing to conserve and utilise natural resources in an orderly and environmentally friendly manner (Vartolomei, 2012).

Watershed services are measured in TEV framework approaches that are used to determine their value to the society. One cannot outline relevant markets for values that ecosystem resources fetch, the value itself can be determined using summation of the values both use and non-use values. Where Use values are calculated using market price methods and non-use values are determined using non-marketed economic valuation techniques. Stated preference and revealed preference methods are key in non-market valuation methods. When it comes to revealed preference, it is represented by other sub-methods called Travel Cost Method (TCM) and Hedonic Pricing Method (HPM) (Small, *et al.*, 2017).

TCM is applied in calculation of recreational values of a given ecosystem, the method shows connection between areas visited for recreation (Small *et al., 2013*). The values in TCM is arrived at through estimation of demand of a given recreational site. HPM used on goods not sold in the market, values identified based on locality of premise. The two sub-methodologies under non-market valuation have been employed in actual market valuations in the characterisation of economic currency and exchange of goods and services. Stated Preference methods techniques includes the Contingent Valuation Method (CVM) and Choice modelling; CVM works by setting up hypothetical situations, and respondents are used to finding the truth about the watershed (Small, *et al.,* 2017). Additionally, WTP is used in CVM as a basic determination of how valuable a watershed is to the society; the more they are willing to pay for it, the higher its value. The price set by the WTP becomes the market value of the resources being offered.

Economic valuation of ecosystem methods is greatly influenced by the types of goods and services to be valued. Additionally, data availability and limitations of the methods affects methods to be applied. Based on desired results, a researcher can choose method to be applied in valuing a given ecosystem. Compared to other techniques, MPM is preferred in valuation of consumptive water use service of a given ecosystem. This can be attributed to the fact that MPM data can easily be obtained from the markets. Further, MPM provides the simplest approach since information on the quantity of goods and services and their current market prices are required in estimation.

2.1.7 World Valuation Studies

In Mexico, myriads of benefits that watersheds fetch have prompted their valuation based on their contribution to the ecosystem and the society. Policies have been set based on the valuations with the intention of helping landowners in Mexico to reduce the impacts of externalities. Research conducted by Bunse, *et al.* in (2015), focused on economic value estimation to help guide favourable policy formulation to reduce anthropogenic activities consequences. The study applied CVM using beneficiaries WTP for resource conservation. The result showed that 90% of the people surveyed were willing to pay for preservation of the watersheds in Mexico, the amount raged between 5-200 MEX$/month. The total benefit was estimated to be MEX$ 1.31million/year (US$100,826/year). However, the variables affecting WTP were water bills, family income, age, and family size. This was different from the current study which does not use WTP by the market price of the resource to generate values.

In China, Tao *et al.* estimated the Heshui Watershed economic value using the CVM. The watershed located within an area of 4103 km^2 to the west of Jiangxi is utilised by four cities and counties namely; Lianhua county, Ji'an city, Yongxin county, and Anfu county. The valuation of the Heshui watershed was done using a CVM. A hypothetical situation was set, and the truth about the economic value of the watershed determined from the responses got from participants. The maximum willingness for improvements and conservation of Heshui by the residents who live within the watershed was determined. 61.8 % of respondents showed the willingness to pay for the conservation of Heshui watershed revealing the significance of its value to the residents (Tao, *et al.,* 2012). From the study it emerged that the respondents are aware of the services the ecosystem provides. Valuation of the ecosystem persuaded the benefices to take necessary measures upon themselves to restore ecosystems in China.

The South African Fynbos ecosystems represent an outstanding analysis of economic valuation of ecosystem services. South Africa is a dry country with limited water resources; as a result, the conservation of watersheds is taken seriously (Van Wilgen *et al.*, 2017). However, the invasion of Fynbos vegetation by alien woody weeds, which are non-indigenous tree shrubs, complicates the conservation. The management considers the eradication of the alien plant as a significant conservation program that must be implemented. The conservation efforts have enabled the South African government to avail watershed reserved water at a cheaper rate, and it has also found the economic exploitation of the Fynbos. Moreover, the Fynbos has led to ecotourism opportunities among other uses such as farming and home consumption; this has led to the sustenance of biodiversity in the region.

In Kenya, Chyulu Hills watershed has recently been monetized in terms of consumptive water supply by (Mwaura *et al*., 2016). Considering that semi-arid climate characterises in Chyulu area, water demand is high, but supply is low. Chyulu ecosystem that supports farmers, herders, and wildlife in water provision services, it is however in the verge of collapse from destruction activities of the ecosystem. Valuation of the watershed was conducted using MPM based on market price of the commodity. Four regions were used whereby each paid differently for water consumption from Chyulu watersheds. Moreover, there are little or no economic activities, meaning that watershed preservation is low based on the economic abilities of residents (Mwaura *et al*., 2016). The ecosystem was valued at Ksh 46,676,192/year, this shows that the economic value of the watersheds is very high. People depend on the ecosystem for farming activities, drinking, and feeding of their animals among other indirect services like climate regulation.

2.2 Empirical Literature Review

South Africa's fynbos ecosystem serves as a significant water supply contribution from natural ecosystems to human well-being. However, the ecosystem has been on the verge of collapse. Sustained supply of water depends on maintaining the ecosystem. Van Wilgen *et al.* (2017) undertook economic valuation of ecosystem services using CVM based on WTP of respondents. The exercise established that the delivery of water from catchment areas in the Western Cape Province depends on healthy functioning of the ecosystem. Fynbos vegetation is adapted to the summer droughts and nutrient-poor soils, as well as to the fires that occur periodically in the Cape Mountains. The fynbos binds the soil, preventing erosion, while it's relatively low biomass ensures conservative water use and low-intensity fires, which in turn ensure high water yields and low impacts on the soil from periodic fires. The ecosystem contributes immensely to the region's economy, with export earnings from the ecosystem estimated at $560 million, employment provided to close to 250,000 people.

Bale Mountains in Ethiopia supplies the local communities with wide range of services to their benefit, this ecosystem contributes to crop production, livestock products and forest goods to the better livelihood of the locals leaving around the ecosystem. However, the ecosystem is being heavily degraded with no proper policies and management strategies in place to protect the ecosystem. Watson, (2007) assessed the importance of the services supporting the livelihoods of the locals. From the study it emerged that household direct consumptive value was at US$ 1157 from crop, US$ 228 for livestock and US$ 407 for the forest ecosystem products. Annually, the consumptive value of the Bale Mountain was estimated at US$ 377,777,500. The study demonstrated the importance of the ecosystem to the Bale locals, and upon erosion of the ecosystem, great loss will be felt by the pastoralists, farmers and those depending on the forest products from the ecosystem (Watson, 2007).

In Kenya's arid areas, watershed ecosystem plays key role in provisioning service for pastoralists' wellbeing through supply of water for livestock maintaining animal health hence more production. Davies, (2007) stated that dry-land watershed ecosystem are considered less important leading to formulation of policies which are not favourable to its management. King-Okumu *et al*, (2016) illustrated in their study that there is close relation between water provisioning and healthy forest ecosystem. The study in Isiolo focused on compiling and synthesing 'direct use values' associated with the ecosystem provisioning services – water, flows of these services were explored and a range of market values associated with them. It emerged that the estimate direct use value of a cubic metres of water for livestock uses was US$13–22, estimating water demand for livestock at over US$20 million (nearly KSh1.8 billion). This works out to a value of US$13–22 per cubic metres of water provided for livestock to drink from the ecosystem.

Additionally, the study identified that the human water demand in was around 40 litres per capita per day in rural areas of Isiolo and closer to 70 litres in town. This estimated household water demand is far higher than survey reports on water consumption in the rural areas, which indicate daily per capita rates of around 7 to 10 litres. Values derived from watershed ecosystem services are known to help in formulation of proper policies. Livestock keeping being main source of livelihood in the area, watershed conservation in the area is key. Destruction from human activities will be curbed through proper policy formulation by the government based on the values generated.

Kenya's Kirisia forest watershed provides wide range of services to locals in Samburu. Study by Kiringe *et al.* (2016) on Kirisia watershed documented various water source types and uses by humans and livestock in the watershed. They found out that the watershed was servicing earth dams, water pans, shallow wells, boreholes, springs and streams. The ecosystem supplies water for livestock and locals estimated at 180,645 and 147, 060 respectively. Earth dams and water pans provided water to the highest population of community members followed by boreholes while streams, springs and shallow wells were used by the least number of people. They also provided water to the highest number of livestock estimated at an average of 15,422 animals. The highest amount of water was abstracted from boreholes at nearly 197,720 litres/day (197.72m^3/day) followed by earth dams and water pans at 91,960 litres/day (91.96m^3/day), and the least was from shallow wells, springs and streams at about 38,000 litres/day (38m^3/day). Daily water abstraction from all the water source types by humans and livestock was nearly 366,540 litres/day or 366.54m^3/day. The projected water demand was approximately 182,238,520 litres/day (182,238.52 m^3/day). Water demand by livestock was estimated at 12,172,600lLitres/day (12,172.60m^3/day). Overall water demand by humans and livestock in all the sub-locations was estimated at 194,411,120 litres/day (194,411.12 m^3/day). These findings demonstrated the critical role played by the watershed in sustaining local's livelihoods and pastoralism (Mwaura *et al.*, 2016).

In conclusion, from the literature reviewed, it is established that there is close relationship between watershed ecosystems and water provisioning for human wellbeing. Further, it emerged that there is little effort in terms of conservation of the same ecosystem.

2.3 Theoretical and Conceptual Frame Work

2.3.1 Theoretical Framework

2.3.1.1 General Systems Theory

Von Bertalanffy (1968) defined systems theory as an interdisciplinary study of systems. System is set of elements interacting with their environment to achieve a certain goal. In addition, the systems can acquire new properties through emergence thus being in continuous evolution, they are also self-regulating. The theory is associated with reductionism doctrine, an approach of understanding complex phenomena by considering smaller parts as unit, by doing this Von Bertalanffy introduced systems on how individual parts are associated to form the whole environment.

Functional ecosystem provides wide range of goods and services as a result of it improving human wellbeing, this provision of benefits links to the deeper structure and procedures resulting from interaction of ecosystem components in support of energy flow (De Groot *et al.,* 2002). In its application, general systems theory clearly shows relation between these components of ecosystem resulting to wide range of services, and upon erosion of one, the effects cascades down to the other factors interfering with the functionality of an ecosystem, this statement can be backed by *"one for all, all for one"* sentiment.

General systems theory is the foundation of the ecosystem concept; this is in the idea that an ecosystem is a complex system exhibiting emergent properties. Ecosystem services to the humans is as a result of interaction and transactions within and between biotic an abiotic factors which is concerned with the way a particular ecosystem functions and how it can be greatly influenced by human interventions. In this study watershed ecosystem is the system with series of inputs and outputs. The provision of ecosystem services and benefits depends on deeper structure as a result of complex interaction between biological factors and the physical and chemical factors and through the energy flow. For instance forest is required to maintain water flow through interception of rainfall and as a result meeting the society water supply demand. This study seeks to value consumptive watershed ecosystem services hence this theory was modified to suit this study.

2.3.2 Conceptual Framework

The conceptual framework of the study is based on the benefits of ecosystem to enhance human welfare. Ecosystems provides wide range of services such as provisioning (e.g. water), regulating (climate regulation), cultural (spiritual, information) and supporting (Oxygen production) which significantly contributes to sustenance of human beings by adding values. These, in return significantly benefits human through values enjoyed by society e.g. economic, ecological and socio-cultural values. Features found within an ecosystem interrelate in their processes. Ecosystem components interact closely, for instance, materials released by one aspect is utilised by the other and also the energy flow keep it functional. This process gives rise to ecosystem functions which sustain human life on earth. If one process is done away with, the burden is put on the other supporting component; this justifies the statement *"one for all, all for one"*. This complex interaction leading to ecosystem services and benefits can be linked to the general systems theory.

The conceptual framework below (Fig. 2-1) indicates that decision making, policy and management measures determines the use and management of the ecosystem and, this further influences the functionality of the ecosystem in the provision of goods and service. This leads to changes of the ecosystem services and further impacting on the human welfare and the consumptive economic value they derive from the ecosystem services. Knowing the economic values of the ecosystem services provides crucial information that can lead to making of proper decision enhancing the conservation of an ecosystem positively impacting on the services to the society.

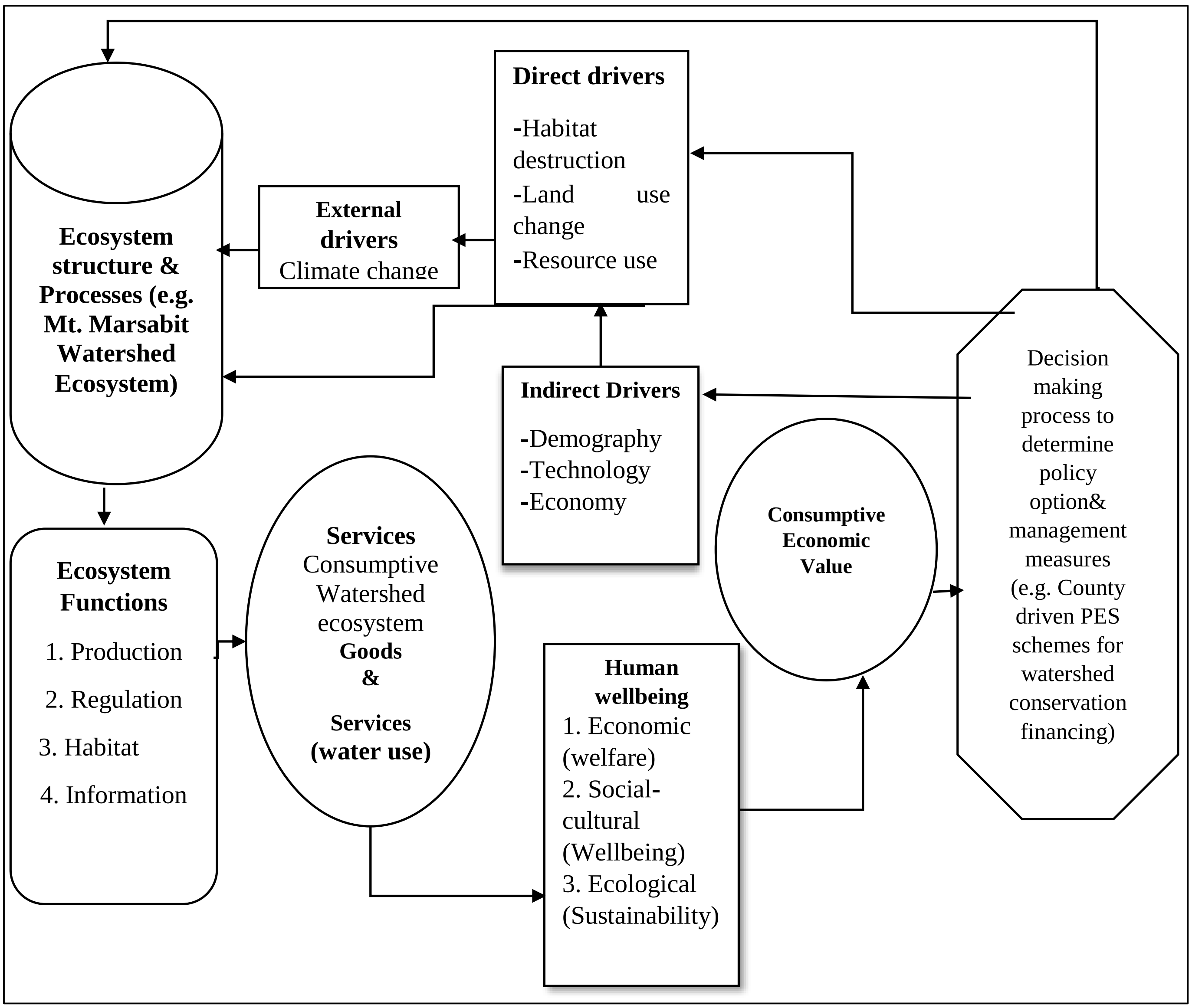

Figure 2-1: Conceptual Framework Modified from (De Groot *et al*., 2002).

From the conceptual framework above, governance and decision making shapes the use and management of ecosystem, this impacts the ecosystems structures and the services provided through direct, indirect and the external drivers; which when managed properly can improve on the services the ecosystem provides impacting human wellbeing. Ecosystem services values generated can influence relevant institutions to make decisions strengthening conservation of ecosystems and as a result of it, service provision to society.

2.4 Research Gaps

Based on the literature review the following are the existing gap identified to be addressed by the study:

a) Methodological gap: - Most of the previous economic valuation studies undertaken in Kenya are based on CVM valuation method using WTP of the resource beneficiaries, this method is biased because the individuals usually give exaggerated or under estimated WTPs leading to inaccurate monetary values. The research uses MPM to address this gap, MPM method relies on the actual reality of the cost of ecosystem goods in the market, adequately filling in the biasness gap by CVM.

❖ In the valuation of Ondiri Swamp by Muhata (2005), the researcher used margin of error set at 0.15%, which shows less confidence the reported results are close to the "True" figures. This study uses margin of error at 0.05% to improve on the gap.

b) Literature on consumptive watershed service valuation is limited; this study will contribute to literature on consumptive water use service of watershed ecosystem valuation.

c) There is scarce economic valuation literature on consumptive watershed services of dry land ecosystem in Kenya, this brings gap in comparative analysis. This study will contribute to address this Gap. Once complete the study can be used in comparison with other similar ecosystem.

CHAPTER THREE: METHODOLOGY

3.0 Introduction

This chapter covers the study area and its exact location in Kenya in detail. It further deals with the research design. It describes sampling design, Target population, sample size determination, data collection methods and data analysis.

3.1 Study Area

The study area is located in Saku constituency, Marsabit Sub-County in Marsabit County. The County lies between Latitude 02˚ 45′ 04.27″N and Longitude 037˚ 57′ 39.21″ E in the extreme end of Northern Kenya 560km from Nairobi City. It borders Samburu County to the south, Lake Turkana to the west, and Isiolo and Wajir Counties to the east. It has an international boundary with Ethiopia to the north. The County is the second largest county after Turkana, covering 70,961.2 km^2. The county has four constituencies, namely, Moyale, North Horr, Laisamis, and Saku. It further has 20 Wards, 58 Locations and 112 Sub-Locations (Marsabit County Government, 2013). The study area covers the three wards namely, Marsabit Central, Sagante/Jaldesa and Karare Wards. Figure 3-1 overleaf provides a location map for the study area.

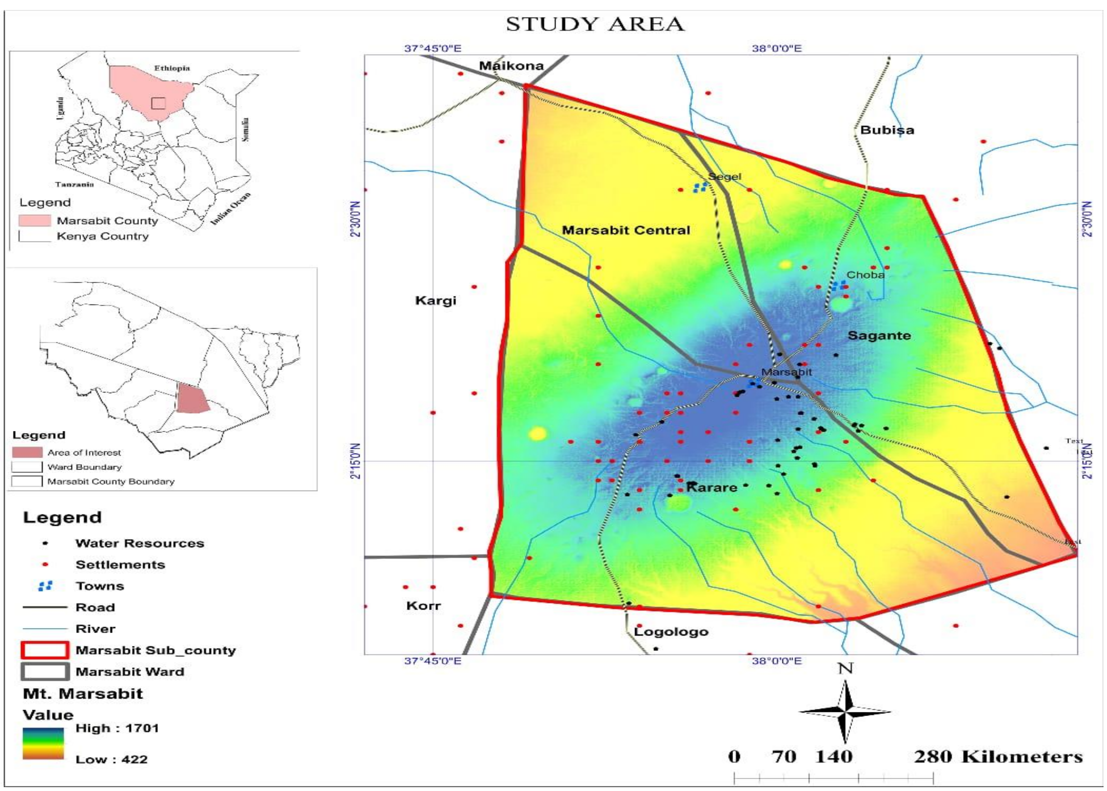

Figure 3-1: Map of the Study Area

3.1.1 Mount Marsabit Ecosystem

Mount Marsabit was built during the Miocene era with some lava flows and explosives maar forming. The massive basaltic shield volcano reaching to an elevation of 1707m is a key ecosystem to tens of thousands of people in Marsabit County. Climate on the mountain significantly varies from the surrounding lowlands forming a unique ecosystem with tropical rainforest amidst deserts like Kaisut and Chalbi desert. It is also a source of groundwater and surface runoff to the environs around, stretching from foothills of the mountain extending to the Chalbi Desert to the west, Milgis Basin to the south and beyond Shura to the east. The ecosystem forms hydrological powerhouse for the entire residents of Marsabit Sub-County who depend on the ecosystem for water provision services. With its vast forest cover, the area forms a biodiversity hub, regulates the climate of the surrounding among other ecosystem services (Government of Kenya, 2011).

Mount Marsabit carries Marsabit National Park estimated to cover an area of 2000 Km^2 and Marsabit National Reserve about 140 – 150 Km^2 (Figure 3-2). The national park has a diversity of wild animals and is famed for its huge tusked elephant, most renowned was Ahmed who was granted 24 hour protection by President Kenyatta in 1970s (Government of Kenya, 2002).

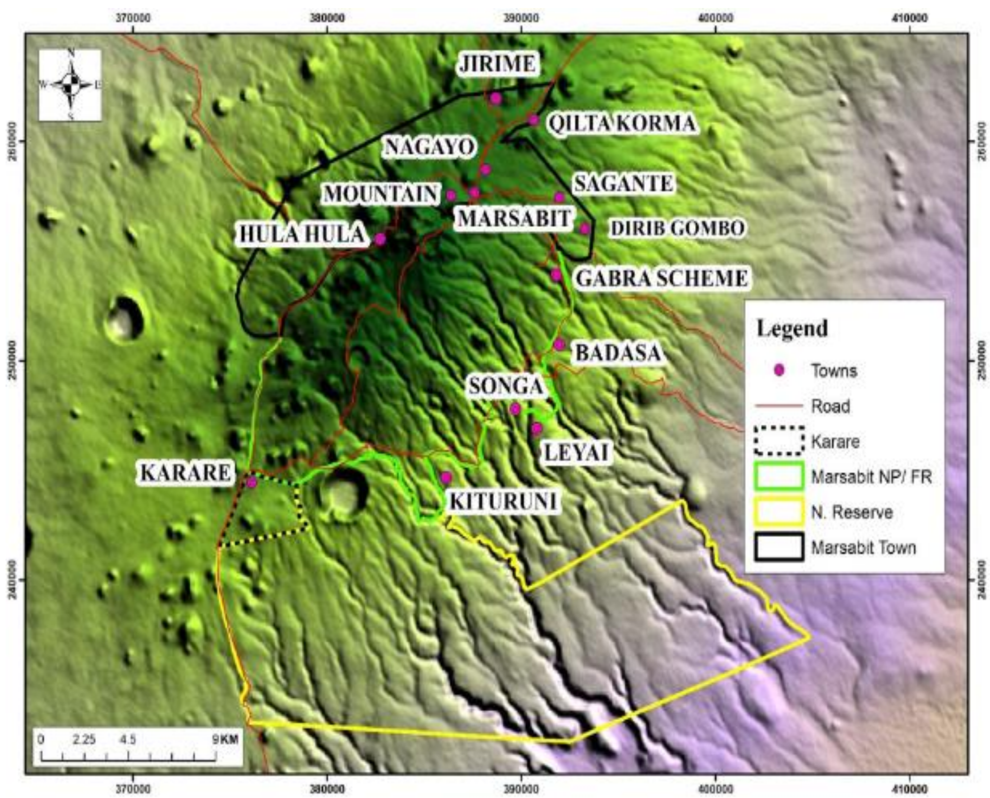

Figure 3-2: The Mount Marsabit Ecosystem National Park/Reserve (Muhati *et al*., 2018)

3.1.2 Climate

The study area has different climatic conditions as compared to the lowlands around the mountain. The Mountain receives mean annual rainfall of 800mm, most parts of the county being arid areas receives mean annual rainfall of approximately 300mm. The county is characterized by tropical climatic conditions with extreme temperatures which range from a minimum of 15^0 C around the Mountain to a maximum of 26^0C, with an annual average of 20.5^0 C (World Weather and Climate Information, 2015). Rainfall duration, reliability and amount increases with the altitude. Moyale receives a mean annual rainfall of 700mm; Mt. Marsabit and Mt. Kulal 800mm while North Horr (550m) has a mean annual rainfall of 150mm (Marsabit County Government, 2013).

3.1.3 Topography

Mount Marsabit is the most notable topographic features with an elevation of 1,865m asl. Most of the surrounding areas of the Mountain constitute extensive plains lying between 300m and 900m gently sloping towards the south-east of the mountain. Chalbi desert which is part of the watershed forms a depression covering 948 sq. km, lying between 435 and 500m elevation. Dirib Gombo area located eastern part of the study area consists of a gently lying slope at about 1,000 to 500masl, associated with the end-Tertiary erosion level. The Pleistocene Basaltic flows originating from the eastern slopes of Mount Marsabit have covered large areas of this surface. Plate 3-2 shows the terrain of the ecosystem.

3.1.4 Vegetation Zones

Vegetation cover of an area plays a key role in water balance and moisture retention, on Mount Marsabit vegetation occur in small communities consisting of a variety of species, the tropical forest is made of deciduous trees consisting of species like *Commiphora* spp, *Croton dichogamous,* wild *Coffee arabica* among others. The forest experiences mist, Bryophytes and canopy of the forest play a critical role of trapping mist water, trickling down moisturizing the ground (Muchura *et al., 2014).* Vegetation of the area ranges from scrublands at the base of the forest to tropical forest at the peak of the mountain. The upper zone of the ecosystem is dominated by mixture of trees, shrubs and climbers, this zone is covered by ever green dense forest; the middle zone is formed with broad leaved species such as *Olea capensis,* the lower edge of the forest has thorn bush trees.

With high vegetation cover on the forest, it retains large stocks of carbon influencing the water catchment of the area; pastoralists also use the forest as water point for their livestock's. Pastoralist communities leaving around the ecosystem graze their livestock in the forest during the dry season.

Plate 3-1: Lake Sokorte near Marsabit Lodge

Plate 3-2: Mount Marsabit Forest Ecosystem Covered with Mist

Plate 3-3: View of the Ecosystem Landscape

Plate 3-4: Researcher and Assistants at the Heart of the Ecosystem

3.1.5 Hydrology and Drainage

Mount Marsabit Ecosystem has no permanent rivers, but there are a number of springs emanating from the ecosystem; Bakuli, Songa, Badassa and Lchuta Springs. Run-off from peak of the mountain flows towards the lower zones of Marsabit, Sagante/Jaldesa and Karare area. The seasonal rivers and run off from the ecosystem flow eastward and drain into the Sori Adio Swamp (Chege, B. 2017). Mount Marsabit watershed is drained by streams and springs found within the forest, Bakuli springs are the major source of water found at the heart of the forest; Lake Paradise and Sokorte Guda (Plate 3-1, 4-2)are the major catchment area in the Marsabit forest, (Oroda, 2011). According to Marsabit county, smart survey report, (2016), the county's water quality, sanitation and hygiene indicators proved to be poor. 41.3% of the residents have access to water from protected sources, 19.6% treat their water before drinking (Marsabit county government, smart survey report 2016).

3.1.6 Population Characteristic

According to Kenya National Bureau of Statistics (KNBS), (2009) National Population and Housing Census projection, Marsabit population stands at 46,502 and 10,502 households with an average of 4.5 persons. The fertility rate estimated at seven children per woman with the life expectancy at 57 years for men and 64 for women. The population growth in the study area is 2.8% among the highest for the country; this clearly shows a growing population and will end up exerting pressure on resources with the trend. Saku constituency where the study is based has a high population density of 25p/km^2 with an expected increase to 27 and 29 respectively. Majority of the people depend on Mt. Marsabit ecosystem for the services provided among them recreation, this calls for conservation and sustainable use. This trend in population change clearly shows that human population depending on Mount Marsabit watershed has multiplied.

Plate 3-5: Livestock Watering in the Ecosystem

Plate 3-6: Farming in Songa Area-Karare Ward

3.1.7 Water Supply

The forest ecosystem serves as a water catchment for the area given that the main water supply comes from the Bakuli spring which is at the heart of the forest. Communal wells were also done in the forest where communities can take their livestock during the drought season. Northern Water Service Board (NWSB) does the water management; water from the Bakuli is piped directly to the locals and the kiosks which serves those with no accessibility to tap water at the homesteads. Bakuli springs discharge is diminishing due to the human activities in the catchment.

3.2 Research Design

The study utilised a cross-sectional survey design to carry out an economic valuation of the watershed ecosystem in the desire to assess the thoughts, opinions and feelings of the beneficiaries of the watershed ecosystem service in Marsabit. The design employed descriptive and observatory techniques at the points of water supply within the watershed ecosystem. The survey method was considered most appropriate based on the fact that it describes systematically, factually and accurately the characteristic of an existing phenomenon. Secondly, this design was chosen because the researcher was seeking information from a large population over a short period. A standard MPM questionnaire was the key tool for the study to capture information from the beneficiaries of the ecosystem (Annex 1).

3.3 Target Population

The populations from which the sample was drawn from consist of beneficiaries of the watershed ecosystem and are residents of Marsabit Sub-County distributed in three Wards of Karare, Sagante/Jaldesa and Marsabit Central. Based on KNBS, (2009) national population and housing census projections, a total 10,002 households and 46,502 people in Marsabit area are entirely dependent on Mount Marsabit watershed ecosystem for their water supply. The study targeted adult's given that these groups ensures an informed response.

3.4 Study Sample Size

The sample was drawn from three Wards (Karare, Songa and Sagante/Jaldesa) in Saku Sub-County, population depending on Mount Marsabit Watershed for water use. Based on KNBS (2009), data, total of 46,502 people reside in the selected area. The desired sample size determined using the formula of Fisher *et al.* (1998) as shown overleaf.

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

Where-:

n- The sample size desired

z- The standard normal deviation, set at 1.96, which corresponds to 95% confidence level

p- The proportion of the target population estimated to have a particular characteristic. Since the prevalence is not known, p was assumed to be 50% (The study used 0.5).

q= (1-p) which is 1-0.5=0.5 and

d- The margin of error (5%) = 0.05

Therefore,

$$(n) = \frac{(1.96^2)(0.5)(0.5)}{(0.05^2)}$$

Therefore the desired sample size for the study 384.

Owing to financial constraints, time, distance between the water points, homogeneity of the data and above all insecurity issues among the warring communities in the area, the researcher managed 158 sample. Additionally, sample size which is more than or equal to 30 is assumed to be representative enough.

3.5 Sampling Frame

The sample of participants selected for this study was from Saku Sub-County; Wards of Karare, Marsabit Central and Sagante/Jaldesa and are the beneficiaries of the consumptive water use service. The study adopted random sampling technique at the point of water supplies within the ecosystem; this is where every subject meeting the inclusion criteria was randomly selected until the desired sample of respondents achieved (Mathieson, 2014). Random sampling was preferred as it minimises biasness in the responses and ensures equal representation. The technique provided a fair description of the variables of the study which was employed to select the beneficiaries. Questionnaire survey conducted at the point of water in the three wards, where 52 questionnaires were administered equally in the three Wards of Karare, Marsabit Central and Sagante/Jaldesa Ward totalling to 156 and 2 administered to the 2 conservancy in the area.

3.6 Data Collection

From the ecosystem cost-benefit analysis, the information required to answer the research questions and help achieve the set objective includes establishing the key water sources, uses, beneficiaries, their accessibility and reliability. Samples were obtained from the residents depending on the ecosystem for their water supply. Both primary data and secondary data were collected to achieve the set objectives and help answer the research questions of the study.

3.6.1 Primary Data

Primary data was collected while in the field. The primary data collected includes information on typology of point of water access for consumptive water use service, the cost of service as measured using the site specific market price of water and the GPS recording of water points. This helped to adequately answer the research question and achieve the set objectives. A standard MPM questionnaire survey (Annex 1), focused group discussions and field observation methods were applied.

3.6.1.1 Questionnaire Survey

Questionnaires are useful for obtaining information that cannot be easily observed but can be used for description and explanation in research. A total of 158 questionnaires were administered and filled in by the beneficiaries of the watershed at the point of water access; this helped in quantitative data collection and obtaining information from the respondents. The questionnaires were divided into sections containing closed and open-ended questions comprising of items developed from the research questions, specific objectives and the literature reviewed. The Likert Scale (1 to 5 where 1 is strongly disagree, 2 is disagree, 3 is moderate, 4 is agree and 5 is strongly agree) was used in the questionnaire to compare the perception levels by respondents against various attributes concerning the watershed ecosystem benefits.

3.6.1.2 Focused Group Discussions

Focused group discussions were utilised to help in data collection, a group of 9 persons, consisting of beneficiaries, among them the youths and elders; this helped prompt free discussion with participants and probe for answers concerning the study. The participants were drawn from those manning water points, youth leaders and beneficiaries’ representatives from the three Wards to enable fair representation.

3.6.1.3 Field Observations and Mapping of Water Points

Field observations were conducted on the use and state of the water sources found within the watershed ecosystem. This method enabled the researcher study the target problem as it occurs. Digital photo camera was also used to capture any related observations to make while out in the field. A GPS (Garmin model) was used to record the locations of various points of water access around the watershed. The GPS reading were then overlain on a map of the area to generate a spatial map of points of water access.

3.6.2 Secondary Data

Secondary data used was obtained from governing bodies in the study area. Among them; Water Resource Management Authority (WRMA), the local water service provider (Marsabit Urban Water Supply), research institutions like Kenya Agricultural and Livestock Research Organization (KALRO), KWS, tourist facilities (Marsabit lodge, Gof bongole) and Non-Governmental Organisations (CIFA). The secondary data included published documents, maps and imagery data.

3.7 Data Capture Tools

Handheld GPS unit was used to help in the mapping of the water points. Digital Camera was used to make photographic evidence and voice recorder used in the FGD exercise.

3.8 Economic Valuation Methodology

Different other tools can be used in ecosystem valuation, these entails methods which generates values directly from the beneficiaries and those on indirect methods. The market price approach is considered as the easiest and most straight-forward method in the valuation of consumptive benefits in ecosystems because it is based on the estimation of the quantity of goods against their market price. The study sought to estimate economic values of consumptive water use service of the ecosystem. MPM used approach because of its suitability to the study, the kind of data available, the simplest approach of estimating the consumptive benefits of ecosystems and the resource service being valued. This method requires only information on the quantity of ecosystem goods and services and their current market prices in order to estimate the monetary value (MEA 2005, Lovett & Noel 2008). In deriving the watershed water use service values, water abstraction per beneficiaries against the values identified were used in computing the service value for each of the beneficiary groups identified around the ecosystem.

Most of the beneficiaries accessing the service from shallow wells, springs, lakes, pans and communal boreholes were not paying for the commodity as of that, the market price of the commodity was obtained from NDMA, (2017) for uniformity of the results and to avoid over estimation of the service. For every beneficiaries identified by the study, the water abstraction in liters was computed against the NDMA, (2017) price of Ksh 5 per jerrican. Number of household depending on the identified water source was obtained from PWA supervisors and borehole operators for communal borehole.

3.9 Data Analysis

Data analysis is the process of getting information from the data collected and presenting it. The data received were in both quantitative and qualitative forms. After the completion of the data collection process, the MPM questionnaires were first examined for completeness and then coded. The quantitative data from the close-ended questionnaires was entered by use of Statistical Package for Social Sciences (SPSS) and analysed using descriptive statistics which include arithmetic mean, standard deviation, percentages and frequencies. While qualitative data from the open-ended questionnaires was analysed by use of content analysis since the focus was on the interpretation of the results rather than quantification. The analysed data were then be represented in figures, charts, tables.

The secondary data was analysed through data evaluation using analytical and logical reasoning to examine each component of the available data. While estimation of the monetary value for the consumptive benefits of the watershed ecosystem services were based on the water used and valuation done through the market price method (MPM) using the cost value.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter illustrates the analysis, data presentation and interpretation. Further, it provides discussions on the findings of the study, compared to other similar studies. Data was computed using frequency, percentages and mean, and results presented using tables and graphs to illustrate the observed relationship.

4.2 Respondents Characteristics

This section presents an analysis of the respondent's background information

4.2.1 Age and Gender

From the study, in terms of respondent's gender, 56% were male and 44% female (**Figure 4-1**). In addition, majority of the males (37.5%) and 40% females were aged between 18-25 years, 27.1% females and 23.9% males were between 26-35 years, 14.3% females and 12.5% males were between 36-45 years, 7.1% females and 13.6% males were aged between 46-55 years and lastly 11.4% females and 2.5% males were within the age bracket of above 55 years. This implies that majority of the respondents were youths who are active and found at the point of water access, the old age respondents were the minority. The male percentage were higher than the female slightly, this is due to the fact that male are the ones mostly at the water points watering their livestock and girls engaged in domestic chores such as fetching of water for domestic use.

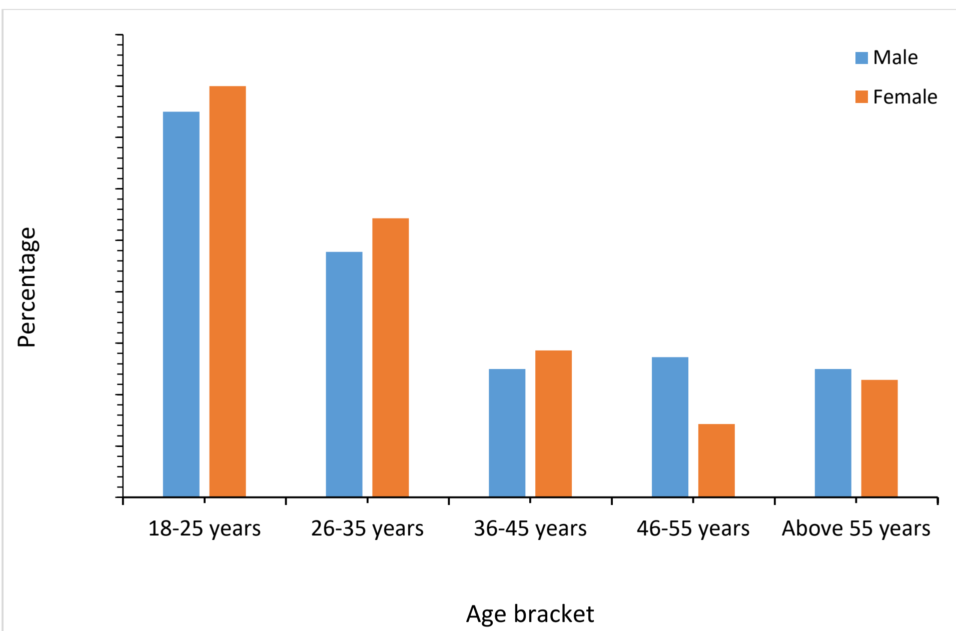

Figure 4-1: Age of the Respondents

4.2.2 Education Level

The study considered the education level held by respondents in order to find out if the respondents had knowledge on and understood the value of the consumptive use services provided by Mount Marsabit watershed ecosystem. From **Figure 4-2**, majority 51.4% females and 46.6% males had not attended schools, 31.4% females and 28.4% males had primary school certificates, 15.7% females and 17% males had secondary school certificates, 4.5% males had college diplomas, 1.4% females and 3.4% males had university degrees. These findings demonstrated that majority of the respondents were not highly educated, this is due to the fact that Marsabit is an arid and marginalized region and uptake of higher education is low as compared to other regions in Kenya. The study established that motivation for education in the area is very minimal due to the reason that the number of graduates in the area are minimal, this indicates that younger generation motivation for higher learning is minimal.

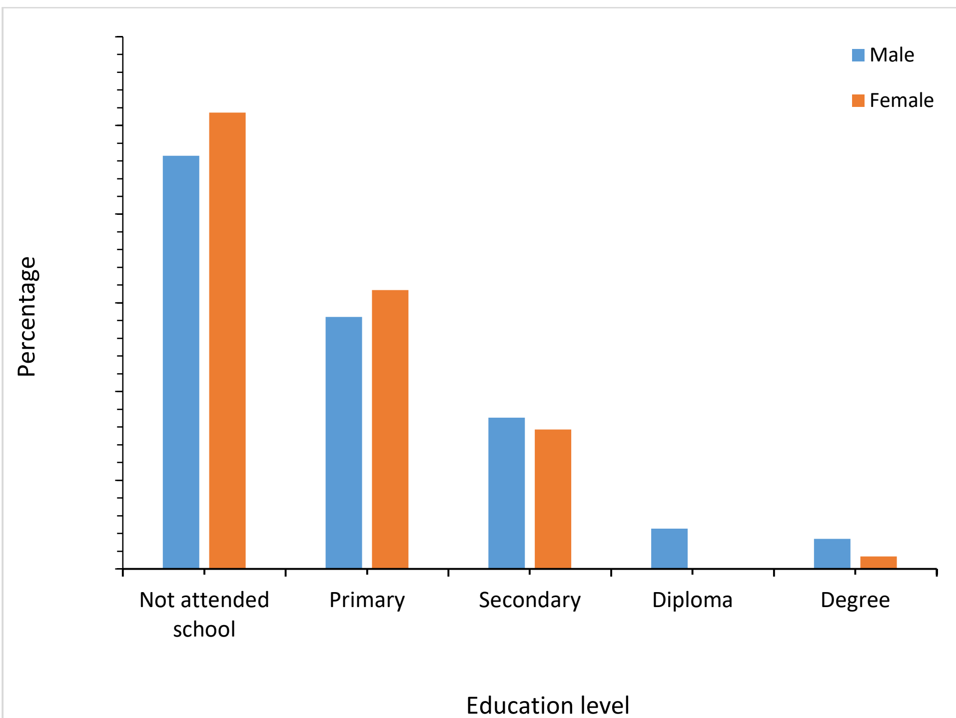

Figure 4-2: Education Level of Respondents

4.2.3 Role in the Community

The study sought to know the respondents' role in the community in order to determine if their role could influence the sustainable utilisation of the consumptive watershed services. The results in **Table 4-1** overleaf depicts that, majority 74.1% were community members with no specific roles to play, 11.4% were youth members, 8.8% were village elders, 1.3% youth secretaries, 0.6% community warriors, relief committees, group chair lady, community health volunteer, chairman WRUA, borehole operator and borehole manager respectively. These indicates that majority of the respondents involved in the study were conversant with the consumptive services provided by Mount Marsabit watershed ecosystem and could easily influence the conservation to enjoy the benefits.

Table 4-1: Respondents Role in the Community

Position	Count	%
Community member	117	74.1
Youth member	18	11.4
Village elder	14	8.8
Youth secretary	2	1.3
Community warrior	1	0.6
Relief committee	1	0.6
Group chairlady	1	0.6
Community health volunteer	1	0.6
Chairman WRUA	1	0.6
Borehole operator	1	0.6
Borehole manager	1	0.6
Total	**158**	**100.0**

4.2.4 Livelihood

The study established the respondents' livelihood dependence as presented in **Table 4-2** below which shows that, majority of the respondents (25.32%) depended on livestock keeping, 4.43% were involved in ecotourism, 5.70% depended on charcoal burning, 11.39% on casual labour, 13.92% on firewood gathering, 7.59% agriculture, 2.53% of the respondents' vehicle driving, 0.63% musicians, 6.33% of the respondents were employed and lastly 22.1% were involved in trading.

Table 4-2: Respondents Livelihood

Livelihood	Count	%
Livestock keeping	40	25.32
Ecotourism	7	4.43
Charcoal making	9	5.70
Casual labour	18	11.39
Collecting firewood	22	13.92
Agriculture	12	7.59
Vehicle driving	4	2.53

Musicians	1	0.63
Employment	10	6.33
Trading	35	22.15
Total	**158**	**100.0**

On livelihoods, the FGD attested pastoralism as the key livelihood among the community, with clear gender related labour divisions. Male activities were more strenuous (casual work, ploughing, looking after livestock) while female livelihood activities revolved mostly around traditional music as a form of ecotourism, bead making, collecting firewood for sale. For casual labourers, the payment rate was approximated to be between Ksh 200-400 per day.

4.3 Watershed Points of Water Access

Multiple water sources types are available across Mount Marsabit watershed ecosystem. The watershed service points of access available in Mount Marsabit ecosystem has different characteristics. The findings are as follows;

4.3.1 Points of Water Access (PWA)

Respondents specified the name and point of the watershed point of water access they rely on. As can be seen in **Table 4-3**, majority 47.3% of the respondents specified borehole as their main watershed point of water access, 15.3% shallow well, 13.3% water kiosks, 12.0% spring, 8.7% water pan, 2.0% stream, 0.7% rain water harvesting and 0.7% crater lake all found with the ecosystem. Atleast every region within the watershed has different types water points available, within an average of 2.4km there are water points serving the community.

Table 4-3: Watershed Point of Water Access

Water shed point	**Count**	**%**
Borehole	71	47.3
Shallow well	23	15.3
Kiosks	20	13.3
Spring	18	12.0
Water pan	13	8.7
Stream	3	2.0
Rain water harvesting	1	0.7
Crater lake	1	0.7
Total	**150**	**100.0**

Plate 4-1: Domestic Water Fetching from a Shallow Well (Research Assistant Capturing Information)

Plate 4-2: Bakuli Spring at the Heart of Mt. Marsabit Ecosystem

Plate 4-3: Research Assistant Capturing Information at PWA

4.3.2 Water Source Types and Functionality

From the survey conducted on the water points within the watershed, majority of the water points (71.9%) were unimproved and 28.1% improved, **Table 4-4**. Improved water points are protected from any contamination, through the role of local NGOs, CBOs and the County Government of Marsabit, Department of Public Health and Sanitation. Unimproved water sources are not protected from any contamination. The coverage of improved water sources is still considerably lower compared to other regions in Kenya. Similarly, the functionality of the water points was assessed on functionality and non-functionality basis. The water points were concluded to be functional in the sense that the beneficiaries were using the water points, whether in improved or unimproved status. Non-functional water points were those where the source was either dry or broken down and no beneficiary was using the water point. From the water points sampled, majority, 92.1% of the water points were functional and in use, while 7.9% are not in use, these water points were dry at the time of the study.

Table 4-4: Water Sources Types and Functionality

Variable	Improved		Unimproved	
Type of water source	Frequency	Percentage	Frequency	Percentage
	25	28.09%	64	71.91%
	Functional		**Unfunctional**	
Water point functionality	Frequency	Percentage	Frequency	Percentage
	82	92.13%	7	7.87%

4.3.3 Water Extraction System

From the findings, different systems are used in the extraction of water from the points of water access for use by the beneficiaries of the watershed. As shown in **Figure 4-3**, Hand manual extraction (i.e. by use of rope and bucket) is the common water extraction technique (60.7%), this is mostly used at the shallow wells. Further, 20.2%, use submersible pump, powered by diesel and solar, these are mostly used in boreholes, 6.7% is run off harvesting, water pans are the main water point where the beneficiaries utilize water as a result of surface run off harvesting and 12.4% extraction is through gravity where water flowing in streams and springs are tapped and used for both domestic and livestock.

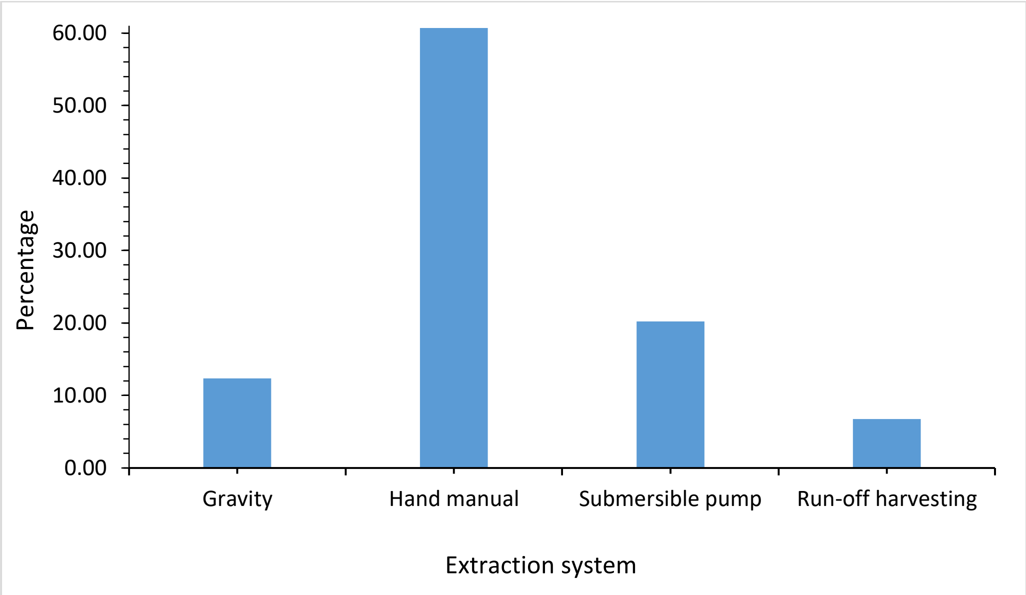

Figure 4-3: Mode of Water Extraction

4.3.4 Point of Water Access Use

From the survey, most of the water points around the ecosystem are utilized for different use. 52.9% of the points of water use consisted of domestic use and livestock watering only while31% consisted of domestic use only, 11.5% of water serves all domestic, irrigation and livestock watering and 4.6% for livestock watering only (**Figure 4-4**). The points of water use which were set aside for livestock watering, were manned to avoid use by other water consumers, this was mostly done to ensure there is enough water for the livestock at all times.

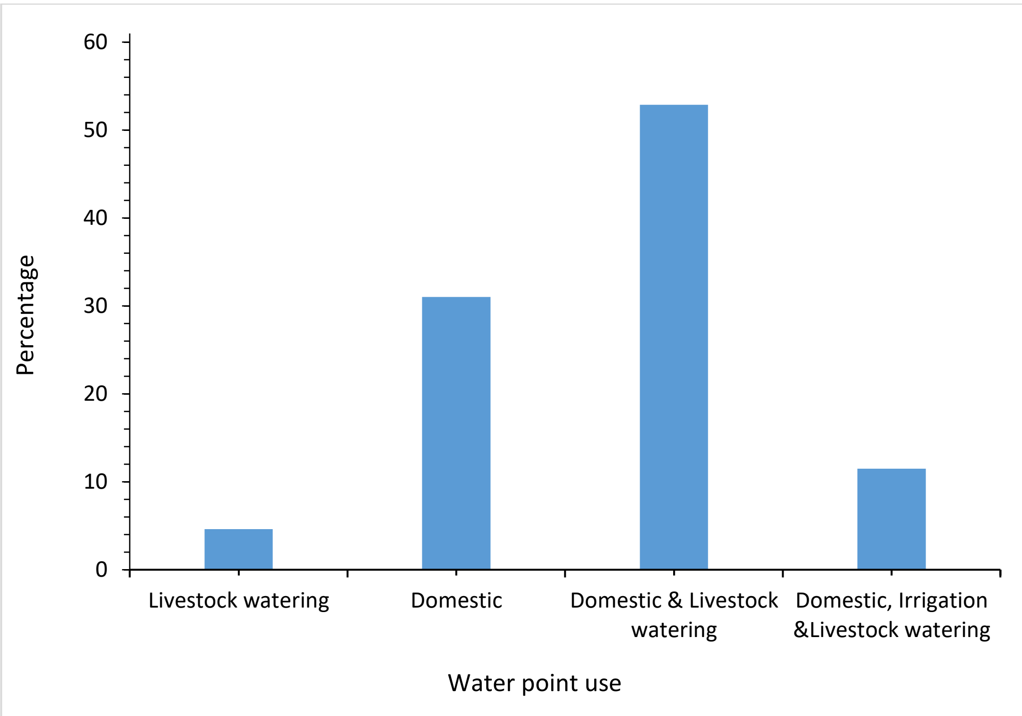

Figure 4-4: Point of Access Water Use

4.4 Characteristics of Watershed Services Consumers

4.4.1 Watershed Ecosystem Service Beneficiaries

From the survey, 99.4% of the 158 respondents were the beneficiaries of Mount Marsabit watershed ecosystem and only 0.6% were not the beneficiaries relying on water from Logologo area, which is outside Mount Marsabit watershed boundary. Majority of the beneficiaries (54.5%) were domestic water users, 31.6% were livestock keepers, 7.3% small scale irrigators, 2.9% commercial water users, 2.5% tourism operators and 1.1% conservationists (**Table 4-5**).

Table 4-5: Watershed Services Beneficiaries

Beneficiaries	Responses (N)	%
Domestic water users	150	54.5
Livestock keepers	87	31.6
Small scale farmer	20	7.3
Commercial water users	8	2.9
Tourism operators	7	2.5
Conservationists	3	1.1
Total	**275**	**100**

4.4.2 Watershed Service Benefit Mode of Access

From the survey, watershed service beneficiaries accessed water from the ecosystem in different ways. The mode of access by the beneficiaries is as per the findings depicted by **Figure 4-5** below.65.2% of the respondents accessed the water directly at the water point, 22.2% from water kiosks within their area, 7% were through direct pipeline connection to their homes and 5.7% were through water bowsers supply.

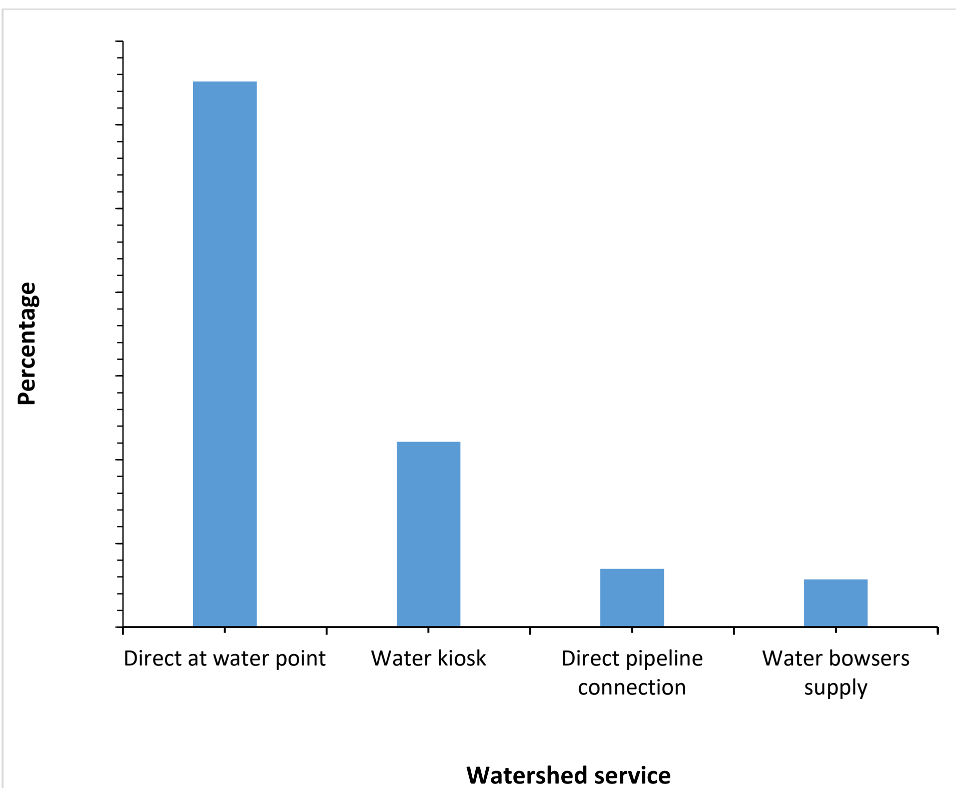

Figure 4-5: Watershed Services Mode of Access

4.4.3 Perception on Water Quality

In terms of water quality based on the respondent's perception, 92.4% reported that water quality was good while7.6% indicated that the water quality was poor. The respondents based their judgement on the state of water freshness, softness, turbidity. Poor water quality was associated with foul smell, saltiness, turbidity and untreated water.

The results in **Table 4-6** show that 28.5% indicated that the water was fresh and clean while 3.2% considered the water as fresh and treated, 2.5% indicated that the water was salty, and 3.8% felt that the water was untreated., Majority (62.0%) of the respondents indicated that they were not sure on the water quality unless chemical assessment is done on water quality.

Table 4-6: Water Quality Perception

Reasons	Count	%
Fresh and clean	45	28.5
Fresh and treated	5	3.2
Salty water	4	2.5
Untreated water	6	3.8
Not sure	98	62.0
Total	**158**	**100.0**

4.4.4 Ownership and Management of the Point of Water Access

From the survey, 64.6%, of the respondents indicated that the owners of the point of water access were community members, 13.3% indicated county government, 11.45 private company and 10.8% national government (**Table 4-7**). These findings indicate that most water supply points are owned by community members. NGOs were found to support the water supply projects in the regions by installing solar panels and generator to pump water at communal water points.

From the findings of the study, 79.1% of water points were mostly managed by the community and 20.9% by self-help groups. These clearly shows that the communities living around the watershed plays the managerial role over the water resources which is the main cause of frequent communal water conflicts in the area.

Table 4-7: Water Points Ownership

	Frequency	%
Community	102	64.6
County government	21	13.3
Private company	18	11.4
National government	17	10.8
Total	**158**	**100.0**

4.4.5 Number of Years of Using Point of Water Access (PWA)

From the survey, majority of the respondents had been using shallow well for close to 22 years, rain water harvesting for 16 years, spring water sources for close to 16 years, water kiosks for 9 years, stream water for 9 years and borehole for 6 years. All the respondents indicated that the lived an average of 2.4 kilometers from the water points, which indicated that communities lived close to the watershed points of supply (**Table 4-8**).

Table 4-8: Point of Water access Use Period

Water source	Mean
Shallow well	22.0
Others(Harvested rain water)	16.44
Spring	16.0
Kiosks	9.32
Stream	9.0
Borehole	6.80

4.5 Characteristics of Consumptive Watershed Services in Mount Marsabit Ecosystem

4.5.1 Overall Condition of the Watershed Ecosystem

Table 4-9 shows that majority (64.6%) of the respondents rated the overall condition of the watershed services provided by Mt. Marsabit to be very good, 27.2% good, 6.3% moderate, 1.3% poor and 0.6% were not sure. The respondents based their judgment on the watershed condition on the reliable water availability from the forest ecosystem.

Table 4-9: Watershed Ecosystem Conditions

	Frequency	%
Very good	43	64.6
Good	102	27.2
Moderate	10	6.3
Poor	2	1.3
Not sure	1	0.6
Total	**158**	**100.0**

4.5.2 Watershed Ecosystem Utilization and Status

From the survey, majority (89.9%) of the respondents indicated that the watershed had been put into good use and only 10.1% of the respondents disagreed with that view. This implies that most of the watershed had been in good use according to the local people.

However, (37.5%) of the respondents indicated that the watershed ecosystem had suffered from forest encroachment, illegal logging (18.8%), lack of proper management by government (12.5%) and overgrazing (12.5%). 6.3% of the respondents indicated lack of proper regulations and corruption as challenges facing the forest ecosystem (**Table 4-10**).

Table 4-10: Watershed Ecosystem Conditions Reviews

Ecosystem poor condition reason	Count	%
Encroachment into the forest	6	37.5
Illegal logging	3	18.8
No maintenance by government	3	18.8
Overgrazing during dry season	2	12.5
No proper regulation in place	1	6.3
Corruption by government officials	1	6.3
Total	**16**	**100.0**

4.5.3 Watershed Ecosystem Service

The respondents were asked to rank the Mount Marsabit watershed ecosystem service against a number of benefit attributes as shown in **Figure 4-6** overleaf. According to the results majority (29.9%) strongly agreed on affordability of water supply in the area, 37.6% strongly agreed on availability of water supply, 26.8% strongly agreed on easy access of the water supply points, 54.1% strongly agreed on the fact that good forest cover enhances provisioning of various goods and service, 46.4% strongly agreed that water quality is good, 67.1% strongly agreed that watershed primary source of water, 36.3% strongly agreed on provide other goods like timber, plant animal products etc. Lastly 58.0% strongly agreed on provide other services like climate moderation, biodiversity conservation, recreation, and carbon sequestration. The benefits emerging from the respondents depicted the characteristics of the ecosystem consumptive water use service as affordable, accessible, good water quality and provision of non-consumptive service.

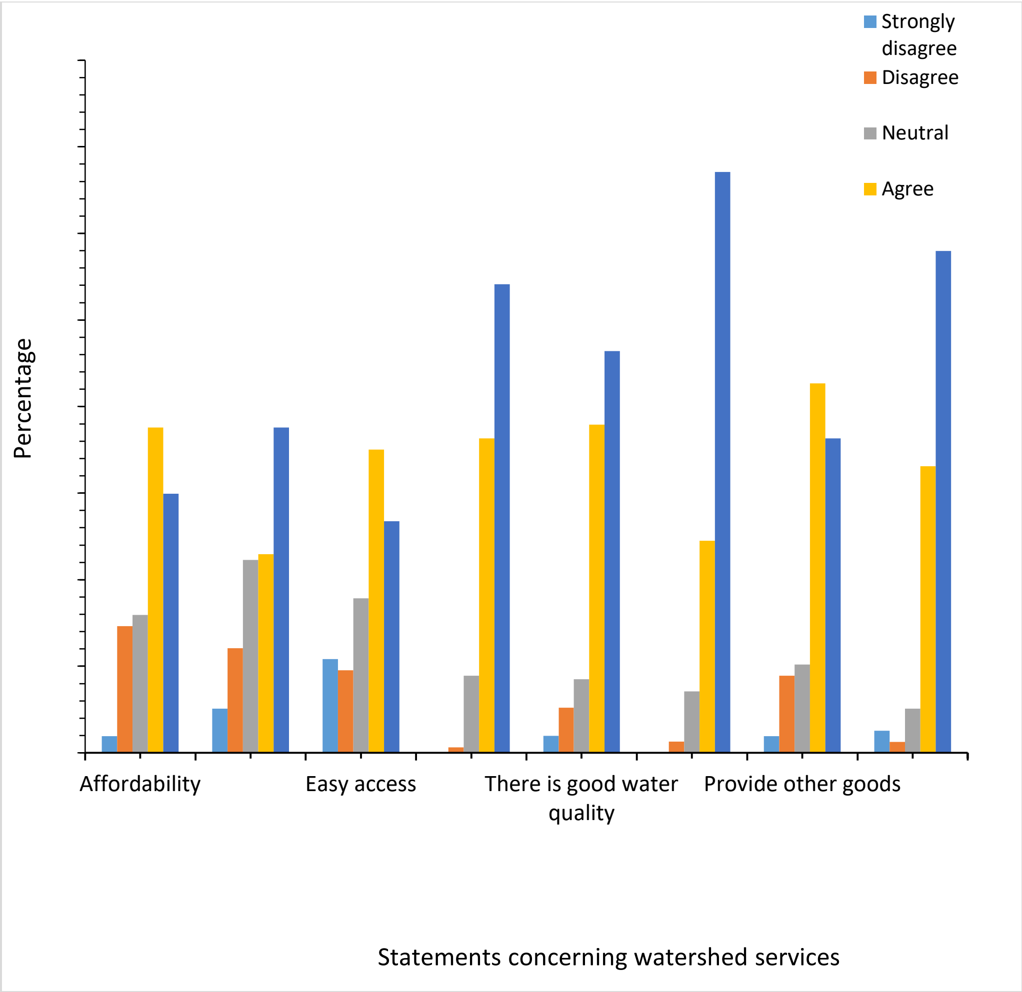

Figure 4-6: Watershed Ecosystem Characteristics

The Likert Scale findings indicated that the respondents had clear understanding that forest ecosystem is crucial in terms of service provision and the benefits they are enjoying from the ecosystem.

4.5.4 Reliance on Point of Water Access

From the survey, majority 52.5% relied on point of water access during dry season, 43% throughout the year and 3.2% wet seasons as illustrated in **Table 4-11**.

Table 4-11: Points Water Supply Reliance Seasons

Reliance season	Frequency	Percent
Dry season	85	53.8
Throughout the year	68	43.0
Wet seasons	5	3.2
Total	**158**	**100.0**

4.5.5 Watershed Ecosystem Service Benefits

Figure 4-7 shows how the respondents rated the benefits of watershed services in the Mount Marsabit ecosystem using the Likert Scale. According to the findings, majority (37.2%) of the respondents agreed to the forest ecosystem ensured sustainable water supply, 40.4% strongly agreed that the ecosystem minimize floods, 35.3% agreed that the ecosystem plays role in climate regulation, 44.9% agreed that the ecosystem was contributing to improved living conditions as a result of the goods produced while 43.6% strongly agreed that the ecosystem was playing an important economic role in the area.

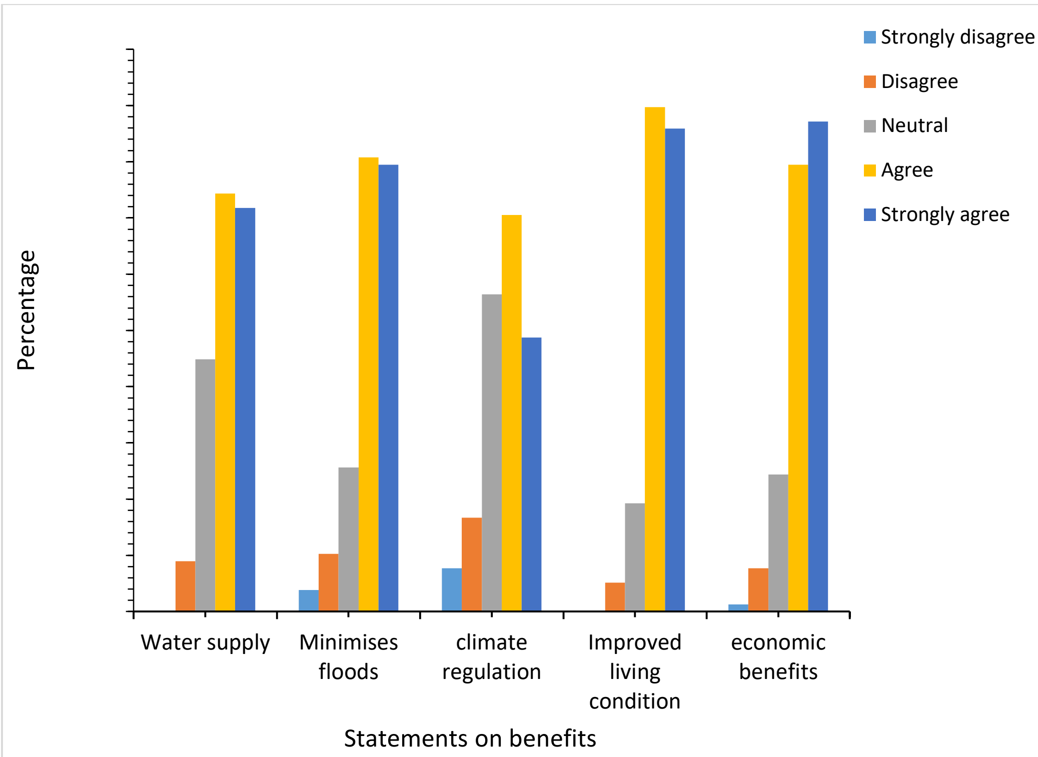

Figure 4-7: Watershed Ecosystem Benefits

4.5.6 Changes in Water Quantity

From the survey, majority of the respondents 58.2% indicated that there were changes in water quantity from the watershed ecosystem from time to time and 41.8% indicated no much changes.

The respondents indicated that there is rise in water quantities during rainy season. Surface run off is retained in water pans and reservoirs making water quantity against consumer demand to go up. During dry season, drought causes water sources to dry up leading the quantity of water to go down. Often, pipeline destruction by wildlife, borehole technical problem also contributes to water quantity reduction from time to time, however such issues can be sorted with the management of water points within the ecosystem.

4.5.7 Effect of Changes in Water Quantity

The respondents indicated that the changes in water quantity from the ecosystem results to inadequate water supply which greatly affected the livestock. Further, this leads to a lot of time being spent looking for alternative water source**.** Similarly**,** people move for long distances in search of water for both domestic use and livestock watering**.** During the season when the water quantity goes down, conflict over the scarce resource arise as a result affecting the livelihood of household due to death and livestock loss. In the season, water quantity increase in some cases excess rainfall after dry season causes soil erosion, this is due to vegetation loss during the dry season. This emerged from the FGD data transcription backed up by NDMA, (2017) data on short and long rains assessment.

4.6 Paying for the Watershed Water Use Services

From the survey, majority of the respondents 51.9%, indicated that they paid for water use services while 48.1% did not for those paying for the services, on average water consumer pays Ksh. 5 for a 20 litre jerrican of water, with the price varying across the ecosystem. The pastoralists, pay depending on the livestock type, with the cost of watering a cow per head at Ksh 20while Ksh10 was paid for goats and sheep were charged, Ksh 40 for camel and Ksh 5 for a donkey. The livestock watering payments at watering point done on monthly basis by the pastoralists.

4.7 Direct Consumptive Water Use Component

Water is the direct consumptive use supplied to the beneficiaries from Mount Marsabit watershed ecosystem, the beneficiaries enjoy water supply at different water points through different mode of supply to their benefits. Water from the ecosystem are mainly sourced from springs, boreholes, shallow wells, water pans. Six different category of direct consumptive beneficiaries were identified (livestock keepers, small scale farmers, conservationists, tourist operators, commercial water traders and domestic water users).The ‘local’ variety prices were used to generate the estimated value for each category of benefits.

4.7.1 Livestock Keeping

From the survey, 51.3% of the respondents kept livestock while 48.7 did not and relied on other livelihoods. Additionally, Majority of the respondents indicated that on average the minimum selling price of cow is Ksh 28,624, Ksh 2,368 for sheep, Ksh 3,784 for goats, Ksh 12,800 for donkeys and Ksh 57,625 for camels. The locals depend on Mount Marsabit watershed ecosystem for pasture and water, this clearly shows linkages between the livestock and the ecosystem value. Cows are taken to water point 3 days per week, sheep's and goats 2 days, donkeys 4 days and camels once a week. At borehole water points, the average cost of paying for watershed services benefits was Ksh 37 for camels, Ksh for 16 for cows, Ksh 8 for sheep and goats, and Ksh 4 for donkey. However, the prices varied across the ecosystem. The water consumption varied depending with the livestock type. **Table 4-12** below summarizes water intake frequency in all the five types found in Saku and the average selling price.

Table 4-12: Livestock Watering Frequency and Price

Livestock	**Frequency of watering livestock (*Days/week*)**	**Average watering Cost per head**	**Average selling prices (*Ksh*) of livestock**
Camel	1	37	57,625
Cow	3	16	28,624
Sheep	2	8	2,368
Goat	2	8	3,784
Donkey	4	4	12,800

From the study, the mean number of livestock at key points of water access around the ecosystem stands at 701 for cows, 512 for goats 512, 468 for sheep 178 for camels and donkeys. This shows that the local communities are mostly keeping small ruminants followed by cows, donkey and camel (**Figure 4-8**). Water consumption and frequency of visit to the water points varied from species to species. The findings showed that number of ruminants are high compared to others, the respondents reported that it is due to the adaptability of small ruminants to dry weather and high productivity. The approximation of water consumption by the livestock does not consider variations due to breed, age, species, lactation and pregnancy as well as climate in terms of dry and season. Plate 4-4 shows livestock heading to water point in heart of the ecosystem, Qarsa Village in Sagante/Jaldesa Ward.

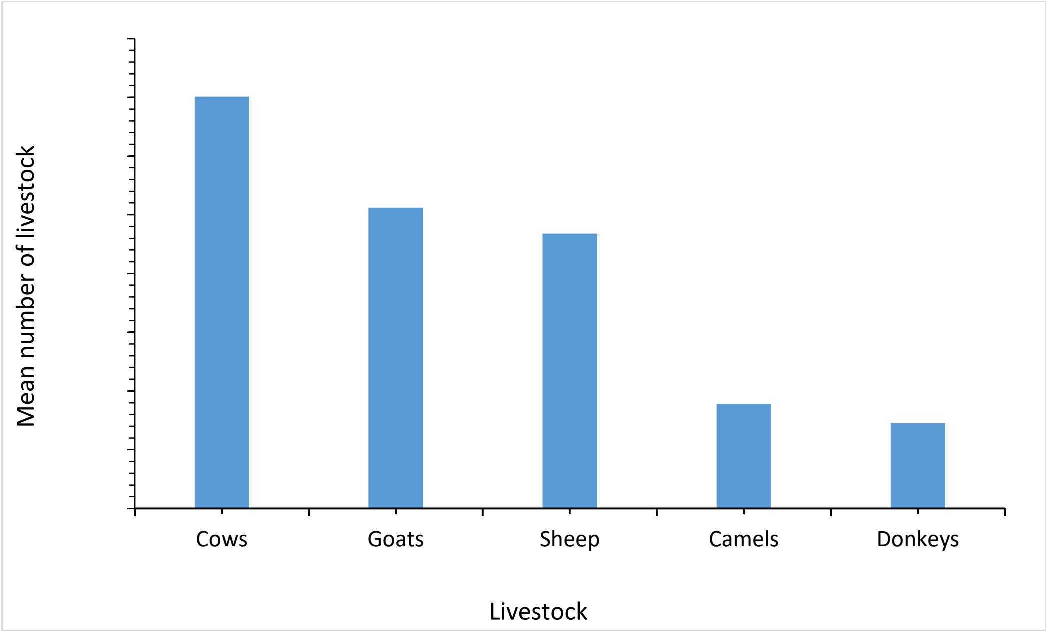

Figure 4-8: Average Livestock Number at Water Points

Plate 4-4: Herd of Cattle Flocking into the Forest for Water and Pasture

Plate 4-5: Livestock Watering at a Water Point within the Ecosystem

4.7.2 Small Scale Farmers

From the survey, up to of the 7.3% of respondents practice farming in small scale. Faming around the ecosystem is practiced mostly in Songa area, which has good climate due to its close proximity to Marsabit forest and enough water from shallow wells, springs and water pans. Jaldesa and Jirime village residents depend on borehole water and Gof-crater for irrigation. Most of the crops produced and for subsistence and only a few sold commercially in the market. Majority (89.2%) of the farmers do not do irrigation, with only 10.8% doing irrigation in small scale. This clearly shows that farming in the area is on the lower side. Most of the community are pastoralist and value their livestock, hence do not value farming. Additionally, overdependence on the livestock products poses a food security risk.

4.7.2.1 Kind of Crops Grown Through Irrigation

Table 4-13 overleaf shows the kind of crops grown by the farmers through irrigation which includes Kales (36.4%), tomatoes (20.5%), Spinach (9.1%), Pepper (4.5%), Onions (4.5%), Maize (4.5%), Fruits (9.1%), Beans (4.5%), Miraa (2.3%), Garlic (2.3%), and Dania, (2.3%). On average it was found out the average income of the crops grown through irrigation was Ksh 65,283.33.

Table 4-13: Crops Gown around the Ecosystem

Crops grown	Count	Column %
Kales	16	36.4
Tomatoes	9	20.5
Spinach	4	9.1
Pepper	2	4.5
Onions	2	4.5
Maize	2	4.5
Fruits	4	9.1
Beans	2	4.5
Miraa	1	2.3
Cow peas	1	2.3
Dania	1	2.3
Total	**44**	**100.0**

Plate 4-6: Small Scale Irrigation Practice around the Ecosystem

4.7.3 Domestic Consumers

Table 4-14 shows information on the categories of consumers, according to the findings in Table 4.5. The number of household consumers had a mean of 6.25 indicating the average number of consumers relying on Mount Marsabit watershed was 6 people per household. Majority (49.4%)

of the respondents indicated the frequency of consumer visit to the point of water access was 7 days per week, meaning they visited the water supply on daily basis, 16.5% indicated 3 days per week, 8.9% visited the water points 4 days per week, 6.3% twice a week and 7% indicated once per week respectively.

Table 4-14: Household Frequency of Visit to Water Points

Frequency of visit	Frequency	%	Mean on No of House holds
1	11	7.0	6.2.5
2	10	6.3	
3	26	16.5	
4	14	8.9	
7	78	49.4	
Missing System	19	12.0	
Total	**158**	**100.0**	

4.7.4 Commercial Consumers (Traders)

Table 4-15 shows commercial consumers of water specific type of business in which 37.5% were water traders, 50%, car wash businesses and 12.5% for hotels and restaurants. The mean score on the number of consumers was 38.22, indicating 38 consumers used the water for commercial purposes. On average, the commercial business makes an income of Ksh 35,777.8 in a month. Commercial water consumers mainly source their water from boreholes in Qubi Qallo, Diriib and a few in Kamboe.

Table 4-15: Watershed Service Commercial Consumers

Types of business	Count	%
Water traders	3	37.5
Car wash	4	50
Hotel & Restaurants	1	12.5
Total	**8**	**100.0**

Plate 4-7: Commercial Water Vendors at Borehole in Sagante/Jaldesa (Qubi Qallo Village)

4.7.5 Conservationists

Mount Marsabit is designated as a national park and forest reserve, which are the key ecosystem conservation areas covering 2000km^2 and 150km^2 respectively (Government of Kenya, 1989, Government of Kenya, 2002). From the study, it was established that KWS and KFS are the main conservationist in the area with Northern Rangeland Trust (NRT) an NGO forming two conservancies (Jaldesa and Songa) in the area to support non-state conservation in the watershed. The source of water for the conservationists are the KWS borehole supplying the KWS offices, campsite and the KFS staff quarters and offices. Songa conservancy rely on springs, shallow wells. Water pans and borehole for water supply.

4.7.6 Tourist Operators

The tourist operators using water from the ecosystem included Marsabit Lodge, the Gof Bongole Resort, and Songa conservancy camp site and lodge. These facilities rely on borehole water, springs and shallow wells to meet their water demand. Jirime Resort, Silvia Inn, Gof and Nomad all rely on borehole water. Mostly, commercial water traders supply these tourist facilities with water for use.

4.8 Watershed Protection Regulation

From the survey, majority, 55.1% of the respondents indicated that they were aware of the existing watershed protection regulation frameworks while 44.9% was not aware of any regulation (**Table 4-16**). Majority 98.8% knew about Forest Act (2015) while 1.2% knew about EMCA, 1999 including the Water Quality Regulations, 2006. The respondents were not aware of the Water Act, of 2016 including the Water Resource Management Rules 2007 because their interaction with the watershed was mainly in areas under the jurisdiction of KFS.

Table 4-16: Watershed Protection Regulations Familiarity

Regulations	Count	%
Forest Act (2015), KFS	84	98.8
EMCA, 1999 and subsidiary regulations (NEMA)	1	1.2
Total	**85**	**100.0**

4.9 Spatial Distribution of Water Sources in Mt. Marsabit Watershed Ecosystem

Marsabit is a dryland land region in Northern Kenya, characterised by dry environment, with varying climate and rainfall patterns. Water sources distribution in the area is strongly dependent on the Mount Marsabit ecosystem, it is a key water tower being source of run off and ground water. The forest on the mountain plays a key role of intercepting rainfall. Around the ecosystem, there are numerous boreholes drilled adding to the water supply for the locals. There are different water sources types documented around the ecosystem, among them; springs, water pan, earth dam, shallow wells, Crater Lake and boreholes. The total number of water sources recorded around the watershed ecosystem was 81. The study mapped the distribution of water sources around the ecosystem. , **Figure 4-9** shows the distribution and concentration of various water sources around the watershed ecosystem.

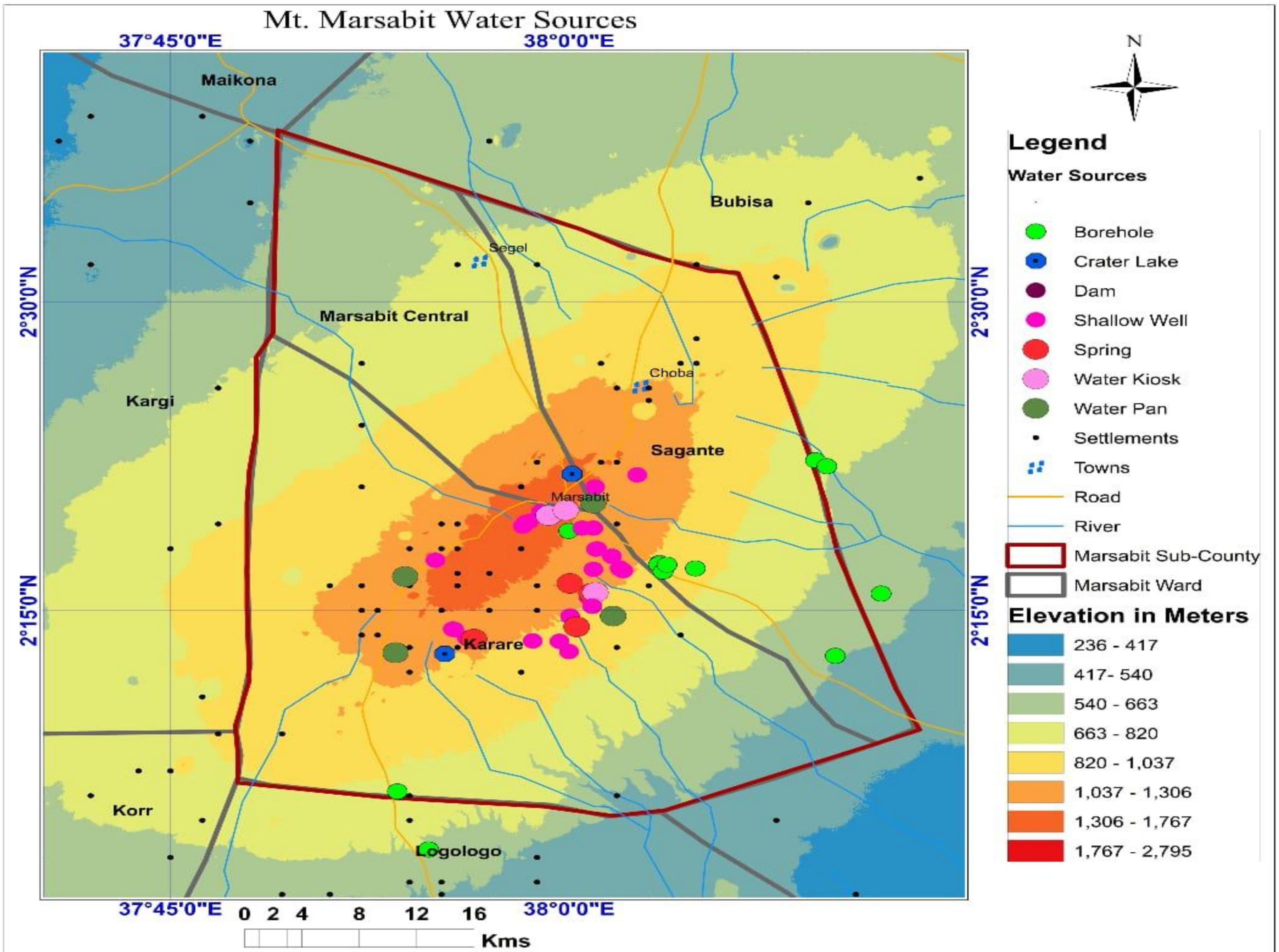

Figure 4-9: Map/Spatial Distribution of Water Source Types in Mt. Marsabit Watershed Ecosystem

4.10 Economic Value of Watershed Services in the Mount Marsabit Ecosystem

Market price method approach using available local market prices was used in computation of the consumptive benefit values. The study identified six categories of the consumptive watershed service beneficiaries as highlighted in Section 4.7. Estimation of monetary value for the consumptive use service were undertaken according to consumption level of each beneficiary category, namely; livestock keepers, conservationists, commercial water traders, tourist operators, small scale farmers and domestic water users. This was based on the number of consumers against the level of water abstraction and purchase price. The watershed ecosystem water use value was computed by adding up all the values per beneficiary category. Water from the ecosystem has wide range of prices, some get it free from source, others pay to pump it from boreholes, and others to transport it via truck, for areas where water was extracted for free. The study used NDMA data on price of water as the available market price in the area, Ksh 5/jerry can (NDMA, 2017).

4.10.1 Tourism Operators

Tourism is important and can generate income through visitors. Additionally, the comfort of tourist facilities is commonly gauged according to the level of water supply reliability. Marsabit had a number of facilities identified and documented which was used in calculation of the consumptive value of the tourism operators' beneficiaries' category. The value calculation used the estimated water consumption at the identified tourism facilities multiplied with the market price of water. For water consumption the research used the estimated water rate for tourists' facilities as per their ratings and class (after GoK 2005). According to GoK, (2005) the tourists in high class hotels were assumed to use 600 litres a day/bed, those in medium class 300 and those in low class hotels 50. **Table 4-17** shows facilities using water from Mount Marsabit watershed ecosystem. Tourist facilities gross income at full occupancy was estimated based on income per unit of water used by the beneficiaries of the facilities. NDMA survey data on water prices in Marsabit was used in value calculation. Estimated gross annual income of tourist facilities within the ecosystem was calculated per unit of water based on full occupancy assumption.

Table 4-17: Estimated Annual Tourism Operator's Consumptive Values

Facility type	**Star rating**	**Number**	**Bed capacity**	**Price (Ksh)**		**Water litres per day**		**Value per unit of water (Ksh/L)**	**Water Source**
				Per bed	**Total**	**Per Bed**	**Total**		
High class	5	0	-	25,000	-	600	-		Qubi Qallo Borehole
	4	2	45	5000	225,000		27,000	8	
Medium class	3	3	88	3000	264,000	300	26,400	10	Dirib Borehole
	2	3	69	2,500	172,500		20,700	8	
Low class	1	2	47	1,500	70,500	50	2,350	30	
	0	15	359	1000	359,000		17,950	20	
Total					1,091,000		94,400	12	

4.10.2 Conservationist

The above category was associated with the water demand for KWS and KFS stations within the Marsabit National Park and Forest Reserve which included offices, staff quarters, and camp supplied with water mainly through boreholes. In addition, both Jaldesa and Songa conservancies under NRT depended on water from boreholes, shallow wells. The estimation of the consumptive water use value for this category was undertaken according to the estimated water use level reported multiplied by the market price of water. The market price used was as per NDMA estimation of average cost, Ksh 5/20ltr jerrican (US$ 0.05) (NDMA, 2017). House hold consumption estimate of 20 litres/person/day from NDMA, (2017) was used for the group in calculating the daily consumption rate. Further, the conservationists' administrative offices were assumed to use 25 litres a day/head (after GoK 2005). Based on KNBS, (2009) national population census projection, average of 4.6 persons per household used. **Table 4-18** shows the findings for the conservationist category.

Table 4-18: Estimated Annual Conservationists' Consumptive Values

Conservationists	Water Source	HH number	Office Staff number	Offices water Litres		Estimated Abstracted water (L/day)	Estimated Annual water L/year)	Estimated annual water value at an average price of Ksh 5 per
				per head	Total			
KWS	KWS borehole	64	32	25	+800	6,688	2,441,120	610,280
KFS		48	24		+600	5,016	1,830,840	457,710
Songa conservancy	Songa Shalow wells	16	10	25	+250	1,722	628,530	157,132.5
Jaldesa Conservancy	Jaldesa Borehole	26	14	25	+350	2,742		250,207.5
Total								1,475,330

4.10.3 Commercial Water Vendors/Users

Commercial water users in terms of mostly vendors constituted 2.9% of the service beneficiaries. Water vendors in the area accessed water from springs and boreholes to sell to the residents. Boarding schools in the areas were considered as commercial water users in Marsabit. The estimation of watershed value was undertaken as follows;

a) Household beneficiaries - The amount of water extracted and the selling price was used to get the value of the commercial vendors' beneficiary.

b) Water kiosks - The households used registered card loaded with the amount provided, from the kiosks, water retails for Ksh 5 for a 20 litre.

c) Water bowsers – They retailed at between Ksh 20-50 which includes fuel and labour charges, we opted to use the selling price to water bowsers at the supply source which is estimated at Ksh 5 for 20 litres.

d) Boarding school - They were assumed to use 50 litres per head per day (after GoK 2005). Average price of Ksh 5/20L Jericans used for kiosks and the institutions. **Table 4.19** shows the commercial water users/vendors water consumption values.

Table 4-19: Estimated Annual Commercial Water Users/Vendors Consumptive Values

Commercial water vendors/users	Beneficiary HH	Water Source	Estimated abstracted water per day (L/day)	Estimated annual water (L/year)	Estimated water value at an average price of Ksh 5
Posta Kiosk	1900	Bakuli Spring	380,000	9,500,000	2,375,000
Shauriyako Kiosk	1248		249,600	6,240,000	1,560,000
Dirib Gombo Kiosk	2000	Muslim Borehole	200,000	5,000,000	1,250,000
Badasa Kiosk	1134	Badassa Spring	104,328	12,519,360	3,129,840
Bowser supplies	-	Borehole	36,720	7,711,200	1,927,080
Sasura Girls Sec.	350	Borehole	17,500	4,532,500	1,133,125
St Paul Sec. School	200	St Paul Borehole	10,000	2,590,000	647,500
Total					12,022,545

4.10.4 Domestic Water Users

Marsabit Urban Water Supply (MUWS) is the key provider for the urban population. Additionally, water kiosks and bowsers supply supplements water supply for domestic use. Bakuli Spring supplies water to the urban population through a MUWS connection line. Those in rural areas depend on water from shallow wells, water pans, springs and boreholes. Abstraction level at the water points was used in calculating the value of the consumptive benefits. House hold consumption estimate of 20 litres/person/day from NDMA, (2017) was used, multiplied by the number of occupants, 4.6 according to KNBS, (2009), population census projection, by the number of household depending on the water point. NDMA data on pricing was used (Ksh 5 per 20L jerry can respectively). **Table 4-20** overleaf shows the domestic water users and their values.

Table 4-20: Estimated Annual Domestic Water User's Consumptive Values

Point of water access	Estimated water yield L/day	Estimated annual water yield L/year	Dependent Household	Estimated annual water value at an average price of Ksh 5 per jerrican
MARSABIT CENTRAL				
Shallow Wells				
El Aite shallow well	7,360	2,686,400	80	100,740
Karatina Shallow wells	11,040	4,029,600	120	151,110
El Jarso Shallow Well	1,288	470,120	14	117,530
Springs				
Bakuli Springs	216,384	78,980,160	2,352	2,961,756
Bore Hole				
Shegel **(I)** Borehole	93,840	34,251,600	1020	8,562,900
Water Pans				
Haro Haroubu Water Pan	64,400	23,506,000	700	881,475
Haro Boota water pan	133,400	48,691,000	1450	1,825,913
SAGANTE/BADASA				
Shallow Wells				
Sagante Shallow Wells	110,400	40,296,000	1200	1,511,100
Gabra Scheme Shallow Wells	46,000	16,790,000	500	629,625
Springs				
Badassa Springs	143,520	52,384,800	1560	1,964,430
Bore Hole				
Badasa Midroc Bore Hole	23,920	8,730,800	260	2,182,700
Water Pans				
Jey Jey Badasa Pan	6,440	2,350,600	70	88,148
Shalow Wells				
Diriib Gombo Shallow Wells	73,600	26,864,000	800	1,007,400
El Qarsa Shallow Wells	73,600	26,864,000	800	1,007,400

Point of water access	Estimated water yield L/day	Estimated annual water yield L/year	Dependent Household	Estimated annual water value at an average price of Ksh 5 per jerrican
Bore Holes				
Kubi Qallo Borehole	21,160	7,723,400	230	1,930,850
Dololo Dokatu Borehole	4,140	1,511,100	45	377,775
Diriib Gombo **(I)** Borehole	6,440	2,350,600	70	587,650
Diriib Muslim Borehole	1840	671,600	20	167,900
Jaldesa Borehole	6,440	2,350,600	70	587,650
St Paul Sec. Borehole	1,840	671,600	20	167,900
Kosi Dida Borehole				
KARARE				
Shallow Wells				
Songa Shallow Wells	7,728	2,820,720	84	105,777
Ula Ula Wells	16,100	5,876,500	175	220,369
El Lekope wells	5,336	1,947,640	58	73,037
Serenanayeki Shallow wells	4,140	1,511,100	45	56,666
Lchuta shallow Wells	4,140	1,511,100	45	56,666
Ewaso Wells	4,600	1,679,000	50	62,963
Lng'urus shallow Wells	11,040	4,029,600	120	151,110
Water Pans				
Lelerai water pan	3,680	1,343,200	40	50,370
Springs				
Songa Springs	110,400	40,296,000	1200	1,511,100
Lchuta Springs	101,200	36,938,000	1100	1,385,175
TOTAL				30,485,185

4.10.5 Irrigation

Majority of locals leaving around Mount Marsabit Ecosystem are livestock keepers, with only a few people and households practicing farming. Out of these, a bigger percentage grew crops for subsistence with only a few of those producing for sale in the local market. The irrigators use shallow wells, springs, borehole and the Crater Lake to water their crops using watering cans, drip irrigation and drums. During the survey, the small scale farmers were noted around, Songa, Leyai, Badasa, Jaldesa and Jirime villages. Crop growing period, number of harvest in a year and crops specific water demand for each crop grown were obtained from the Ministry of Water and Irrigation manual, (GoK, 2005).

To calculate the volume of crop production water use, we used estimates of Marsabit water demand developed by Millennium Water Alliance (IRC-WASH, (2014). We selected the demand estimates to use in valuation of small scale farmers water use volumes due to challenges concerning the supply estimates per crop, generating the supply for each crop proved hard to discern due to bulkiness and data deficient. We assumed that irrigation is applied throughout the 5 month long dry season in Marsabit. **Table 4.21** shows the findings for this beneficiary category.

Table 4-21: Estimated Annual Small Scale Farmer's Consumptive Values

Crops grown	Water Sources (Point supplying small scale farmers)	Crop water need mm/growing period	Growing period
Kales	Songa Shallow wells	500	90
Tomatoes		600	140 (Inc. in nursery)
Spinach	Leyai-Kituruni	600	90
Pepper		900	120
Onions	Gof Jirime Crater	550	130 (Inc. in nursery)
Maize		800	140
Fruits: Mellon	Jaldesa borehole	600	110
Beans		500	120
Khat (Miraa)		-	-

Cow pea		500	110
Coriander (Dania)		-	-
Irrigation water demand m^3/day	14m^3/day		
Irrigation water need m^3/year	2142m^3/year		
Total (Estimated annual water vale at an average price of Ksh. 5 per jerry can**)**	**Ksh 535,500**		

4.10.6 Livestock Watering

Mount Marsabit watershed ecosystem is very crucial in its services to the local pastoralists. Marsabit County is dominated by a pastoralist community. Consequently, the ecosystem supports large population of livestock in water provision and pasture. The pastoralists' water their livestock using a number of boreholes sunk, water pans, Crater Lake, shallow wells and springs in the forest. In calculating the volume of livestock water consumption, we used the livestock water requirement and the number of livestock watered at the identified water point around the ecosystem. In calculating the livestock water use, we settled for water demand estimates developed for Water Resource Management Authority (WRMA, 2013). This source provides water intake by the livestock, whose water demand estimates are based on size of the herd and generic assumptions concerning daily livestock water requirements. The total number of livestock watered at every point of access was used in generating estimates of the total water consumed by the livestock (**Table 4.22**). The valuation results are as depicted by **Table 4-23** overleaf.

Table 4-22: Livestock Water Requirements

Herd Type	**Litres per capita per day**
Cattle	33.25
Camel	43.5
Sheep	5.5
Goat	5.5
Donkey	22.5

Source: WRMA (2013): 50

Table 4-23: Estimated Annual Livestock Water Consumptive Values

Point of water access	Type of livestock (numbers)								
	Cows	Camel	Goats	Sheep	Donkey	Livestock Total	Water requirement L/day	Water requirement L/year	Estimated annual water value at average price of Ksh 5/Jerry can
MARSABIT CENTRAL									
Crater Lake									
Gof Jirime	50	20	150	100	20	**340**	4,907	685,390	25,702
Shallow Wells									
Karatina Shallow wells	200	30	200	100	30	**560**	10,280	1,547,760	58,041
Bore Hole									
Shegel **(I)** Borehole	500	200	700	400	80	**1,880**	33,175	4,919,500	1,229,875
Shegel **(II)** Borehole	400	300	500	300	50	**1,550**	31,875	4,750,000	1,187,500
SAGANTE/BADASA									
Shallow Wells									
Sagante Shallow Wells	500	100	200	150	20	**970**	23,350	2,165,020	541,255
Gabra Scheme Shallow Wells	300	100	300	250	30	**980**	18,025	2,672,300	100,211
El Nadeni Shallow Wells	400	20	400	200	50	**1,070**	18,595	2,784,240	104,420
Bore Hole									
Midroc Borehole	50	-	100	150	10	**310**	3,263	449,150	112,288
Jey Jey Badasa Pan	200	-	200	100	20	**520**	8,750	1,302,600	48,848
SAGANTE/JALDESA/DIRIB									
Shallow Wells									
Diriib Gombo Shallow Wells	100	50	200	100	10	**460**	7,375	1,067,700	266,925
El Qarsa Shallow Wells	500	150	300	150	50	**1,150**	26,750	4,887,380	1,221,845
Bore Holes									
Kubi Qallo Borehole	700	200	500	400	100	**1,900**	39,175	5,936,100	1,484,025

Point of water access	Cows	Camel	Goats	Sheep	Donkey	Livestock Total	Water requirement L/day	Water requirement L/year	Estimated annual water value at average price of Ksh 5/Jerry can
	Type of livestock (numbers)								
Kubi Qallo China Borehole	500	100	300	200	40	**1,140**	24,625	3,727,900	931,975
Dololo Dokatu Borehole	700	100	400	200	50	**1,450**	32,050	4,869,300	1,217,325
Diriib Gombo **(I)** Borehole	500	100	300	100	30	**1,030**	23,850	3,623,900	905,975
Jaldesa Borehole	700	150	400	200	100	**1,550**	35,350	5,433,900	1,358,475
Diriib Gombo **(II)** Borehole	300	50	200	150	20	**720**	14,525	2,180,500	545,125
KARARE									
Lake									
Gof Bongole	200	50	300	100	50	**700**	12,150	1,830,800	457,700
Shallow Wells									
Songa Shallow Wells	200	100	300	100	50	**750**	14,325	2,161,400	81,053
Ula Ula Wells	100	50	200	100	50	**500**	8,275	1,254,900	313,725
El Lekope	200	50	200	150	30	**630**	11,425	1,708,600	64,073
Serenanayeki Shallow wells	200	30	200	100	20	**550**	10,055	1,500,960	56,286
Lchuta shallow Wells	400	100	200	100	50	**850**	20,425	2,907,600	109,035
Ewaso Wells	200	50	300	100	50	**700**	12,150	1,830,800	68,655
Lng'urus shallow Wells	400	100	200	50	30	**780**	19,700	3,019,400	113,228
Water Pans									
Silango water pan	200	80	300	150	20	**750**	13,055	1,917,360	71,901
Subtotal	8,700	2,280	7,550	4,200	1,060	23790	477,480	71,134,460	
TOTAL VALUE									12,675,466

4.11: Summary of the Beneficiaries Values

Table 4-24: Summary of Beneficiaries Values

Watershed Beneficiaries	Estimated Annual Water Value (Ksh)
Tourism operators	1,091,000
Conservationists	1,475,330
Commercial water vendors/users	12,022,545
Domestic water users	30,485,185
Irrigation/small scale farmers	535,500
Livestock keepers	12,675,466
Total	**58,285,026**

The computed values per beneficiaries showed that, domestic water use had high water use value due to high number of domestic water users depending on water from the ecosystem. Small scale irrigators' value was the lowest, this is due to less population involved in farming and in small scale for subsistence. Domestic water users gaining more from the ecosystem and small scale farmers gaining the least (**Table 4-24**). In case of the ecosystem degradation in terms of service provision, domestic water users will suffer the most followed by the livestock keepers. If watershed ecosystem levy is to be instituted, the domestic water users will pay more for its conservation to enjoy the services.

4.12 Overall Value of Consumptive Watershed Benefit

The overall consumptive water use benefits value of Mount Marsabit watershed ecosystem estimated at Ksh 58,285,026 or $582,035 per year, this overall value was computed through addition of the values of the beneficiaries identified around the ecosystem. The value was highest in the Sagante/Jaldesa (eastern zone) covering an area of 624 Sq. km at approximately Ksh 30,477,943, followed by the Marsabit central zone covering 877 Sq. km at Ksh 22,105,532 and lowest in the Karare/Songa (western zone) at Ksh 5,701,550. Water resources from the ecosystem is unexploited in the Karare/Songa zone, the community rely on shallow wells and springs. There is need to sink boreholes in the area to reduce pressure on the ecosystem through overgrazing while in search of water at the heart of the ecosystem. Sagante/Jaldesa zone is hydrologically productive due to high number of boreholes sunk in the area compared to other area around the ecosystem.

Table 4-25: Summary of the Watershed Zone Values

Watershed Zone	Approximate area (km^2)	Estimated Values per Beneficiaries	
		Beneficiaries	**Estimated Values**
		Tourism operators	1,091,000
Sagante/Jaldesa		Conservationists	250,207.5
(Eastern Zone)		Commercial water vendors/users	8,087,545
	624	Domestic water users	12,210,528
		Irrigation/small scale farmers	-
		pastoralists'/Livestock watering	8,838,692
		Total	*30,477,972.5*
		Tourism operators	0
Marsabit Central		Conservationists	1,067,990
(Central Zone)		Commercial water vendors/users	3,935,000
	877	Domestic water users	14,601,424
		Irrigation/small scale farmers	-
		pastoralists'/Livestock watering	2,501,118
		Total	*22,105,532*
		Tourism operators	0
		Conservationists	157,132.5
Karare/Songa		Commercial water vendors/users	0
(Western Zone)	577	Domestic water users	3,673,233
		Irrigation/small scale farmers	-
		pastoralists'/Livestock watering	1,335,656
		Total	*5,166,021.5*
Small scale farming			535,500
TOTAL			**58,285,026**

The Sagante/Jaldesa zone of the ecosystem has more beneficiaries with higher ecosystem values compared to Marsabit Central and the Karare/Songa zone. Commercial water vendors/users value is higher in Sagante/Jaldesa zone, followed by the Marsabit Central zone, there is no commercial water vendors/users in Karare/Songa zone of the ecosystem. Tourism operators water use values is high in Sagante/Jaldesa zone compared to Marsabit Central and Karare/Songa zone with none. Livestock keepers high in Sagante/Jaldesa zone followed by Marsabit Central zone and Karare/Songa zone with the least, this is due to fewer water sources in zone. The results showed that the ecosystem was hydrologically productive in the Sagante/Jaldesa zone, this is due to high number of water points found in the zone. **Table 4-25** above clearly illustrates the values from the ecosystem as per zones and beneficiaries values in each zone.

4.13 Discussion

4.13.1 Mount Marsabit Watershed Ecosystem

Mount Marsabit watershed plays key role in water provisioning for locals and livestock, which falls under direct ecosystem service termed consumptive. The study established that both surface and ground water existed in the ecosystem comprising: springs, crater lakes, water pan, boreholes and shallow wells. The ecosystem has no permanent rivers, the rivers are seasonal. Of the springs, Bakuli spring serves the central region, Marsabit Lodge spring serving the park and Marsabit central area, Badassa and Songa Springs serving the western region. Further, shallow wells and borehole supplements water provisioning to the residents. At least every other village has shallow wells dug within the vicinity.

Boreholes have been sunk mostly to support the livestock keepers. With overdependence on Mount Marsabit, water supply is diminishing in the area. Generally, the ground water table varies immensely, however, efforts have been made to meet water demand. Earth dams, water pans and harvest of flood water is used as an alternative water source to the residents. Over 15 borehole sunk around the ecosystem, the highest concentration being in Sagante/Jaldesa area, eastern part of the ecosystem. Government of Kenya, (2011) documented water types in the watershed ecosystem, this is in-keeping with the findings of our study. In Kirisia Forest (Samburu County) Kiringe *et al.* (2016), documented different water source type in the ecosystem, attributing their findings to the wide area coverage and diverse characteristics of the Kirisia ecosystem.

4.13.2 Consumptive Watershed Service Beneficiaries and Their Characteristics

Mount Marsabit watershed is the only source of water, the ecosystem supplies water to the residents of Saku. Mount Marsabit watershed ecosystem is crucial in water provision to pastoralists' and the population around using water for domestic purpose, calculated values are high for livestock keepers and domestic water users, this is in keeping with Robinson, (2013), reporting that the ecosystem is of crucial importance as a water tower; through surface run off and ground water sources, not only around the mountain but extending kilometers away into Chalbi Desert. From the study, majority of the respondents were beneficiaries of the watershed ecosystem. These findings are in line with Chege (2017) who found out that Marsabit community entirely depend and benefit from services in Mount Marsabit watershed ecosystem. The forest intercepts rainfall, which replenishes both thee surface and underground sources. Majority of the water sources is communally owned, County government and National government owns and manages a few sources e.g. springs and borehole.

The study established that livestock keeping was the major source of livelihood for the beneficiaries in Sagante/Jaldesa and Karare/Songa Wards. The communities kept cow, camel, goats, sheep and donkey. Beneficiaries residing in town have business, due to high unemployment rate, locals also survive on casual labour. Residents in Karare ward practice small scale farming for their livelihood, this was practiced mostly for subsistence and only small percentage of the produce sold. Commonly grown crops in the areas included kales, tomatoes, spinach, pepper, onions, miraa, garlic and fruits. Agriculture was practiced in small scale due to lack of funds to set up irrigation kits and farm size which are relatively small. Watering cans, pipes and a few farmers use drip kit in irrigation.

The assessment of water users' revealed six categories of consumptive watershed service beneficiaries in Mount Marsabit ecosystem namely: - domestic water users, livestock keepers, commercial water traders, small scale farmers, tourism operators and conservationists. This is almost similar to Chyulu Ecosystem as found by Mwaura *et al.* (2016), reporting 6 types of beneficiaries with Large scale irrigators missing from Marsabit ecosystem beneficiaries. The domestic water users are the communities who abstract water from the available water points within the ecosystem for household uses. Small scale irrigators were majorly recorded in Songa, Kituruni and Leyai area mostly using shallow wells water. Farmers in Jaldesa area used water pan and Jaldesa borehole for farming. Famers in Jaldesa and Jirime area of Sagante/Jaldesa and Marsabit Central Wards were growing mostly subsistence crops and those from songa and Kituruni grew commercial crops like Kales, onions, spinach, green pepper, coriander and fruits like pawpaw, bananas. Commercial water traders were mostly community members with water bowsers, the fetch water from boreholes for sale to communities' members in urban areas mostly. In Chyulu Hills study, Mwaura *et al.* (2016), documented large scale irrigators; KALRO and University of Nairobi research farms on 155ha and 12,000 acres respectively; Kya Kyai community project and Dwa sisal estate. Compared to Marsabit ecosystem, where the beneficiaries practice small scale irrigation. Marsabit being a dry land like Makueni area, dryland field research is unexploited in the area.

7.6% of the respondents indicated that the water quality was poor, they based their judgment on the taste of water which is salty and hard water. Additionally, treated water supply to homes is minimal. These findings confirm hydrologist report by Chege (2017) where they found out that water in most part was hard and salty, only few regions in Marsabit had fresh and clean water. In many parts of the ecosystem, water was untreated Marsabit County (2018). There is however need to undertake water quality assessment around the ecosystem.

The ownership of the point of water access in the Mount Marsabit ecosystem are majorly community members at 64.6%, the county government owning 13.3% of the water points, private companies 11.45% and lastly 10.8% by the national government. These results are as presented in table 4.5. According to Davies *et al* (2016) water scarcity is the biggest challenge, in dryland areas communities' fight over this scarce resource, ownership of water points contributing to fights over resources, during dry season the population rely on ground water for their domestic use and livestock watering.

The study established that, most of the points of water supply are managed by the community members. Self-help groups manage a few other points; this is as shown in table 7. These findings concur research findings by Chege (2017) where he found out that the management point of water access in most regions in Marsabit County were managed by community members and self hep groups.

The major categories of water consumption in Mount Marsabit ecosystem includes; domestic, pastoralism and commercial use. Domestic consumption takes a lead with the community members using the water for household purpose like cooking, washing, bathing among other uses, pastoralism, consumes water mostly for livestock watering, finally commercial water use, mostly boarding schools and water bowsers traders fetch water from water points outside town and sell to households with big storage tanks, hotels, cash wash and construction sites. The number of consumers is on an average 6 people per household and most house hold member's visits point of water access on daily basis i.e. 7 days per week. Agriculture, Conservationists and tourism operators benefit the least. According to Ministry of Agriculture Livestock and Fisheries, (2017) agricultural sector in the area is underutilised, only small percentage of the locals practice farming but in small scale for family sustenance and a small amount taken to the local market, farm products are imported into the town from the neighbouring County of Meru, this is blamed on unfavourable climatic condition, agricultural production is predominantly livestock based.

On the category of farm consumer use, it was found that, majority of consumers had an average income of Ksh 35,778, with an average farm size of 5 acres and the no of crops an average of 4 types. These implies that water services in Mount Marsabit ecosystem played a key role in uplifting agricultural economic activities in the region. If fully exploited farmers could realize good income through cultivation of drought resistant crops in their lands, which can be supported through irrigation. Study by Jillo (2013) identified that 1000 ha of arable land is unutilized, to its full exploitation, income from agricultural economic activities will be the key benefits from the ecosystem adding to the economy of the area.

4.13.3 General Characteristics of Mount Marsabit Watershed Ecosystem

The study established that the key point of water access (PWA) in Mount Marsabit ecosystem includes; borehole, shallow wells, springs, water pans, streams and Crater Lake. Beneficiaries with storage tank also harvests rain water for use during dry season. Water kiosks placed in town and villages for use by locals leaving far from water points. Further, major watershed point of water access (PWA) are bore holes. Boreholes sunk mostly by NGO, National and County Government in support of livestock keepers. Private and community owned boreholes also supply water for commercial traders. Shallow well within the ecosystem supply water for domestic use and livestock. Water pans provides water for livestock and a few households who depend on them during dry season. Further, spring supply water to Marsabit central and livestock keepers from Karare area. Crater Lake supply water to small percentage of Marsabit residents. From the study, the mean distance to the nearest water point is 2.4 kilometers. These findings confirm findings by MoALF, (2017) where they found out that in Mount Marsabit ecosystem the key types of the watershed point of water access is borehole, shallow well, kiosks, springs, water pans, streams, rain water harvested and Crater Lake. However, due to poor water resource management and overgrazing in the forest ecosystem leading to drying up of water points. This affects the locals mostly during the dry season where women trek for close to 6 km in search of water, this is contrary to the findings from Bale region study, where the mean distance to water points is 2km in both wet and dry seasons respectively (Watson, 2007). Men on the other hand move with livestock in search of pasture, this affects households, contributing to food security.

The community members had been using most of the points of water supply in Mount Marsabit watershed for over 10 years. From the study most of the water points are unimproved (71.9%) water sources, most of these are found in rural areas. 28.1% are improved, the county government, local NGOs and CBOs have played major role under WASH programmes protecting these water points. This findings are in keeping with Baur & Woodhouse, (2009) study that a good number of people in rural areas have no access to improved water compared to population in urban areas, Generally, improved water sources coverage in arid areas are still considerably lower compared to other regions in Kenya and there is need to address the issues.

The overall condition of the Mount Marsabit Watershed Ecosystem was perceived to be very good by majority (64.6%) of the respondents, this was based on the water extracted and supply from the ecosystem. 1.3% of the respondents stated that condition of Mount Marsabit watershed ecosystem is poor. The main reasons for the poor condition of the watershed includes; encroachment into the forest, illegal logging, lack of maintenance by government, overgrazing during dry season, lack of proper regulation in place and corruption by government officials, the KFS staffs allows charcoal burning, fire wood fetching and grazing of livestock within the forest. Poor governance. Corruption and conflict among organization also contributes to the worsening of the ecosystem condition, KWS and KFS compete in taking action. These findings concur with Government of Kenya (2012), where they identified that the watershed in Mount Marsabit ecosystem has been under threat as result of encroachment into the forest, illegal logging, lack of maintenance by government bodies and poor governance due to zero implementation of regulation.

Mount Marsabit watershed ecosystem provides other services; indirect benefits such as; climate regulation, pollination, tourism and recreation activities such as bird watching, swimming, research among others, these findings were confirmed by majority of the respondents who indicated to have benefited indirectly from Mount Marsabit watershed ecosystem. These findings confirms research by Ouko *et al*. (2018) where they posited that the key indirect benefits supply to the community members around Mount Marsabit watershed ecosystems as; climate regulation, pollination, tourism, habitat for wildlife, and recreation activities such as fishing, swimming among many others.

Most community members rely on water supply from the watershed during dry season, those residing in town rely on the ecosystem for their water supply throughout the year. Majority of the beneficiaries relying on the ecosystem for water supply kept livestock. The study noted that there are normally changes in water quantity from the point of water access around Mount Marsabit watershed ecosystem. This was confirmed by majority of the respondents indicating water quantity changes during dry season, water evaporation being the cause of water quantity reduction. Further, the study noted that during wet season, water quantities rise around the ecosystem, this is as a result of surface run off taping in water pans and earth dams, supply increases. Additionally, indirect factors which cannot be controlled leads to water shortage crisis in Marsabit; water lines destruction by wildlife and spoilt borehole pumping machines. These changes were confirmed by majority of the respondents. These findings confirm findings by Afullo *et al*. (2014) where they found out that that in many arid ecosystems, there are normally changes in water quantity from the point of water access mostly during dry season where the locals trek for long in search of water for domestic use and livestock watering, during wet season, the distance in search of water reduces since the supply is in plenty.

During the dry season, the major effects of changes in water quantity leads to inadequate water supply, a lot of time spent looking for alternative water source, long queues at the water point, people track for long distances in search of water. Conflicts over the limited water resources also arise mostly during the dry, this leads to displacement, loss of lives and livestock affecting the livelihoods of the victim community. Additionally, during the dry season livestock are grazed in the forest affecting the vegetation cover. Consequently, during the wet season, flood havoc hits the areas with less vegetation due to overgrazing. These findings concurs with Jillo (2013) where he noted that changes in water quantity during the dry season from the point of water access in Mt. Marsabit watershed ecosystem results to, inadequate water supply, a lot of time spent looking for alternative water source, people trek for long distances in search of water, children overburdened and worst of all conflicts over the few water sources.

Most community members in Saku are livestock keepers and rely on the watershed services in Mount Marsabit. Cows, camels, donkey, sheep and goats are the common livestock’s kept by the community members. The average selling prices of the livestock’s kept in the area are as; cows with an average selling price of Ksh 28,624, goats Ksh3,784, sheep Ksh 2,368, donkeys at price of Ksh 12,800 and lastly those who kept camels, with an average selling price of Ksh 57625. The cattle selling prices are slightly lower than Isiolo, this is attributed to by poor market availability in Marsabit. King-Okumu *et al*. (2016) estimated livestock prices in Isiolo as; Cattle at Kshs 40,000, Sheep and goats at Ksh 3,000, lower than the value in Marsabit.

Mount Marsabit water shed services plays a major role in enhancing livestock survival through provision of water and pasture which is highly required to sustain these livestock's. The livestock's kept by community members in Marsabit region consumes water at different rate, they are taken to water point as follows, cows taken to water point 3 days per week, sheep and goats 2 days in a week, donkeys 4 days and camels once a week. Additionally, the number of livestock taken to water point each day varies in different areas around the ecosystem. This was in keeping with King-Okumu *et al*. (2016) reporting the water consumption frequency of the livestock as that of Marsabit.

From the study, it emerged that majority of the respondents knew about environmental protection regulation, they reported familiarity with the forest act and the NEMA's Environmental Management and Coordination Act. Environmental committees formed around the ecosystem for environmtal protection proves the value of the services attached to the ecosystem. Additionally, this proved their understanding of the importance of regulating to protect the ecosystem from destruction. The respondents agreed Mount Marsabit ecosystem had many resources, water being the main. The residents are supplied with water from the ecosystem through different available sources around the ecosystem. Bakuli spring supplies Marsabit central residents with water. Shallow wells, water pans and bore holes supply water to the livestock keepers in rural areas of Sagante, Badasa, Karare, songa, Jaldesa, Qubi Qallo anad Dakabaricha.

Notably, the respondents found the ecosystem crucial and majority were willing to pay for the conservation of the ecosystem to enjoy more benefits from it, however, 35.4% of the respondents felt no need to pay for conservation, they stated that governments conservation is governments role, no need to pay for natural commodity and a few were willing but could not pay since they cannot afford. FGD indicated that the beneficiaries' willingness to pay for continued enjoyment of the service were guided by the demand in water supply from the water points. Through willingness to pay, the locals opted to contribute for the improvement of the ecosystem supplying water for domestic and livestock watering use.

4.13.4 Water Sources Distribution

The study established existence of both surface and ground water in Mt. Marsabit watershed ecosystem; springs, Crater Lake, water pans, earth dam and boreholes. Water kiosks are placed strategically near settlements for easy access of water by the residents. Key spring was Bakuli springs supplying water to the urban population, Songa, Badassa and Lchuta spring supplying the rural population, most of these sources were found in western region of the ecosystem. Boreholes and shallow wells were many in the Sagante/Jaldesa zone of the ecosystem. Additionally, Crater Lake were found both in Marsabit central and Karare/Songa zone. The stalled Badassa dam had water being used for livestock watering. Boreholes were critical water source for livestock watering, shallow wells supplies water for domestic use. This is not in line with study by Mwaura *et al.* (2016), who found out that the Chyulu watershed had network of rivers all feeding into Athi River, number of springs in the ecosystem were also higher. Shallow wells supply water for domestic use.

Notably, boreholes are many in the Sagante/Jaldesa zone, a few in the Marsabit central zone, and no boreholes in Karare/Songa zone. There is need to exploit the aquifer in those zones in a planned manner. Over abstraction of water from boreholes can exert pressure on aquifer, causing water table fall and salinization if proper procedures not followed. Groundwater abstraction can be done in those areas where the aquifers are less exploited putting into consideration the WRMA guidelines of water abstraction. Central, Karare and southern zone is ideal for abstraction.

4.13.5 Economic Value of Watershed Services in Mount Marsabit Ecosystem

Monetary value estimation around the ecosystem was undertaken according to water abstraction by different beneficiaries identified across the ecosystem, this was similar to Chyulu Hills ecosystem valuation as calculated by Mwaura *et al.* (2016). Water users across the ecosystem pay differently to enjoy the benefit, some get the service for free. The highest price was recorded in Marsabit central, Ksh 12 for 20 Littre Jerry can and lowest at Ksh 4. The average price of 20 litre jerry was estimated Ksh 5, this is same as the value calculated by (NDMA, 2017). Additionally, WRMA was charging a levy for water abstraction from the ecosystem. Study by Mwaura *et al.* (2016), estimated water price for Chyulu Hills at Ksh 3/jerrican and 0.50 as WARMA levy which is slightly lower than the Marsabit ecosystem levy's value of Ksh 0.75 and Ksh 5/jerrican which is high.

Findings from the study indicate that Mount Marsabit watershed ecosystem is critical to the welfare of the local communities, they entirely depend on the resource for their wellbeing. Majority of the residents are livestock keepers with a few practicing agro pastoralism. The direct consumptive use value derived from different beneficiaries varied significantly. From the beneficiaries values calculated, domestic water users' value was the highest and the small scale irrigator's value being the least. The ecosystem provided other services such as fuel wood, herbal medicine, it also supports tourism sector and research institutions. The benefits connected to Mount Marsabit ecosystem are found similar to that found by Tao *et al.* (2012) in China's Heshui watershed, Jiangxi province.

The overall value of Mount Marsabit watershed consumptive service was estimated at Ksh. 58,285,026, this is higher than Chyulu Hills value found by (Mwaura *et al.,* 2016). The higher values could be attributed to livestock numbers depending on the ecosystem for water. Additionally, comparisons are limited out of the original context due to the substantial differences in valuation, Chyulu ecosystem valued using the water points discharge measurement. From Watson, (2017) study, Ethiopia's Bale Mountain ecosystem provides annual flow of consumptive service of US$ 377,777,500, this higher value from Mount Marsabit ecosystem due to great difference in environmental conditions, Ethiopian highlands being key contributing factor.

The value of livestock watering was estimated at Ksh. 12,675,466, this is lower than the estimated value by King-Okumu *et al.* (2016), who calculated the value of water for livestock to be over KSh1.8 billion in Isiolo. The higher value in Isiolo could be because of high population of camel unlike Marsabit dominated by goats and sheep. The value of tourist operators in Marsabit is lower compared to the values in Isiolo. Isiolo tourism operator's consumptive value was estimated at Ksh. 3,110,000 which is thrice the value in Marsabit, Ksh. 1,091,000.

Ecosystem service valuation targets improving the social appropriateness of a given ecosystem characteristics and biological component supporting the service making ecosystem contributions to human well-being clear. Valuation of ecosystem is one of the significant scientific priorities for conservation. However, valuation has been disregarded in many parts. There is inadequate research effort in ecosystem valuation. However, the field is slowly gaining popularity in the field of conservation, for instance in China, valuation is gaining increased attention among decision makers as a way to improve ecosystem management, Lei and Zhang, (2005).

The Chinese Government recognizes the socio-economic importance of ecosystem, wetlands being important both socially and economically, several policies have been generated by the government to reverse damage causing ecosystem decline. However, policy makers face challenges in setting up incentives for incorporation by stakeholders to aid wetland protection. To solve the challenges, ecosystem service valuation is gaining increased attention to help improve ecosystem management (Jiang, *et al.*, 2016). From Heshui watershed valuation study using CVM by Tao *et al.* (2012), restored forest ecosystem provided wide range of services compared to deforested ecosystem. This has helped inform policies in China to in ecosystem repair. In Kenya valuation studies has been undertaken in various ecosystem, among them; Chyulu Hills, Ondiri Swamp, Mau forest, Shompole swamp among other key ecosystems to help inform policies, more has to be done for the valuation recommendations to be incorporated into policies to form part of decision making process.

Scaling up over Marsabit population, Mount Marsabit ecosystem provides a local annual flow of direct consumptive ecosystem services valued at Ksh 58,285,026 or US$ 582,849.96. This is a substantial value, demonstrating the largely unaccounted benefits arising from the ecosystem. Mount Marsabit forest has been reducing in size over the years; this reduction is likely to interfere with the ecosystem service more so water supply in the near future. To avoid erosion of its services, majority of the community members were willing to pay for the support of conservation of the ecosystem as their water supply watershed.

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter gives a summary of the major findings and draws the study conclusions on the economic value of the consumptive use services provided by Mount Marsabit watershed ecosystem. The chapter also discusses major recommendations for policy formulation and management of Mount Marsabit watershed ecosystem.

5.1 Summary of the Findings

5.1.1 Consumptive Watershed Services Beneficiaries

The key types of consumptive watershed service beneficiaries in Mount Marsabit includes, domestic water users, livestock keepers, commercial water users, conservationists, tourism operators and small scale farmers. The beneficiaries enjoy water supply from Mount Marsabit ecosystem through direct pipeline connection, direct at the water point, water kiosks, and water bowsers supply to offices, homesteads and hotels. The water quality from Mount Marsabit watershed ecosystem is perceived to be good by the majority. Some community members in Mount Marsabit ecosystem reported that the water quality is poor the main reason being saltiness, turbidity and foul smell. Most of the water supply points was owned and managed by the community members, these sources are mostly, water pans and shallow wells. Boreholes, springs and lakes in the ecosystem are owned and managed by the national and county government.

For domestic water use, the study revealed number of beneficiary consumers to be average 6 people per household with majority visiting point of water access on daily basis i.e.7 days per week, depending on the distance from the water points. The distance to water sources is on average 2.4km, distances increase with time as a result of drying up of water points or siltage of pans. Majority of commercial consumers make an average income of Ksh 35,777.8 annually, small scale farmers had an average of 5 acres and growing at least 4 different types of crops. Water services in Mount Marsabit ecosystem played a key role in uplifting agricultural economic activities in the region since most farmers had realized good income through cultivation of over of crops in their lands, which was supported through irrigation.

5.1.2 Typology and General Characteristics of Consumptive Watershed Services in Mount Marsabit Ecosystem

Mount Marsabit watershed ecosystem services have major economic value to the members of the community. Most community members benefit economically through livestock rearing, using water for business and agricultural economic activities through irrigation of crops. The types of the watershed point of water access (PWA) in Mount Marsabit ecosystem includes, borehole, shallow well, kiosks, springs, water pans, streams, and Crater Lake, rain water harvested by those with storage reservoirs. Most of the water points in the area are found next to villages, and water points named after it. On average, community members had been using PWA for approximately 22 years and other for over 10 years. The key challenges facing the watershed is encroachment, illegal logging, lack of maintenance by government, overgrazing during dry season, lack of proper regulation in place and corruption by government officials. The key indirect benefits realized by the community members from the watershed services in Mount Marsabit includes benefits such as climate regulation, pollination, tourism and recreation activities such as fishing, swimming.

Majority (52.5%) of the community members rely on the watershed services in Mount Marsabit during dry season and a few (3.2%) throughout the year, these are mostly those in close proximity to the water points. There are normally changes in water quantity from the point of water access across Mount Marsabit watershed. During dry season, water reduces drastically forcing pastoralist to trek for long distances in search of pasture. During wet season, water quantity increases and the discharge level from water sources improved pipeline. Technical problems like destruction by wildlife, borehole technical problem and power outages affects water supply.

During dry season, the major effects water quantity reduction from the point of water access includes, inadequate water, a lot of time spent looking for alternative water source, people track for long distances in search of water, taking long in queues when supply is cut. Irrigation mostly practiced in Karare/Songa (western zone). Majority of the pastoralist were found on the Sagante/Jaldesa (eastern zone), on average household in pastoral zone had 20 livestock. Over 20 boreholes have been sunk in different part of the ecosystem, mostly supplying water to livestock and a few domestic and water for commercial users/vendors. Springs and shallow wells were supplying water for domestic use.

5.1.3 Economic Value of Watershed Services in Mount Marsabit Ecosystem

The economic value of consumptive watershed services of Mount Marsabit ecosystem was determined by the market price of water and the water usage by each of the identified beneficiaries across the ecosystem. Majority of the residents were paying for the watershed services, others got it for free from shallow wells, springs, water pan and crater lakes. At the boreholes, the cost of watering livestock per head on average was; camels an average of Ksh 37 per month, cows 16, sheep and goats 8.33 and donkey 4. The approximate daily water consumption (in Jerri cans, *1 Jrcn= 20 litres*) for domestic consumption was an average of 80L per household. In calculations of tourist operator's value, GoK (2005), manual for water supply services was used in calculation. For small scale farming, Marsabit agricultural water demand was used in calculation, calculating values of water requirement for each of crop grown was ruled out on basis of expenses and time.
The values of the identified consumptive values of beneficiaries includes: - Domestic water user Ksh 30,485,185; livestock watering Ksh 12,675,466; commercial water user Ksh 12,022,545; conservationists, Ksh, 1,475,330; tourism operators Ksh 1,091,000 and small scale irrigators at Ksh 535,500. The total value of the ecosystem amounts to Ksh 58,284,996/$582,035.

Economic valuation of dry land ecosystem studies is few, this is a concern in terms if comparisons between such ecosystems value findings in terms of resource allocation and decision making. Mount Marsabit watershed value is slightly higher compared to similar watershed ecosystem. Mwaura *et al.* (2016), for example, estimated the economic value of consumptive water use services in Chyulu Hills watershed in Makueni, classified under ASAL County as Marsabit. Their study used MPM using cost value, the team estimated consumptive water resources value at Ksh 46, 676,192 per year. Further, the team estimated the average consumer price at Ksh 3 for a 20 litre jerry can, and 0.50 regulatory levy by WRMA. The difference was brought about by the average cost price for a 20 Litre jerry can and WRMA charges which was Ksh. 5 and 0.75 respectively.

The local beneficiaries of the ecosystem are projected to increase to over 59,599 by 2020 in Marsabit area. Additionally, with devolution industrialization will increase and farming to large scale, these activities will greatly exert price on the ecosystem, with recent increase in human activates around the ecosystem, several water points will dry up. Bakuli spring being the main source of water, its reduction will greatly affect the locals.

5.2 Conclusion

The study gives out valuable insights on the values of consumptive services provided by Mount Marsabit watershed ecosystem. Further, it highlights the key beneficiaries of the consumptive service in terms of water supply from the ecosystem and the value the resource contributes towards the local economy. Key types of beneficiaries in Mount Marsabit includes domestic water users, livestock keepers, commercial water users/vendors, conservationists, tourism operators and small scale irrigators. The beneficiaries enjoyed the service either directly water point, at local water kiosks, direct pipeline connection to homestead and water bowsers supply.

Compared to Isiolo, a dryland water tower, Mount Marsabit watershed ecosystem recorded a lower consumptive value, this finding was attributed to valuation technique used. While this study used market price method using the average market price of water in the area. Water supply was the only service valued, Isiolo study used TEV assessment framework on the direct use value of the ecosystem. The study proved the ecosystems water provisioning services for the surrounding deserts. Additionally, the ecosystem has economic and biological connections providing invaluable services. Upon erosion of the integrity of this ecosystem, people depending on them will become impoverished. Being the only dry-land water tower in the region, the ecosystem is under too much pressure from overgrazing, excessive water abstraction and logging for fuel from the ecosystem. Inappropriate management and poor policies escalates the effects of these pressures generally threatening ecological and socio-economic services provided by the ecosystem.

The ecosystem is faced with wide range of challenges in terms of conservation: i) Competition between KWS and KFS- as a result of the ecosystem double gazette, a National Reserve and as a Forest Reserve, ii) There is no clear demarcation of the boundaries, iii) poor capacity and governance, iv) No proper regulation and enforcement of law leading to poor management v) politics and poor vision as these organizations grapple for ownership of the forest and its resources. Lack of funds is the key challenges in conservation of the ecosystem. Payment for Ecosystem Services (PES) can help in solving the issue of funds availability. Introduction of at least 3% on the total value (Ksh 58,285,026), it would raise almost Ksh 2 million annually which could support conservation activities of the ecosystem.

The decision-makers should explore the impacts of development activities that might bring about changes in the system. These might include investments planned under the CIDP, water and irrigation, Environment or Natural Resource Sector. This assessment approach could also be introduced to county investment forums. Effective accounting for ecosystem services at the County level could enable better tracking of green growth at the national level.

5.3 Recommendations

The study suggests the following recommendations as measures to conserve and increase economic value of Mount Marsabit watershed ecosystem.

5.3.1 Policy Recommendations

The study recommends formulation of new environmental conservation policies by the county government that will help in promoting sustainable use of Mount Marsabit watershed resources. Further, effective enforcement of existing policies and regulations to enhance sustainable development. Policy on rain water harvesting should be developed by the County Government of Marsabit to encourage greater reliance on rainwater harvesting to ease pressure on Mt Marsabit.

5.3.2 Management Recommendations

- ❖ County government of Marsabit should consider formation of PES framework alongside related stakeholders to help generate conservation income.
- ❖ Borehole should be sunk in Central and Karare/Songa zone of the ecosystem, this should be done to discourage pastoralists from accessing the forest to water their livestock.
- ❖ The government through environmental conservation agencies should strengthen capacity building in order to equip the management personnel with the right and the required knowledge and skills for watershed ecosystem management.
- ❖ Proper demarcation of the forest reserve and the national reserve to end competition between KFS and KWS. Additionally, demarcation of the ecosystem should be done to properly control grabbing and encroachment into the ecosystem.

5.4 Recommendations for Further Studies

The study determined the economic value of the consumptive use services provided by Mount Marsabit watershed ecosystem using MPM. There are many other values of ecosystem goods and services flowing from Mount Marsabit ecosystem that have not been quantified in this research, water supply was the only investigated consumptive service value, hence the study proposes further research be done on valuation of other direct use services provided by the ecosystem. Moreover, the methodology applied in this study could be enhanced with a need to do valuation of the ecosystem through TEV framework.

Additionally, consumptive value of Mt. Marsabit ecosystem can be accurately calculated by measuring discharge from water points around the ecosystem, hydrologically rich zone can be identified and mapped.

REFERENCES

Global Environmtal Facility, *(2002)*, Development and Implementation of a Sustainable Resource Management Plan for Marsabit Mountain and Its Associated Watershed. Marsabit: Agricultural Research Foundation

Afullo A. O., Danga BO, Odhiambo F. Implications of time to water source on water use in the arid and semi-arid land counties of Kenya. International Journal of Water. 2014; 8(4):381-400

Baur, P. & Woodhouse, M. (2009). Enhancing private sector in rural water supply: An action-oriented study.

Brauman, K. A., Gretchen C. Daily, T. Ka'eo Duarte and Harold A. Mooney (2007) *The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrological services. Journal of Annual Review of Environment and Resources*, Vol.32: 67-98.

Bunse L., Rendon, O., & Luque, S. (2015). What can deliberative approaches bring to the monetary valuation of ecosystem services? A literature review. *Ecosystem Services*, *14*, 88-97.

Caroline King-Okumu, Oliver Wasonga, Ibrahim Jarso and Yasin Mahadi S. Salah, (2016). Direct use values of climate-dependent ecosystem services in Isiolo County, Kenya. IEED.

Charlene W., (2007), Direct Consumptive Use Valuation of Ecosystem Goods and Services in the Bale Mountains Eco-Region, Ethiopia. MSc Research Project. Faculty of Natural Sciences, Imperial College London, Centre of Environmental Policy.

Chege, B. M., (2017), Hydrological Survey Report for Dirib Gombo area, Marsabit Town. Unpublished report.

Davies, J., (2007) Total Economic Valuation of Kenyan Pastoralism. The World Initiative for Sustainable Pastoralism. IUCN, Nairobi.

Davies, J., Barchiesi, S., Ogali, C.J, Welling, R., Dalton, J., and P. Laban (2016). Water in dry lands: adapting to scarcity through integrated management. Gland, Switzerland: IUCN. 44pp.

De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics*, *41*(3), 393-408.

Dudley, N. & S. Stolton (2003). Running Pure: The Importance of Forest Protected Areas to Drinking Water. Washington D.C.: WWF/World Bank.

European Environment Agency (2006) Using the market for cost-effective environmental policy: Market based instruments in Europe. EEA, Copenhagen. Report: 1/2006.

Fisher, A.A., Laing, J.E., Stoeckel, J.E. and Townsend, J.W. (1998) Handbook for Family Planning Operations Research Design. Population Council, New York.

Government of Kenya (2011), Northern Wildlife Conservation Project 2011-2017. Nairobi: BRL Ingénierie & ESF Consultants.

GoK, 1989: *Marsabit District Development Plan 1989 – 199*3: Ministry of Planning and National Development, Government of Kenya: Government Printer, Nairobi, Kenya, pp. 1-24.

Government of Kenya, 2002: *Marsabit District Development Plan 2002 – 2008*: Government of the Republic of Kenya, Ministry of Planning and National Development, Government Printers, Nairobi, Kenya, pp. 3 – 49.

GoK (2005) Practice manual for water supply services in Kenya, October, 2005. Ministry of Water and Irrigation, Republic of Kenya, Kenya – Belgium Study and Consultancy Fund

Hausarbeit. (2013). GRIN - The Economic Value of Natural and Environmental Resource.

IRC (2014), *towards a better balance between water demand and supply Marsabit Report 2013: Kenya Arid Land Disaster Risk Reduction-WASH.* The Hague, Netherlands.

Jiang, B., Wong, C.P., Cui, L., &Ouyang, Z. (2016). *Wetland economic valuation approaches and prospects in China.* Chinese Geographical Sciences, 26 (2), 143-154.

Jillo, A.J. (2013), *Water Cooperation and Peace building In Marsabit County, (1991-2009)*. MA Research Project. Department of History, University of Nairobi.

Kenya National Bureau of Statistics. (2009). *2009 Population Distribution by Sex, Number of Household, Area and Density by County and District. Kenya census 2009, 1-5.*

Kipkoech A., Mogaka H., Cheboiywo, J., & D. Kimaro (2011), *The Total Economic Value of Maasai Mau, Trans Mara and Eastern Mau Forest Blocks, of the Mau Forest, Kenya. Environmental Research and Policy Analysis (K),* Nairobi, Kenya.

Kipkoech, J.O. (2015), Forest Management and Conservation in Kenya: A Study of the Role of Law in the Conservation of Forest Resources. PhD Thesis. Faculty of Law, University of South Africa.

Kiringe, J.W., Mwaura F., Warinwa, F. (2016): Characterization of Water Sources Types and Uses in Kirisia Forest Watershed, Samburu County, Kenya. Environment and Natural Resources Research Journal 6(3), 77-90.

Lei Kun, Zhang Mingxiang, 2005. The wetland resources in China and the conservation advices. *Wetland Science*, 3(2): 81–86.

Lovett, J. C & S. Noel (2008): Valuing ecosystem goods and services. *Afr. J. Ecol., 46, 117–118*.

Luck, G. W., Chan, K. M., & Fay, J. P. (2009). Protecting ecosystem services and biodiversity in the world's watersheds. *Conservation Letters*, *2*(4), 179-188.

Marsabit County (2018). Marsabit Water and Sanitation Sector, Climate Change Mainstreaming - (DFID).

Marsabit County Government (2016), Smart Survey Report. Nairobi: Government Printer.

Marsabit County Government of (2013), Marsabit County Integrated Development Plan 2013-2017. Nairobi: Government Printer.

Mathieson, K. (2014) 'Making Sense of Biostatistics: Probability versus Nonprobability Sampling', Journal of Clinical Research Best Practices, 10 (8).

Millennium Ecosystem Assessment (MEA). (2005). *Ecosystems and human well-being: synthesis.* Island Press, Washington, DC.

MoALF. (2017)**.** Climate Risk Profile for Marsabit County. Kenya County Climate Risk Profile Series. The Ministry of Agriculture, Livestock and Fisheries (MoALF), Nairobi, Kenya. Prepared.

Muchura, Henry M., Min S., Chua, Mworia, John K., N. N. Gichuki. (2014), *Role of Bryophytes and Tree Canopy in Mist Trapping in Mt. Marsabit Forest,* Kenya. *Journal of Environment and Earth Science.* Vol. 4, No. 21, 2014, pp. 128-138.

Muhati, Godwin & Olago, Daniel & Olaka, Lydia. (2018). Land use and land cover changes in a sub-humid montane forest in an arid setting: A case study of the Marsabit forest reserve in northern Kenya. Global Ecology and Conservation. 16. E00512. 10.1016/j.gecco.2018.e00512.

Mwaura F., Kiringe J.W., Warinwa F & P. Wandera (2016): Estimation of the Economic Value for the Consumptive Water Use Ecosystem Service Benefits of the Chyulu Hills Watershed, Kenya. International Journal of Agriculture Forestry and Fisheries 4(4):36-48.

Mwaura, F. & L.N. Muhata (2009): The use of contingent valuation to assess the community willingness-to-pay for the conservation of Ondiri Swamp, Kikuyu, Kenya. *Regional Development Studies 12-65-79*.

Nairobi City County (2014). *The Project on Integrated Urban Development Master Plan for the City of Nairobi in the Republic of Kenya Final Report* - Part I: Current Conditions. Technical Support from Japan International Cooperation Agency (JICA).

NDMA (2017) Marsabit County 2017–18 short rains assessment report, February, 2017. Nairobi: NDMA.

Oroda, Ambrose S.K. (2011), *The Impact Of Increased Population And Sedentarization Of The Pastoral Communities On The Land Cover And The Resources Of Mount Marsabit Forest And The Surrounding Lands*. MSc. Research Project. Department of Environmental Studies, Kenyatta University.

Ouko, C. A.; Mulwa, R.; Kibugi, R; Owuor, M. A.; Zaehringer, J. G.; Oguge, N. O. (2018). Community Perception of Ecosystem Services and the Management of Mt. Marsabit Forest in Northern Kenya. Environments, 2018, 5, 121.

Paterson W, Rushforth R., Ruddell B. L., Konar M., Ahams, I. C., Gironas j., Mijic A & A. Mejia (2015). Water footprint of cities: A review and suggestions for future research. *Sustainability 7(7):8461–8490*.

Perez-Verdin, G., Navar-Chaidez, J. J., Kim, Y. S., & Silver-Flores, R. (2016, September 5). Economic Valuation of Watershed Services for Sustainable Forest Management: Mexico.

Porras, I., Alyward, B. and Dengel, J. 2013. *Monitoring payments for watershed services schemes in developing countries*, IIED, London.

Porras, I., and Maryanne Grieg-Gran, (2008). *All that glitters: A review of payment for watershed services in developing countries. Natural resource issues* No.11. International Institute for environment and development. London, UK.

Robinson, L. W. 2013. Mt. Marsabit, Kenya: An Assessment of the Governance System. Landscape-Level Ecosystem-Based Management Working Paper no. 2.

Safriel, U. N. (2011). Ecosystem Services, Water Resource Development, and Human Infectious Disease. *Water and Sanitation-Related Diseases and the Environment*, 421-437.

Small, N., Munday, M., & Durance, I. (2017). The challenge of valuing ecosystem services that have no material benefits. *Global Environmental Change*, *44*, 57-67.

Tao, Z., Yan, H., & Zhan, J. (2012). Economic Valuation of Forest Ecosystem Services in Heshui Watershed using Contingent Valuation Method. *Procedia Environmental Sciences*, *13*, 2445-2450.

U.S. Geological Survey, 2017, Earthquake Facts and Statistics, accessed December 2, 2016 at URL http://water.usgs.gov/edu/earthhowmuch.html

Van Wilgen, B. W., Cowling, R. M., & Burgers, C. J. (2017). Valuation of ecosystem services; a case study from South African fynbos ecosystem. *Oxford University Press*.

Vartolomei, F. (2012). Integrated Measurements for Biodiversity Conservation in Lower Prut Basin. *Biodiversity Conservation and Utilization in a Diverse World*.

Von Bertalanffy, L. (1968). *General System Theory: Foundations, Development, Applications*. New York: George Braziller.

WEHAB Working Group (2002), *Sustainable Development*. A Paper Presented at the World Summit on "Sustainable Development". Johannesburg, South Africa, ZA, August 26-Septemebr 4.

WRMA (2013) Final report: surface and groundwater assessment and planning in respect to the Marsabit County mid-term ASAL program study. Volume 1, main report.

World Weather and Climate Information, (2015) https://weather-and climate.com/average monthly-Rainfall-Temperature-Sunshine, Marsabit, Kenya.

APPENDICES

Appendix I: MPM Questionnaire

Study on ***The Economic Valuation of Consumptive Water Use Service: A Case Study of Mount Marsabit Watershed Ecosystem, Kenya***. The study seeks to generate evidence on the economic values of the consumptive use services provided by Mount Marsabit watershed to enhance sustenance of ecosystem stability through proper policy development. All information received will be treated confidentially and used for academic purposes only. Answer by writing in the spaces provided or by ticking √ in the appropriate box.

SECTION A: BACKGROUND INFORMATION (Please tick√ where appropriate)

1. GPS location: East:---------------------- North:------------------------ Altitude---------------------
2. i) Location: ---------------------------- ii) Ward: ------------------------------

Point of water access----------------------------- Functionality----------------

3. Approximate distance from Mt. Marsabit ecosystem [__________] km
4. Gender. 1. Male [ ] 2. Female [ ]
5. Age bracket
    1. 18 – 25 years [ ]
    2. 26 – 35 years [ ]
    3. 36 – 45 years [ ]
    4. 46 – 55 years [ ]
    5. Above 55 years [ ]
6. What is your level of education?
    1. Not attended School [ ]
    2. Primary [ ]
    3. Secondary [ ]
    4. Diploma [ ]
    5. Degree [ ]
    6. Others, please specify: …………………………………………………………….
7. What is your role or position in the community? …………………………………………

8. What is your source of livelihood? -------------------------

Charcoal Making [ ] 2. Livestock Keeping [ ] 3. Agriculture [ ]

4. Employment [ ] Others……………...

SECTION B: WATERSHED SUPPLY POINTS SPECIFIC INFORMATION

9. Are you a beneficiary of watershed services in Mount Marsabit ecosystem?

   1. Yes [ ]   0. No [ ]

10. What is your watershed service benefit mode of supply?

    1. Direct pipeline connection [ ]
    2. Communal water Kiosk [ ]
    3. Water bowsers supply [ ]
    4. Water source [ ]

11. What is your perception of the water quality? *Give reasons for your answer*

    1. Good [ ]   2. Poor [ ]

…………………………………………………………………………………………………

12. Who manages the point of water access?

    1. Community [ ]
    2. Self-help group [ ]
    3. Government [ ]
    4. Others, please specify--------------------

13. Who owns the water supply points within the watershed?

    1. Private company [ ]
    2. Community [ ]
    3. Government [ ]
    4. Others, Specify--------------------

14. Which is your category of water consumption?

    1. Domestic [ ]
    2. Commercial [ ]
    3. Agricultural [ ]

Fill out the information below

1. Domestic: i) No. of household consumers ------------

   ii) How frequent do you visit the point of water access (Day/week) -----------

2. Commercial: i) Type of business ----------------------

ii) Number of consumers ----------------

iii) How much income

3. Agricultural: i) Farm size -----------------acres

ii) No. of Crops --------------

SECTION C: TYPOLOGY AND GENERAL CHARACTERISTICS OF CONSUMPTIVE WATER USE SERVICES IN MOUNT MARSABIT WATERSHED ECOSYSTEM

15. Kindly specify the name of the watershed point of water access (PWA)

1. Shallow well [ ]
2. Spring [ ]
3. Borehole [ ]
4. Stream [ ]
5. Kiosks [ ]
6. Others, specify ………………………………………………

Give the number of years you have been using the PWS

Watershed services	**No. of years**
Shallow well	
Spring	
Borehole	
Stream	
Kiosks	
Others (specify)	

16. How far do you leave from the water point? ....

17. What is the overall condition of the watershed services provided by Mt. Marsabit?

1. Very Good [ ]
2. Good [ ]
3. Moderate [ ]
4. Poor [ ]
5. Very Poor [ ]

18. In your opinion is the watershed put in to good use?

1. Yes [ ] 0. No [ ]

If No, give reasons

…………………………………………………………………………………………………

…………………………………………………………………………………………………

19. Please rate following statements regarding watershed services in Mount Marsabit using a scale of 1 to 5 where; **1 is strongly disagree**, **2 is disagree**, **3 is neutral**, **4 is agree**, and **5 is strongly agree**. (**Tick √ appropriately)**

Statement	**1**	**2**	**3**	**4**	**5**
Affordability of water supply					
Water supply is always available.					
Easy access of the PWS					
Good forest cover enhances the way watersheds provide various goods and service.					
There is good water quality.					
Watersheds are the primary source of raw water.					
Watersheds provide other goods like timber, plant and animal products.					
Watersheds provide other services like climate moderation, biodiversity conservation, recreation, and carbon sequestration.					

20. Please indicate ways you have benefited from watershed services in Mount Marsabit ecosystem

1. Farming through irrigation [ ]
2. Domestic water supply [ ]
3. Livestock water supply [ ]
4. Recreation activities such as fishing, swimming [ ]
5. Tourism [ ]
6. Indirect benefits such as climate regulation, pollination [ ]
7. Electricity generation [ ]
8. Others, specify……………………………………………………………………..

21. When do you rely on the point of water access?

1. Throughout the year [ ]
2. Dry season [ ]
3. Wet seasons [ ]

Season	**No. of months**
Throughout the year	
Dry season	
Wet seasons	

22. Do you keep livestock?

1. Yes [ ] 0. No [ ] *If yes, Specify type, Number and average price of livestock kept*

Livestock	Number of livestock	Average selling price
1.Cows		
2.Sheep		
3.Goat		
4.Donkey		
5.Camel		
6.Others, Specify		

23. How many times do you take your livestock's to the PWA? (*Days per week)*

Livestock	**Number of times taken to the water points**
1.Cows	
2.Sheep	
3.Goat	
4.Donkey	
5.Camel	
Others, Specify	

24. Please rate the following statements on the benefits of watershed services in the Mount Marsabit ecosystem using a scale of 1 to 5 where **1 is strongly disagree**, **2 is disagree**, **3 is moderate**, **4 is agree** and **5 is strongly agree**. (**Tick √ appropriately**)

Statement	**1**	**2**	**3**	**4**	**5**
Provides more sustainable water supply					
It minimises floods during the rainy season					
Ensures equal water provision					
It has drastically improved the living conditions of the community.					
Is a great source of economic benefits					

25. Have there been changes in water quantity from the point of water access?

1. Yes [ ] 0. No [ ] if yes, When………………………. How were you affected…………………………………………………………………………………………...…

…………………………………………………………………………………………………

…………………………………………………………………………………………………

26. What is the number of livestock watered each day

Livestock	Number of livestock
Cows	
Sheep	
Goats	
Camels	
Donkeys	

SECTION D: ECONOMIC VALUE OF WATERSHED SERVICES IN THE MOUNT MARSABIT ECOSYSTEM

27. Do you pay for the watershed services? 1. Yes [ ] 0. No [ ]

If yes,

i. How much per twenty liter (Ksh) [______________]

ii. How much for the livestock per head (Ksh)

Livestock	Water price per head
1.Cows	
2.Sheep	
3.Goat	
4.Donkey	
5.Camel	
6.Others, Specify	

28. What is your approximate daily water consumption (in Jerricans, 1 Jrcn= 20 Litres)?

Water uses	Daily water consumption in Jericans
1.Domestic Consumption	
2.Irrigation	
3.Livestock uses	
4.Other uses, Specify	

29. Do you do irrigation?

1. Yes [ ] 0. No [ ] if yes, what kind of crops do you grow through irrigation?

1. ---------------------------
2. ---------------------------
3. --------------------------
4. --------------------------
5. --------------------------
6. --------------------------

30. How much income (Ksh) on average do they bring per year? [________]

31. Do you know of any watershed protection regulation? If yes, which ones

1. Yes [ ] 0. No [ ]

…………………………………………………………………………………………………

32. Mount Marsabit forest in the region has been reducing in size over the years; this reduction is likely to interfere with the ecosystem service more so water supply in the near future. Concerned residents need to take necessary precautions to ensure its conservation. How much would you be willing to pay each year to support the government in the conservation of Mt. Marsabit as your water supply watershed?

1. 0 Ksh [ ]
2. 500 Ksh [ ]
3. 1000 Ksh [ ]
4. 5,000 Ksh [ ]

If you bid is '0' what is your reason for not being willing to pay for the conservation of Mt. Marsabit ecosystem.

i. I cannot afford it
ii. The conversation of the ecosystem is of no value to me
iii. I see no reason to pay for a God given commodity
iv. The government should pay or carry out conservation
v. Others, specify___________________________________

THE END

Thank you for your time

Interviewers Name-----------------------------------

Date of Interview-------------------------------------

TASK FOR FOCUS GROUP DISCUSSION

Appendix II: FGD

Dear Participant,

This study seeks to obtain information concerning ***Economic Valuation of Consumptive Water Use Service: A Case Study of Mount Marsabit Watershed Ecosystem, Kenya***. The study aims to generate evidence on the economic values of the consumptive use services provided by Mount Marsabit watershed so as to enhance sustenance of ecosystem stability through proper policy development. You have been chosen purposively due to the expected level of information and knowledge you have on the study topic. Be honest, free and active in your participation in addressing the questions raised. There will be a moderator and assistant for our group discussion. Recordings will also be made by use of tape recorders to store information as presented. All information received will be treated confidentially and used for academic purposes only.

1. What are the direct threats to watershed ecosystem in this area?
    a) What are the root-causes to these threats?
2. Why are the threats on ecosystem on the rise?
3. What policies are in place in conservation of the watershed?
4. What is your view towards paying for the ecosystem service to help in conservation of the forest?
5. What is your take towards willingness to pay for conservation?
6. What options should be considered to prevent destruction of the forest regarding watering livestock within the ecosystem?

Appendix III: Pictorial Presentation

Plate 7-1: Donkeys used to fetch water for domestic water use

Plate 7-2: Discussion at Point of Water Access

Plate 7-3: Locals queuing at a water kiosk

Plate 7-4: Point of Water Access Assessment

Appendix IV: Originality Declaration

Declaration form for students

UNIVERSITY OF NAIROBI

Declaration of Originality Form

This form must be completed and signed for all works submitted to the University for examination.

Name of Student: ***Bubicha Mohamed Jaldesa***……………………………………......................

Registration No: ***C50/5303/2017***…………………………………………………………………......

College: ***Humanities and Social Sciences***…………………………………………………

Faculty/School/Institute: ***Faculty of Arts***…………………………………………………………......

Department: ***Geography and Environmental Studies***………………………………

Course Name: ***Master of Arts in Biodiversity and Natural Resources Management***

Title of the work: ***Economic Valuation of Consumptive Water Use Service: A Case Study of Mount Marsabit Watershed Ecosystem, Kenya.***

DECLARATION

1. I understand what Plagiarism is and I am aware of the University's policy in this regard.
2. I declare that this …**Project Paper**………………………... (Thesis, project, essay, assignment, paper, report, etc.) is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work, or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements.
3. I have not sought or used the services of any professicnal agencies to produce this work.
4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing It off as his/her own work
5. I understand that any false claim in respect of this work shal! result in disciplinary action, in accordance with University Plagiarism Policy.

Signature: ………………………………………………………………………..

Date: ……**24/10/2019**………………………………………………

Appendix V: NACOSTI Research Permit

THIS IS TO CERTIFY THAT:
MR. MOHAMED JALDESA BUBICHA
of UNIVERSITY OF NAIROBI, 70665-400
NAIROBI,has been permitted to conduct
research in *Marsabit County*

Permit No : NACOSTI/P/19/63711/29167
Date Of Issue : 2nd October, 2018
Fee Recieved :Ksh 1000

on the topic: *ECONOMIC VALUATION OF CONSUMPTIVE WATERSHED SERVICES: A CASE STUDY OF MOUNT MARSABIT ECOSYSTEM, KENYA*

for the period ending:
2nd October,2019

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014.

CONDITIONS

1. **The License is valid for the proposed research, location and specified period.**
2. **The License and any rights thereunder are non-transferable.**
3. **The Licensee shall inform the County Governor before commencement of the research.**
4. **Excavation, filming and collection of specimens are subject to further necessary clearance from relevant Government Agencies.**
5. **The License does not give authority to transfer research materials.**
6. **NACOSTI may monitor and evaluate the licensed research project.**
7. **The Licensee shall submit one hard copy and upload a soft copy of their final report within one year of completion of the research.**
8. **NACOSTI reserves the right to modify the conditions of the License including cancellation without prior notice.**

National Commission for Science, Technology and innovation
P.O. Box 30623 - 00100, Nairobi, Kenya
TEL: 020 400 7000, 0713 788787, 0735 404245
Email: dg@nacosti.go.ke, registry@nacosti.go.ke
Website: www.nacosti.go.ke

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH LICENSE

Serial No.A 24436

CONDITIONS: see back page

Appendix VI: Plagiarism Test Result

Document Viewer

Turnitin Originality Report

Processed on: 07-Aug-2019 09:50 EAT
ID: 1158292267
Word Count: 28106
Submitted: 1

ECONOMIC VALUATION OF CONSUMPTIVE WATER USE S...
By Jaldesha Bubicha

Similarity Index	Similarity by Source	
10%	Internet Sources:	7%
	Publications:	2%
	Student Papers:	6%

include quoted include bibliography excluding matches < 3 words download refresh

print mode: quickview (classic) report Change mode

1% match (Internet from 24-Sep-2018)
http://pubs.iied.org

1% match (Internet from 21-Aug-2018)
http://ccsenet.org

<1% match (Internet from 03-Jan-2017)
http://www.ccsenet.org

<1% match (Internet from 21-Feb-2019)
https://www.marsabit.go.ke/wp-content/uploads/2017/11/Marsabit-County-Revised-CIDP.pdf

<1% match (Internet from 12-Apr-2009)
http://www.science.oregonstate.edu

<1% match (Internet from 25-Aug-2014)
http://www.iccs.org.uk

<1% match (Internet from 19-Jul-2019)
http://ojs.excelingtech.co.uk

Helga Schröder

<1% match (student papers from 09-May-2012)
Submitted to American University of Nigeria on 2012-05-09

<1% match (Internet from 24-Oct-2010)
http://www.crdi.ca

FACULTY OF ARTS UNIVERSITY OF NAIROBI
29 AUG 2019
P. O. Box 30197 NAIROBI

<1% match (student papers from 24-Oct-2016)
Submitted to University of Nairobi on 2016-10-24

<1% match (publications)
Bo Jiang, Christina P. Wong, Lijuan Cui, Zhiyun Ouyang. "Wetland economic valuation approaches and prospects in China", Chinese Geographical Science, 2016

Prof Francis Mwaura
14.08.19