WILLINGNESS TO PAY FOR ECOSYSTEM SERVICES IN CONSERVING KAPINGAZI CATCHMENT IN EMBU COUNTY, KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for the Award of Master of Science Degree in Environmental Science of Egerton University

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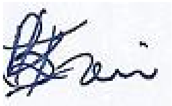
DECLARATION AND RECOMMENDATION

This thesis is my original work and has not been presented in this university or any other for the award of a degree.

Declaration

Signature:  Date: 16th June 2025

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Recommendation

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DEDICATION

This work is dedicated to God, my husband Simon Gitonga Karuri and my parents; my dad Newton Felix Ireri and mum Lucylane Njura Ireri, sisters and brother who supported and encouraged me throughout the Masters programme.

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ABSTRACT

Ecosystems provide a wide range of ecosystem services such as food supply, soil erosion control, and carbon sequestration which are important for human survival. Kapingazi catchment is home to a variety of ecosystem services mainly water provision to downstream users. Kapingazi River flowing from this catchment contributes to the Tana River, which supports several national hydroelectric power stations that generate 52.1% of Kenya's electricity. However, increasing anthropogenic pressures such as agricultural and industrial activities are threatening the catchment. These factors are affecting the water quality and flow in the Kapingazi River, since local inhabitants are currently lacking financial incentives to engage in conservation efforts. In order to ensure water provision for downstream users and maintain ecological balance, there is urgent need for Kapingazi catchment to be managed sustainably. The research aimed to assess the status of ecosystem services in the Kapingazi catchment, identify catchment users, examine perceived human activities affecting water provision, and determine respondents' willingness to pay (WTP) for these services in order to explore the potential of implementing Payment for Ecosystem Services (PES) schemes to encourage conservation and sustainable management practices. The study used cross-sectional research design and data was collected from households, focus group discussions, and key informants using questionnaires, interview schedules, and field observations. The collected data was analysed using the Statistical Package for the Social Sciences (SPSS) version 22 by applying descriptive statistics and logistic regression. Results showed that water is the main ecosystem service (98%) in the Kapingazi catchment and farmers were the main catchment users (40.4%). Logistic regression results revealed that poor agricultural practices had significant impact on both changes in water quality ($p = 0.002$) and water quantity ($p = 0.036$) while industrial activities, tea factories ($p = 0.014$) and coffee factories ($p = 0.013$) had significant impact on changes in water quantity at 95% confidence level. The study revealed that 67% of respondents were willing to pay for improved water services and age ($p = 0.005$), education ($p = 0.025$), and household size ($p = 0.05$) were the factors that influenced the WTP for improved water services. There is need for soil and water conservation in Kapingazi catchment and positive WTP supports policy development for payment for ecosystem services (PES) programmes. These results aim to encourage stakeholder engagement, promote sustainable practices and guide policy decisions in order to ensure ecological resilience of the Kapingazi catchment through payment for ecosystem services (PES).

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LIST OF ABBREVIATIONS AND ACRONYNMS

BOD Biochemical Oxygen Demand

CAAC Catchment Area Advisory Committee

CARE Kenya Cooperative for American Remittances to Everywhere Kenya

CBD Convention on Biological Diversity

CFA Community Forest Association

CICES Common International Classification of Ecosystem Services

CIDP County Integrated Development Plan

CIMMYT International Maize and Wheat Improvement Centre

CV Contingent Valuation

CVM Contingent Valuation Method

DO Dissolved Oxygen

ES Environmental/ Ecosystem Service

EMCA Environmental Management and Coordination Act of 1999

EWASCO Embu Water and Sanitation Company

FAO Food and Agricultural Organization

FDA Focal Development Area

FDAC Focal Development Area Committee

FGD Focus Group Discussion

GOK Government of Kenya

HEP Hydro Electric Power

CIFOR-ICRAF The Centre for International Forestry Research and World Agroforestry

IIED International Institute for Environment and Development

IPBES Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IWRM Integrated Water Resource Management

KALRO Kenya Agricultural and Livestock Research Organization

KaWRUA Kapingazi Water Resource Users Association

KenGen Kenya Power Generation Company

KES Kenya Shillings

MEA/MA Millennium Ecosystem Assessment/Millennium Assessment

MKEPP Mount Kenya East Pilot Project

NACOSTI National Commission for Science, Technology and Innovation

NEMA National Environment Management Authority

NGOs Non-Governmental Organizations

NRM Natural Resource Management

PES Payment for Ecosystem Services

PRESA Pro-poor Rewards for Environmental Services in Africa

REDD+ Reduced Emissions from Deforestation and forest Degradation

SIWI Stockholm International Water Institute

SMS Safe Minimum Standards

SPSS Statistical Package for the Social Sciences

SWC Soil and Water Conservation

TARDA Tana and Athi River Development Authority

TDS Total Dissolved Solids

TEEB The Economics of Ecosystems and Biodiversity

TMDL Total Maximum Daily Load

TSS Total Suspended Solids

UNEP United Nations Environment Programme

UNON United Nations Office in Nairobi

USD United States Dollars

UTaNRMP Upper Tana Natural Resources Management Project

VIF Variance Inflation Factor

WBWDR World Bank World Development Report

WRA Water Resources Authority

WRUA Water Resource User Association

WTP Willingness to Pay

WTA Willingness to Accept

WWF World Wildlife Fund for Nature

WWF-KCO World Wildlife Fund for Nature - Kenya Country Office

CHAPTER ONE
INTRODUCTION

1.1 Background information

Ecosystem services are the various benefits that humans obtain from the environment, and they play an important role in supporting life and improve human welfare (MA, 2005). These services are vital in sustaining ecosystem functions and maintaining the quality of human life. They are categorized into four main groups; provisioning, regulating, supporting and cultural services. Provisioning services refer to the tangible goods that ecosystems provide, including food, water, timber, and fibre. Crops and livestock are derived from agricultural lands, timber and non-timber commodities are obtained from forests while fish and drinking water are provided by fresh water systems such as rivers; Regulating services like climate regulation, flood control, water purification, and disease and pest regulation maintain the balance and stability of natural systems by moderating ecological processes. Flood impacts are mitigated by wetlands by absorbing excess rainfall, while forests sequester carbon, thereby contributing significantly to regulation of climate; Supporting services which include habitat provision, nutrient cycling, pollination and soil formation, are the underlying ecological functions necessary for the maintenance and operation of all other ecosystem services and they underpin the production of biomass and the cycling of nutrients, which are critical for plant growth and ecosystem productivity. The intangible advantages that people obtain from the environment such as leisure, education possibilities, spiritual fulfilment and aesthetic experiences are known as cultural services. For many communities, natural landscapes are a source of inspiration, leisure activities and community identity.

In order to preserve the ecological health and well-being of dependent communities, proper comprehension and managing these ecosystem services efficiently is required. Degradation of ecosystems can reduce important services, leading to adverse effects on human health, economic activities and overall welfare (Petrosillo *et. al.*, 2023).

In recent years, the concept of Payment for Ecosystem Services (PES) has become prominent as a way of promoting sustainable environmental conservation and management. In order to preserve the ecosystem services, individuals or communities are compensated to carry out measures that strengthen them through this mechanism. Land owners and resource managers who implement sustainable practices are rewarded financially or in kind since this model acknowledges the economic importance of ecosystem services. PES seeks to secure long-term delivery of ecosystem services by establishing a direct economic connection between beneficiaries of the services and their providers (Cavelier & Gray, 2014).

Payment for ecosystem services (PES) programmes have notably increased worldwide, with annual transactions at around USD 36 – 42 billion (Salzman *et al.,* 2018). PES is a voluntary economic initiative that protects biodiversity and ecosystem functioning while also meeting the needs of local people. It has been implemented at several levels, focusing on essential ecosystem services such as carbon sequestration, watershed management, conservation of habitats and biodiversity (Perrot-Maître, 2006; Salzman *et al.,* 2018). The main idea of PES is establishing a market based mechanism that internalizes the environmental benefits produced by ecosystems and provide incentives to landholders to adopt sustainable practices that protect these services (Turner & Daily, 2008).

According to Wunder (2005), PES is a voluntary transaction where a well-defined ecosystem service or a land use likely to secure that service is being bought by an ecosystem buyer from an ecosystem seller or provider, if and only, if the ecosystem provider secures the ecosystem service provision. PES programmes pay land owners for producing environmental benefits, only if they implement land use strategies that enhance ecosystem services (Bond & Mayers, 2010). Global ecosystem degradation and rapid land use changes are as a result of not paying land owners for supplying ecosystem services (Butchart *et al.,* 2010). Vital goods (such as food and timber) and services that support human well-being, which are often public goods with little or no financial value are provided by healthy ecosystems (Forest Trends & Katoomba Group, 2008). By assigning monetary value to ecosystem services through establishment of a market whereby users pay land owners to improve or restore ecosystem services is the main objective of PES programmes (Engel *et al.,* 2008).

Clear agreements that link changes in land use to provision of ecosystem services define effective PES initiatives (Wunder *et al.,* 2008). Also, flexible contracts, minimum transaction costs, dependable income streams, careful compliance monitoring and changing conditions adaptability are necessary for effective programmes (Sommerville *et al*., 2009). There are several steps to be followed for the PES initiatives to be successful: enrolment of service providers, contract term compliance and change in land use behaviour which would have otherwise not be there if the initiative was not implemented. (Wunder *et al*., 2008).

There are three categories of PES schemes: those that are funded by users, those that are financed by governments and those that are driven by compliance requirements. User-funded PES is a mechanism whereby direct payment of upstream land owners by beneficiaries of ecosystem services such as hydroelectric companies to control soil erosion. Government-funded PES schemes involves payment of land owners by third parties for providing ecosystem services, such as the reduction of deforestation programme in Costa Rica. Compliance PES schemes, allow parties to meet regulatory requirements through offsetting ecosystem services, such as emissions trading. (Fripp, 2014).

While PES programmes are still underdeveloped in the African region, they have shown potential for conservation in areas like carbon sequestration and biodiversity. However, watershed PES programmes in Tanzania and projects such as Tree for Global Benefit in Uganda have gained momentum (Lopa *et al*., 2012). In spite of challenges, PES programmes in Africa have been driven by community based natural resource management and international demand focusing on biodiversity conservation and carbon sequestration. Water-related PES schemes are not common because of low demand locally but there are promising projects like Naivasha watershed programme in Kenya (Nyongesa, 2011).

PES programmes addresses environmental and economic challenges caused by changes in land use and ecosystem degradation as a market-based approach. Their main aim is conserving the environment and advancing rural development while reducing poverty by directly rewarding land owners financially for enhancing ecosystem services (Wu *et al*., 2021). Despite its successes, ensuring equitable compensation, balancing conservation with economic development, and overcoming limited demand for certain ecosystem services are some of the challenges that PES programmes face. However, PES continues to be a viable tool globally in reconciling sustainable land management practices with environmental conservation.

The Kapingazi catchment provides water and a variety of ecosystem services to the communities in the surrounding and downstream users, is located in a region of significant ecological importance. Different landscapes, including forests, wetlands and agricultural land, characterizes the catchment, all of which contribute to its rich biodiversity and an array of ecosystem services it provides. The water from the Kapingazi catchment is used for domestic use, agriculture, industry, and ecological functions.

This catchment is important for local communities since provides essential resources that support livelihoods and ecological balance. However, agricultural expansion, industrialization and population growth are the increasing anthropogenic pressures in addition to climate variability, which are causing significant challenges to sustainability of ecosystem services. Water abstraction, pollution from agricultural and industrial activities, deforestation, and land degradation are the main challenges that are undermining the sustainability of Kapingazi catchment. These challenges leads to weakened ability of the catchment to produce vital ecosystem services as well reduced water quality and supply and loss of biodiversity. (Soko, 2014).

With the knowledge gained, this research will assist in designing and implementation of PES initiatives specifically for Kapingazi catchment focusing on transforming acknowledged ecosystem services through building stakeholder relationships and participation and willingness to pay into conservation strategies that are operational and effective. These will lead to establishing mechanisms for equitable benefit-sharing, and piloting these interventions to evaluate their effectiveness in enhancing water provision and other ecosystem services by designing participatory and context-specific PES models that align ecological goals with the socio-economic realities of local communities. Also, while monitoring long-term ecological and livelihood outcomes, the research will inform the institutional, policy, and financial frameworks required to support and sustain PES implementation. By bridging the gap between science, policy and practice, this roadmap offers an integrated approach to sustainable catchment management that ensures both environmental resilience and socio-economic well-being.

1.2 Statement of the problem

The Kapingazi catchment provides essential ecosystem services such as water and food that sustain livelihoods of local communities, agriculture and industry is experiencing environmental degradation caused by human activities such as agricultural intensification, industrial pollution and population growth. These pressures have led to declining water quality, reduced water supply, and significant loss of biodiversity. Besides jeopardizing the health, economic stability and the general well-being of the communities dependent on these services, these pressures undermine the catchment's ability to sustain agriculture and other ecological functions. While there is insufficient data on stakeholders' willingness to participate and invest in such schemes, Payment for Ecosystem Services (PES) offers a promising solution by incentivizing conservation practices.

Lack of an integrated ecological and socio-economic assessment necessary to inform effective conservation and sustainable management strategies that can restore and protect ecosystem services is the problem in Kapingazi catchment. Therefore, it is important to characterise the status of ecosystem services, identify key stakeholders, assess the perceived human activities impacting on water-related services, and assess willingness to pay, in order to provide guidance for sustainable strategies such as PES that ensure long-term health of the catchment.

1.3 Objectives

1.3.1 Broad objective

The broad objective of this study was to improve the conservation strategies in Kapingazi catchment through the assessment of the willingness to pay for ecosystem services scheme in conservation of Kapingazi catchment in Embu, Kenya.

1.3.2. Specific objectives

The study specifically looked at the following objectives:

i. To characterize the status of ecosystem services in Kapingazi catchment.
ii. To identify the catchment users, catchment management practices, organization, functions of catchment users and challenges of catchment management in Kapingazi catchment.
iii. To determine the perceived catchment user activities that are affecting water provision service in Kapingazi catchment.
iv. To establish the willingness to pay for water provision services by the catchment users in Kapingazi catchment.

1.4 Research questions

The research aimed at answering the following questions:

i. What is the status of ecosystem services in Kapingazi catchment?
ii. Who are the catchment users? What are the catchment management practices, organization, functions of catchment users and challenges of catchment management in Kapingazi catchment?
iii. What are the perceived catchment user activities that are affecting water provision service in Kapingazi catchment?

iv. What is the willingness to pay for water provision service by catchment users in order to conserve Kapingazi catchment?

1.5 Justification

Ecosystem services such as provisioning, regulating, supporting and cultural services provide essential benefits that support human well-being and the natural environment. Kapingazi catchment is an ecologically significant area because it provides important ecosystem services such as water, which supports agriculture, industry, livelihood of the communities and ecological processes. However, growing anthropogenic pressures such as agricultural expansion, industry and population increase are undermining the sustainability these ecosystem services. Both human communities and ecological health of Kapingazi catchment are potentially being impacted by degradation caused by deforestation, water abstraction, pollution, and land degradation which poses serious risks to water quality and availability.

It is important to understand the ecosystem services provided in Kapingazi catchment, assessing the activities of key stakeholders, and analyzing the perceived human activities impacting water ecosystem services. The study offers a thorough overview of the ecosystem dynamics of the catchment so as to develop mitigation strategies against environmental threats. In order to create sustainable management strategies that balance human well-being and environmental sustainability, it is crucial to look at the activities of catchment users that are impacting water service provision.

One innovative component of this research is the investigation of payment of ecosystem services (PES) as a possible conservation method. By incentivising conservation initiatives, PES' objective is to financially compensate land owners or communities for activities that improve ecosystem services. Implementing PES in Kapingazi catchment would encourage stakeholders to adopt land use practices that ensure long-term ecological resilience by balancing financial incentives with environmental sustainability.

This study elicits stakeholders' willingness to pay for improved water services, producing new knowledge of how ecological and socio-economic aspects could be integrated. It assesses the status of ecosystem services, important stakeholders and focus areas for intervention as a result of perceived human activities affecting water ecosystem services. The study's suggestions for policy measures and sustainable management practices can provide guidance to future initiatives to conserve ecosystem services provided in Kapingazi catchment. Therefore, this study ensures long-term benefits for both communities and the environment by promoting the resilience of ecosystem services within the catchment, with an emphasis on PES and sustainable conservation strategies.

1.6 Scope

This research examined the ecosystem services and catchment users in Kapingazi catchment, assessed the human activities affecting water provision and determined the willingness to pay for this service. The data was collected between March 2018 and June 2018 from community members, community associations within Kapingazi catchment as well as from institutions. The research was limited to Kapingazi catchment in Embu North and Embu West sub-counties in Embu County, Kenya.

1.7 Assumptions

It was assumed that the respondents would cooperate and respond truthfully to the questions during data collection. It was assumed that the climatic conditions will be favorable to allow for adequate data collection. It was also assumed that the catchment was accessible and secure from any insecurity issues to allow free movement and interviews with the community.

1.8 Limitations

The diverse terrain in certain areas posed a limitation, rendering some locations, particularly flooded zones, inaccessible during data collection in the rainy season. To overcome this challenge, a transport method adaptable to all terrains was utilized. It was not easy to get some officers from government institutions due to their engagement with their official duties. Booking an appointment was first made to schedule interview’s date and time when they deemed that they would be free from other demanding activities.

1.9 Definition of terms

Biodiversity – Biological diversity is the variance among living things from all sources, including terrestrial, marine, and other aquatic habitats, as well as the ecological complexes they inhabit. Diversity among species, across species, and among ecosystems are all included.

Catchment users – These are people who live and/or use the resources in a particular catchment, whose sources of livelihoods are derived from their work in the agriculture and forest lands in a catchment.

Confluence – This is where a river joins another river.

Contingent valuation – This is the process of allocation of monetary value to ecosystem goods and services that are not bought or sold in a traditional market using survey-based approach.

Ecosystem: This describes a dynamic system of living things such as plants, animals, and microorganisms, as well as their physical surroundings, that function as a unit through continuous exchange of matter and energy.

Ecosystem services: These are advantages that people obtain from the environment. These include provisioning services like water and food; regulating services that help control diseases, drought, floods, and land degradation; supporting services that preserve basic processes like nutrient cycling and soil formation; and cultural services that provide non-material benefits like recreation and spirituality.

Payment for ecosystem service (PES*)* – It is a system of providing financial incentives in order to encourage individuals or communities to embrace sustainable land management and practices that preserve and conserve natural resources.

Stakeholders – These are people who are interested parties in the activities of the project.

Water catchment – It is a topographic region in which all water drains to a common outlet, such as a river.

Willingness to pay – This is the maximum value that a person is prepared to forgo in order to secure an ecosystem good or service, or to avoid an undesirable consequence.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides a comprehensive review of the literature of the study's subject specifically with the commitment to engage in payment mechanisms for ecosystem services aimed at conserving catchments. It includes an assessment of the status of ecosystem services, identification of catchment users, identification of human activities affecting water provision ecosystem services and the willingness to pay for enhanced water ecosystem services. It includes findings of related undertaken research.

In section 2.2, the first objective, which is to characterize the status of ecosystem services is discussed. The definition of ecosystem services, their types, classification frameworks of ecosystem services, and empirical research on the status of ecosystem services in various catchments in Brazil, Italy, and Northern Kenya are all introduced. With implications for regulation and supporting services in various ecosystems, Periotto and Tundusi (2018) evaluate the ecosystem services of the Jacare Guacu and Jacare Pepira watersheds in Sao Paulo, Brazil. In order to assess the effects of power generation based on water resource use and determine which aspects to maintain while utilizing renewable energy, Pettenella and Portacio (2017) examine the provision of ecosystem services in the Mis and Mae watersheds in Italy. According to Ericksen *et al.* (2012), ecosystem service supply was represented as bundles that were grouped by geographic region and land use type. The goal of this study was to list all of the ecosystem services provided in the Kapingazi catchment and rank them according to how important they are to the respondents.

The second objective; identification of catchment users is highlighted in section 2.3. The section introduces the importance of stakeholder identification and participation in water management. According to Zekele *et al.* (2006), rather than using top-down methods, it is important for different stakeholders to participate in the planning and governance processes of natural resources. Borisova *et al*. (2012) shows a clear example of conflicts among stakeholders due to inadequate stakeholder involvement in policy decisions. Mukeria *et al*. (2021) focuses on major stakeholder groups involved in carrying out landscape restoration initiatives in Hawassa catchment in Ethiopia. This study however, filled the gap by identifying the catchment users in Kapingazi catchment, their awareness on catchment management and how they were organized in managing Kapingazi catchment which are important in payment for ecosystem services initiative implementation.

The third objective; perceptions of human activities affecting water provision ecosystem service is discussed in section 2.4. It introduces human activities impacting water service provision. Soko (2014) identifies urbanization, deforestation, mining, agriculture and power generation affecting water quality of River Crocodile in South Africa. Ekka *et al*. (2020) acknowledges human-induced alterations including inter-basin water transfer, agriculture, urbanization, industrialization, ground water abstraction, the modification of stream channels, the building of dams, and the extraction of sand resources had impact on river ecosystems services. However, this does not identify precise effects on a given water catchment's water quality as well as its overall quantity. This study aimed to fill the gap by identifying the human activities influencing the availability and quality of water resources in the Kapingazi catchment.

The fourth objective; establishing a willingness to pay for ecosystem services related to water provision is highlighted in Section 2.5. It discusses empirical research and the estimation of willingness to pay. Domestic water consumers' willingness to pay for improved watershed services in the Philippines' Lawayan Catchment was evaluated by (Calderon *et al.* 2013). The water user fee that would be collected from residential water users in the Lawayan watershed was established using the quantities obtained from the computation. The calculated values were used as the foundation for the water user charge that was intended to be collected from the household water users in the watershed of Lawayan. Bogale and Urgessa (2012) evaluated the willingness of rural households to pay for improved water services and identified the factors that influence this willingness. The purpose of the study was to assess the willingness to make monetary contributions to a conservation fund in order to improve water service provision in terms of water quality and supply in Kapingazi catchment.

2.2 Characterization of the status of ecosystem services

According to Convention on Biological Diversity (CBD), an ecosystem is a dynamic system made up of living things like plants, animals, and microorganisms as well as the physical environment of soil, water, air, and other non-living elements that interact as a single functional unit. These interactions involve energy flows, nutrient cycling, and biological processes that sustain life. Ecosystems vary in size, from small-scale habitats like a pond or a single tree to large-scale systems such as forests, rivers, or even the entire biosphere. (United Nations 1992: Article 2). Both living (plant, animals and microoganisms) and non-living (soil, water, air and climate) components influence the structure, composistion and functioning of ecosystems.

Examples of ecosystems are coral reefs, estuaries, and open oceans are examples of marine ecosystems, terrestrial ecosystems encompasses grasslands and forests whereas freshwater ecosystems include rivers, lakes, and wetlands. Transitional Zones such Mangroves, brackish waters all encompass aquatic ecosystems. Ecosystems perform important functions that support life on the planet and provide necessary services to humans and other species. These functions are comprised of provisioning, regulating, supporting, and cultural roles into which they are divided. Therefore, ecosystems are important to the health of the planet, enhance human well-being by providing essential goods and services, regulate environmental processes, and sustain cultural and recreational needs. In order to secure a sustainable future that harmonizes ecological well-being and human advancement, recognizing and protecting ecosystems is essential.

According to The Economics of Ecosystems and Biodiversity (2010) human activities either directly or indirectly shapes ecosystems, and that people rely on these ecosystems to deliver necessary services. As a result, ecosystems and humans are interconnected parts of larger social ecological systems. A wide range of services are provided by ecosystems, and these services interact in intricate ways and are frequently connected in both positive and negative ways. As a result, different services are provided; however, other services are frequently adversely affected when an ecosystem is largely managed for one service, like food production. The advantages that ecosystems provide to humans are known as ecosystem services. They encompass the conditions and processes that promote and enhance human well-being in natural systems and the species that inhabit them.

Natural resources used by humans such as fruits, nuts, timber, game, textiles, fodder, and medicinal plants, are known as ecosystem goods. Ecosystem services which sustain life such as crop pollination, nutrient and soil cycling, waste breakdown, and air and water purification, are equally significant. By stabilizing the temperature, lowering the likelihood of extreme weather, minimizing soil erosion, and reducing floods and droughts, these services help regulate the environment (Newcome *et al*., 2005).

The Millennium Ecosystem Assessment (2005) classifies ecosystem services into four categories: provisioning, regulating, cultural, and supporting services as illustrated in Table 2.1.

Table 2.1

Ecosystem services

Provisioning Services	Cultural Services	Regulating Services	Supporting Services
Food	Spiritual and religious	Climate regulation	Soil formation
Fuel wood	Recreation and ecotourism	Disease regulation	Nutrient cycling
Fresh water	Aesthetic value	Water regulation	Primary production
Fiber	Inspirational	Water purification	Water cycling
Biochemicals	Educational	Flood control	Provision of habitat
Genetic resources	Sense of place	Bioremediation of waste	Production of atmospheric oxygen
Ornamental resources	Cultural heritage	Pollination	

Source: Millennium Ecosystem Assessment (2005)

In order to raise awareness of the benefits ecosystem services provide to human well-being and the necessity of protecting natural systems, assessing ecosystem services and the factors influencing their provision as well as quantifying their economic value is crucial (Periotto & Tundisi, 2018). The significance of identifying and assessing ecosystem services is universally recognized as crucial for determining their global value (Constanza *et al*., 2014; Groot *et al*., 2012).

Drivers that shape changes in ecosystem services are highlighted in the (Millennium Ecosystem Assessment, 2005). Building on this, several classifications and frameworks have been advanced, such as those presented by (Constanza *et al.*, 2016; de Groot *et al*., 2002; Wallace, 2007). By providing a standardized system that enhances the comparability of assessments worldwide, Haines-Young and Potschin (2013) developed the Common International Classification of Ecosystem Services (CICES) to harmonize these varying typologies.

In Brazil, few studies have looked at these services in the context of catchments; most have concentrated on the local and regional effects of intensive agriculture on biodiversity and the ecosystem services it provides. In order to close this gap, Periotto and Tundisi (2018) evaluated the ecosystem services of the Jacaré-Guaçu and Jacaré-Pepira watersheds in São Paulo State, Brazil, over a ten-year period. Through detailed mapping of these regions, their analysis assessed the ability of land cover and land use to deliver ecosystem services as well as the main drivers of change. The results showed that there was reduction of regulating and supporting services in cultivated and terrestrial regions. The wetlands and natural vegetation covered small areas and they played an important role in preserving regulating and supporting services in both watersheds, illustrating their ecological and economic significance. Degradation extent and the necessity for maintenance or restoration were also highlighted.

Pettenella and Portacio (2017) assessed the ecosystem services provision in the pilot regions of Mis and Mae Rivers catchments in Belluno Province, Veteno Region, Italy through the project recharge.green. With the objective to identify the most important qualities to protect while generating renewable energy, they assessed the effects of power generation utilizing water resources and woody biomass on ecosystem services. An economic approach to ecosystem service valuation offers a useful way to examine the costs and benefits of exploitation of natural resources, because it enables both to be evaluated within a consistent framework of measurement for profitability analysis. By considering the social costs associated with using natural resources, trade-offs between renewable energy and ecosystem services can be highlighted within energy production. In order to maintain the environment and at the same time generate renewable energy, this assisted the decision makers in developing efficient strategies for the location of renewable energy. The study identified key ecosystem services by ranking them across two pilot catchments and highlighting potential areas for energy-related implementation, using a participatory approach with local authorities and stakeholders. The results showed that while participants in Mis emphasized environmental, tourism-recreational, and aesthetic landscape values, participants in Mae emphasized ecosystem services mainly in terms of social, family, and economic values which reflected the communities' activities and interactions with their territories.

In order to analyze ecosystem services in the Ewaso Nyiro catchment which is located in the arid and semi-arid lands (ASALs) of Northern Kenya, Ericksen *et al.* (2012) applied a framework that categorized ecosystem services into intermediate services, final services, and benefits. The provision of ecosystem services were characterized and mapped as bundles and they were organized by geographic location and the type of land use. Its aim was to categorize land units ecosystem service profiles which are unique and to quantify key services relevant to policy makers, pastoralists, crop farmers, the tourism industry, and conservationists. Using knowledge on land use patterns, information on livestock and wildlife distribution, forage production, and surface water availability, seven different land use categories were identified and the ecosystem services linked to each were determined. Crop and livestock production, freshwater quality and quantity, water security, climate regulation, tree and woody species, wildlife resources, flood regulation, groundwater recharge, and the cultural values of livestock were the services highlighted in the study. The results had significant implications for policy formulation and land management. They demonstrated how land holders and decision-makers could better integrate ecosystem-based approaches into catchment-level management and use ecosystem service information to guide future land use planning and conduct comprehensive economic valuation.

It s important to incorporate ecosystem services into national and sub-national development planning proedures, especially in the management of water and land resources. Both poverty alleviation efforts and environmental sustainability risk being undermined if development initiatives overlook the value of ecosystem services supplied by catchment areas, as well as the local communities who rely on these services. This study therefore aimed to assess the status of ecosystem services within the Kapingazi Catchment in Embu County, Kenya. Since no prior characterization of ecosystem services in this catchment had been undertaken, the research addressed this gap by conducting a straightforward inventory of the ecosystem services available. The findings provide a descriptive baseline that can be enhanced in future through more dynamic approaches such as the development and validation of predictive models for specific system interactions or controlled ecosystem experiments. The study identified a range of ecosystem services supplied in the Kapingazi Catchment such as food production, water supply, fuelwood provision, air purification, among others.

2.3 Catchment users and their functions, catchment management practices, organization and challenges of catchment management

2.3.1 Catchment users and their functions

Globally, access to clean water has been expanded successfully due to stakeholder identification and participation, which have become important in water management. (Koppen, 2000). In order to reduce the influence of well-connected and influencial stakeholders in decision-making over underrepresented groups, the concept is applied and described at three possible levels: accounting for water uses, analyzing the legal and institutional frameworks in which water is used and managed, and addressing issues of exclusion and (inclusion) of specific and particularly disadvantaged social groups. This is an issue that is severe when resources (water quantity) are scarce and are being utilized in unsustainable manner. Bringing stakeholders together much earlier in the planning process ensures solutions are developed in a participatory manner, thus improving the outcome of their implementation (Global Water Partnership, 2017). It entails water, people and society. By identifying key stakeholders, there is better comprehension of the system and enables evaluation of their needs, priorities and interests. (Reed *et al.*, 2009).

In natural resource management (NRM), stakeholder identification has largely stemmed from concerns that projects often do not meet their objectives because key stakeholders who stand to be negatively impacted, choose not to cooperate or oppose the proposed changes (Talley *et al.,* 2016). Through identification of stakeholders relying on catchment's natural resources, trade-offs can be identified and resolved as well as conflicts of interests (Mekuria *et al.*, 2021). The stakeholders range from farmers, non-governmental organizations, government institutions as well as institutions at national and multinational level.

In Hawassa catchment in Ethiopia, Mukeria *et al.* (2021) examined the main stakeholder groups engaged in carrying out landscape restoration. Using the conceptual framework of Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), land degradation drivers and the interactions between ecological and social systems were analysed. The study considered all groups affected by or involved in restoration activities, including those with interests, rights, claims, or potential costs linked to restoration outcomes. Stakeholders identified ranged from government agencies, private sector, NGOs, and local administrations to civil society, the private sector, and farmers. Their roles were comprised of technical and financial assistance, capacity building, community mobilization, provision of labor, and the generation of best practices. The results showed that top-down approach was used since the government authorities and NGOs made decisions about community involvement leading to lack of incentives to the locals and reduced adaptability of restoration strategies that are community-specific.

2.3.2 Catchment management practices, organizations and challenges of catchment management

Globally, catchment management practices have increasingly emphasized integrated approaches that balance ecological sustainability with socio-economic needs, incorporating measures such as afforestation, soil and water conservation, riparian buffer restoration, and controlled land-use practices to mitigate degradation and enhance ecosystem services (Taylor *et* *al*., 2018). Effective catchment management often involves various organizations such as government agencies, water resource authorities, community-based organizations, and non-governmental organizations, whose roles includes policy formulation, implementation, monitoring, and stakeholder engagement. However, catchment management faces numerous challenges, for example limited financial and technical resources, weak institutional coordination, overlapping mandates, low stakeholder participation, and resource use conflicts. Rapid population growth, agricultural expansion, deforestation, and industrial pollution also exert pressure on catchment ecosystems, complicating conservation efforts. Successful catchment management requires not only technical interventions but also strong governance structures, stakeholder collaboration, and mechanisms such as Payment for Ecosystem Services (PES) that provide rewards for sustainable practices and help ensure that benefits are distributed fairly across different users.

According to Zekele *et al.* (2006), top-down approaches rely heavily on command-and-control systems that connect stakeholders seeking quick solutions in natural resource management. However, this oftenly leads to short-term results such as quantity over quality and area coverage over meaningful impact and sustainability. Since natural resource management is comprised of multiple actors and challenges, it requires the understanding of local conditions. Therefore, it is important to undertake broad stakeholder involvement in both decision-making and management processes.

Borisova *et al.* (2012) exposed weaknesses in stakeholder engagement in the development and implementation of a Total Maximum Daily Load (TMDL) plan in a Florida watershed. Due to inadequate voting procedures, limited watershed representation on the TMDL executive committee, inadequate information sharing and concerns that trade-offs for achieving water quality goals were insufficiently evaluated caused conflicts. Effective stakeholder identification was necessary for collaborative watershed management, given Florida's mandatory TMDL abatement requirements and complex institutional settings. The study noted that the watershed's diverse land uses and stakeholders including agricultural producers, forestry representatives, local governments, utilities, developers, academia, environmental organizations, and industry held competing interests. Engaging these groups in informal reviews of the water quality model ultimately facilitated the successful development and adoption of a TMDL for the watershed.

In Kenya, human activities such as agriculture, livestock development and domestic water use have negatively impacted water resources leading to serious water management related challenges for continued social and economic development. Against this background, Mwando (2009) focused to analyse community involvement in water resource management, stakeholder collaboration, their role in enhancing access to reliable water, and the participatory approaches challenges within Machakos Sub-County, Machakos County, Kenya. The main key stakeholders identified were Water Resources Authority, Tana Athi Water Services Board, Catchment Area Advisory Committee (CAAC), National Environment Management Authority, self-help groups, Machakos water and sanitation company, WRUAs, private water service providers and TARDA . The study identified the main challenge the stakeholders were facing were financial constraints. For participatory approach in water resource management to take root, the community based self-help groups required to be supported financially and through capacity building. Bringing together stakeholders with conflicting interests, alongside creating awareness among them, was essential.

The Water Act (2016) has distinguished various roles of different stakeholders to advance integration that supports the sustainable governance of water resources and results in better water access for all in Kenya. The potential for diverse stakeholders working together leads to consensual decision making despite differences in their interests, either in implementing policies, land restoration efforts or addressing challenges faced in water catchment management. Therefore, this study sought to identify the catchment users/stakeholders in Kapingazi catchment, their awareness on catchment management and how they were organized in managing the catchment which was and is very important in carrying out a payment for ecosystem services scheme.

2.4 Human activities affecting water provision ecosystem service

Water catchments play an important role in sustaining lives and livelihoods. They supply essential ecosystem goods such as water, food, and hydroelectric power, alongside critical services such as nutrient cycling, flood regulation, water purification and recreation. Despite this importance, they remain among the most endangered ecosystems worldwide (Dudgeon *et al.*, 2006). Globally, there are three major human activities affecting fresh water ecosystems; growing population, growing economies and growing environmental insecurity (Heathewaite, 2010). With human population growing exponentially and economic development expansion, water continues to grow in demand, placing river ecosystems at risk of further deterioration if not managed sustainably. Moreover, the large volumes of waste produced through industrialization further strain and deplete vital natural resources (Fuggle & Rabie, 1994). While certain human activities contribute to stabilizing and enhancing ecosystem services, a larger proportion generate ecological crises and disasters that threaten human survival and development. Both positive and negative human impacts shape water ecosystem services. The negative impacts reduce service provision by altering habitats, disrupting ecosystem structures, and modifying biogeochemical cycles. Key human-induced drivers include urbanization, land reclamation, grazing, industrialization, hunting, agriculture and international trade.

According to Soko (2014), Industrialization, urban growth, deforestation, mining, agriculture, and energy production have long been associated with significant changes in water resources. Ecological processes that maintain natural water purification are affected by pollutants such as effluents, discharges, and seepage from these sectors. Because human activities within a catchment inevitably manifest in the quality of river water through runoff, the condition of rivers serves as an indicator of the socio-economic situation and the environmental attitudes of surrounding communities. In Soko (2014) study, pollution issues were detected by measuring parameters such as ammonia, dissolved oxygen (DO), total dissolved solids (TDS), biochemical oxygen demand (BOD), heavy metals, nitrates, pesticides, phosphorus, pH, TSS, and turbidity directly impacted the water quality of the Crocodile River in South Africa through industrialization, urbanization, and agricultural activities. Land use activities such as agriculture influenced nutrient loading and discharge into the river.

According to Ekka *et al.* (2020), inter-basin water transfer, urbanization, industrial expansion, agricultural practices, groundwater abstraction, channelization, damming, and sand mining are among the multiple anthropogenic activities at both catchment and reach levels that have altered river ecosystem services. These modifications reduced ecological and socio-cultural benefits but improved economic values. Hydrology and water quality were affected by land use changes such as urban growth, deforestation, and agriculture which disrupted water balance by increasing impervious surfaces and compacting soils through infrastructure like pavements, rooftops, and parking areas. Deforestation modified local microclimates, influencing precipitation and evaporation patterns and consequently runoff flows. Interventions such as groundwater abstraction, inter-basin transfers, channelization, and sand mining reduced water availability. Supporting these findings, Hu (2019) demonstrated that excessive sand mining not only reduced water supply in downstream areas but also compromised river stability in the Hanjiang River Basin.

Water ecosystem services degradation due to anthropogenic pressures has become an urgent environmental concern worldwide. Significant changes in water catchments continue to undermine the ecological balance of rivers. While rivers have self-purification functions, these mechanisms are increasingly disrupted by human interventions within their catchments. It is therefore important to understand the extent and mechanisms through which human activities affect water ecosystem services. Therefore, this study sought to identify the key human activities affecting water quality and availability in the Kapingazi catchment, Embu County, Kenya.

2.5 Establishment of the willingness to pay for water provision ecosystem services

Willingness to pay (WTP) for ecosystem services refers to the financial value that people, communities, or organizations are ready to offer to protect, improve or restore the benefits that ecosystems provide. However, the concept is two-sided because it involves both the payer (the party willing to compensate for ecosystem services) and the payee (those who manage or provide the services).

2.5.1. Willingness to pay (WTP)

This part of the transaction highlights the need for ecosystem services where people, businesses, and governments commit financial resources to ensure a continuous supply of ecosystem services like carbon storage, air purification, clean water and biodiversity preservation. People's value for protecting or improving ecosystem health and the benefits they derive from it is reflected in their payment. This side is driven by factors such as personal benefit, ethical consierations and environmental degradation awareness.

2.5.2. Willingness to accept (WTA)

In the other side, the payee typically landowners, communities or organizations in charge of natural resource management must be open to receiving compensation in order to preserve or improve ecosystem services. For instance, these payees might forgo activities (such farming, logging, or development) in return for monetary rewards for preserving or responsibly managing the land sustainably. Their willingness to accept varies depending on the opportunity costs of protecting ecosystems as opposed to engaging in other economic activities.

Example of Two-Way Payments in Ecosystem Services:

- Payers: These are governments, industries or individuals who may pay for protection of a forest for its biodiversity or carbon sequestration benefits.
- Payees: These are landowners or forest managers who receive payments to ensure that the forest remains intact and continues to provide ecosystem services.

By treating ecosystem services as valuable commodities that can be paid for by those who benefit from them and compensated for by those who are responsible for their maintenance, this dynamic produces a transaction that is market-like. Payment for ecosystem services (PES) programs formalize these exchanges, ensuring equitable transactions between those who benefit from ecosystems and those who provide or protect them.

There are several factors that determine willingness to pay (WTP) for ecosystem services such as socio-economic characteristics, cultural values, trust in institutions, awareness of ecosystem benefits, policy frameworks, and local environmental conditions. According to previous research, WTP increases when people understand the value of these services and when transparent processes link their contributions to quantifiable results, like improved resource accessibility or environmental quality (Udugama *et. al.*, 2024). Understanding these factors helps in designing effective conservation campaigns, payment schemes for ecosystem services (PES), and policies that can encourage greater public participation in conserving the environment.

Various studies use contingent valuation methods (CVM) to estimate willingness to pay (WTP) (Tanellari *et al.*, 2015). According to economists, a policy is desirable if it meets the criterion of Pareto optimality meaning that those who benefit ("winners") could, in theory, compensate those who are negatively affected ("losers") and still retain a net benefit (Loomis, 2002). For watershed management, this principle suggests that downstream users who gain from enhanced services could offset the losses experienced by upstream communities, while continuing to benefit from the improved catchment services.

Using contingent valuation method, a survey-based valuation technique, respondents can make hypothetical economic decisions about goods or services for which there is no real market. With this approach, the valuation is dependent on the questionnaire's simulated market. For environmental goods or services, CVM aims to ascertain the maximum willingness-to-pay (WTP) (Wedgwood & Sansom, 2003). In environmental economics, it is commonly used to calculate the use and non-use values of environmental resources (Venkatachalam, 2004). The basic principle is that people may value environmental quality improvements as stated in the survey. WTP was utilized as the dependent variable in this study.

CVM has been used in various studies to quantify the value of ecosystem services related to water that are not marketable. In their research, Calderon *et al.* (2013) evaluated household water users' willingness to pay (WTP) for better watershed services of the Layawan Catchment in Oroquieta City, Philippines. Over 50% of participants said they would be ready to make a monetary contribution to watershed conservation in a contingent valuation referendum used in the study. According to parametric and non-parametric estimates, the average monthly WTP per home was Php 57.48 and Php 53.89, respectively. This amounts to around 0.68% of the average household income of Php 8,198.84. These figures were meant to serve as a reference in order to determine a water user fee for residential customers in the Layawan Watershed.

Bogale and Urgessa (2012) using contingent valuation method in their study, analyzed rural households' willingness to pay (WTP) for better water services and determined its drivers in an Eastern Ethiopian. According to their findings, the average price that families were ready to pay for a 20-liter jerry can was 2.30 cents. Income, education, gender, time spent fetching water, water treatment methods, water quality, and water expenditure were important factors that positively influenced WTP but age had a negative and significant impact on WTP. This was important in providing affordable water supply for the rural community by the government and enhanced water quality supply for the rural community.

Similarly, Durham and Wake residents in North Carolina, USA were willing to pay for land conservation upstream for water quality improvement with a mean WTP of USD 10.3 and USD9.96 per month, respectively, given the environmental degradation and population increase in the areas (Joo, 2011). In Lahore, South Asia, the household heads' education level was a key determinant of willingness to pay (WTP) for better drinking water quality in order to ease the burden of diseases at the hospitals in the monsoon due to water borne diseases. The willingness to pay calculated enabled effective pricing policies to cover the incurring losses and ensure sustainable water quality and supply (Noor *et al.*, 2010).

The CVM was used in a study conducted in Southern Ethiopia's Shebedino District to find out how much families were willing to pay (WTP) for better water services (Behailu *et al.,* 2012). According to the study, 83.62% of respondents said they would be willing to pay 10 cents a month for 25 liters of water. Just 1% said they were unwilling to pay for better services, while 17.1% indicated that they used clean water at no cost. Perceptions of water as a public good that ought to be freely accessible, along with claims that taxes already cover service provision, a lack of faith in the government because of corruption, and opinions that either the private sector should bear the cost or contributions should remain voluntary were the main causes of the reluctance to pay.

Bautista (2003) explained that there are several factors influencing beneficiaries' willingness to pay for watershed protection services such as the payment required for existence and enforcement of policies, current water quantity's perceived threats, unpredictable future availability, identification of the service's economic utility and confidence in the transparent use of funds. Likewise, according to Amponin *et al.* (2007), 78% of respondents indicated that they preferred a more reliable water supply while 21% of respondents regarded watershed protection primarily for future generations. Other motivators were preventing the deterioration of watersheds (12%), continuous supply of ecosystem services (7%), believing that everyone would benefit (4%), being willing to contribute (3%) and feeling a sense of obligation as water users (2%).

Ndeteiwo *et al.* (2013) conducted a study in Lower Moshi of the Pangani Basin which indicated that about 79% of the farmers surveyed were willing to pay extra fees to reward landowners around catchment forests in order to improve both the quality and quantity of water. The value of proposed contributions varied depending on the respondent. About 21% of the farmers were against paying additional amount of money because they received poor service despite, paying for irrigation water through water user rights unless they were assured of a reliable water supply.

Several environmental initiatives emphasising on community involvement, sustainable land management, and ecosystem restoration have been implemented in Kenya. The Kapingazi River Restoration Project's in Embu County objective was to preserve riverine regions while improving river flow and recharge by encouraging communities to plant trees. It involved 800-1000 homes in five focal development areas, supporting poverty reduction and environmental conservation. The program removed invasive species and replaced them with indigenous ones under the instructions of Community Forest Associations(CFAs) while providing incentives and monitoring to encourage the sustainable practices adoption (Kagombe *et al.*, 2018).

In order to address severe environmental degradation in Nyando and Yala river catchments due to high sediment and phosphorus deposits in Lake Victoria, the Western Kenya Integrated Ecosystem initiative was conducted. It encouraged shifts from short-term maize cultivation to sustainable approaches such as tree-based enterprises for 8,000 – 12,000 households across 5-10 million hectares with the objective of promoting sustainable land management. In support of these efforts, a stakeholders' consortium, comprised of KALRO, CIFOR-ICRAF, universities, and government agencies, worked together through financial assistance provided by the World Bank and GEF. Soil and water management practices were introduced by the project, halting soil degradation and improving crop yields while building resilience against climate change. Farmers were incentivized through materials support, capacity building, and soil management techniques (Kagombe *et al.,* 2018).

The Naivasha Equitable Payments for Watershed Services project sought to reduce sediment deposits entering Lake Naivasha from the Turasha and Kinja river catchments in Nyandarua County through the restoration of riparian vegetation. Through scoping, implementation and scaling up, it aimed to test mechanisms for sustainable watershed management and livelihood improvement. The project encouraged sustainable land management strategies such as tree planting initiatives, agroforestry, and soil conservation methods by working with 565 small-scale farmers. WWF and CARE facilitated incentives amounting to $20,000 in compensation to farmer groups and agro-input vouchers, with payments delivered through Water Resource Users Associations (WRUAs). The payments were negotiated between farmers and buyers such as Lake Naivasha Growers Group creating a buyer-seller forum for long-term management of the scheme. The project’s objective was to provide benefits like firewood, fruits, and health improvements, alongside enhanced farm productivity and strengthen community institutions over time (Kagombe *et al.,* 2018) .

With the aim of addressing environmental degradation through payment for ecosystem services, the Sasumua Pro-poor Rewards for Environmental Services in Africa (PRESA) project in Kenya, led by ICRAF and JKUAT focused on watersheds providing water to the Sasumua Reservoir, where smallholder farms contributed to sediment and pollution. The project spent USD 159,864 since 2008 to compensate farmers through vouchers for farm inputs, tree planting, and terracing. The Nairobi City Water and Sewerage Company (NWSC) was to save up to US$23,256 annually on water treatment costs by reducing sediment yield through sustainable land management practices. A proposed grass-covered waterway was to reduce sediment by 20%, benefiting both NWSC and local farmers, who would receive US$9 per household annually. The willingness to contribute to funding watershed conservation was expressed by over 40% of

Nairobi's water consumers. Each project emphasized the importance of strong partnerships, baseline data, and incentives for successful implementation (Kagombe *et al.*, 2018).

Cowling *et al*. (2008) indicated that in order to achieve broad uptake of ecosystem service initiatives, early engagement of key stakeholders is important in designing effective PES programmes. Cocklin *et al.* (2007) highlighted that beyond biophysical elements, PES initiatives should reflect the social, ecological and economic realities of a given area as well as capacities of local institutions and communities by integrating stakeholder perspectives. Thus, the River Kapingazi catchment emerged as a suitable case for assessing willingness-to-pay or co-investment strategies towards a conservation fund since it delivers critical water and ecosystem services to multiple stakeholders both within and outside its boundaries. This presented a unique opportunity, as such a study had not previously been implemented in the catchment.

Table 2.2

Identification of research gaps

Specific Objective	Authority	Nature of study (Empirical, Framework, Theoretical)	Gaps
1. Characterization of the status of ecosystem services	Periotto and Tundisi (2018) Pettenella and Portacio (2017), Ericksen *et al.*, (2012)	Empirical	Identification of all ecosystem services provided in catchments and ranking them in terms of their importance by the respondents.
	TEEB (2010)	Framework	
	Millennium Ecosystem Assessment (2005)	Framework	
	Common International	Framework	

	Classification of Ecosystem Services		
2. Identification of catchment users/ Stakeholders in catchment	Zekele *et al*., (2006) Borisova *et al*., (2012) Mukeria *et al*., (2021)	Empirical	Identification of the catchment users in Kapingazi catchment, their awareness on catchment management and how they were organized in managing Kapingazi catchment which are important in the implementation of payment for ecosystem Services scheme.
	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)	Framework	
3. Perceived human activities impacting water provision ecosystem service.	Soko (2014), Ekka *et al*., (2023), Hu (2019)	Empirical	Identification of the perceived anthropogenic activities impacting on both water quality and water quantity.
4. Establishment of the willingness to pay for water provision ecosystem service	Calderon *et al*., (2013) Bogale and Ergessa (2012), Joo (2011), Noor *et al*., (2010),	Empirical	Eliciting the willingness to pay towards a conservation fund to improve water service provision in terms of

	Behailu *et al*., (2012) Kagombe *et al*., (2018)	water quality and water quantity in catchments.

2.6 Theoretical framework

This study is based on two key frameworks: the demand and supply theory and the Driving forces, Pressures, States, Impacts and Responses (DPSIR) framework of the European Environment Agency (Tapio & Willamo, 2008). How the prices and the quantities of goods and services are determined in a market are explained in the theory of demand and supply. Demand is the willingness and ability of consumers to buy a product at different price levels, while supply is the willingness of producers to sell at those prices. When demand increases while supply remains constant, the prices rises; on the other hand, when supply increases while demand remain constant, the prices fall. Where demand and supply meet, establishing the prevailing market price, equilibrium occurs at that point (Dean *et al.,* 2020).

Through ecosystem services and particularly through payment for ecosystem services programmes, the concept of demand and supply can be applied. Kapingazi catchment, provides important ecosystem services such as water, which are highly sought after by industries and local communities. When population growth and industrial activities increase, the pressure on these services intensifies. At the same time, environmental degradation and unsustainable exploitation limits their supply especially clean water and flood regulation.

In order to incentivize landowners to conserve ecosystems, PES creates a market mechanism whereby beneficiaries of ecosystem services (demand side) compensate the individuals or communities who manage and sustain them (supply side). To encourage behavioural change that ensures continuous supply of ecosystem services, payments have to be made. By balancing demand and supply through internalizing the external benefits of ecosystem services (like water purification), PES programmes align the interests of users and land managers. Without proper management, there would be reduced ecosystem functions causing an imbalance, highlighting the importance of mechanisms like PES in regulating ecosystem demand and sustainable use.

The dynamics of ecosystem services combined with the concept of willingness to pay in the Kapingazi catchment can further be explained by the theory of demand and supply. As the demand for water provision increases due to population growth and industrialization, the WTP of users becomes a key factor in determining how much they value these services. The WTP on the demand side reflects their willingness to invest in conserving ecosystem services and the recognition of the importance of these services. On the supply side, ecosystem managers or landowners deliver essential ecosystem services such as improved water quality an quantity as well as flood control. However, the supply of these services are threatened by environmental degradation and over-extraction. PES fills this gap by compensating landowners for protecting and improving them by making the supply of these services more sustainable.

The price the beneficiaries are prepared to contribute for continued supply of ecosystem service is established through the WTP. Resource users are more likely to support conservation efforts when they place high value to clean water and related benefits (Udugama *et al.,* 2024). In order to promote the sustainable provision and management of ecosystem services, PES connects the demand and WTP of users with their supply. When the WTP is low, there would be insufficient funds to compensate landowners, leading to reduced supply of ecosystem services.

The interactions between human society and the environment is analysed using the DPSIR framework (Tapio & Willamo, 2008). This framework outlines causal linkage beginning with driving forces, followed by pressures, then states and impacts, which leads to responses. Drivers are the underlying causes or socioeconomic forces such as population growth, industrialization that lead to environmental pressures which are direct effects of human activities (e.g., deforestation, pollution) that affect the environment. The state is the current condition of the environment (e.g., water quality, ecosystem health) as a result of pressures. Changes in the environmental state leads to impacts on the functioning of ecosystems, their ability to sustain life, health, economic stability, and social development of society (e.g., loss of biodiversity, water shortages). These undesired impacts lead to responses through actions or measures taken by society, including policies and management strategies, to mitigate pressures, restore the environment or adapt to impacts. These responses serve as corrective functions through compensation for, reduction prevention and elimination. The framework was particularly useful in clarifying how the literature review, significance of the study, the problem statement, and the objectives relate to the applied methodology as shown in Figure 2.1.

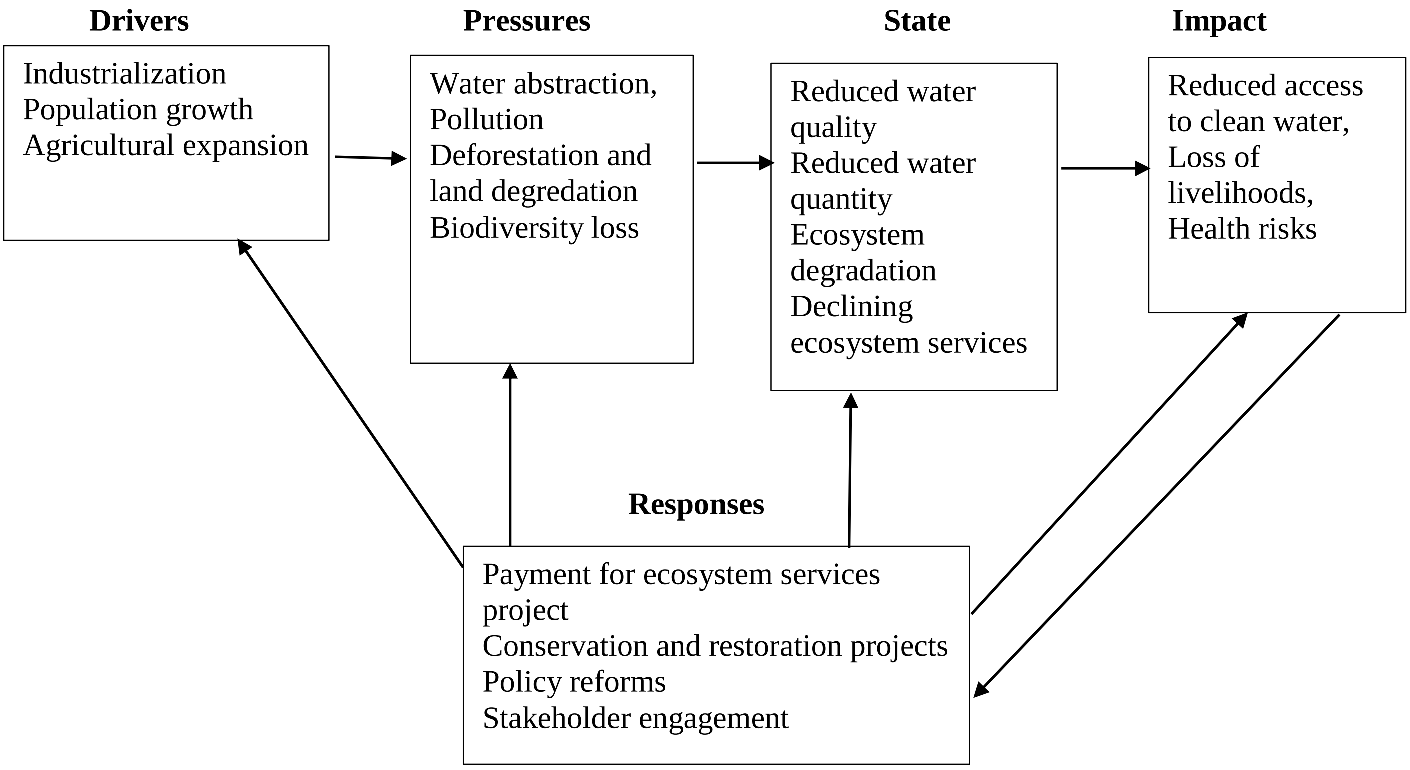

Figure 2.1: The DPSIR model for Kapingazi catchment

2.7 Conceptual framework

The conceptual framework highlights how the dependent, independent and intervening variables are connected, thereby providing understanding on how the various factors influence one another. This facilitated the study to concentrate in important variables and how they affected one another, ensuring data collection and analysis were in line with the study's objectives.

2.7.1 Dependent variables

The status of ecosystem services which constitute the dependent variable was assessed by identifying various ecosystem services provided in Kapingazi catchment such as water provision, food, timer, flood regulation among others. The study ranked various ecosystem services by importance in order to conserve them and water was the most important ecosystem service in Kapingazi catchment. This operationalization allowed the study to understand that there was need to conserve Kapingazi catchment in order to improve the delivery of water services, both in quality and quantity implying that the catchment had water shortage. Water provision is an important ecosystem service. In order to directly inform strategies for improving water conservation and management practices in the catchment, its important to understand its status.

2.7.2 Independent variables

Various catchment users such as farmers and industries were identified in the study and their conservation practices within the catchment. It then looked into how these management practices contributed to environmental degradation or promoted conservation. Organization of catchment users, functions of the organizations in catchment management were also assessed thereby revealing the key challenges in managing the catchment. In order to recommend interventions and improvements, it was important to understand current management practices in Kapingazi catchment.

The study also focused on perceived catchment user activities (agricultural and industrial) like deforestation, water abstraction, and lack of soil and water management practices, affecting water provision i.e. water quality and water quantity. These constituted the independent variables. These measurements helped in quantification of the perceived negative human activities affecting the catchment's capacity to deliver clean and adequate water. Water quality and quantity as well as ecosystem health are directly affected by human activities. Recognizing these activities helps in assessing their positive or negative impacts on water provision.

The independent variable WTP was elicited through household survey to assess the financial commitment respondents were willing to make for improved water services provision. Age, education level, and the household size were the socio-economic factors influencing respondents' WTP for improving water provision services. Assessing WTP was important in determining the feasibility of introducing PES to incentivize conservation in Kapingazi catchment, which is important for funding sustainable practices.

2.7.3 Intervening variables

Government policies on water management, land use, and conservation (e.g., restrictions on deforestation or pollution limits) influence how catchment user activities (e.g., farming, industrial discharge) are carried out with water in high demand. Through effective environmental regulation enforcement, negative effects of human activities on water quality and supply can be mitigated. By having in place strong policies, the negative effects of human activities on the environment can be reduced, leading to improved water provision. But when there are weak policies, degradation is exacerbated.

How effectively policies are implemented and how well users comply with conservation regulations depends on the strength of local governance and institutions. Strong institutions ensure better management of the catchment, reducing illegal or unsustainable activities and improve ecosystem services and water provision. Catchment users may not follow regulations if local institutions are weak, leading to degradation of ecosystem services. Both ecosystem health and WTP can positively be influenced by strong institutional frameworks.

The intervening variables such as government policies and institutional capacity act as an intermediary linking human activities (independent variables) with the status of ecosystem services and water provision (dependent variables). Their existence can either increase or mitigate the consequences of impacts on the ecosystem, directing the study towards identification of sustainable practices and improving management strategies.

In order to align data collection, analysis, and the study's intended objectives, the conceptual framework was highly useful during the execution of the study by clarifying relationships between variables which helped in focusing on relevant variables and how they influence each other. The study had enhanced practical application of results since the conceptual framework guided data collection and analysis ensuring comprehensive study execution by ensuring that the study's outcomes were actionable. Through the analysis of the relationships among variables such as policies and institutions, the framework facilitates the formulation of policy recommendations and sustainable management strategies by clarifying how they affect the management of the ecosystem.

The conceptual framework was important in the execution of the study since it clarified how various factors such as catchment users, human activities, willingness to pay (independent variables), policies and institutions (intervening variables) influenced water provision i.e. water quality and quantity (as the dependent variables) in the Kapingazi catchment, directing the course of the research and helping to achieve the study's objectives effectively.

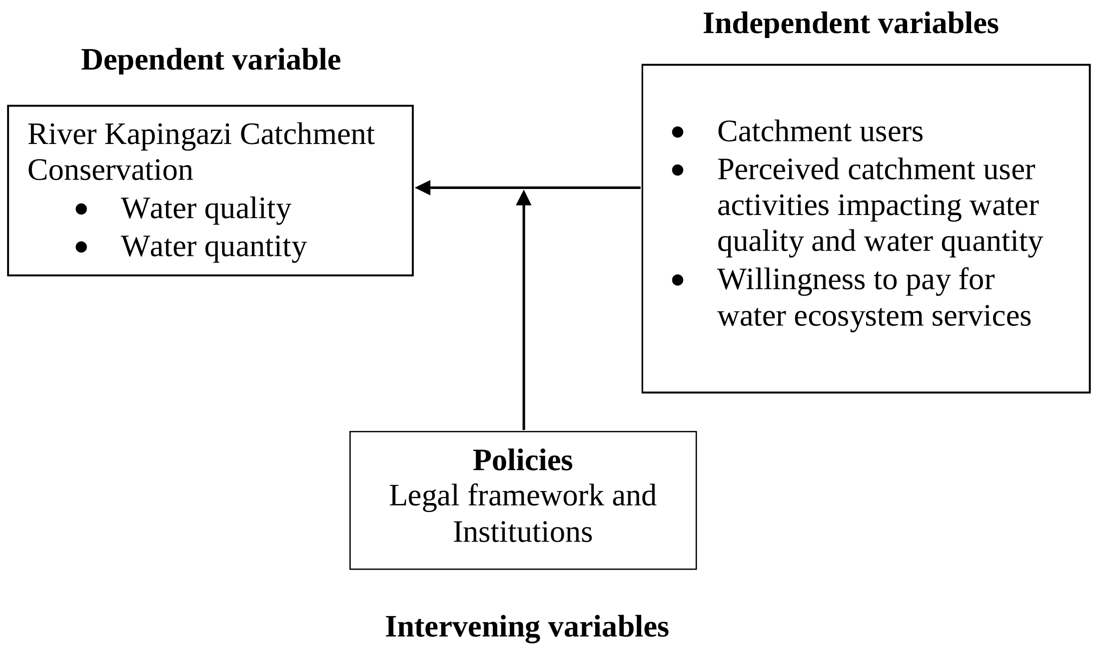

Figure 2.2: The conceptual framework for the willingness to pay for ecosystem services in Kapingazi catchment

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

In this section, the research methodology of the study is described in detail. The chapter includes the outline of the study area, research design, target population, data collection instruments and procedures and winds up by providing a narrative on data analysis. Validity and reliability are covered to justify the study.

3.2 Study area

3.2.1 Location of the study area

The study was conducted in Embu North and Embu West sub-counties in Embu County, specifically targeting farmers in the Kapingazi catchment in the sub-counties. The total area coverage of the catchment is 61.23 km², encompassing five Focal Development Areas (FDAs): Kithunguriri, Kiriari, Kairuri, Mutunduri, and Muthatari. It extends approximately 24.5 km from its northern most point in the Mt. Kenya Forest Reserve to the confluence where the Kapingazi River joins the Rupingazi River. The catchment lies within coordinates 37°27′–37°31′ E and 0°20′–0°34′ S, with altitudes ranging from 1,200 to 2,100 meters above sea level.

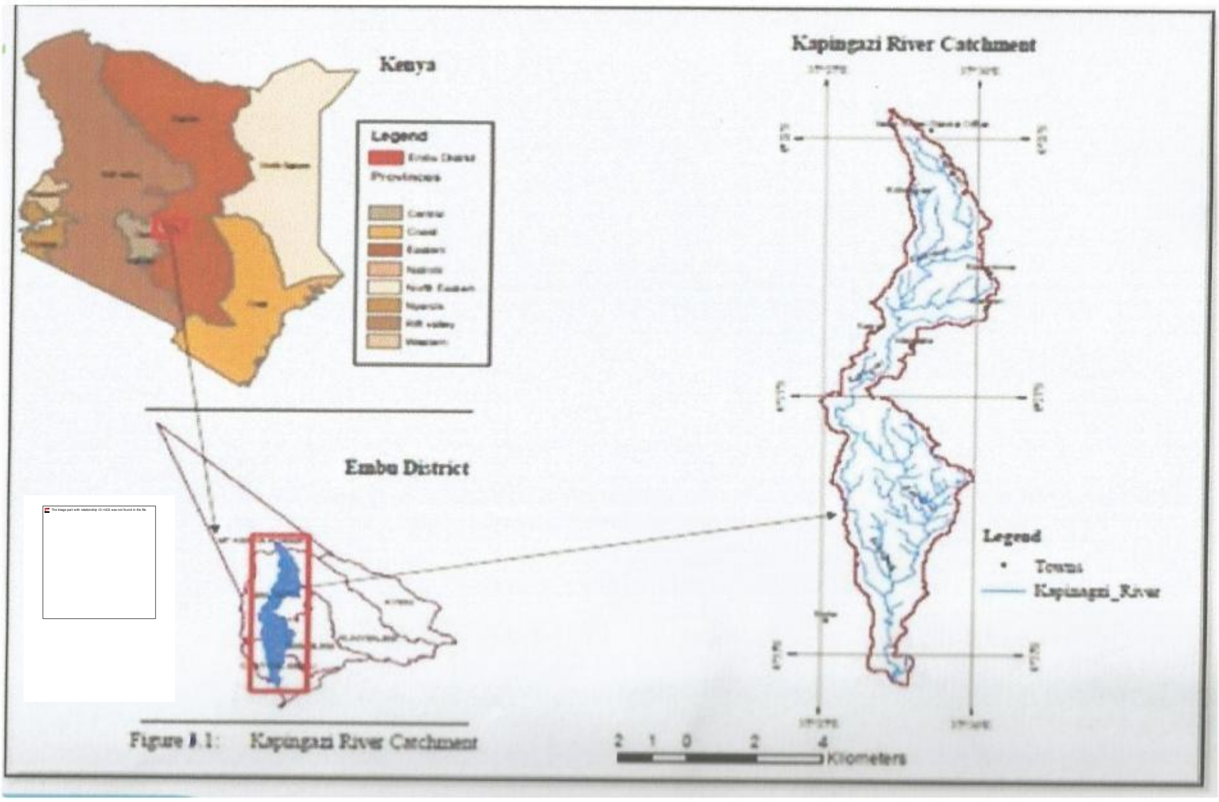

Figure 3.1: Map of Kapingazi catchment

Source: PRESA- World Agroforestry Centre (2011)

3.2.2 Ecological characteristics

3.2.2.1 Climate, rainfall and temperature

The catchment is situated across four agro-ecological zones: the Lower Highland Zone 1, Upper Midland Zone 1, Upper Midland Zone 2, and Upper Midland Zone 3. The area experiences a bi-modal rainfall regime, whereby long rains occur between March and June, and short rains between October and December. The average annual precipitation is approximately 1,067.5 mm, though totals vary with altitude, ranging from 640 mm to 1,495 mm per year. Temperatures fluctuate seasonally, with a minimum of 12°C in July and a maximum of 30°C in March, averaging 21°C annually. Due to its broad altitudinal variation, the catchment exhibits notable temperature differences, with July recording the lowest monthly average of 15°C and September reaching the highest at 27.1°C (Embu CIDP, 2019).

3.2.2.2 Soils, relief and drainage

The soils in the catchment falls under the volcanic foot ridges fertile soils but very erodible and dark reddish brown in colour. This type of soil are well-drained, very deep to extremely deep (GOK, 2007). These are loam to clay soils which exhibit low erodibility due to their cohesive nature. However, when they have low organic matter content and moderate permeability, they can affect water retention and increase susceptibility to erosion under certain conditions. Areas with disturbed vegetation or improper land use practices are particularly at risk. The catchment is characterized by a varied terrain. The upper catchment features hilly and undulating landscapes, predominantly covered by Mt. Kenya forest and tea plantations. The elevation here contributes to steep slopes, which are prone to erosion, especially when vegetation cover is removed. The terrain gradually transitions into gentler slopes in the lower catchment. The drainage system in Kapingazi catchment is influenced by its topography and land use. The catchment has a network of streams and River Kapingazi that contribute to the Tana River system.

3.2.3 Economic activities

The catchment has high agricultural potential for growing cash, horticultural and food crops. The main cash crops were tea and coffee, while other key crops cultivated were food crops grown in the catchment both under irrigation and rain fed agriculture. They include maize, beans, tomatoes, onions, cabbages, French beans, rice, Asian vegetables and capsicums. The farm sizes range from 1 acre to 15 acres. Livestock production in the catchment is also practiced.

3.2.4 Population

The population of the catchment was 41,000 people with an estimated 9,150 households (MKEPP, 2009). This population density is significantly higher than Kenya's national average at the time, which was about 66.4 persons per square kilometer. The high density in the Kapingazi catchment is attributed to its fertile soils and favorable climatic conditions, which support intensive agriculture. Distinguished by small farms and increasing agricultural intensification, the region’s key crops include maize, beans, tea and coffee. The target population comprised of farmers in Kapingazi catchment, who lived adjacent to River Kapingazi in the five Focal Development Areas, the beneficiary organizations and catchment management groups in the catchment.

3.3 Research design

According to Kasomo (2006), survey design plays a key role in enabling researchers to assess, interpret, and connect various phenomena, events, and issues with accuracy. This study utilized a cross-sectional approach combined with a social survey research design to observe situations in their natural state and explain the factors influencing them. This design allowed for a clear and adequate description of individuals, activities, and objects. Data collection was both qualitative and quantitative, drawn directly from respondents through the cross-sectional approach. The method was not only efficient and cost-effective but also provided valuable self-reported insights into respondents' habits, attitudes, opinions, and feelings. (Kombo & Tromp, 2007; Kothari, 2007).

3.4 Sampling

3.4.1 Sample size

The households in Kapingazi catchment were the sampling units. The number of households in Kapingazi river catchment was estimated to be 9,150 which constituted the sampling frame. For statistical purpose and analysis Nassiuma, (2000) offers a formula for calculating the sample size. The sample size was calculated using the following formula:

$n = NC^2/C^2 + (N-1)\,e^2$

Where;

- n required sample size
- N the given population (9,150)
- C Coefficient of variation (30%)
- e Margin of Error (3%)

Through substitution, the sample size was calculated to be 100. This sample was considered high enough for the required accuracy of the data. The population (N=9150) is relatively large, so selecting a sample size that was statistically sufficient to represent the population was important.

Although a sample of 100 is relatively small, when the variability and margin of error are managed appropriately, it still provided enough data for meaningful analysis. It would be time-consuming, expensive, and impractical collecting data from 9,150 households. In order to maintain efficiency in terms of time, labor, and financial resources, a sample size of 100 struck a balance between gathering enough data for robust statistical analysis. A sample size of 100 captured the diversity and variability within the population since the population was homogeneous, therefore minimizing the likelihood of new data yielding substantially different results. There was moderate variability in the population which was indicated by a coefficient of variation of 30%, meaning that there was some diversity in the characteristics being studied. The formula adjusted the sample size to ensure that 100 responses could still provide a reliable estimate of the population's characteristics since a higher coefficient of variation would require a larger sample size, but at 30%. The sample estimates were expected to be within 3 percentage points of the true population values since a margin of error of 3% is quite precise for most surveys. Where a high degree of confidence is desired, this level of precision is typical in survey-based studies. Regardless of the population being of moderate size, by applying this margin of error, the formula ensured that the calculated sample size was large enough to reach the required precision level.

Using a sample size of 100, the variability within the population was statistically adequate and provided accurate estimates with a 3% margin of error and a coefficient of variation at 30%. This struck a balance between the need for representativeness and the practical limitations of time and resources for data collection by collecting data from 100 households. The sample size strengthened the validity of the results, making the conclusions drawn highly reliable about the entire population based on the sample. Therefore, with a population of 9,150, a 3% margin of error, and a 30% coefficient of variation, a sample size of 100 is justified using the formula, as it meets the statistical requirements for accuracy and precision.

To achieve this sample size a combination of stratified sampling in focal development areas and systematic random sampling technique were used. The sample population were respondents along Kapingazi River within the catchment.

3.4.2 Sampling procedure

The catchment is divided into five Focal Development Areas (FDAs) (Enjebo and Oborn, 2012). Each FDA had a sample size of 20 households which were randomly selected adjacent to river Kapingazi. This was arrived at by obtaining the sample per stratum through dividing the sample size (100) by the total number of strata (number of FDAs) providing an equal representation from each stratum. The equal allocation is justified since this approach assumed that the population in each FDA was sufficiently similar. This ensured that there was no over- or under-sampling of any group, hence a balanced and fair representation of each stratum. This avoided the risk of bias that could arise from disproportionately large or small samples in any stratum. This is shown in Table 3.1.

Table 3.1

Focal development areas and the respective sample size of households for data collected

Focal Development Areas	No. of Households
Kithunguriri	20
Kiriari	20
Kairuri	20
Mutunduri	20
Muthatari	20
Total	**100**

3.5 Research instruments and their validity

Household questionnaires, focus group discussions questionnaire, and key informant interview schedules were utilized as the primary instruments for data collection in the study to gather information on demographic, socio-economic, the status of ecosystem services in Kapingazi catchment, the catchment users/stakeholders in Kapingazi catchment, catchment user activities that are impacting on water provision service in Kapingazi catchment and establish the willingness to pay for water provision services by the catchment users in Kapingazi catchment used in the study are attached as Appendix 3, 4, 5, 6, and 7.

3.6 Data collection and analysis

3.6.1 Data collection

The data collection process involved several steps to ensure accuracy, reliability, and validity: It involved getting consent from National Commission for Science, Technology and Innovation (NACOSTI), and local administration for authority to conduct research from Kapingazi catchment, Embu County, Kenya. The study objectives were defined, clarifying the research goals by specifying the questions to be answered, variables involved, and the population that served as the source for the sample i.e. from households, community organizations and institutions.

The study objectives guided the data collection methods to be used. Primary data was collected directly from households through household questionnaires, focus group discussions with

Kapingazi WRUA, Irangi CFA and FDA committees, key informant schedules with institutions like NEMA, WRA, Upper Tana NRMP, KenGen, Embu Water and Sanitation Company (EWASCO) and observation list for in-depth responses, phenomena and observed activities. The study relied on books, journals reports and other research publications to collect secondary data.

Straightforward and unbiased closed- and open-ended questions were used to develop Household questionnaires, focus group discussion guides, key informant interview guides, and observation checklists were developed to facilitate effective data collection. The study adopted random and stratified sampling methods, with a sample size of 100 households. Pilot testing was done in Rupingazi catchment to test the data collection instruments on a small scale to ensure clarity and functionality. The data collection tools were refined to address issues that arose.

Household questionnaires were used to collect data, with respondents receiving guidance through the items and the responses recorded down. Administered questionnaires were preferred since the researcher clarified any misunderstanding and misinterpretation of words or questions where necessary which led to clearer answers. It also minimized chances of respondents not responding to the entire questionnaire. Information on social economic characteristics, status of ecosystem services, catchment users, their organization, functions and challenges, anthropogenic activities and willingness to pay for enhanced water services was collected using both open-ended and closed-ended questions. Questionnaires were administered by making visits to every sampled household and interviewed a member of the household selected. Each Focal Development Area acted as a stratum and the Focal Development Area members list as a sampling frame.

The focus group discussions were conducted in one venue using guided discussions through questions which were answered by Kapingazi WRUA, Irangi CFA and Focal Development Area committees. Key informant schedules were administered to various officers of NEMA, WRA, Embu Water and Sanitation Company and KenGen. They were intentionally selected to be part of the study. Notes of observations or interview insights were taken, ensuring accurate and comprehensive documentation. The process ensured that the participants had willingly given their informed consent and were aware of the study's objectives.

Data accuracy and consistency was ensured to avoid introducing bias through data cleaning to check for errors and any other issues that arose were addressed. Data was stored securely ensuring confidentiality and following ethical guidelines. To enter and analyse data, SPSS version 22 software was used. The results were analysed in accordance with the objectives of the study and presented in a final report in form of a thesis, detailing the data collection process, analysis, findings, conclusions and recommendations. These steps ensured effective data collection process.

3.6.2 Data analysis

The study organized the data to ensure it directly responded to the defined objectives and research questions. Data processing started with the coding of the questionnaire items. The coded data was tabulated in data and variable view in SPSS version 22 software. Using descriptive statistical methods, the study examined the status of ecosystem services and identify the catchment users/stakeholders, their organization, functions and challenges in Kapingazi catchment. Logistic regression statistical tools were used to determine the perceived catchment user activities that were affecting water provision service in Kapingazi catchment and establish the willingness to pay for water provision services by the catchment users in Kapingazi catchment. The study met the assumptions required for applying the logistic regression model in assessing perceived human activities influencing changes in water quality and quantity, as well as willingness to pay for improved water services in the Kapingazi catchment. The dependent variables were dichotomous (Yes/No) while the independence of observations in dataset was confirmed by the Durbin-Watson test. The variance of inflation factor (VIF) of linear regression confirmed that there was no multicollinearity among the independent variables. A linear relationship between the independent variables and the logit of the dependent variables, as well as overall goodness of fit, were further verified by the Hosmer–Lemeshow test.. In addition, Cook's distance indicated that there were no influential outliers. Data analysis was conducted in alignment with the specific objectives and research questions of the study.

3.7 Reliability

The study tested the degree to which the results remained consistent over time and accurately reflected the characteristics of the entire population under study. This determined whether the research instrument yielded uniform data when repeated multiple times i.e. how consistent a set of measurements are. This was done through pre-testing of research tools through administration questionnaires to 15 households selected through simple random sampling in Rupingazi river catchment in Embu County which was not to be included in the sample size since it had similar characteristics to those of Kapingazi River catchment. This assisted in the identification of issues in the data collection instruments and find possible solution to the problems that arose from the questionnaire.

3.8 Validity

To establish whether the research genuinely measured its intended objectives and reflected truthful results, validity testing was conducted to ensure credibility. It assessed whether the conclusions derived from the findings were accurate and relevant. This was done though re-checking each filled questionnaire just after the interview in order to correct any missing data or under response. The filled interview schedules and questionnaires were carefully checked to confirm correctness and consistency in the responses each day after data collection. This involved going through the entire filled schedules and if an error was found, it required verification from the respondents and the information was filled in the missing information. To test validity, triangulation using information from different sources such as key informants and focus group discussion was also used. It reduced bias and tested consistency of findings obtained through different instruments.

3.9 Contingent valuation method for eliciting willingness to pay for improved water service provision

This research defined a hypothetical market as improved water service provision, focusing on both water quality and supply. The benefits of water services and watershed management were clearly outlined for it to be realistic and plausible. A method of discrete choice was adopted to elicit willingness to pay (WTP), whereby respondents indicated amounts they were prepared to contribute. A dichotomous choice format was used, requiring a simple “yes” or “no” answer to predefined payment levels (Bishop & Heberlein, 1979). To analyze the socio-economic factors influencing WTP, the study applied a logistic regression model, a method widely used in environmental valuation research (Ahtiainen, 2007; Lindberg *et al*., 1997; Mehrara *et al*., 2009). This approach enabled examination of whether independent variables significantly affected respondents’ willingness to pay for enhanced water services.

$$WTPi = X\beta + e \quad \text{……………………………………………………………………………} \quad (10)$$

Simplified as $WTP = a + \beta í\ 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + e$

In this model, ßi represents parameters to be estimated (a vector of coefficients for the explanatory variables), *e* is the error vector that captures unobservable random factors, while *x* is the *i-th* explanatory variable, comprising of observed characteristics such as demand, socio-demographic attributes, attitudes, and behaviors.

Table 3.2

Summary of statistical data analysis

Specific Objectives	**Research Questions**	**Variables**		**Statistical Tools**
		Dependent	**Independent**	
1. To characterize the status of ecosystem services in Kapingazi catchment.	What is the status of ecosystem services in Kapingazi river catchment?	Water quality and Water quantity of River Kapingazi .	Ecosystem services in Kapingazi catchment	Descriptive statistics
2. To identify the catchment users of Kapingazi catchment.	-Who are the catchment users in Kapingazi catchment? -Are the catchment users aware of catchment management? -How are the catchment users organized in catchment management?	Role of catchment users. Management practices.	- Farmers -Resource users associations -Conservation agencies -HEP producers -Water companies	Descriptive statistics
3. To determine the perceived anthropogenic activities by the catchment users that are impacting on	-What are the catchment users doing and who is doing what in terms of catchment management practices that are	Water quality Water quantity	-Perceived catchment user anthropogenic activities -Changes on water quality	Logistic regression

water provision service in Kapingazi catchment.	impacting on water service provision in Kapingazi catchment?		-Changes in water quantity	
4. To establish the willingness to pay for improved water provision services by the catchment users in Kapingazi catchment.	-What is the willingness to pay for water provision service by catchment users in order to conserve Kapingazi catchment?	Improved water quality and water quantity	Willingness to pay	Logistic regression

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This section presents results and discussions of the study conducted in Kapingazi catchment, Embu County, Kenya. Both qualitative and quantitative data were gathered through questionnaires, while additional qualitative information was obtained using focus group discussions, key informant interviews and direct observations. The quantitative data from questionnaires was collected using open ended questions whose responses were analysed to show patterns and frequencies of answers in form of charts and tables. The key informant interviews and focus groups discussion provided qualitative data through taking notes, identifying key answers that capture the essential points, linking them to the research objectives. Triangulation by using the multiple data sources was used to confirm consistency of information given.

The findings from household questionnaires, focus group discussions and key informants are presented in this section. The organization of this chapter is highlighted below: social demographic data of the study population in section 4.2, which influences the willingness to pay for enhanced water quality and water quantity in Kapingazi catchment; section 4.3 which addresses the results and discussion for the first objective which is characterization of the status of ecosystem services in Kapingazi catchment; section 4.4 which addresses the results and discussion for the second objective which is identification of catchment users in Kapingazi catchment; section 4.5 which addresses the results and discussion of the third objective which is perceptions of human activities impacting on water provision service in Kapingazi catchment; section 4.6 which addresses the results and discussion for the fourth objective which is establishment of the willingness to pay for water provision services by the catchment users in Kapingazi catchment.

4.2 Socio-demographic information of the study population

The socio-demographic information showed the characteristics of the study population in Kapingazi catchment. These included the gender, main activity, education, type of wall building material, source of water, age, household size, income, land size, land tenure of the respondents, irrigation, food crops production and livestock production in Kapingazi catchment. These characteristics were significant in the study in examining the determinants affecting willingness to pay for enhanced water services in Kapingazi catchment.

4.2.1 Age and household size of the respondents in Kapingazi catchment

The survey targeted household heads or members aged 18 years and above. In Kapingazi catchment, the respondents' average age was 54.6 years, placing them within the economically productive population. According to Mwamnyange (2008), age influences maturity and decision-making capacity. Therefore, as most respondents were adults in their productive years, they were well positioned to make informed decisions regarding their willingness to pay (WTP) for improved water services, despite potential challenges. Results indicated that age significantly affected WTP for improved water provision in the catchment.

The mean household size in Kapingazi catchment was established to have 6 members. According to Moffat *et al.* (2011), the assumption is that larger households are less willing to pay for improved water services due to cost implications associated with water use implying larger household size consequentially results to high costs due to large quantities of water used. Water quantity in Kapingazi catchment being on the decline as shown in Figure 4.0, the household size may be willing to pay for improved water services in Kapingazi catchment to meet the needs of respondents' household. Also, the demand for large quantity of food to sustain the households would lead to demand for water supply for food production. Therefore, ensuring a reliable water supply was vital for enhancing agricultural production and meeting domestic needs in households within the Kapingazi catchment. Findings from the research also showed that household size played a significant role in influencing willingness to pay for improved water service provision.

4.2.2 Gender of the respondents

Interviews were conducted with respondents of both genders (male and female) to ensure a balanced perspectives representation. However, survey results indicated a higher number of female respondents (53%; n=53) than males (47%; n=47) as shown in Figure 4.1. This is because females were left at home to take care of the households as the males went out to work. Majority of the households were headed by men (62%; n=62) and the rest (38%; n=38) were headed by women, therefore men provided manual labour in conservation activities in Kapingazi catchment and influenced decision making on willingness to pay for improved water services and other conservation matters in their households. According to WBWDRT (1993), studies across different regions of the world have shown that gender significantly influences the willingness to pay for improved water services. Mezgebo and Ewnetu (2015), for example, found notable differences between households headed by male and female, with the latter showing greater willingness to pay, largely because women are primarily responsible for water collection and are more directly affected by challenges related to water. However, the willingness to pay was not influenced by gender in this study within the Kapingazi catchment. This was because 95% of respondents already had access to tap water, hence having time for other productive activities that otherwise would have increased willingness to pay if households had to spend significant time fetching water from the River Kapingazi.

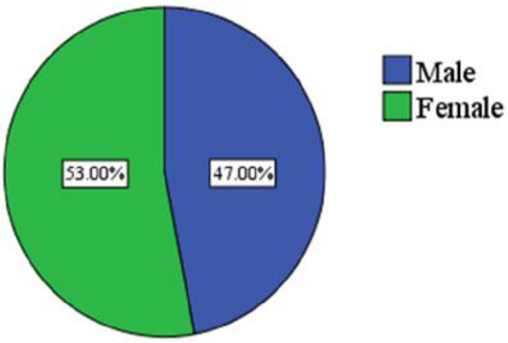

Figure 4.1: Gender of the respondents in Kapingazi catchment

4.2.3 Main activity of the respondents

Figure 4.2 reveals that the majority of respondents (79%; n=79) rely on agriculture as their primary livelihood. This can be partly as a result of the fertile soils of the study area, which favor farming, and partly to the prevalence of primary level education among respondents, which limits access to formal employment opportunities. This was followed by respondents who are self-employed (13%; n=13) who were mainly involved in small scale enterprises in villages, local shopping centres and Embu town which was the main urban centre in the catchment. The study also established that 6% (n=6) were formally employed in the public sector whereas (2%; n=2) were private sector employees. This can be linked to the college or tertiary education attained, which enhanced respondents' access to employment opportunities. However, since most respondents engaged in small-scale agricultural activities, their households had relatively low incomes, potentially limiting their willingness to pay for improved water services in the Kapingazi catchment. Moreover, reliance on agriculture could also influence this willingness, as farming directly depends on the natural environment for food production (Swai, 2016). For example, the use of Kapingazi River for irrigation highlights how improved water availability in the catchment supports higher food production. In this study, the main activity did not influence the willingness to pay for improved water services in Kapingazi catchment.

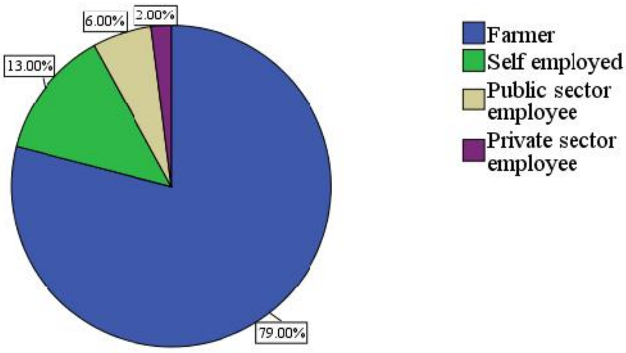

Figure 4.2: Main economic activities of the respondents in Kapingazi catchment

4.2.4 Education level of the respondents

Out of 100 respondents, 11% (n=11) were found to have no formal education. As shown in Figure 4.3, 49% (n=49) of respondents had attained primary education, 30% (n=30) secondary education, while only 10% (n=10) had college or tertiary qualifications. This demonstrates that the majority possessed at least a basic level of education, enabling them to appreciate the importance of conserving the Kapingazi catchment to secure advantages such as clean and reliable water supply. Therefore, their willingness to participate in payment schemes aimed to enhance ecosystem services may be influenced by understanding of catchment management and ecosystem services. Khan *et al.* (2010) also observed that education and awareness significantly shape respondents' willingness to pay (Figure 4.1). It was also found that, the male respondents had higher level of education than the females whereby more males had secondary (n = 17) and college education (n = 6), while more females had no formal education (n = 11) and primary education (n = 27) in Kapingazi catchment as shown in Table 4.1. Better educated respondents could influence the willingness to pay for improved water services than those with lower level of education because of better understanding on the importance of conservation of water resources (Kayaga *et al.*, 2003).

Table 4.1

Education level by gender

	Zero education	Primary education	Secondary education	Collage education	Tertiary education	Total (%)
Male	2	22	17	6	0	47
Female	9	27	13	4	0	53
Total (%)	**11**	**49**	**30**	**10**	**0**	**100**

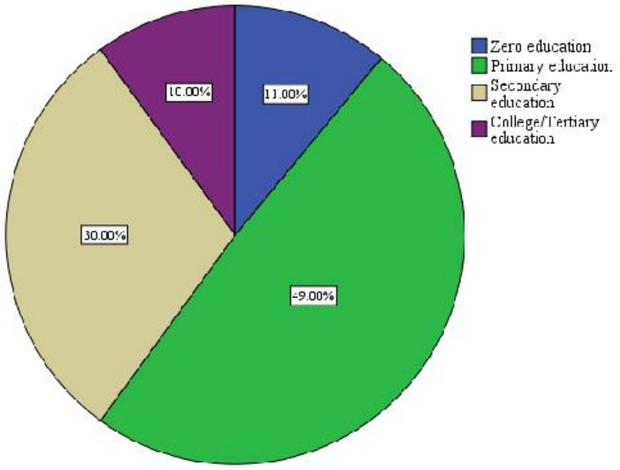

Figure 4.3: Education level of the respondents in Kapingazi catchment

4.2.5 Type of wall building material

Figure 4.4 indicate that most houses of the respondents in Kapingazi catchment were made of timber (59%; n=59), followed by stone walled houses (25%; n=25), brick walled houses which comprised of (12%; n=12), 3% (n=3) had mud walled houses, then only (1%; n=1) had iron sheet walled house (Plate 4.1).

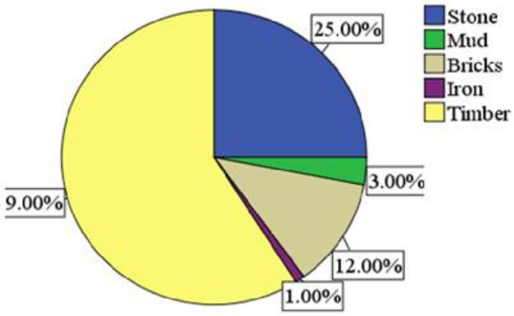

Figure 4.4: Types of walls for houses in Kapingazi catchment

Majority of the houses being constructed using timber, indicated that deforestation within the catchment was high to provide raw materials for construction of houses in Kapingazi catchment. Deforestation had an effect on water supply and water quality in Kapingazi catchment as shown in Plate 4.1.

Plate 4.1: Timber houses in Kiaragana and Miandari villages in Kapingazi catchment

4.2.6 Source of water of the respondents in Kapingazi catchment

As shown in Figure 4.5, most households in the Kapingazi catchment (95%; n=95) indicated using tap water as their main source, with 4% (n=4) relying on the river and only 1% depending on neighbors who had tap connections.

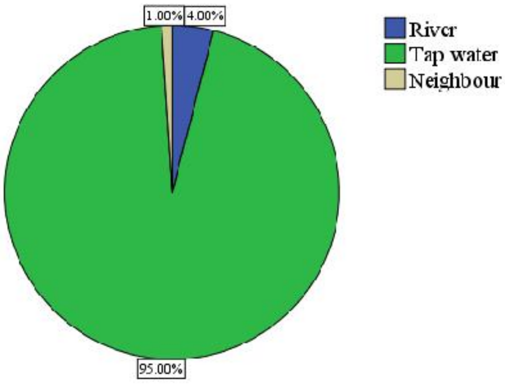

Figure 4.5: Sources of water in Kapingazi catchment

The results reveal that most respondents had access to tap water, with only a minority lacking the service. Thus, the majority in Kapingazi catchment did not depend on the river for domestic water needs and did not have to travel long distances to collect water. This situation may partly shape their willingness to pay for improved water services. Previous studies by Coster and Otufale (2014) and Mezgebo and Ewnetu (2015) demonstrated that households located far from sources of water tend to be more willing to pay for water service improvement compared to those living near the source. However, this study found that willingness to pay was not significantly influenced by the distance to the source of water source.

4.2.7 Income of the respondents in Kapingazi catchment

Income is a key determinant of willingness to pay for watershed services. According to Moffat *et al.* (2011), the demand for environmental goods typically increases with income while the economic theory indicates that higher income should positively influence the willingness to pay for improved water services. However, the findings from Kapingazi catchment, where the average annual household income was KES 146,782, show otherwise. The predominantly small-scale agricultural activities contributed to low income levels, which could explain limited financial capacity. The results indicate that income did not significantly affect willingness to pay. Instead, awareness of catchment conservation and concerns over declining water quality and quantity appeared to drive willingness to pay more than income levels.

4.2.8 Land size of respondents in Kapingazi catchment

The average land size in Kapingazi catchment was 2.3 acres as shown in Table 4.2. However, this size was below FAO's recommended land size of 3.6 acres to sufficiently sustain households for subsistence purposes. This indicates land scarcity as a result of fragmentation into uneconomical units due to high population densities (Amondo *et al.*, 2013). This indicates that most respondents practicing agriculture in the study area were small-scale farmers. While land size might influence their willingness to pay for improved water services in the Kapingazi catchment, as landowners could weigh trade-offs between supporting ecosystem services such as water provision and allocating land for food production. However, the study's results revealed that land size had no significant influence on willingness to pay for improved water services in Kapingazi catchment.

Table 4.2

Land size owned (Acres)

Statistic	Value
N (Valid)	100
Missing	0
Mean	2.35
Median	1.50
Mode	1.00
Standard Deviation	2.28
Variance	5.19
Range	14.75
Minimum	0.25
Maximum	15.00
Sum	234.83

Note. *N* represents the number of valid cases. The mean, median, and mode are presented with two decimal places, while the standard deviation is rounded to two decimal places.

4.2.9 Land tenure in Kapingazi catchment

Land tenure in Kapingazi catchment was freehold with (74%; n=74) of respondents owning the land with title deeds while (26%; n=26) of the respondents own the land without title deed as shown in Figure 4.6. The respondents who had no title deeds inherited the land from their parents therefore owning the land but without the title deed since the succession processes had not been completed in order to be issued with title deeds. Land tenure was important in assessing respondents' willingness to pay for enhanced services since the land owners can make decisions on land uses aimed to improve water service provision and ultimately conserve Kapingazi catchment. Most decisions on how the land would be utilized were made by both spouses (56%, n=56) while the rest of the households only one spouse (44%; n=44) could decide as shown in Figure 4.7 This indicated that most respondents in Kapingazi catchment could make decisions on how land would be utilized to secure improved water services in Kapingazi catchment.

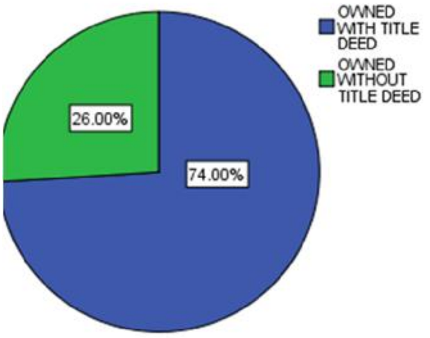

Figure 4.6: Land tenure in Kapingazi catchment

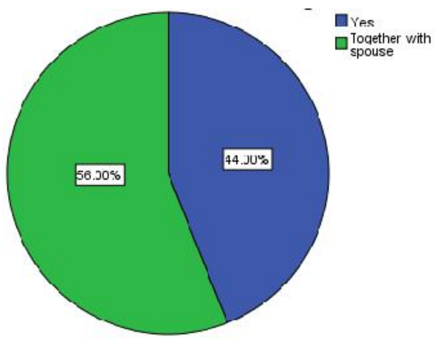

Figure 4.7: Decision making in households in Kapingazi catchment

4.2.10 Irrigation in Kapingazi catchment

The percentage of respondents that did not irrigate their farms using Kapingazi River was 86% while a small proportion of 14% of the respondents irrigated their crops as shown in Figure 4.8. This is due to water use regulations stipulated by the water resources authority through Kapingazi Water Resources Users Association who monitor water use in the catchment due to less water quantity in the river in order for downstream water users to get the water. This indicates majority of the respondents rely on rain-fed agriculture and the respondents who irrigated, did so to supplement rain fed agriculture's reduced harvests in the dry season, while ensuring a steady food supply for their households. Erratic rainfall, repeated dry spells, insufficient irrigation, and water-related conflicts heavily impacts agriculture (Mahoo *et al.*, 2007). This therefore threatens food availability in Kapingazi catchment. This indicates that there was water shortage in Kapingazi catchment and this determined by how the catchment was being managed.

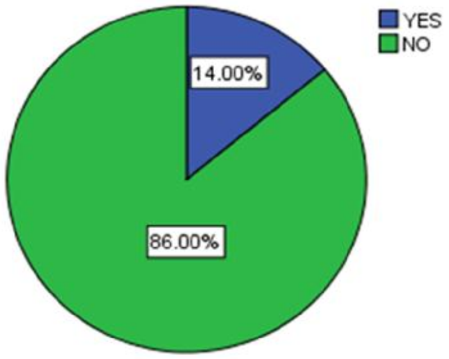

Figure 4.8: Respondents irrigating crops in Kapingazi catchment

4.2.11 Food production in Kapingazi catchment

All the respondents in Kapingazi catchment engaged in either crop or livestock production or both. Figure 4.9 shows the main crops produced in Kapingazi catchment.

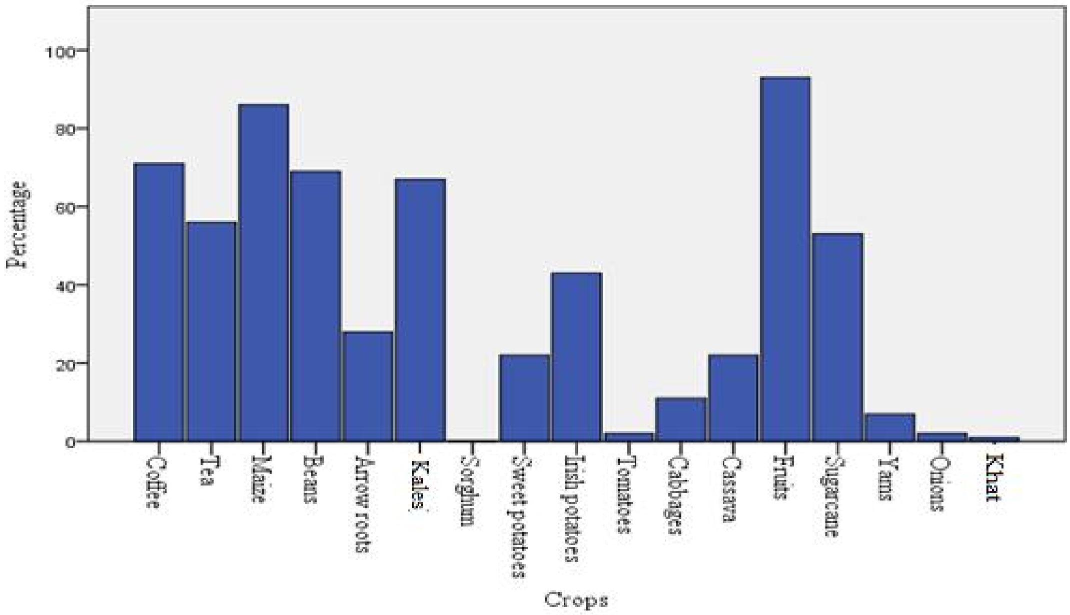

Figure 4.9: Crops planted in Kapingazi catchment

The crops produced in Kapingazi catchment were mainly for subsistence purposes though there were respondents who had both food and cash crops for income generation for their households. Tables 4.3 and 4.4 summarizes various types of crop productions in Kapingazi catchment.

Table 4.3

Cash crop production in Kapingazi catchment

Crop Type	**N**	**%**
Coffee	71	52.6
Tea	56	41.5
Vegetables	1	0.7
Irish potatoes	1	0.7
Fruits (avocados, mangoes, passion fruits, guavas, loquats)	4	3.0
Sugarcane	1	0.7
Khat (*Catha edulis*)	1	0.7
Total	**135**	**100.0**

Table 4.4

Food crop production in Kapingazi catchment

Crop Type	N	%
Maize	86	17.3
Beans	69	13.9
Arrowroots	28	5.6
Leaf vegetables	66	13.3
Sweet potatoes	22	4.4
Irish potatoes	42	8.4
Tomatoes	2	0.4
Cabbages	11	2.2
Cassava	22	4.4
Fruits (avocados, mangoes, passion fruits, guavas, loquats)	89	17.9
Sugarcane	52	10.4
Yams	7	1.4
Onions	2	0.4
Total	**498**	**100.0**

4.2.11.1 Cropping seasons

Kapingazi catchment experiences two cropping seasons; long and short rains due to the area's bimodal precipitation pattern. Each year, the long rains fall between April and August while the short rains occur between October and December. Permanent/perennial crops constituted 49.2% as they persist for many growing seasons. The percentage of crops that were planted during both long and short cropping seasons was 31.8% in order to have continuous supply of food all year round while 14% of the crops were planted during long rains and only 5% of crops were grown during short rains only. Figure 4.10 shows cropping seasons for various crops in Kapingazi catchment.

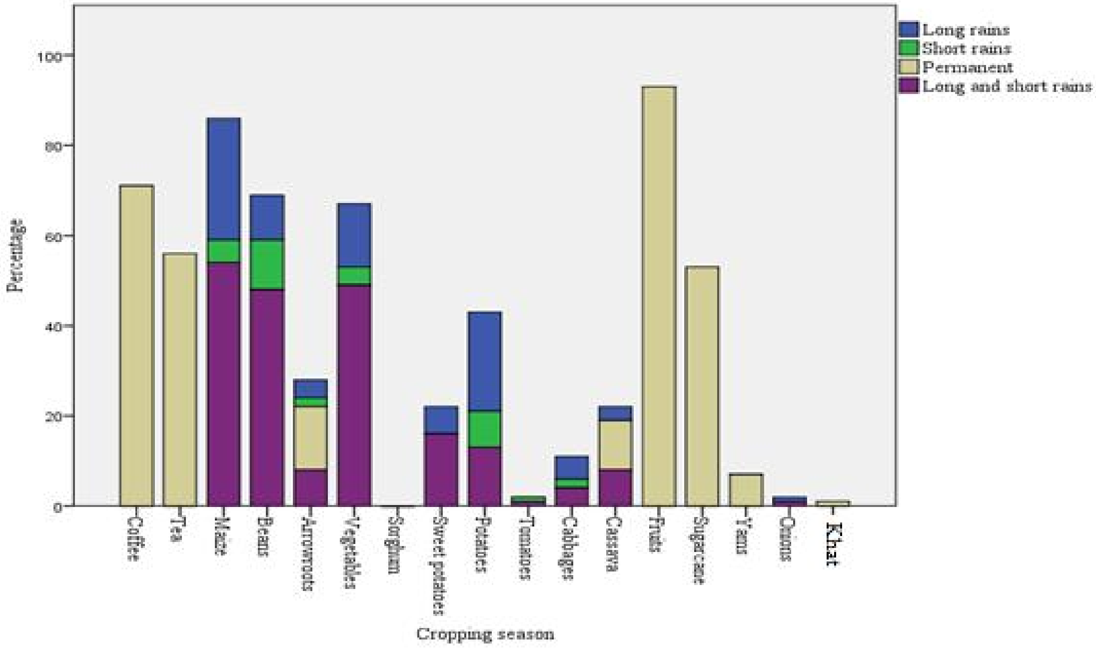

Figure 4.10: Cropping seasons for various crops in Kapingazi catchment

4.2.12: Livestock production in Kapingazi catchment

Livestock production was also practised in Kapingazi catchment whereby 86% of the respondents kept various types of livestock. The livestock kept in Kapingazi catchment was mainly for food and earn some income from livestock products such as milk, meat, eggs and organic manure. Figure 4.11 summarizes the percentage of respondents that kept each type of livestock in Kapingazi catchment.

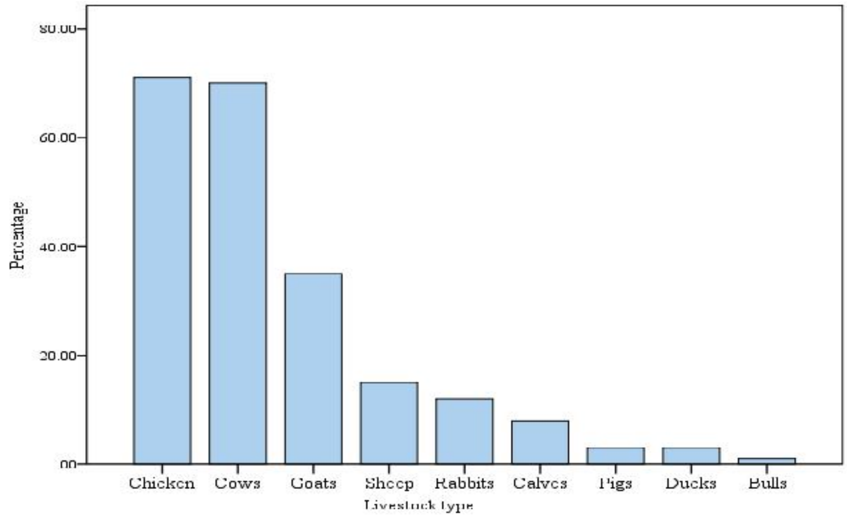

Figure 4.11: Livestock kept in Kapingazi catchment

The findings indicate that coffee and tea are the main cash crops cultivated in the Kapingazi catchment (Table 4.2), whereas the predominant food crops include maize, fruits, beans, and vegetables (Table 4.3). In terms of livestock, respondents mainly keep chickens, cattle, goats, and sheep, as illustrated in Figure 4.4. This therefore shows that the main farming system in Kapingazi catchment was mixed farming, where crop production was combined with keeping livestock. Dixon *et al.* (2001) identifies fifteen Sub-Sahara Africa's farming systems, with the maize mixed farming system being the most prominent in East and Southern Africa. This system primarily relies on maize, cattle, goats, and poultry for livelihoods. The central parts of Kenya where Kapingazi catchment lies are classified in the maize mixed farming so the results supports the report. The main reason why the respondents in Kapingazi catchment were adopting mixed farming system was to diversify agricultural activities for increased output value, increase their income sources in the midst of pressures like high population density and small land sizes where the average land size is 2.3 acres in Kapingazi catchment

4.3 Characterization of the status of ecosystem services in Kapingazi catchment

Kapingazi catchment is a complex system where living and non-living components interact to deliver ecosystem services. These services, which humans rely on, include provisioning, regulating, supporting, and cultural benefits. This study sought to identify the various ecosystem services provided in Kapingazi catchment and rank them according to importance in order to conserve them. This was significant in the study in order check the knowledge and preferences of ecosystem services to be conserved by the respondents of Kapingazi catchment.

The respondents were inquired about their understanding of a water catchment and its role in providing ecosystem services like water provision, carbon sequestration, food provision, climate regulation. Majority of the respondents (77%) had an understanding of a water catchment and the role it played in providing ecosystem services. Besides food production, water provision was the major ecosystem service provided in Kapingazi catchment as shown in Figure 4.12. This can be ascribed to the respondents' education levels, as the majority had completed primary education, which provided them with knowledge of water catchments and their function in delivering ecosystem services within the Kapingazi catchment. These results are in line with those of Mshigwa (2014) in Bagamoyo District, where approximately 98% of respondents had a high level of awareness of the Wami Basin as a catchment. Swai (2016) also reported that 76.8% of domestic water users were aware of the functions of water catchments in providing ecosystem services in Babati District, Tanzania. The Figure 4.12 shows ecosystem services provided in Kapingazi catchment.

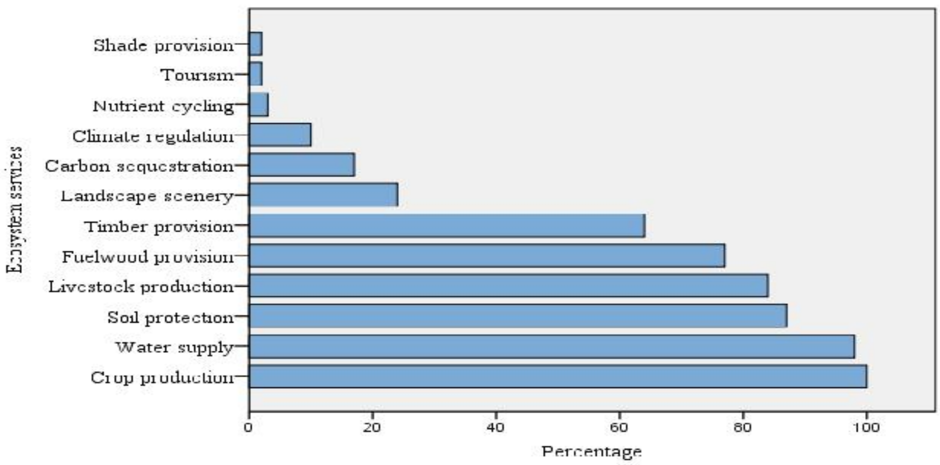

Figure 4.12: Ecosystem services in Kapingazi catchment

From the results, the respondents identified crop production (100%), water provision (98%), soil protection (87%), livestock production (84%), fuel wood provision (77%) and timber provision (64%) as the major ecosystem services provided in Kapingazi catchment as shown in the Figure 4.5. Other ecosystem services identified by the respondents were landscape scenery

(24%), carbon sequestration (17%), climate regulation (10%), nutrient cycling (3%), tourism (2%) and shade provision (2%). These results showed that most respondents were more aware of the provisioning ecosystem services more than the regulating, cultural and supporting ecosystem services which shows varied knowledge of ecosystem services in Kapingazi catchment. This shows reliance by the respondents on provisioning ecosystem services from the immediate environment for their food, water, livestock production, raw materials and source of energy.

In many developing African nations, people's reliance on provisioning ecosystem services is particularly high due to widespread poverty and dependence on natural resources. The degree of reliance varies according to local factors such as climate, vegetation, and socio-economic changes (Eboh *et al.,* 2012). A study conducted in Northern Ghana indicated that the high level of direct use of provisioning ecosystem services are attributed to high level of poverty and food insecurity (Boafo *et al.,* 2014). Kapingazi catchment, largely being a rural landscape, majority of the respondents were farmers with a high percentage using timber for construction of their houses as well as use fuel wood as their main source of energy. This shows that food, water, livestock production, fuel wood, raw materials coupled with other agricultural activities like soil protection, are the most important ecosystem services, which require to be sustainably supplied since they are highly crucial to the livelihood sustenance of the respondents of Kapingazi catchment.

Respondents' recognition of additional ecosystem services may reflect the dependence of provisioning services, like food crop production, on regulating and supporting services such as soil protection, climate regulation, and nutrient cycling. Disruptions in any of these services can influence livelihoods, demonstrating the centrality, interconnection, interdependence, and both tangible and intangible value of ecosystem services to human welfare (TEEB, 2010). This also reveals that there is information gap for the least mentioned ecosystem services and those that are not mentioned at all like genetic resources, pollination, sense of place, educational experiences, soil formation and productivity.

4.3.1 Ranking of ecosystem services in Kapingazi catchment

Various studies have employed ranking approaches to assess ecosystem services. These approaches are components of broader assessment processes that both identify ecosystem services and prioritize the most significant ones (Lopez-Marrero and Hermansen-Baez, 2011). Participants were additionally requested to rank the ecosystem services according to their perceived importance

(5=Very important 1= Least important) based on their own experiences, perception and preference which is shown in Table 4.5.

Table 4.5

Ranking of ecosystem services by importance in Kapingazi catchment

Ecosystem services	Very important %)	More (inimportant (in %)	Important (in %)	Slightly important (in %)	Least important (in %)
Water provision	100	0	0	0	0
Food crop production	95	2	2	1	0
Timber provision	82	2	1	3	2
Carbon sequestration	92	4	3	1	0
Air purification	95	3	2	0	0
Aesthetic value	84	6	6	3	1
Soil erosion control	93	2	5	0	0
Climate regulation	93	4	1	2	0
Nutrient cycling	91	5	4	0	0
Fuel wood provision	92	4	1	1	2
Fibre	58	1	5	12	24
Genetic resources	80	10	2	2	6
Diseases regulation	96	0	4	0	0
Pollination	92	3	3	2	0
Water regulation	97	2	0	1	0
Sense of place	98	1	0	1	0
Educational	86	8	2	2	2
Soil formation	92	3	4	0	1
Primary production*	93	6	1	0	0

Note ** Primary production refers to the process in which chemical energy is produced from solar energy, mainly by terrestrial green plants, supplying the energy that sustains earth's ecosystems (Knapp et al., 2014).*

The majority of respondents considered numerous ecosystem services provided by the Kapingazi catchment such as water provision, water regulation, air purification, food and timber production, and landscape aesthetics as highly important. Among these, water was unanimously ranked by 100% of respondents as the most critical ecosystem service. This was followed by food production at 95% due to agricultural productivity of the catchment. According to 92% of the respondents, fuel wood was the third most important ecosystem service since it's the main source of energy within the catchment. Timber, genetic resources and fibre follow in that order in level of importance with 82%. 80% and 58% of the respondents respectively in the provisioning services category. Other categories such as regulating, supporting and cultural services were also perceived as very important after explaining what they were. This implied that the catchment had water shortage hence the preference of water ecosystem service showed the need to conserve Kapingazi catchment in order to improve its provision since it was required for food production through irrigation and for domestic use in households in Kapingazi catchment.

A similar study conducted in El Yunque indicated that all stakeholders recognized multiple ecosystem services such as habitat provision, clean water, air purification, recreational opportunities, and scenic landscapes with water being rated as the most essential service (Lopez-Marrero & Hermansen-Baez, 2011). Also, Ericsen *et al.* (2012) reported comparable results when assessing and ranking ecosystem services in Northern Kenya's Ewaso Ng'iro catchment.

4.4 Identification of catchment users, management practices, organization, functions and challenges in Kapingazi catchment

4.4.1: Identification of catchment users in Kapingazi catchment

Effective conservation and sustainable management of the Kapingazi catchment require the identification of all catchment users, which is critical for ensuring inclusive participation in decision-making, especially among marginalized groups. This participatory approach fosters collaborative solutions, enhances equitable water distribution, and improves both water quality and quantity in the catchment.

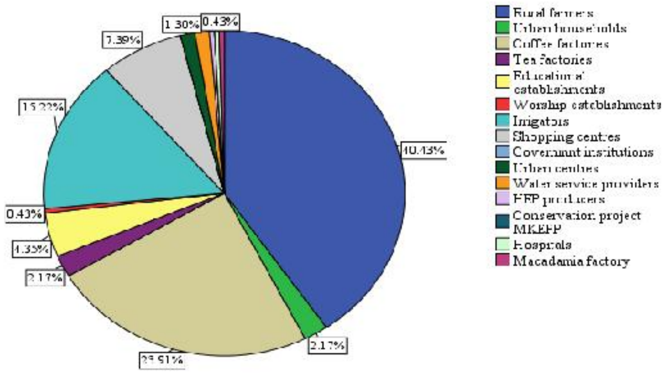

Figure 4.13: Catchment users in Kapingazi catchment

Figure 4.13 illustrates the various users of the Kapingazi catchment, with rural farmers comprising the largest group at 40.4%. During dry seasons, these farmers relied significantly on the the catchment as their main source of domestic water and irrigation. Their water use can reduce downstream flows, making them central stakeholders in water regulation and conservation efforts led by entities like the Kapingazi Water Resource Users Association (KaWRUA).

The second and third most significant users are coffee factories (23.9%) and irrigators (15.2%). Coffee factories required large volumes of water for processing and often contributed to water pollution through effluent discharge into oxidation ponds, which may overflow and leach into Kapingazi River during rainy seasons. Irrigators abstract water from rivers to support crop cultivation but can negatively impact water quality through agrochemicals that seep into the river.

Other users included shopping centres (7.39%), which contributed to runoff entering the river, affecting water quality, schools (4.35%), tea factories (2.17%), urban centres (1.3%), water service providers (1.3%), worship establishments (0.43%), hospitals (0.43%), and a macadamia factory (0.43%), all of which depended on the catchment for water but also exert varying degrees of pressure on its resources.

These diverse users highlight the multiple demands placed on Kapingazi River and the need for coordinated management. Their activities directly influence the availability and cleanliness of water, reinforcing the significance of engaging them during planning and implementation of conservation strategies.

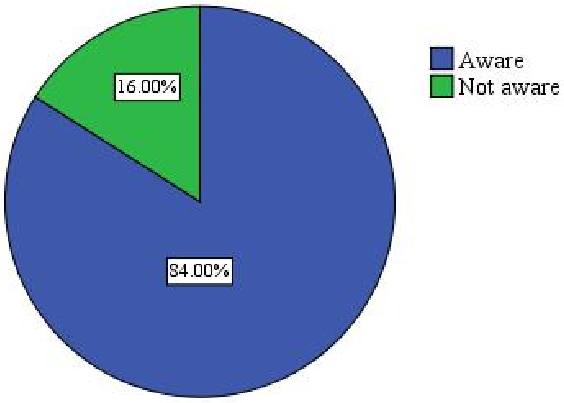

Figure 4.14: Respondents awareness on catchment management

As shown in Figure 4.14, 84% of respondents were aware of catchment management, demonstrating a high comprehension of the importance of protecting water resources and related ecosystem services. This awareness is essential for fostering stakeholder engagement and promoting sustainable practices. Thus, identifying catchment users allows for monitoring and regulating water use, conflict reduction among users, inclusion of all stakeholders in conservation decisions and targeted interventions based on user impact and needs.

This inclusive approach aligns with findings from Mukeria *et al.* (2021), who highlighted the importance of identifying stakeholder groups to successfully implement catchment restoration programs, such as in the Hawassa catchment in Ethiopia. Similarly, Kapingazi catchment can benefit from broad stakeholder participation to ensure sustainable water management and resource conservation.

4.4.1.1 Importance of conserving and managing Kapingazi catchment

The importance of conserving and managing the Kapingazi catchment was strongly recognized by the community, with 99% of respondents affirming its necessity. As illustrated in Figure 4.15, the reasons cited reflect the community's high reliance on the catchment for essential ecosystem services associated with land productivity and water provision.

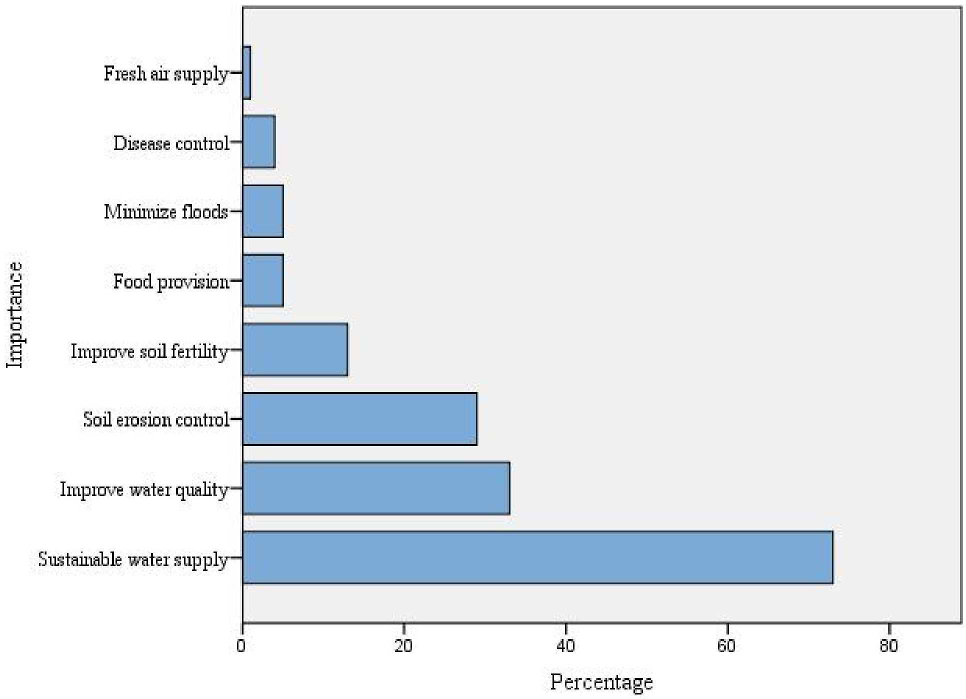

Figure 4.15: Importance of conserving and managing Kapingazi catchment

The respondents highlighted multiple reasons for catchment conservation, with the majority (73%) citing the necessity of ensuring consistent and sustainable water supply. The high percentage reflects the severity of water scarcity in the region and stresses the urgent need for conservation measures to maintain a reliable water supply for domestic, agricultural, and industrial purposes. Another key reason identified by 33% of the respondents was the need to improve water quality. This concern stems from the increasing decline in water quality resulting from contamination caused by agricultural runoff, factory effluents, and sedimentation from soil erosion. These issues emphasize the need of integrated catchment management practices that seek to safeguard and improve water quality to promote public health and support environmental sustainability.

Soil erosion control was also a major concern, with 29% of respondents recognizing the role of conservation in preventing the loss of topsoil. Erosion has become a significant problem in the catchment, largely due to insufficient measures for soil and water conservation. When fertile topsoil is removed, agricultural productivity declines while river sedimentation rises, negatively impacting water quality and aquatic ecosystems. Improving soil fertility was another important reason, cited by 13% of the respondents. Declining soil fertility is likely a result of overcultivation and the erosion of nutrient-rich topsoil, which has led to reduced crop yields and increased food insecurity. Conservation and improved land management practices are therefore essential to restore soil health and boost agricultural productivity.

Food provision was mentioned by 5% of the respondents, emphasizing the link between a healthy catchment and reliable food production. Well-conserved catchments provide the water and fertile soil necessary for successful farming, which serves as the main source of income for various households in the region. Another 5% pointed to flood minimization as a benefit of catchment management. During the wet season, wetlands and low-lying areas often experience flooding, particularly where unsustainable land use practices, such as dry-season cultivation, are common. Effective catchment management can help regulate surface runoff and reduce the frequency and severity of floods.

Disease control was identified by 4% of respondents, reflecting the connection between water quality and public health. When water sources are contaminated, the risk of waterborne diseases increases, making clean water a top health concern in the catchment. Conservation activities that protect and improve water quality are therefore important for preventing illness and promoting community well-being. Only a small number of respondents (1%) also mentioned clean air as a benefit of conservation. Trees and plants in the catchment help filter the air and support the ecosystem, though this advantage is less visible than water and soil benefits.

The responses demonstrate a strong community awareness of the various benefits of conserving and managing the Kapingazi catchment. From water security and soil health to food production and disease prevention, the catchment plays an important function in supporting livelihoods and environmental health. These results suggest that conservation initiatives in

Kapingazi should be community-driven and aligned with the locally recognized needs to ensure long-term sustainability and effective stakeholder engagement.

4.4.1.2 Water quantity trend between 2008 and 2018 of River Kapingazi

The need to conserve and manage the Kapingazi catchment was strongly attributed to declining trends in water quantity in River Kapingazi over the ten-year period between 2008 and 2018. This was acknowledged by 79% of the respondents in the catchment area. This observation is presented in Figure 4.16, which illustrates the water quantity trend as perceived by the respondents over the ten-year period.

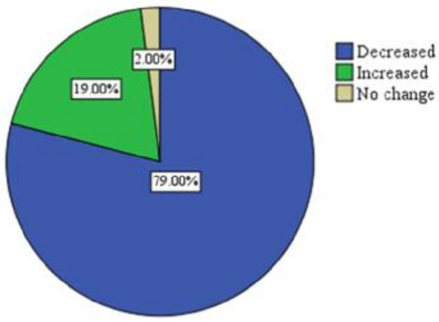

Figure 4.16: Water quantity trend for the last ten years in Kapingazi catchment

Further corroboration came from focus group discussions with local institutions such as the Kapingazi Water Resource Users Association (KaWRUA), the Focal Development Area Committee (FDAC), and the Irangi Community Forest Association (Irangi CFA), who unanimously reported that both the amount and condition of river water have been worsening with time. In line with this, Kariithi (2016) classifies the Kapingazi catchment as being in an “Alert” state, attributing it to declining trends in surface water availability and quality. To gain insight into the drivers of reduced water quantity, Table 4.6 provides an overview of the main causes as identified by respondents.

Table 4.6

Reasons for water quantity declining trend in Kapingazi catchment

Reasons for water quantity decrease	**N**	**%**
Water abstraction	32	31.4%
Poor water management	4	3.9%
Increased number of water users	13	12.7%
Deforestation	30	29.4%
Drought	19	18.6%
Cultivation at the riparian area	4	3.9%
Total	**102**	**100.0%**

Water abstraction was the major reason for water quantity declining trend in Kapingazi catchment as alluded by 31.4% of the respondents. Water abstaction was caused by coffee factories, institutions, community water project like Kamiu Kavanga irrigation project, licensed individuals and illegal abstractors who had reduced the amount of water in Kapingazi river. This was also observed by KenGen, EWASCO and WRA during key informant meetings which disclosed that there was a lot of water abstraction upstream for irrigation purposes and industrial use by coffee factories leading to reduction of water quantity in Kapingazi catchment. Abstracted water for irrigation purposes was for food production especially during dry seasons in order to have all year round of agricultural produce both for subsistence and for sale, which otherwise would have led to food shortage. Also, abstracted water used by coffee factories, households or for agriculture, the resulting waste water caused pollution through chemical discharges, sewage, nutrient and pesticide runoff from farm land affecting the water quality of Kapingazi river. Reduced water quantity affects energy production downstream, thus affecting energy costs which is cascaded to the user to meet the cost of other energy sources such as fossil fuels to produce electricity.

Deforestation was another major cause for water quantity decline for the last ten years within the catchment as noted by 29.4% of the respondent which had further worsened the situation since it has affected the water cycle therefore affecting the water quantity within the Kapingazi catchment. The principal pressures on trees in Kapingazi catchment were increased demand for charcoal and firewood, which served as the main sources of energy for households and tea factories and rising demand for wood-based products, such as timber for construction purposes and selling to local artisans. This has effect on biodiversity from mammals to bird, insects, amphibians, thus endangering the whole ecosystem creating natural imbalances and putting life at threat. Deforestation causes soil erosion which causes sedimentation in rivers therefore affecting its water quantity. This also leads to infertile soils since most of the top fertile soils are normally washed away leading to low food production and ultimately hunger. Deforestation also makes the soil fragile leaving the area vulnerable to floods and landslides. Deforestation contributes to climate change since it affects capture and storage of carbon dioxide, therefore negatively contributing to the greenhouse effect.

The catchment experiences drought from time to time causing decline in water quantity in Kapingazi river due to lack of rainfall as highlighted by 18.6% of the respondents. Due to climate change, the catchment has increasingly experienced periods of drought, whereby there had been erratic change in rainfall patterns within the catchment which had become unpredictable. Since there is no guarantee of access to a sustainable water source, drought threatens food security in the catchment. This leads to migration and even conflicts among water users. Inadequate management of drought and water resources also puts the entire aquatic ecosystem under greater stress.

The respondents (12.7%) also disclosed that increased number of water users had contributed to decline in water quantity in the catchment. This was due to population growth, new water connections to address the needs of an increasing population since the old water infrastructure installed in the late 1970s was unable to satisfy the demands of the people thus reducing water quantity. This led to competition for water resources within the catchment among different catchment users like farmers, coffee factories and irrigation water supply projects and caused conflicts among water users especially during dry season when the water quantity was less.

Cultivation at the riparian reserve was cited by a few respondents (3.9%) as cause for water quantity decrease and by 1% for water quality decrease although about 94% of the respondents interviewed had a riparian area in their farms. This could have been attributed to a larger area of the riparian area was under trees (35%), 30% was under fodder and 2% was covered by bush which were important in slowing down water flow and minimize soil erosion and flood damage in the event of heavy downpour. Table 4.7 presents the distribution patterns of vegetation types across riparian areas.

Table 4.7

Vegetation types at the riparian area in Kapingazi catchment

Plant	Frequency	%
Food crops	21	21.0
Cash crops	3	3.0
Fodder	30	30.0
Trees	35	35.0
Bush	2	2.0
No vegetation	3	3.0
Not Applicable	6	6.0
Total	**100**	**100.0**

This could be as a result of conservation efforts in Kapingazi catchment by Ministry of water and irrigation project that is Mount Kenya East Pilot Project and The Upper Tana Natural Resource Management Project (UTaNRMP). However, EWASCO was of the view that encroachment of the riparian area should be stopped in order to increase water supply. Poor management was cited by 3.9% as cause for water quantity decline in Kapingazi catchment for the past ten years. This requires monitoring and enforcement of water regulations to prevent unlicensed water abstraction, monitor water quantity usage by licenced individuals and institutions for water abstraction, deforestation, riparian cultivation through enhanced management through implementation of catchment management plans.

This was triangulated through key informant discussions for example, EWASCO mentioned that, although their water supply is adequate from River Rupingazi but due to increased demand, water supply may not be adequate in the future. On the other hand, KenGen was affirmative that water supply was not sufficient to fulfill their demand. There was also indication by some farmers that the water connection infrastructure installed in the late 1970s, had not been expanded to accommodate the increasing population. This had led to enforcement of water regulation on catchment users with regards to water use for both tap water and water from Kapingazi River. For example, using tap water for irrigation was prohibited in order to ensure continuous water supply to connected residents of Kapingazi catchment. Irrigation using water from Kapingazi River without a permit authorized by KaWRUA was also not allowed to ensure water flows downstream. This explains why, during the dry season, only 2.3% of respondents irrigate crops using water from the Kapingazi River. This might be due to monitoring of the amount of water in the river by having controlling and measuring devices in the river for measuring the volume of water abstracted from the river by Kapingazi Water Resource Users Association (KaWRUA). Also by managing rationing programmes when the flows were low. This shows water quantity had declined for the last ten years in Kapingazi catchment.

However, 21% and 3% of the respondents' riparian area was under food and cash crops production respectively as shown in Table 4.7 above while 3% of the respondents agreed that the riparian area on their land had no vegetation. Additionally, the respondents (17%) recognized the riparian area as one of the areas experiencing the highest level of soil erosion occurring on their farms, as indicated in Figure 4.17.

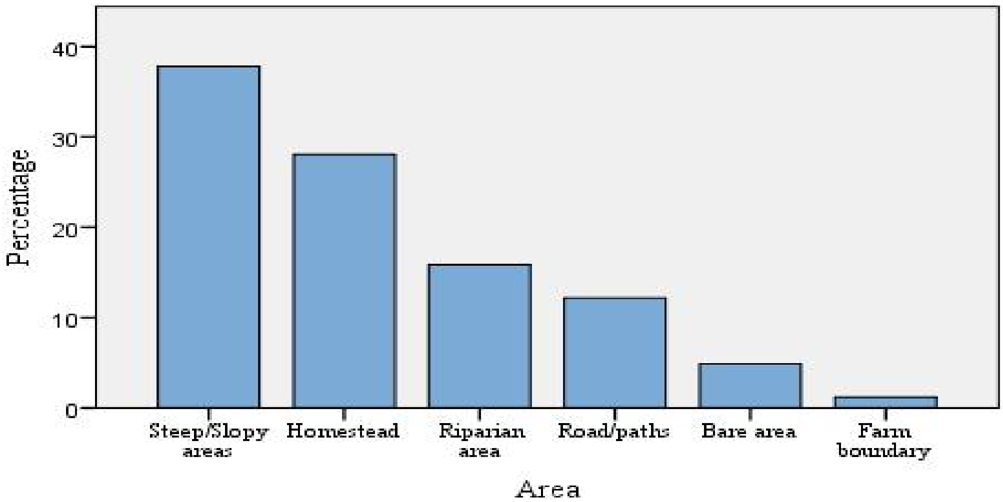

Figure 4.17: Areas of farms experiencing most soil erosion in Kapingazi catchment

The quantity of water in the Kapingazi catchment has significantly decreased during the past ten years due to both natural and man-made influences such as abstraction of water, deforestation, drought, population pressure, and riparian encroachment. The findings emphasize the need for catchment management practices, community engagement and regulatory enforcement to ensure sustainable water availability and improved ecosystem health in Kapingazi catchment.

4.4.1.3 Water quality trend between 2008 and 2018 of River Kapingazi

The water quality of River Kapingazi experienced a marked decline between 2008 and 2018, a trend recognized and highlighted by a majority of stakeholders in the catchment area. As illustrated in Figure 4.18, 79% of the respondents observed a negative trend in water quality over the decade, attributing this to both anthropogenic and natural factors.

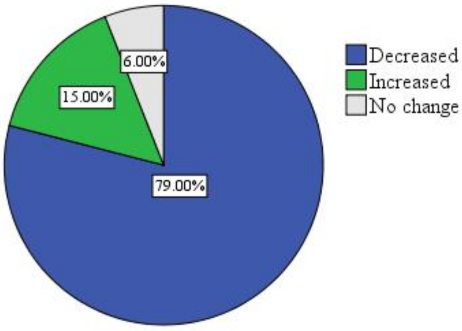

Figure 4.18: Water quality trend for the last ten years in Kapingazi catchment

Deterioration in water quality in Kapingazi River from 2008 to 2018 was mainly affected by surface runoff, according to 27% of the respondents. Surface runoff from shopping centres, homesteads, roads, farms and farm boundaries collect into the river causing pollution of river Kapingazi. The surface run off carries pollutants such as sediments, oil, grease, toxic chemicals from vehicles, agricultural pesticides and fertilizers, heavy metals, and thermal pollution from heat-absorbing surfaces such as tarmac roads directly into river Kapingazi seriously affecting water quality of the river. These pollutants destroy aquatic habitat, threatens fish and wildlife populations, destroys native vegetation, and contaminates drinking water sources as well as making recreational areas unsafe and unpleasant. To decrease surface runoff from farms, use of integrated pest management, compost manure should be encouraged to reduce dependence on harmful pesticides. Designated carwash facilities that do not generate surface runoff should be established to avoid impacts from car wash such as grease, oil, detergents and grime.
Conservation practices for soil and water, including mulching, terracing, and the use of grass strips should be promoted to reduce runoff speed and erosional power but infiltrate into the ground. Lack of adequate practices for conserving soil and water and intensive cultivation were also pointed out

by 24.6% and 23% of the respondents respectively as causes for water quality decrease in Kapingazi catchment as shown in Table 4.8**.**

Table 4.8

Reasons for water quality declining trend in Kapingazi catchment

Reasons for water quality decrease	**N**	**%**
Very steep slopes	4	3.2%
Intensive cultivation	29	23.0%
Lack of soil and water conservation measures	31	24.6%
Pollution	16	12.7%
Deforestation	10	7.9%
Run off	34	27.0%
Quarrying/Mining	1	0.8%
Cultivation at the riparian area	1	0.8%
Total	**126**	**100.0%**

Lack of strategies to conserve soil and water such as terracing, grass strips, contour farming, crop rotation, reforestation/afforestation and intensive cultivation leads to land degradation which can either be natural or human induced. This leads to accumulation of organic matter and silt from the surrounding farms in to the river contributing to water pollution and reduced water levels as a result of soil erosion. Waterborne diseases are likely to occur due to agricultural pollution associated with the unsustainable farming practices in Kapingazi catchment. Also these can have adverse effect on food production leading to increased use of farm input by the farmers in the attempt to combat reduced yields particularly fertilizers which affect water quality when washed off into river Kapingazi. The respondents (12.7%) cited that pollution affected the water quality of River Kapingazi. This could be from agricultural inputs such as pesticides and fertilizers, surface run off, industrial effluent from coffee and tea factories and, untreated waste from sewerage from shopping and urban centres within Kapingazi catchment.

Water pollution can become toxic to both humans and to the environment. This causes adverse effect on aquatic life such as fish killed by the pollutants. Pollutants such as lead and cadmium are consumed by small fish therefore affecting higher levels of the food chain through biomagnification. Eventually, humans are affected by these food when they consume fish that is contaminated. Ground water can be affected by pesticides through leachate and excess use of fertilizers causes nitrate contamination of ground water when above the recommended levels. Sewage carries microbial pathogens that cause diseases to humans while domestic waste water, agricultural runoff increase nutrients in the river causing eutrophication. Sustainable agricultural practices and better catchment management can help reduce pollution of water in Kapingazi river.

Deforestation was another reason for water quality decrease for the last ten years in river Kapingazi which was observed by 7.9% of the respondents. Unsustainable vegetation clearing and deforestation within the Kapingazi catchment has led to reduced water levels and quality of river Kapingazi affecting downstream water users such as hydroelectric power stations due to siltation as was noted by KenGen. Loss of vegetation cover results to the reduction of rainfall infiltration into the soil leading to greater runoff, which intensifies soil erosion and raises both sediment load and turbidity in water sources, ultimately lowering the quality of water in the Kapingazi River. This therefore affects humans' access to clean water predisposing them to diseases. Other reasons for decrease in water quality were presence of very steep slopes as highlighted by 3.2 % of the respondents which accelerates runoff into the river as well as quarrying and cultivation at the riparian area as observed by 1% of the respondents respectively.

This point was reinforced by EWASCO and further supported during the focus group discussion, which indicated that lack of conservation of water catchments contributed to deterioration of water quality. Surface run off was a major challenge affecting water quality in Kapingazi catchment due to slope gradient in the catchment. The catchment was characterized by gradual to steep slopes which facilitated surface run off collection leading to soil erosion during rainy seasons. Figure 4.19 shows that 70% of the respondents experienced soil erosion on their farms.

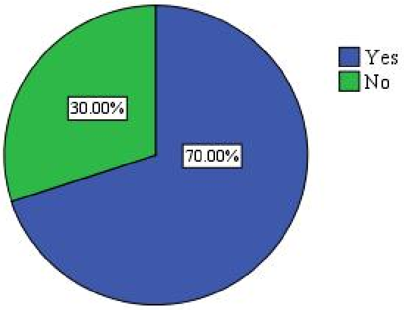

Figure 4.19: Respondents experiencing soil erosion in Kapingazi catchment

This indicates that soil and water conservation measures in Kapingazi catchment was minimal and requires to be implemented by the farmers. Soil erosion is strongly linked with clearance of natural vegetation to allow land to be used for arable farming. This implies that there was loss of top soil, a valuable natural resource which results in habitat destruction, declining water quality in the Kapingazi River, wetland siltation, and disruption of natural drainage systems. and intensification of flooding in Kapingazi catchment as shown in Plate 4.2. Also, agricultural production would be on the decline since the top fertile soil is eroded requiring more farm inputs to improve production for the respondents' sustenance. Soil and water conservation measures implementation should be considered in the sub-catchment management plans of Kapingazi catchment.

Plate 4.2: Flooding of River Kapingazi in Kivumburi village

According to a 2011 physiographic survey of the Upper Tana catchment, the area was found to contribute 36% of the total sediment inflow into the downstream Masinga reservoir (Hunink & Droogers, 2015). This was observed especially on unpaved roads and gullies in some farms as shown in Plates 4.3 and 4.4.

Plate 4.3: A deep gulley in a farm in Kanyakiri village in Kapingazi catchment

Plate 4.4: Run off on unpaved road in Kiaragana village in Kapingazi catchment

Intensive cultivation within the catchment for continuous supply of food leads to loss of loose top soil by water therefore increasing the surface run off and sediments from surface erosion during rainy season. Rainy seasons significantly increase suspended sediment concentrations in waterways. With yields up to ten times higher in agricultural catchments than in forested ones, studies show that 60–96% of these sediments originate from surface sources (Allan *et al.*, 1997; Walling, 2005). Cultivated land often experiences higher erosion rates, which result in excessive fine sediment deposits in rivers and consequently lower water quality. This could be attributed to inadequate conservation agriculture practice in Kapingazi catchment since it was practiced by 16.4% of the respondents as shown in Figure 4.20.

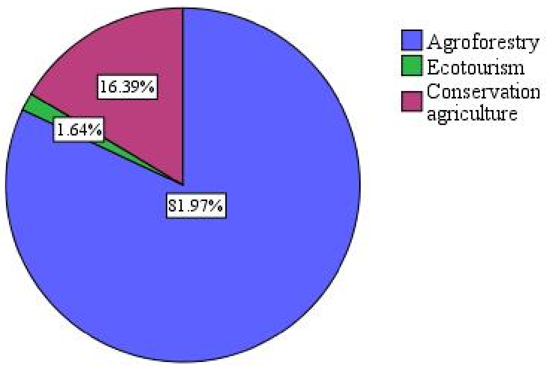

Figure 4.20: Conservation practices in Kapingazi catchment

Steep/slopy areas experienced most soil erosion in Kapingazi catchment as identified by 37.8% of the respondents as shown in Table 4.9. The steep slopes surrounding River Kapingazi accelerate bank erosion, leading to significant siltation, pollution, and overall deterioration of water quality. On such slopes, the use of residue cover crops is often impractical, as these materials are easily washed downhill, further polluting the river. Consequently, cultivation on steep terrain within the catchment has negatively affected water quality due to insufficient or absent soil and water conservation measures. This has intensified soil erosion, reduced soil productivity, and emerged as a key land degradation threat, as acknowledged by 89.6% of respondents in the Kapingazi catchment. Erosion remains a main driver of land degradation, frequently stripping away fertile topsoil.(Jara-Rojas *et al.*, 2013).

Soil productivity loss was due to unsustainable agricultural practices. The soil experienced a decline in organic matter, reduced biodiversity, compaction, both point-source and diffuse contamination, along with pollution leading to soil fertility loss due to acidification or nutrient deficiency. Nutrient deficiency was caused by over cultivation or failure to replace nutrients or removal through harvest of nitrogen fixing legumes or fertilizers. This means that the livelihood of the respondents was threatened in regards to food security and household income as shown in Figure 4.21.

Table 4.9

Areas of the farms experiencing most soil erosion in Kapingazi catchment

Area	N	Percent
Bare area	4	4.9%
Riparian area	13	15.9%
Homestead	23	28.0%
Road/paths	10	12.2%
Steep /slopy area	31	37.8%
Farm boundary	1	1.2%
Total	**82**	**100.0%**

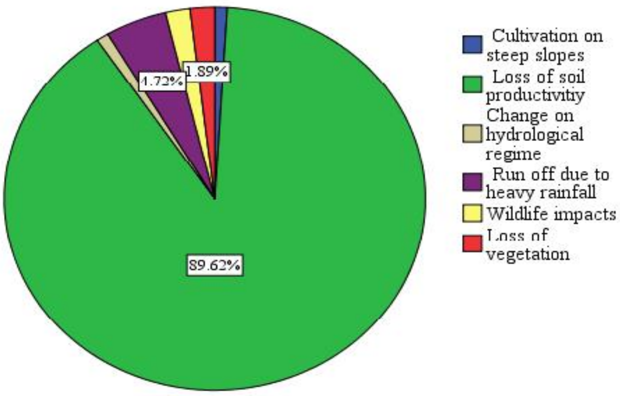

Figure 4.21: Land degradation in Kapingazi catchment

Besides loss of soil productivity, runoff contributed to reduction of water quality because it collects soil sediments and water pollutants such as agrochemicals from the farms, petrochemicals and solid waste from shopping and urban centres such as Embu town which was observed by 12.7% of the respondents as it collected into the river.

Over the past decade, water quality and quantity in the Kapingazi River have declined, largely due to cumulative human activities along the riparian zone and within the catchment. Similar trends have been documented in studies examining the effect of land use on rivers across Kenya. For instance, Masese *et al.* (2009) reported that turbidity levels rise downstream, mainly due to agricultural practices and soil erosion from unpaved roads. Other investigations in the Kapingazi River confirm that the deterioration of water quality is closely linked to intensified farming and deforestation, a finding also supported by local respondents as well as by KenGen and EWASCO.

4.4.2 Catchment management practices

Catchment management involves implementing sustainable land and water use practices to prevent negative environmental impacts especially concerning water quality and quantity. The Kapingazi catchment community adopted various soil and water conservation measures to safeguard natural resources and strengthen water security. The results of this study, illustrated in Figures 4.22 and 4.23, demonstrate strong local involvement in catchment management practices, with a focus on agroforestry and other land-based conservation interventions.

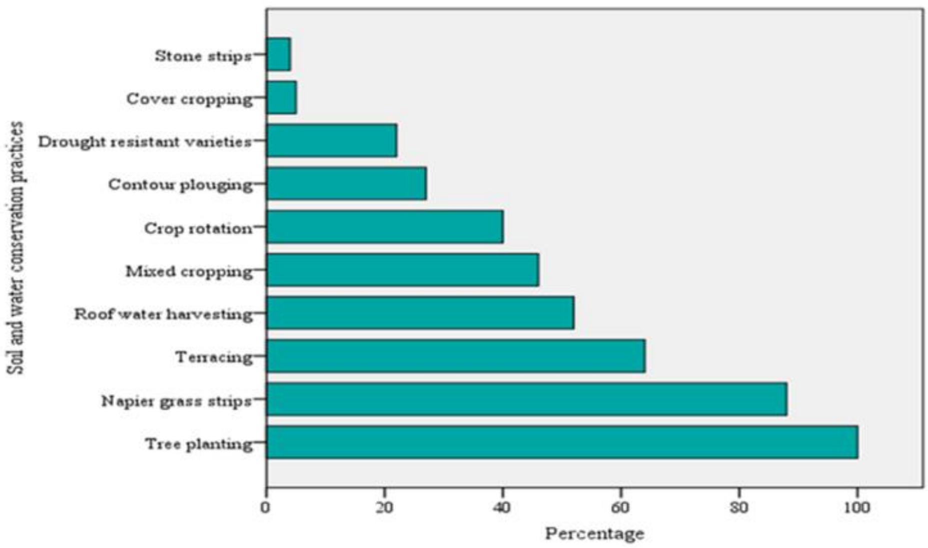

Figure 4.22: Soil and water conservation practices in Kapingazi catchment

As shown in Figure 4.22, 100% of the respondents reported planting trees on their farms as a conservation measure. This widespread practice reflects a strong awareness of the functions of trees in maintaining water quality and quantity. Indeed, 99% of the respondents believed that planting more trees improved water quality, while 95% perceived a positive impact on water quantity. The community planted a variety of tree species including indigenous, exotic, and fruit trees demonstrating the broad adoption of agroforestry systems.

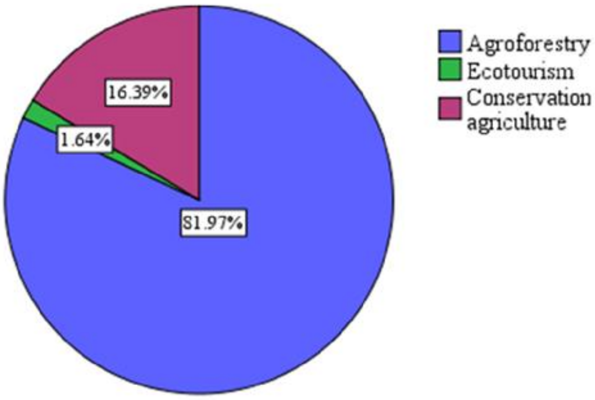

Figure 4.23: Conservation practices in Kapingazi catchment

Agroforestry was particularly prevalent in the upper catchment, as shown in Figure 4.23, where steep slopes increase the risk of soil erosion and runoff. Trees were planted to reduce runoff, minimize siltation, and mitigate flooding in Kapingazi River. Additionally, they helped regulate the water cycle, thereby maintaining consistent water flow and availability. Beyond environmental benefits, trees also contributed economic value: fruit trees such as macadamia, avocado, and mango generated income, while others provided timber, fuelwood, and boundary demarcation.

A significant 88% of respondents used Napier grass strips along contours, a practice effective in preventing soil erosion on the catchment's hilly terrain. These strips enhanced water absorption, stabilized terraces, and reduced pollutant loads from runoff, thereby improving water quality. Moreover, Napier grass served a dual purpose as fodder for livestock, aligning conservation with livelihood needs.

Terracing was practiced by 64% of respondents, particularly in coffee-growing zones, where steep slopes made farming more challenging. Terraces slowed down surface runoff and increased the land’s water retention capacity, making intensive farming possible.

Plate 4.5: Washed off terraces in Kamiu village in Kapingazi catchment

However, field observations such as in Plate 4.5 show that many terraces were poorly maintained, leading to soil erosion during heavy rains. As highlighted by Tefera and Sterk (2010), the lack of short-term benefits from terraces may have discouraged maintenance. This underscores the need for rehabilitating collapsed terraces and constructing new ones where none exist to ensure effective catchment management.

Several other soil and water conservation methods were also in use: Roof Water Harvesting (52%): This was used to store water in tanks and jerry cans, helping households cope with seasonal shortages and infrastructure-related disruptions. Mixed Cropping (46%): Practiced on small landholdings (average 2.3 acres), it allowed efficient land use and soil coverage, thereby reducing erosion. Crop Rotation (40%): Extended periods of soil cover helped retain moisture and improved soil health, indirectly benefiting water quality. Contour Planting (27%): Helped reduce runoff and sedimentation, increasing infiltration and protecting water resources. Planting Drought-Resistant Crops (22%): Species like cassava improved water-use efficiency, especially important during dry spells. Cover Cropping (5%) and Stone Strips (4%): Though practiced by fewer farmers, these contributed to erosion control and runoff reduction.

The results show that Kapingazi catchment has a highly engaged farming community practicing various soil and water conservation techniques. Agroforestry, Napier grass strips, and terracing were the dominant strategies, closely linked with improvements in water quality and quantity. However, maintenance challenges especially for terraces and limited adoption of some conservation practices indicate areas needing further support and education. Strengthening community capacity, promoting awareness of short- and long-term benefits, and integrating economic incentives with conservation goals will be vital for sustaining these efforts and achieving holistic catchment management in Kapingazi.

The uptake of soil and water conservation (SWC) measures in Kapingazi catchment appears to be closely tied to the perceived and actual benefits experienced by farmers. As noted by Musiyiwa *et al*. (2016), farmers are more likely to embrace conservation practices when they can observe tangible improvements in productivity or economic gain. This insight helps explain why certain measures, such as agroforestry and Napier grass strips, are widely practiced in Kapingazi farmers recognize their dual value in conserving soil and water while also supporting livelihoods through fodder, timber, and fruit production.

The absence of adequate conservation interventions, on the other hand, poses significant risks. Without these measures, soil erosion accelerates, washing away topsoil rich in fertilizers and pesticides. This not only deteriorates the water quality in the Kapingazi River posing risks to downstream users and aquatic ecosystems but also reduces soil fertility and structure, leading to lower crop yields and undermining food security in the region.

Evidence from other regions supports this view. For instance, a study conducted by (Dagnew *et al*. 2015) in the Blue Nile Basin in Ethiopia found that adopting soil and water conservation practices in areas where none previously existed significantly reduced runoff and sedimentation. These improvements in turn led to enhanced water quality and quantity, similar to the goals being pursued in Kapingazi catchment.

These findings reinforce the importance of continued education, extension services, and incentives for farmers in Kapingazi. By linking SWC measures directly to economic and productivity benefits and demonstrating long-term environmental gains stakeholders can enhance the adoption of conservation practices. This will not only secure sustainable agricultural production but also help protect the ecological integrity and water resources of the Kapingazi catchment.

4.4.3 Organization of the catchment users in Kapingazi catchment management

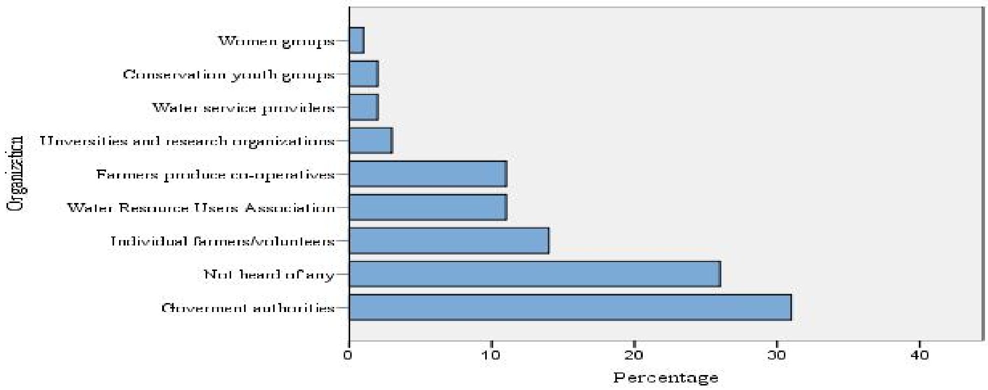

Figure 4.24: Organization of catchment management in Kapingazi catchment

Figure 4.24 presents the organizations involved in the management of the Kapingazi catchment, highlighting the key players involved, their level of participation, and the awareness of their roles among the local population. Effective catchment management depends on the collaborative engagement of multiple stakeholders involving government institutions, private entities, community based organizations and local populations in efforts aimed at sustainable natural resource utilization and the improvement of water quality and supply.

The majority of respondents (31%) identified government authorities as the principal actors in managing the Kapingazi catchment. These authorities include the Water Resources Authority (WRA), National Environment Management Authority (NEMA) and government-supported projects such as the Mt. Kenya East Pilot Project (MKEPP) and the Upper Tana Natural Resources Management Project. These institutions are responsible for enforcing regulations (e.g., banning quarrying along rivers, removing water-intensive eucalyptus trees), issuing water abstraction permits, and initiating conservation programs. Their active presence is likely why they were most recognized by respondents.

However, 26% of respondents were unaware of any organizations involved in catchment management. This significant portion points to a gap in awareness and outreach, which could be attributed to limited interaction between conservation institutions and the general public, or the lack of visibility of institutional activities on the ground. This lack of awareness suggests a need for improved stakeholder engagement and education to enhance local participation and support for catchment management initiatives.

Only 11% of respondents recognized the Kapingazi Water Resource Users Association (KaWRUA) as active in the catchment. KaWRUA has been involved in key management tasks such as riparian protection, tree planting, and monitoring of water abstraction, especially to safeguard water access for downstream users. Their outreach through farmer meetings also plays an important role in educating communities about water conservation practices, though evidently, more visibility and support may be needed to strengthen their impact.

Another 11% of respondents cited agricultural cooperatives, particularly tea and coffee cooperatives, as contributors to catchment management. These organizations engage in activities such as distribution of macadamia seedlings to prevent soil erosion, environmental education campaigns, and tree planting efforts to offset deforestation caused by fuel wood extraction for factory operations. This participation reflects a growing trend of linking agricultural production with environmental conservation.

Universities and research organizations were identified by 3% of respondents, indicating a limited but important role in conducting studies that inform catchment management practices. Institutions such as KALRO, CIFOR-ICRAF, and CIMMYT have conducted relevant research within the catchment, although their indirect involvement may explain their low visibility.
Surprisingly, only 2% of respondents reported involvement of water service providers, and interviews confirmed that most providers were not engaged in catchment management. This aligns with the separation of roles introduced in the Water Act of 2002, which delineated responsibilities between water service provision and water resources management. However, Embu Water and Sewerage Company (EWASCO) and KenGen expressed willingness to participate in catchment conservation, indicating potential for future collaboration with WRA and Embu County Government in initiatives such as tree planting and stormwater harvesting.

Youth and women groups were minimally involved, with only 2% and 1% of respondents recognizing their participation, respectively. These groups are primarily focused on economic empowerment and remain underrepresented in environmental management efforts. This highlights a gender and age-based disparity that must be addressed to foster inclusive catchment governance.

The results demonstrate a mixture of active involvement, partial participation, and significant gaps in awareness and inclusion among catchment users. While government agencies dominate the landscape, there is a clear need to improve the visibility and involvement of local groups, cooperatives, and marginalized stakeholders such as women and youth. Enhancing coordination, building awareness, and encouraging multi-stakeholder participation are critical for effective and sustainable catchment management in Kapingazi.

4.4.4 Functions of organizations in catchment management in Kapingazi catchment

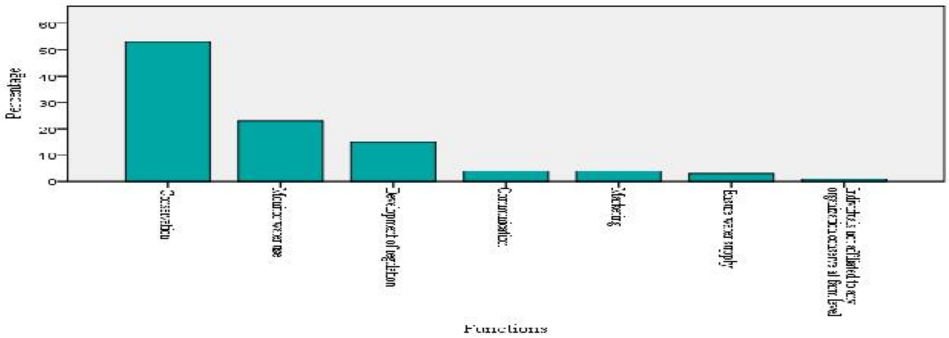

Figure 4.25: Functions of the organizations in management of Kapingazi catchment

Figure 4.25 presents the diverse roles that organizations play in managing the Kapingazi catchment, as reported by local respondents and supported by insights from Focus Group Discussions (FGDs). The results reveal that catchment management is a multifaceted process involving both governmental and community-based institutions with complementary functions.

The most prominent function, as indicated by 51.5% of the respondents, was the implementation of conservation activities. This role is primarily driven by the presence of various government institutions and development projects operating in the catchment, such as the Water Resources Authority (WRA), National Environment Management Authority (NEMA), Kenya Forest Service (KFS), Kenya Wildlife Service (KWS), and the Ministry of Water, Sanitation and Irrigation through the Upper Tana Natural Resource Management Project. These institutions collaborate with local communities, including Kapingazi Water Resources Users Association (WRUA) and Community Forest Associations (CFAs), to promote conservation through initiatives like afforestation and soil erosion control.

The monitoring of water use, cited by 22.3% of the respondents, was another key function. This responsibility was particularly critical as a result of the increasing irrigation water demand from the Kapingazi River. Kapingazi WRUA plays a central role in this area by conducting regular monitoring, stopping illegal water abstractions, and ensuring water flows are maintained for downstream users. The issuance of water abstraction permits, a responsibility of the Water Resources Authority, complements this monitoring function by regulating who can legally access and utilize water resources.

Development and enforcement of water regulations were also highlighted by 14.6% of respondents. These roles aim to reduce pollution risks and ensure equitable and sustainable distribution of water resources. Organizations such as NEMA and WRA are mandated to create and implement regulatory frameworks that integrate land-use planning with water quality control, ensuring that activities within the catchment do not degrade the river ecosystem.

A smaller proportion of respondents recognized other functions. For example, 3.9% noted the communication of environmental information, typically carried out during chief's barazas and through community training sessions on topics such as tree planting. Another 3.9% pointed out marketing roles undertaken by agricultural-based institutions like tea, coffee, and macadamia processing factories, which help local farmers sell their produce. Only 2.9% mentioned ensuring water supply, a function fulfilled by institutions such as WRA and KaWRUA through enforcement of permit conditions and by environmental projects like the Mt. Kenya East Pilot Project (MKEPP), which supported tree planting to enhance water retention and supply.

A further 1% of respondents indicated that individual farmers were also actively engaged in farm-level conservation practices. These efforts were attributed to heightened awareness and education likely fostered by training programs from environmental initiatives like MKEPP.

From the FGDs, further insights were gathered on the specific functions of local organizations. Kapingazi WRUA is instrumental across various activities such as conservation (e.g., tree planting), monitoring pollution, reporting to WRA, carrying out abstraction surveys, and delineating riparian zones through marking and pegging. FDAC, which was established during MKEPP implementation, shares similar conservation responsibilities but also focuses on community economic empowerment through agriculture and livestock programs. The Irangi Community Forest Association is primarily concerned with forest management, particularly within the Mt. Kenya Forest where Kapingazi River originates, but also contributes to water resource management within forested areas.

Regulatory authorities like NEMA and WRA are important in enforcing environmental and water-related legislation, respectively. They contribute to the development and execution of catchment-specific policies and regulations. The functions of these organizations span a wide spectrum, including water allocation, natural resource planning, public education, conflict resolution, consensus-building, and restoration of degraded areas core aspects of Integrated Water Resources Management (IWRM). Thus, the organizations involved in managing the Kapingazi catchment perform a range of essential functions. While conservation and regulation are dominant themes, other areas such as economic support, community education, and inter-agency coordination are equally important for ensuring the sustainable management and long-term preservation of the catchment's water and natural resources.

4.4.5 Challenges in catchment management in Kapingazi catchment

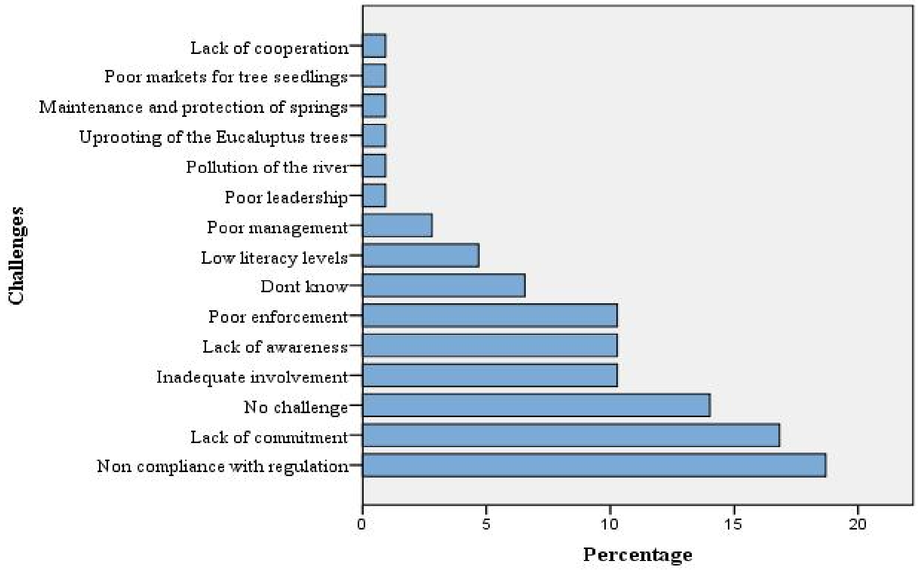

Figure 4.26: Challenges in the management of Kapingazi catchment

Figure 4.26 illustrates the various challenges encountered in the management of the Kapingazi catchment as reported by stakeholders and respondents. The most significant challenge, identified by 18.7% of respondents, was non-compliance with existing water regulations such as the Environmental Management and Coordination Act (EMCA) of 2015 and the Environmental Management and Coordination (Water Quality) Regulations of 2006. These regulations are essential for safeguarding water sources, aquatic ecosystems, and other environmentally sensitive areas. However, respondents and focus group discussions (FGDs) with stakeholders such as the Kapingazi Water Resources Users Association (KaWRUA) and the Forest Development and Advisory Committee (FDAC) revealed frequent violations. Examples included unlicensed irrigation, direct discharge of effluent into rivers, and illegal quarrying along riparian zones.

Closely linked to non-compliance was the issue of weak enforcement mechanisms, cited by 10.3% of respondents. The lack of government action and limited institutional capacity to monitor and enforce regulations have allowed environmentally harmful practices to persist. Another concern was the lack of commitment among catchment users toward conservation efforts, which reflects a broader issue of stakeholder disengagement.

However, 14.8% of the respondents indicated that they observed no challenges in catchment management. This could be indicative of limited awareness, lack of education on environmental issues, or low levels of involvement in catchment activities. Indeed, another 10.3% attributed the challenges to a lack of awareness resulting from insufficient environmental education campaigns and low literacy levels within the catchment communities.

Plate 4.6: Focus group discussion with KaWRUA, FDAC and Irangi CFA

In addition, FGDs (as shown in Plate 4.6) revealed poor coordination among stakeholder groups, including KaWRUA, CFAs, and FDAC, which was highlighted by 2.8% of the respondents. These coordination failures often led to conflicting interests and undermined collective management efforts. A case in point involved water tankers illegally extracting water from the Kapingazi River despite lacking permits from KaWRUA, yet carrying authorization from Embu County Government and the police. Such overlaps in authority and inconsistent enforcement further erode the effectiveness of catchment governance.

These findings align with Global Water Partnership (2015), which identified poor inter-agency coordination and lack of stakeholder cooperation as key impediments to water governance in Kenya. They are also consistent with Mukeria *et al*. (2021), who documented similar challenges among stakeholders in Ethiopia's Hawassa Catchment, underscoring the universal nature of stakeholder-related barriers in catchment management. Ineffective catchment management not only threatens water quality and quantity but also impacts downstream users and undermines sustainable agriculture and environmental conservation. A holistic and integrated approach comprised of better stakeholder coordination, regulatory compliance, public awareness, and economic incentives such as Payment for Ecosystem Services (PES) is essential. PES could encourage sustainable land management and enhance community participation by delivering practical conservation benefits that strengthen the resilience, health, and sustainability of the Kapingazi catchment.

4.5 Perceptions of human activities affecting water provision service in Kapingazi catchment

The effects of human activities on the Kapingazi catchment were apparent. The biodiversity structure of the ecosystem has been simplified by such activities. As a result, both water quality and quantity are increasingly undermined by different sectors within the catchment, thereby threatening and reducing the availability of ecosystem services and resources. Therefore, this study sought so to find out the perceived human activities affecting changes on water quality and water quantity whether by farmers, urban households and shopping centres, coffee factories, tea factories, transport industry, education institutions and irrigators in Kapingazi catchment as shown in Appendix 1 using logistic regression model. The significance of establishing the human activities affecting water service provision in Kapingazi catchment is to be able to identify the negative impacts which could be addressed in the payment for ecosystem services scheme in Kapingazi catchment. The validity of the logistic regression was ascertained by carrying out preliminary analyses to verify that its assumptions were met when examining the perceived effects of changes in water quality and water quantity within the Kapingazi catchment.

4.5.1 Perceived human activities affecting changes in water quality

As procedure to run logistic regression for checking perceived human activities affecting changes in water quality, the study checked for assumptions satisfied by the model.

4.5.1.1 Assumptions of logistic regression satisfied by the model for changes in water quality

The diagnostic tests for the logistic regression of perceived human activities affecting changes in water quality was tested as shown below:

i. The dependent/response variables were dichotomous with the response of Yes or No as shown in the dependent variable encoding Table 4.10.

Table 4.10

Dependent variable encoding for changes in water quality

Original value	Internal value
No	0
Yes	1

ii. The dataset comprised independent observations, with no repeated measures from the same individual or interrelated entries. The assumption was verified by the Durbin-Watson test of linear regression between the dependent and independent variables, resulting in a value of 1.842, which falls within the permissible range of 1.5 to 2.5, showing the absence of autocorrelation as shown in the Table 4.11.

Table 4.11

Model summary[b] for changes in water quality

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.657[a]	0.432	0.389	0.25534	1.842

a. Predictors: (Constant), Irrigators' Activities, Urban/Shopping Centre's And Urban Household Activities, Coffee Factories' Activities, Farmer's Activities, Education Institution Activities, Tea Factories' Activites, Transport Activities

b. Dependent Variable: Changes In Water Quality

iii. Multicollinearity was not detected among the independent variables. The VIF test indicated that none of the explanatory variables showed strong correlation, so confirming that each provided unique information to the regression model. There was no relationship between a predictor and the other variables as indicated by a VIF score of 1 in the model as shown in Table 4.12.

Table 4.12

Coefficients[a] for changes in water quality

	Collinearity Statistics	
Model 1	**Tolerance**	**VIF**
Farmer's Activities	.899	1.112
Urban/Shopping Centre's And Urban Household Activities	.846	1.182
Coffee Factories' Activities	.896	1.116
Tea Factories' Activites	.889	1.124
Transport Activities	.779	1.284
Education Institution Activities	.846	1.181
Irrigators' Activities	.776	1.289

a. Dependent Variable: Changes In Water Quality

iv. The independent variables showed a linear relationship with the logit of the dependent variable. This assumption was evaluated using the Hosmer-Lemeshow test, which yielded an insignificant result ($p = 0.972$, $p > 0.05$) as shown in Table 4.13.

Table 4.13

Hosmer and Lemeshow test for changes in water quality

Step	Chi-square	df	Sig.
1	2.260	8	0.972

v. The sample size was sufficiently large, tested through the Hosmer and Lemeshow test for goodness of fit to the data which was insignificant with p = 0.972 as shown in Table 4.13.

vi. There were no influential outliers in the dataset. This was checked through the Cook's distance test as shown in Figure 4.27. The highest value did not exceed 1 in the Cook's distance therefore there were no extreme outliers.

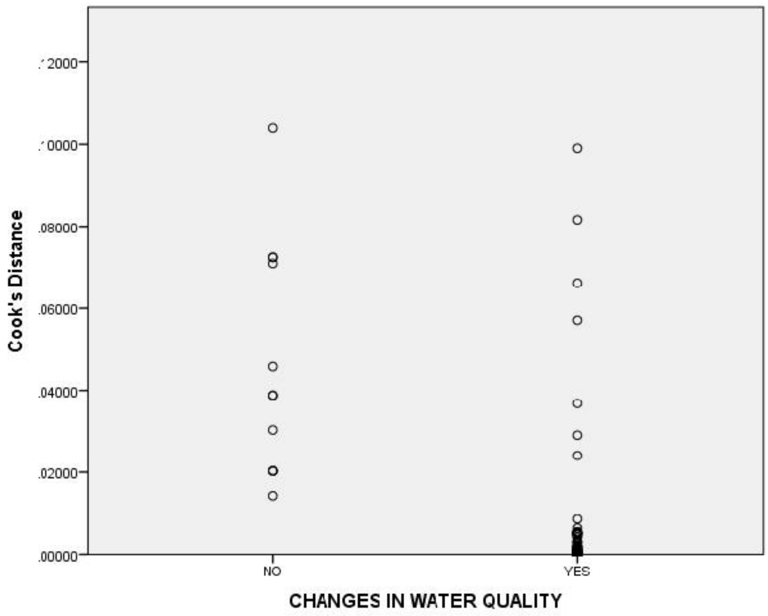

Figure 4.27: Cook's distance for changes in water quality

4.5.1.2 Logistic regression for human activities impacting on changes in water quality in Kapingazi catchment

Following the logistic regression analysis, farming activities emerged as the most influential anthropogenic factor significantly affecting water quality changes in the Kapingazi catchment at a

95% confidence level, as indicated in the output below. This section also presents the overall model assessment from the Omnibus Tests of Model Coefficients table.

Table 4.14

Omnibus tests of model coefficient

Step 1	Chi-square	df	Sig.
Step	41.223	7	.000
Block	41.223	7	.000
Model	41.223	7	.000

The Omnibus test of model coefficients demonstrated that the model as a whole was statistically significant, $X^2(7, n = 100) = 41.22$, $p < 0.0005$ as shown in Table 4.14.

Table 4.15

Model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	32.162[a]	.338	0.650

a. Estimation terminated at iteration number 20 because maximum iterations has been reached.

The model summary table (Table 4.15) summarizes the Cox & Snell R^2 and Nagelkerke R^2 statistics, which measure the proportion of explained variation and are frequently referred to as pseudo R^2 values. These values are generally lower than those in multiple regression but can be interpreted in a similar way, with added caution. According to our model, the dependent variable's (changes in water quality) explained 34.0% of the variance using Cox & Snell R^2 and 65.0% using Nagelkerke R^2.

Table 4.16

Hosmer and Lemeshow test

Step	Chi-square	df	Sig.
1	2.260	8	.972

The Hosmer-Lemeshow test (Table 4.16) evaluated whether the model's predictions aligned with the observed group classifications. By comparing the observed and expected frequencies under the linear model, a chi-square statistic was calculated. A non-significant result (0.972) indicates a good fit between the model and the data.

Table 4.17

Classification table

Observed Changes in Water Quality	**Predicted Changes in Water Quality**		**Percentage Correct**
	No	Yes	
Step 1			
No	8	4	66.7
Yes	3	85	96.6
Overall Percentage			**93.0**

The cut value is 0.500

Table 4.17 presents the classification results from logistic regression, which estimated the likelihood of an event (changes in water quality) occurring. If the probability was greater than or equal to 0.5, SPSS Statistics classified the event as occurring; otherwise, it was classified as not occurring. Evaluation of the model's classification performance was made possible by the binomial logistic regression, which assessed whether cases were correctly predicted from the independent variables.

The model correctly classified 93.0% of cases overall (see the "Overall Percentage" row), representing the overall classification accuracy, with the inclusion of the independent variables. Activities that caused changes in water quality were correctly predicted 96.6% of the time (see the "Percentage Correct" column under "Yes"), reflecting the model's sensitivity. Activities that did not cause changes in water quality were correctly predicted 66.7% of the time (see the "Percentage Correct" column under "No"), representing the specificity. The positive predictive value the proportion of correctly predicted cases with the characteristic relative to all cases predicted as having it was calculated as $100 \times (85 \div (4 + 85)) = 95.5\%$**,** meaning 95.5% of cases predicted to cause changes were correct. The negative predictive value the proportion of correctly predicted cases without the characteristic relative to all cases predicted as not having it was 100 × (8 ÷ (8 + 3)) = 72.7%**,** indicating that 72.7% of cases predicted not to cause changes were correct.

Table 4.18

Variables in the equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Farmers(1)	3.607	1.139	10.031	1	.002	36.863	3.955	343.591
	Urbanhhcentreshoppingcentres(1)	19.444	5139.439	.000	1	.997	278370315.301	.000	.
	Coffeefact(1)	1.496	1.021	2.147	1	.143	4.465	.603	33.039
	Teafact(1)	1.778	1.126	2.493	1	.114	5.915	.651	53.737
	Transport(1)	17.345	6310.943	.000	1	.998	34089873.543	.000	.
	Educationinstit(1)	-1.325	16134.131	.000	1	1.000	.266	.000	.
	Irrigators(1)	-1.517	1.180	1.653	1	.199	.219	.022	2.216
	Constant	-2.172	1.071	4.108	1	.043	.114		

Variable(s) entered on step 1: Farmers, Urbanhhcentreshoppingcentres, Coffeefact, Teafact, Transport, Educationinstit, Irrigators

The Wald test, which is shown in the "Wald" column, was applied to evaluate the statistical significance of each independent variable in the variables in the equation table (Table 4.18). The corresponding significance values are reported in the “Sig.” column. The results indicate that Farmers ($p = 0.002$) contributed significantly to the model, whereas Urban households ($p = 0.997$), Coffee factories ($p = 0.143$), Tea factories ($p = 0.114$), Transport ($p = 0.998$), Educational institutions ($p = 1.000$), and Irrigators ($p = 0.199$) did not show significant contributions**.**

The probability of an event occurring given a one-unit change in an independent variable, while holding all other variables constant, was estimated using the "Variables in the Equation" table. Results indicate that the odds of farmers’ activities affecting water quality (“yes” category) are 36.863 times higher than those of urban households, coffee factories, tea factories, the transport sector, educational institutions, and irrigators within the Kapingazi catchment.

To assess the impact of various stakeholders including farmers, urban households, tea and coffee factories, transport, educational institutions, and irrigators on changes in water quality in the Kapingazi catchment, a logistic regression was performed. The analysis was statistically significant, $X^2(7, n = 100) = 41.22$, $p < 0.0005$, accounting for 65.0% of the variance (Nagelkerke R^2). The model correctly predicted 93.0% of water quality change cases, with the effect of farmers’ activities estimated at -2.17 ± 3.61.

Perceived Farmers' activities were 36.836 times more likely to cause changes in water quality in Kapingazi river. Increasing farmers' activities was associated with an increased likelihood of changes in water quality of Kapingazi river. The observed increase in riparian cultivation, chemical pest and disease control, river washing, deforestation, quarrying, and poor waste management is likely to reduce the water quality of the Kapingazi River. According to Appendix 1, the results indicated that the odds ratio for the impact of additional agricultural activities on changes in water quality in the Kapingazi catchment was 36.863, indicating that the likelihood of changes in water quality increases by a factor of 36.863 as farming activities increase.

This could be attributed to farming activities such as cultivation at the riparian area as elucidated by 16.4% of the respondents which from the results was the highest among farming activities contributing to changes in water quality in Kapingazi catchment as shown in Plate 4.7. The cultivation of riparian areas arises from small landholdings, with these zones offering critical space for growing food crops throughout the year, particularly in dry periods. Such agricultural activities, however, have significant effects on riparian structure and functioning. Clearing riparian vegetation modifies river hydrology and geomorphology, as roots that stabilize soil are removed, hydraulic roughness declines, and near-bank flow velocities increase (Sedell & Beschta, 1991). These changes accelerate bank erosion during high flows, especially in the rainy season. Furthermore, research by Bunn *et al*. (1999) indicates that the removal of shade and large plants encourages filamentous algae proliferation, altering habitats and diminishing water quality. The cumulative effects are reflected in the deteriorated water quality of the Kapingazi River catchment.

Plate 4.7: Cultivation at the riparian area in Kivumburi village in Kapingazi area

Chemical control of pests and diseases at the riparian area and in the farms (5.2%) and washing clothes in the river (4.9%) were also cited as contributors to changes in water quality of Kapingazi River. Pollutants such as herbicides, fertilizers, fungicides, pesticides and detergents used by farmers were washed into Kapingazi River, thereby causing water pollution hence reducing the water quality. This could be as a result of cultivation at the riparian area which reduces its ability to filter sediments, nutrients and pesticides entering the river from the farms. According to 3.4% of the respondents, soil erosion contributed to water quality decrease due to lack of adequate soil and water conservation measures in farms which was observed in various farms as shown in Plate 4.8. There was evidence of gullies and rills in farms and areas that had less vegetative cover or lacked structural soil and water control measures such as terraces and gabions.

Plate 4.8: A farm with inadequate soil and water conservation measures in Thigingi village in Kapingazi catchment

The respondents (2.8%) noted that deforestation at farm level also contributed to water quality decrease since it exposed the soils to the agents of soil erosion such as water which carried the soil particle sediments causing turbidity of water and siltation in Kapingazi River. Deforestation was incidental within Kapingazi catchment to provide fuel wood for households as shown in Plate 4.9 and tea factories in the area. Fuel wood collection and charcoal production contributed much to the depletion of vegetation types which led to exposure of soil. The fuel wood was used for cooking food. Similarly, charcoal provided alternative source of energy for households within the catchment as a coping mechanism when there was decrease in fuel wood provision. Local industries such as carpentry workshops also depended on the local timber from farms as their raw materials.

Plate 4.9: Photo showing timber, firewood and charcoal burning in Kibugua and Mutuandu villages in Kapingazi catchment

Quarrying/stone mining and poor waste management had the lowest impact on changes on water quality according to 2.2% and 1.9% of the respondents respectively. Some farmers in the catchment mined building stone blocks and harvested sand from the river mostly along the riparian area which were sold to building contractors in order to supplement their household incomes as shown in the Plate 4.10. Quarrying activities can significantly disrupt existing ecosystems and alter hydrogeological and hydrological patterns. The environmental impacts of stone and sand extraction include deterioration of water quality due to scouring and accumulation of suspended sediments, elevated turbidity levels (Chutter, 1996), river channel erosion, groundwater depletion, loss of fertile topsoil, forest degradation, and reductions in aquatic biodiversity, as well as diminished landscape aesthetics (Ozcan *et al.*, 2012). Beyond direct habitat disturbance, stone mining can also generate long-range impacts on downstream communities, extending beyond the immediate area of operations.

Plate 4.10: Quarrying activity in Kariari village in Kapingazi catchment

Poor waste management was noted as a contributor to changes in water quality whereby waste especially used agrochemical containers was observed lying in farms uncollected as shown in Plate 4.11 or directly disposed into the river after use by the farmers who sprayed crops at the riparian area.

Therefore, increased activities such as riparian cultivation, chemical pest and disease control, washing clothes in the river, soil erosion, deforestation, quarrying, and poor waste management by farmers in the Kapingazi catchment are likely to further degrade water quality, as they substantially influence changes in the catchment's water quality.

Plate 4.11: Disposed agrochemical containers in a farm in Kithangari village in Kapingazi catchment

4.5.2 Perceived human activities impacting on changes in water quantity

As procedure to run logistic regression for checking perceived human activities affecting changes in water quantity, the study checked for assumptions satisfied by the model.

4.5.2.1 Assumptions of logistic regression satisfied by the model for changes in water quantity

The diagnostic tests for the logistic regression of perceived human activities affecting changes on water quantity were tested as shown below.

i. The dependent/response variables were dichotomous with the response of Yes or No as shown in the dependent variable encoding Table 4.19.

Table 4.19

Dependent variable encoding for changes in water quantity

Original Value	Internal Value
No	0
Yes	1

ii. The dataset comprised independent observations, with no repeated measures from the same individual or interrelated entries. The assumption was verified by the Durbin-Watson test of linear regression between the dependent and independent variables, resulting in a value of 2.216, which falls within the permissible range of 1.5 to 2.5, showing the absence of autocorrelation as shown in the Table 4.20.

Table 4.20

Model Summary[b] for changes in water quantity

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.488[a]	.238	.180	.30611	2.216

a. Predictors: (Constant), Irrigators' Activities, Urban/Shopping Centre's And Urban Household Activities, Coffee Factories' Activities, Farmer's Activities, Education Institution Activities, Tea Factories' Activites, Transport Activities
b. Dependent Variable: Changes In Water Quantity

iii. Multicollinearity was not detected among the independent variables. The VIF test indicated that none of the explanatory variables showed strong correlation, so confirming that each provided unique information to the regression model. There was no relationship between a predictor and the other variables as indicated by a VIF score of 1 in the model as shown in Table 4.21

Table 4.21

Coefficients[a] for changes in water quantity

	Collinearity Statistics	
Model 1	**Tolerance**	**VIF**
Farmer's Activities	.899	1.112
Urban/Shopping Centre's and Urban Household Activities	.846	1.182
Coffee Factories' Activities	.896	1.116
Tea Factories' Activites	.889	1.124
Transport Activities	.779	1.284
Education Institution Activities	.846	1.181
Irrigators' Activities	.776	1.289

a. Dependent Variable: Changes In Water Quantity

iv. The independent variables showed a linear relationship with the logit of the dependent variable. This assumption was evaluated using the Hosmer-Lemeshow test, which yielded an insignificant result ($p = 0.964$, $p > 0.05$) as shown in Table 4.22.

Table 4.22

Hosmer and Lemeshow test for changes in water quantity

Step	Chi-square	df	Sig.
1	2.443	8	0.964

v. The sample size was sufficiently large tested through the Hosmer and Lemeshow test for goodness of fit to the data which was insignificant with $p = 0.964$ as shown in Table 4.22.

vi. There were no influential outliers in the dataset. This was checked through the Cook's distance test as shown in Figure 4.28. The highest value did not exceed 1 in the Cook's distance therefore there were no extreme outliers.

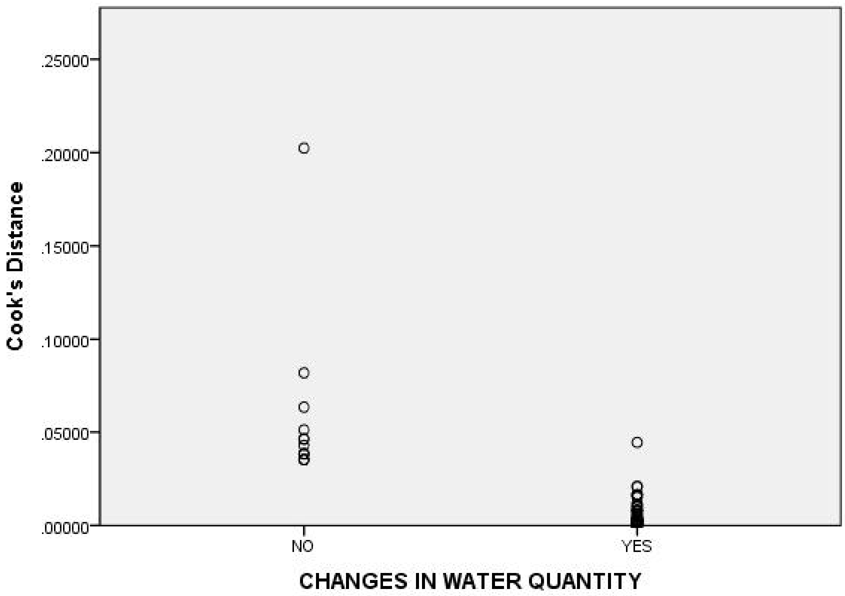

Figure 4.28: Cook's distance for changes in water quantity

4.5.2.2 Logistic regression for human activities impacting on changes in water quantity in Kapingazi catchment

Following the logistic regression analysis, farming and industrial activities emerged as the most influential anthropogenic factor significantly affecting water quality changes in the Kapingazi catchment at a 95% confidence level, as indicated in the output below. This section also presents the overall model assessment from the Omnibus Tests of Model Coefficients table.

Table 4.23

Omnibus tests of model coefficients

Step 1	Chi-square	df	Sig.
Step	32.384	7	.000
Block	32.384	7	.000
Model	32.384	7	.000

The Omnibus test of model coefficients indicated that the model as a whole was statistically significant, $X^2(7, n=100) = 32.384$, $p < 0.0005$ as shown in Table 4.23.

Table 4.24

Model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	44.893[a]	.277	.514

a. Estimation terminated at iteration number 20because maximum iterations has been reached.

The model summary table (Table 4.24) summarizes the Cox & Snell R^2 and Nagelkerke R^2 statistics, which measure the proportion of explained variation and are frequently known as pseudo R^2 values. These values are generally lower than those in multiple regression but can be interpreted in a similar way, with added caution. According to our model, the dependent variable's (changes in water quality) explained 28.0% of the variance using Cox & Snell R^2 and 51.0% using Nagelkerke R^2.

Table 4.25

Hosmer and Lemeshow test

Step	Chi-square	df	Sig.
1	2.443	8	0.964

The Hosmer-Lemeshow test (Table 4.25) evaluated whether the model's predictions aligned with the observed group classifications. By comparing the observed and expected frequencies under the linear model, a chi-square statistic was calculated. A non-significant result (0.964) indicates a good fit between the model and the data.

Table 4.26

Classification table

Observed Changes in Water Quantity	**Predicted Changes in Water Quantity**		**Percentage Correct**
	No	Yes	
Step 1			
No	5	8	38.5
Yes	1	86	98.9
Overall Percentage			**91.0**

a. The cut value is .500

Table 4.26 presents the classification results from logistic regression, which estimated the likelihood of an event (changes in water quality) occurring. If the probability was greater than or equal to 0.5, SPSS Statistics classified the event as occurring; otherwise, it was classified as not occurring. Evaluation of the model's classification performance was made possible by the binomial logistic regression, which assessed whether cases were correctly predicted from the independent variables.

The model correctly classified 91.0% of cases overall (see the "Overall Percentage" row), representing the overall classification accuracy, with the inclusion of the independent variables. Activities that caused changes in water quantity were correctly predicted 98.9% of the time (see the "Percentage Correct" column under "Yes"), reflecting the model's sensitivity. Activities that did not cause changes in water quantity were correctly predicted 38.5% of the time (see the "Percentage Correct" column under "No"), representing the specificity. The positive predictive value the proportion of correctly predicted cases with the characteristic relative to all cases predicted as having it was calculated as 100 × (86 ÷ (8 + 86)) = 90.5%**,** meaning 90.5% of cases predicted to cause changes were correct. The negative predictive value the proportion of correctly predicted cases without the characteristic relative to all cases predicted as not having it was 100 × (5 ÷ (5 + 1)) = 83.3%**,** indicating that 83.3% of cases predicted not to cause changes were correct.

Table 4.27

Variables in the equation

							95% C.I.for EXP(B)	
Step 1[a]	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**	**Lower**	**Upper**
Farmers (1)	2.087	.997	4.385	1	.036	8.065	1.143	56.899
Urban households and centres (1)	-.533	.849	.394	1	.530	.587	.111	3.098
Coffee factories (1)	2.015	.816	6.104	1	.013	7.500	1.517	37.087
Tea factories(1)	3.036	1.236	6.034	1	.014	20.826	1.847	234.815
Transport industry(1)	-.830	.960	.747	1	.387	.436	.066	2.862
Education institutions(1)	-.545	17634.955	.000	1	1.000	.580	.000	.
Irrigators(1)	19.646	5727.455	.000	1	.997	340626688.514	.000	.
Constant	-1.507	.956	2.482	1	.115	.222		

a. Variable(s) entered on step 1: Farmers, Urbanhhcentreshoppingcentres, Coffeefact, Teafact, Transport, Educationinstit, Irrigators.

The Wald test, which is shown in the "Wald" column, was applied to evaluate the statistical significance of each independent variable in the variables in the equation table (Table 4.27). The corresponding significance values are reported in the "Sig." column. The results indicate that Farmers (p = 0.036), coffee factories (p=0.013) and tea factories (p=0.014) contributed significantly to the model, whereas Urban households (p = 0.530), Transport (p = 0.387), Educational institutions (p = 1.000), and Irrigators (p = 0.997) did not show significant contributions**.**

The probability of an event occurring given a one-unit change in an independent variable, while holding all other variables constant, was estimated using the "Variables in the Equation" table. Results indicate that the odds of farmers' activities, coffee factories and tea factories affecting water quantity ("yes" category) were 8.065, 7.5 and 20.826 times higher than those of urban households, the transport sector, educational institutions, and irrigators within the Kapingazi catchment.

To assess the impact of various stakeholders including farmers, urban households, tea and coffee factories, transport, educational institutions, and irrigators on changes in water quantity in the Kapingazi catchment, a logistic regression was performed. The analysis was statistically significant, $X^2(7, n = 100) = 32.384$, $p < 0.0005$, accounting for 51.4% of the variance (Nagelkerke R^2). The model correctly predicted 91.0% of water quantity change cases, with the effect of farmers' activities estimated at -1.51 (farmer's activities+ 2.02 (Coffee factories' activities) + 3.04 (Tea factories' activities).

Farmers', coffee factories and tea factories activities were 8.065, 7.5 and 20.826 times respectively more likely to cause changes in water quantity in Kapingazi river. Increased activities by farmers, coffee factories, and tea factories were associated with a higher likelihood of changes in the water quantity of the Kapingazi River. Among these, coffee factory activities had the strongest effect. Specifically, as coffee factory activities increased, the probability of changes in water quantity rose by 7.5 times, corresponding to an odds ratio of 7.5. This increase is largely attributed to water abstraction by coffee factories located along the Kapingazi River, as reported by 23.6% of respondents. There were five coffee factories which abstracted water from Kapingazi River which used the water for processing coffee therefore reducing the amount of water in it. Therefore an increase in water abstraction by coffee factories would adversely affect the amount of water flowing in Kapingazi River. This was supported by KenGen and EWASCO who noted that there was over abstraction of water from the river which reduced its base flows.

It was also found that tea factories had a significant influence on water quantity in Kapingazi catchment. As tea factory activities affecting water quantity increase, the likelihood of changes in water quantity rises by a factor of 20.826. The corresponding odds ratio for increased tea factory activity is 20.826, indicating a substantial impact on water quantity. 12.7% of the respondents agreed that deforestation by tea factories affected the amount of water in Kapingazi catchment. Tea factories used fuel wood as their source of energy for processing tea as it was the cheapest energy source. This fuel wood was sourced from farms within and outside Kapingazi catchment. Deforestation has adverse effect on water quantity because it affects hydraulic regulation which destroys and reduces the absorption capacity. Hlasny *et al*. (2015) found that deforestation can substantially impact water hydrology as it induces a significant decrease in interception of rain and evapotranspiration rates leading to reduced water availability. This study therefore shows if deforestation continues, the amount of water available in Kapingazi River would decrease. Therefore reforestation programmes should be implemented to reverse the trend.

Observations indicate that Farmers' activities had a notable impact on changes in water quantity in the Kapingazi catchment. The results reveal that a one-unit increase in farmers' activities raises the likelihood of changes in water quantity by 8.065 times. The odds ratio of 8.065 indicates that for each incremental increase in farmers' activities, the odds of experiencing changes in water quantity increase by a factor of 8.065. This is due to cultivation at the riparian area as indicated by 7.1% of the respondents. Cultivation of the riparian area was due to small land sizes in Kapingazi catchment. This led to siltation of the Kapingazi river which caused reduced water quantity in the river as a result of destruction of the riparian buffer zone which was supposed filter the sediments if it was unaltered. Deforestation of riparian zones diminishes wildlife habitats and corridors and directly affects stream ecosystems by reducing water quality and habitat availability, through the removal of leaf litter, woody debris and dissolved organic carbon inputs (Castelle & Johnson, 2000). Deforestation was a major cause of decreased water quantity in Kapingazi River as elucidated by 4.3% of the respondents. This was because of need for fuel wood and charcoal as source of energy in households in Kapingazi catchment. Also, tea factories in Kapingazi catchment sourced fuel wood for processing tea from local farmers at a fee besides the local artisans in carpentry and in building and construction. Deforestation exposes soils to agents of soil erosion and changes to sediment and nutrient loadings which affect water supply. Deforestation in the catchment likely decreased dry-season water flows while increasing peak flows, resulting in increased water scarcity during critical periods and worsening erosion on hill slopes (Mango *et al.*, 2011).

Water abstraction affected water quantity in Kapingazi catchment by coffee factories and irrigators as was observed by 3.4% of the respondents as shown in Plate 4.12. This could be due to water abstraction by coffee factories was high as there were five coffee factories along the river for processing coffee after harvest. Irrigators abstracted water from the river to grow crops especially during dry season months when river flows were low thus reducing water quantity for downstream water users. Water was allocated through a system of permits but adequately failed in controlling abstractions since abstraction limits were exceeded or due to lack of enforcement of water rules. This was also noted by EWASCO who were of the view that encroachment of the riparian area and inadequate tree cover had contributed to decreased water supply. This means if these activities by farmers if continued unabated, they would lead to significant reduction in water quantity in Kapingazi River within the catchment.

Plate 4.12: Water abstraction using water channels from River Kapingazi in Kivumburi village

These results therefore shows that activities by farmers had a significant impact on both water quality and water quantity while tea factories and coffee factories had a significant effect on water quantity in Kapingazi catchment. This shows agricultural and agricultural related industrial activities were major human activities affecting water provision service in Kapingazi catchment. This research is similar to that done by Ekka *et al*. (2020) and Soko (2014) that anthropogenic modification through agriculture, industry, urbanization, deforestation and mining had impact on river ecosystem services such as changes in water quality and water supply. Also a study carried out by Omokhua and Koyejo (2008) in Rivers states, Nigeria which revealed that farming activities were an important primary human activity which had a strong impact on aquatic ecosystems. Davari *et al.* (2010) also found that agricultural-induced environmental changes impacted various ecosystem services, including both water quality and quantity. The study revealed that chemical use and soil erosion resulting from agriculture significantly affected water quality. The effect of agricultural practices on water bodies includes the introduction of sediments, pathogens, nutrients, metals, altered dissolved oxygen levels, and other habitat changes. According to Alavaisha (2020), agriculture affected both water quality and availability in the Kilombero Valley, Tanzania, due to land-use activities like cultivation and deforestation. These shifts in water quality and quantity reflect the integrated influence of various human activities along the Kapingazi River within its catchment.

The findings of this study support Peters and Maybeck (2000), who observed that modifications to landscapes and their vegetation affect not only the water balance but also the mechanisms controlling water quality and quantity. Anthropogenic pressures, such as industrial and agricultural practices and the intensified exploitation of water resources, contribute to the degradation of surface waters and compromise their usability for drinking, recreation, and other functions (Jarvie *et al.*, 1998). In addition, deforestation and intensified agriculture have been linked to increased runoff frequency and volume, reduced base flows, higher pesticide contamination, and elevated erosion and sedimentation in rivers and streams (Raini, 2009). Studies by Ekka *et al*. (2020) and Soko (2014) also established that industry, urbanization and agriculture cause modification of water resources by affecting water quality and water quantity.

4.6 Establishment of the willingness to pay for water provision services by the catchment users in Kapingazi catchment

The contingent valuation (CV) method was used to determine the economic value respondents attributed to water services, such as enhanced supply and quality, which are not directly traded in markets, in order to assess their willingness to pay for water provision services in the Kapingazi catchment. The respondents were presented with a hypothetical scenario of contributing towards a conservation fund in which they were asked to express the maximum amounts they were willing to pay for enhanced water service provision in terms of water quality and quantity. The significance of establishing the respondents willingness to pay for improved water services in Kapingazi catchment was to provide WTP data that assigned economic values to improved water services, making it possible to incorporate their importance into decision-making processes when designing a payment for ecosystem services scheme in Kapingazi catchment. Also policymakers can use the WTP information to ensure that the costs of compliance or participation are justified by the perceived benefits.

This study revealed that 99% of respondents were willing to participate in conserving the Kapingazi catchment to ensure sustainable water supply, provision of ecosystem goods, and improved water quality, despite 28% having low awareness of payment for ecosystem services (Figure 4.29). Additionally, 67% of respondents expressed willingness to pay for enhanced water services, including improved quality and quantity, through contributions to a conservation fund, even though 28% were not familiar with PES schemes. These findings align with Swai (2016), who reported that 71% of domestic water users were willing to pay for improved catchment services. The results suggest that respondents in Kapingazi catchment prioritize improved water quantity due to shortages and enhanced water quality.

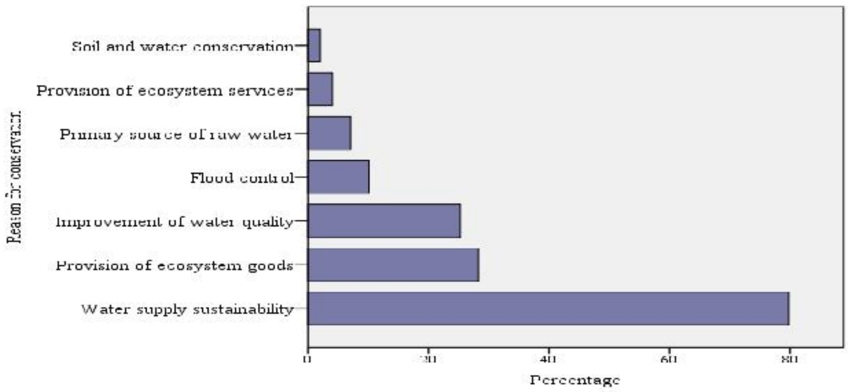

Figure 4.29: Respondents' reasons for willingness to participate in conserving Kapingazi catchment

People’s initiative to participate in conservation of the environment is positively affected by their awareness of environmental protection subject. Respondents willing to pay were asked how much the would be ready to contribute annually in Kenya Shilling. The results indicated an average willingness to pay of KES 916.50 per year for improved water services in the Kapingazi catchment. A majority of respondents (80.6%**)** expressed willingness to pay, with maximum amounts mostly below KES 1000. Specifically, KES 500 was the most frequently cited maximum amount (21 respondents), followed by KES 1000 (15 respondents). These results indicate that, despite already incurring monthly water connection fees, the respondents were willing to pay an additional amount for enhanced water services, since 94% of respondents were connected to piped water, either through in-house or on-compound taps as shown in Figure 4.30 and Table 4.27.

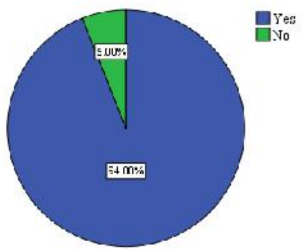

Figure 4.30: Percentage of respondents paying for water in Kapingazi catchment

This is because water quality and quantity had been declining over the last ten years as was observed by 79% of the respondents respectively as shown in Figures 4.31 and 4.32 respectively.

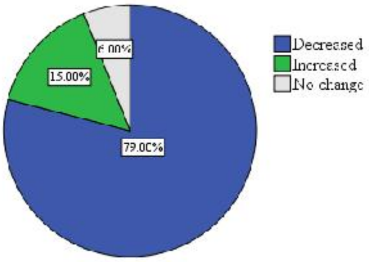

Figure 4.31: Water quality trend for the last ten years in Kapingazi catchment

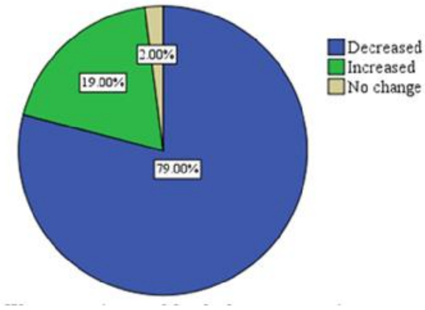

Figure 4.32: Water quantity trend for the last ten years in Kapingazi catchment

Most of the respondents in Kapingazi catchment had been connected to tap water. 16.1% had in-house tap water while 75.4% had compound tap water as shown in Table 4.28. The other sources of water used in Kapingazi catchment were borehole by 0.8% of the respondents. Out of the respondents, 3.4% sourced their water from Kapingazi River, while 1.7% depended on water from neighbors and 2.5% on rainwater. This indicates that the majority of respondents did not rely directly on water from River Kapngazi for domestic purposes. This could be as a result of awareness and the need for clean treated water from water supply companies in order to prevent waterborne diseases in as opposed to water of River Kapingazi. Those respondents who were not connected to tap water could have been attributed to lack of disposable income to pay for water connection fee.

Table 4.28

Main sources of water in Kapingazi catchment

Water Source	**N**	**%**
In-house tap water	19	16.1
Compound tap water	89	75.4
Borehole	1	0.8
River	4	3.4
Neighbour’s supply	2	1.7
Rain-harvested water	3	2.5
Total	**118**	**100.0**

According to this study, more than half of the respondents had moderately to somewhat available water with their households. This shows that water was not available throughout in majority of the households which is occasioned by water rationing especially during the dry season hence the willingness to pay for improved watershed services in Kapingazi catchment.

According to the study, 22% of participants indicated that their household water supply did not adequately meet their requirements. According to 50 % of these respondents, water shortage had been attributed to drought occasioned by the effects of climate change, deforestation (22.7%), increased number of water users (13.6%) since the water infrastructure had not been expanded to correspond with the growing population and inadequate maintenance of water infrastructure (13.6%) as shown in Table 4.29, therefore triggering the willingness to pay for improved water services in Kapingazi catchment.

Table 4.29

Causes of water shortage in Kapingazi catchment

Causes of water shortage	N	%
Drought	11	50.0
Deforestation	5	22.7
Increased number of water users	3	13.6
Inadequate maintenance of water infrastructure	3	13.6
Total	**22**	**100.0**

Source: (Field Data, 2018)

It was also apparent from the key informant meetings with water supply companies and projects that Kapingazi River had inadequate water flows to sustain water supply to the residents of Kapingazi catchment since five water companies and projects shown in Table 4.30, besides Kamiu Kavanga irrigation water project, none sourced water from Kapingazi river that was connected to the respondents within the catchment but sourced water from other rivers outside the catchment.

Table 4.30

Water supply companies and projects in Kapingazi catchment

Water Supply Company/Project	N	%
Kararitiri Water Project	15	15.0
Ngagaka Water Supply Company	16	16.0
Ngandori Nginda Water Consumers Association	56	56.0
Embu Water and Sanitation Company	6	6.0
Kamiu Kavanga Irrigation Project	1	1.0
Runga Irrigation Water Project	1	1.0
Not Applicable	5	5.0
Total	**100**	**100.0**

In order to cope with water shortage, 39.13% of the respondents with inadequate water supply fetch water from Kapingazi River while 34.78% and 26.09% harvest rain water from rooftops and store it in water tanks and 20 litre water jerry can containers when water for domestic use is unavailable respectively.

The remaining 5% of the respondents who had no piped water connection, was due to costs, disconnections for lack of payment of the monthly water connection fee and proximity to the river. When asked on their opinion on whether it was important to pay for water, 60% of the respondents disapproved because according to them it was government's responsibility to provide water and cost implications for connecting water to their households. Nonetheless, 40% of the respondents without piped water felt that it was an obligation to pay for water connection into their households in order to maintain the infrastructure.

4.6.1 Respondents' reasons for willingness to pay for improved water service provision in Kapingazi catchment

The motivation for willingness to pay amounts was also determined. The respondents were asked to indicate the reasons why they were willing to pay for enhanced water services. In this study, 43.9% of respondents cited that the main reason was the provision of clean and reliable water as shown in Table 4.31.

Table 4.31

Respondents' reasons for willingness to pay for improved water service provision in Kapingazi catchment

Reasons for WTP	**N**	**%**
To have a clean, reliable water supply	47	43.9
For the catchment to produce ecosystem services	13	12.1
My responsibility	1	0.9
For future generations	1	0.9
To benefit the local community	8	7.5
Water is a problem	3	2.8
Enhanced security	1	0.9
The money will be used to conserve the catchment	29	27.1
Reduced cost of health	1	0.9
Income from surplus food	1	0.9
Improvement of aesthetic value	1	0.9
To control soil erosion	1	0.9
Total	**107**	**100.0**

This is because majority of the respondents relied on agriculture for their sustenance for food and livelihood hence more water availability required to enhance production, and clean water is necessary to safeguard their health. Some respondents (27.1%) believed that the money would be used to conserve the catchment so that ecosystem goods and services could be produced that would benefit the local population, as reported by 12.1% and 7.5% of respondents, respectively. Other reasons reported by 0.9% of the respondents each for willingness to pay were to ensure water was available for future generations. Others felt it was their responsibility to pay for improved water services due to knowledge on importance of water conservation attributed by their education. Enhanced security was another reason for willingness to pay due to having water within their vicinity and reduced conflicts due to enhanced water availability. Reduced cost of health prompted willingness to pay for improved water quality as it would reduce incidences of waterborne diseases. Other respondents were willing to pay to improve food production due to improved water quantity in Kapingazi river to irrigate their farms. The other reason for WTP was to improve the aesthetic value of Kapingazi catchment.

Amponin *et al.* (2007) reported similar findings, offering possible explanations for water users' willingness to pay. Their study found that 78% of respondents desired a dependable water supply, while 21% valued protecting watersheds for future generations. EWASCO was willing to pay through contribution towards a conservation fund for conservation of Kapingazi catchment, whereas KenGen, was not willing to pay since they contribute to catchment protection through Water Resources Authority's Water Services Trust Fund.

4.6.2 Respondents' reasons for not willing to pay for improved water service in Kapingazi catchment

Approximately 35.3% of respondents were unwilling to pay for improved water services due to financial constraints. Among them, 8.8% indicated they could not afford any additional costs on top of their existing water bills, alongside other expenses such as electricity. as shown in Table 4.32.

Table 4.32

Respondents' reasons for not willing to pay for improved water service provision in Kapingazi catchment

Reason for Not WTP	**N**	**%**
Inadequate finances	12	35.3
Money paid will be mismanaged	1	2.9
Public good	5	14.7
No improved catchment	1	2.9
No trust	1	2.9
Other bills to pay	3	8.8
Old age	3	8.8
Small land sizes	2	5.9
Common fee agreed by all	2	5.9
Strict rules on river water usage	1	2.9
Family land disputes	1	2.9
Have done enough conservation on my farm	2	5.9
Total	**34**	**100.0**

This reason is as a result of low incomes due to engagement in small scale agriculture. Also, about 14.7% of the respondents argued that water is a public good therefore the conservation activities should be conducted by the government. This could be explained by the fact that watershed services are perceived as public goods. For example, upstream landholders can affect the quantity and quality of water by their land management decisions, but since they are not immediately impacted, they oftenly lack motivation to take these effects into consideration. Also, water users may lack motivation to pay for enhanced water services if non-payers cannot be excluded from enjoying the benefits (Pagiola *et al.*, 2002).

Among other reasons provided, 8.8% of respondents indicated that they had other bills to pay for example electricity due to low household incomes and reasons as a result of attrition due to passage of time. Therefore they were comfortable with the status quo and had no or little contribution towards future efforts to conserve the catchment to improve water services. 5.9% of the respondents indicated that small land sizes hindered them from paying for improved water services since the land available was agricultural production and had no space for conservation activities such as tree planting. Some respondents (5.9%) believed that the amount to paid had to be a common amount agreed by all to have equality and fairness in contributions. 5.9% of the respondents cited that they had done enough conservation in their farms evidenced by terracing, Napier grass strips, cover cropping, agroforestry among others. Other respondents (2.9%) had no trust on to who will manage the funds while others believed money will be mismanaged. This could be as a result of mismanagement of public funds in public offices therefore discouraging the respondents in contributing as the money would be misappropriated other than for the intended purposes of conservation. Also, 2.9% of the respondents argued that the payment would not result in improved catchment management.

Strict river water regulation had discouraged 2.9% of the respondents from paying because they were not supposed to use the river water especially for irrigation without permits from Water Resources Authority which according to them had hefty annual renewal charges. Land disputes among family members was also mentioned by 2.9% of the respondents therefore they could not commit at the time of the household interviews until the issues would be resolved. These results coincides with those of Calderon *et al.* (2006), whereby among the respondents not willing to pay, 9% claimed they they were unable to pay extra charges, another 9% believed that the government should be responsible for watershed management, while 4% indicated that the existing water tariff was already too high.

4.6.3 Factors influencing willingness to pay for improved waters services in Kapingazi catchment

As procedure to run logistic regression for checking willingness to pay for improved water services in Kapingazi catchment, the study checked for assumptions satisfied by the model.

4.6.3.1 Assumptions of logistic regression satisfied by the model for willingness to pay for improved water services in Kapingazi catchment

The diagnostic tests for the logistic regression for willingness to pay for improved water services in Kapingazi catchment were tested as shown below.

i. The dependent/response variables were dichotomous with the response of Yes or No as shown in the dependent variable encoding Table 4.33.

Table 4.33

Dependent variable encoding for willingness to pay for improved water services

Original Value	Internal Value
No	0
Yes	1

ii. The dataset comprised independent observations, with no repeated measures from the same individual or interrelated entries. The assumption was verified by the Durbin-Watson test of linear regression between the dependent and independent variables, resulting in a value of 2.426, which falls within the permissible range of 1.5 to 2.5, showing the absence of autocorrelation as shown in the Table 4.34.

Table 4.34

Model summary[b] for willingness to pay

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.452[a]	0.205	0.099	0.44750	2.426

a. Predictors: (Constant), Watsource1recoded, Activity1recoded, Fda1recoded, Household Income, Tnr1recoded, Gen1recoded, Household Size, Land Size Owned (Ha), Educ1recoded, Age (Years)

b. Dependent Variable: Willing To Pay

iii. Multicollinearity was not detected among the independent variables. The VIF test showed that none of the explanatory variables were highly correlated, ensuring that each contributed unique information to the regression model. There was no relationship between a predictor and the other variables as indicated by a VIF score of 1 in the model. When a predictor variable's value is between 1 and 2, it means that there is no correlation with any other predictor variables in the model as shown in Table 4.35.

Table 4.35

Coefficients[a] for willingness to pay

Model 1	Collinearity Statistics	
	Tolerance	**VIF**
Age (Years)	.416	2.401
Household Income	.833	1.200
Land Size Owned (HA)	.715	1.398
Household Size	.448	2.232
FDA1Recoded	.918	1.090
Tenure1Recoded	.815	1.227
Gender1Recoded	.809	1.236
Activity1Recoded	.749	1.335
Education1Recoded	.728	1.374
WaterSource1Recoded	.820	1.219

a. Dependent Variable: Willing To Pay

iv. The independent variables showed a linear relationship with the logit of the dependent variable. This assumption was evaluated using the Hosmer-Lemeshow test, which yielded an insignificant result ($p = 0.272$, $p > 0.05$) as shown in Table 4.36.

Table 4.36

Hosmer and Lemeshow test for willingness to pay

Step	Chi-square	df	Sig.
1	9.908	8	0.272

v. The sample size was sufficiently large, tested through the Hosmer and Lemeshow test (Table 4.35) for goodness of fit to the data which was insignificant with $p = 0.272$

vi. There were no influential outliers in the dataset. This was checked through the Cook's distance test as shown below. The highest value did not exceed 1 in the Cook's distance therefore there were no extreme outliers as shown in Figure 4.33.

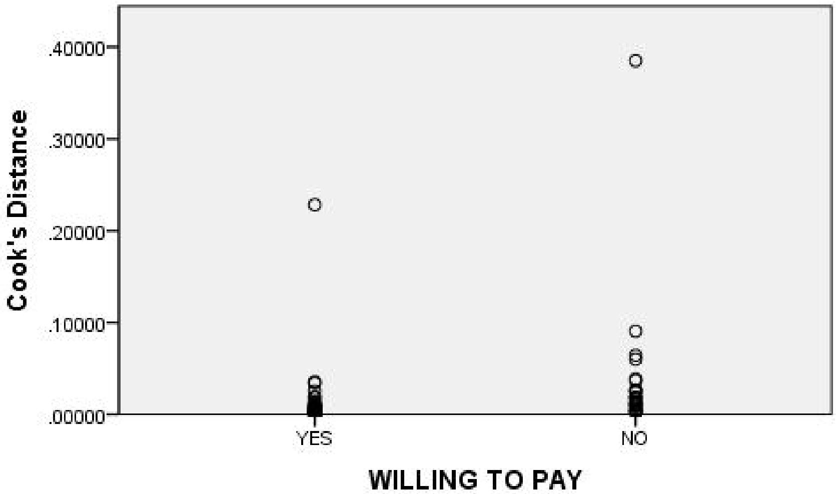

Figure 4.33: Cook's distance for willingness to pay

4.6.3.2 Logistic regression for willingness to pay for improved water services in Kapingazi catchment

As shown in Table 4.41, the factors influencing the Kapingazi catchment's respondents' willingness to pay (WTP) for enhanced water services were determined using logistic regression analysis. The results demonstrated that age, education, and household size were the most influential factors at the 95% confidence level. This section outlines the model's overall performance using the Omnibus Tests of Model Coefficients, along with the regression coefficients and odds ratios summarized in the Variables in the Equation table. The diagnostic test results revealed a statistically significant chi-square statistic at the 5% level, $X^2(10, n=86) = 18.711$, $p < 0.044$, confirming that the independent variables collectively influence willingness to pay.

Table 4.37

Omnibus tests of model coefficients

Step 1	**Chi-square**	**df**	**Sig.**
Step	18.711	10	.044
Block	18.711	10	.044
Model	18.711	10	.044

The Omnibus test of model coefficients indicated that the model as a whole was statistically significant, $X^2(10, n=86) = 18.711$, $p = 0.044$ as shown in Table 4.37.

Table 4.38

Model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	89.822[a]	.196	.273

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

The model summary table (Table 4.38) summarizes the Cox & Snell R^2 and Nagelkerke R^2 statistics, which measure the proportion of explained variation and are frequently known as pseudo R^2 values. These values are generally lower than those in multiple regression but can be interpreted in a similar way, with added caution. According to our model, the dependent variable's (changes in water quality) explained 19.6% of the variance using Cox & Snell R^2 and 27.3% using Nagelkerke R^2.

Table 4.39

Hosmer and Lemeshow test

Step	Chi-square	df	Sig.
1	9.908	8	0.272

The Hosmer-Lemeshow test (Table 4.39) evaluated whether the model’s predictions aligned with the observed group classifications. By comparing the observed and expected frequencies under the linear model, a chi-square statistic was calculated. A non-significant result (0.272) indicates a good fit between the model and the data.

Table 4.40

Classification table

Observed WTP (Recoded)	**Predicted WTP (Recoded)**		**Percentage Correct**
	No	Yes	
Step 1			
No	10	18	35.7
Yes	7	51	87.9
Overall Percentage			**70.9**

. The cut value is .500

Table 4.40 presents the classification results from logistic regression, which estimated the likelihood of an event (willingness to pay for improved water services) occurring. If the probability was greater than or equal to 0.5, SPSS Statistics classified the event as occurring; otherwise, it was classified as not occurring. Evaluation of the model's classification performance was made possible by the binomial logistic regression, which assessed whether cases were correctly predicted from the independent variables.

The model correctly classified 70.9% of cases overall (see the “Overall Percentage” row), representing the overall classification accuracy, with the inclusion of the independent variables. The responses of individuals willing to pay for enhanced water services was correctly predicted 87.9% of the time (see the “Percentage Correct” column under “Yes”), reflecting the model’s sensitivity. The responses of individuals who were not willing to pay for enhanced water services was correctly predicted 35.7% of the time (see the “Percentage Correct” column under “No”), representing the specificity. The positive predictive value the proportion of correctly predicted cases with the characteristic relative to all cases predicted as having it was calculated as 100 × (51 ÷ (18 + 51)) = 73.9%**,** meaning 73.9% of cases predicted to cause changes were correct. The negative predictive value the proportion of correctly predicted cases without the characteristic relative to all cases predicted as not having it was 100 × (10 ÷ (10 + 7)) = 58.8%**,** indicating that 58.8% of cases predicted not to cause changes were correct.

Table 4.41

Variables in the equation

Step 1	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Age	-.073	.026	7.963	1	.005	.929	.883	.978
Income	.000	.000	.061	1	.805	1.000	1.000	1.000
Land size	.053	.167	.099	1	.752	1.054	.760	1.461
FDA(1)	-.634	.549	1.334	1	.248	.531	.181	1.556
Land tenure(1)	-.226	.644	.123	1	.726	.798	.226	2.820
Gender(1)	.112	.596	.036	1	.851	1.119	.348	3.596
Main activity(1)	-.672	.752	.798	1	.372	.511	.117	2.231
Education level(1)	1.481	.662	5.003	1	.025	4.396	1.201	16.089
Water source(1)	-1.187	1.577	.567	1	.451	.305	.014	6.704
Household size	.297	.151	3.836	1	.050	1.345	1.000	1.810
Constant	4.002	1.949	4.215	1	.040	54.691		

a. Variable(s) entered on step 1: Age, Income, Land size, Focal Development Area (FDA),

Land tenure, Gender, Main activity, Education level, Water source and Household size.

Willingness to Pay = 4.002 - 0.073(Age) + 1.481 (Education level) + 0.297 (Household size)

The Wald test, which is shown in the "Wald" column, was applied to evaluate the statistical significance of each independent variable in the variables in the equation table (Table 4.41). The “Sig” column reports the corresponding significance values. The results indicate that age (p = 0.005), education (p=0.025) and household size (p=0.05) contributed significantly to the model, whereas income (p = 0.805), land size (p = 0.752), FDA (p=0.248), land tenure (p = 0.726), Gender (p = 0.851), economic activity (p = 0.372) and water source (p = 0.452) did not show significant contributions**.**

The probability of an event occurring given a one-unit change in an independent variable, while holding all other variables constant, was estimated using the "Variables in the Equation" table. Results indicate that the odds of age, education and household size influencing willingness to pay for improved water services (“yes” category) were 0.929, 4.396 and 1.354 times higher than those of income, land size, focal development area (FDA), land tenure, gender, economic activity and water source within the Kapingazi catchment.

To determine the factors influencing the willingness to pay for enhanced water services such as age, income, land size, focal development area, land tenure, gender, activity, education, water source and household size in the Kapingazi catchment, a logistic regression was performed. The analysis was statistically significant, $X^2(7, n = 86) = 18.711$, $p < 0.044$, accounting for 27.3% of the variance (Nagelkerke R^2). The model correctly predicted 70.9% of willingness to pay for improved water services estimated at 4.002 - 0.073(Age) + 1.481 (Education level) + 0.297 (Household size).

The pseudo R-squared for the logistic regression model was 0.273, indicating that 27.3% of the variation in WTP is explained by the explanatory variables. This is considered sufficiently high, given that low R-squared values are commonly expected in cross-sectional contingent valuation (CV) studies (Hundie & Abdisa, 2016). According to Mitchell and Carson (1989), CV studies yielding an R-squared below 0.15, when based on only a few key variables, raise concerns about reliability. By this standard, the present model is reliable. Furthermore, the Likelihood Ratio Chi-Square test ($p = 0.044$) and the count R-squared confirm that the model provides a good and reliable fit to the data.

Age, education and household size were 0.929, 4.396 and 1.345 times respectively more likely to to influence willingness to pay for improved water services in Kapingazi catchment in Embu County, Kenya. A higher likelihood of influencing respondents' willingness to pay for improved water services in the Kapingazi watershed, Embu County, Kenya, was associated with respondents' younger ages, household sizes, and levels of education.

Depending on variations in explanatory variables, the signs indicate the direction of change in the probability of willingness to pay for improved water services. A positive sign denotes an increase in willingness, whereas a negative sign indicates otherwise. The analysis revealed that respondents' age, education, and household size were significant determinants of willingness to pay, while factors such as location (Focal Development Areas), gender, land tenure, main activity, watersource, income, land size, and occupation were not statistically significant. The positive coefficients for education and household size increased the likelihood of households being willing to pay for improved water services.

4.6.3.1 Age

The coefficient of respondents' age was negatively associated with willingness to pay for enhanced water services and was statistically significant at the 5% level. This indicates that as age increases, the probability of willingness to pay decreases. Each additional year of age reduced the odds of willingness to pay by a factor of 0.929, meaning older respondents were less likely to contribute than younger ones. This could be attributed to older individuals having adapted to the current water service system and facing income limitations, which reduce their preference for improved services. However, younger respondents, who generally have higher disposable incomes, expressed greater willingness to pay. These findings are consistent with Gidey and Zeleke (2015), who observed that older individuals hesitate to invest in projects with long-term returns, while Fujita *et al.* (2005), reported that younger people are more willing to pay for enhanced water services due to higher income levels.

4.6.3.2 Education level

Respondents' education level is positively signed therefore has a significant positive influence on the willingness to pay WTP, which means that respondents with higher education had higher probability of willingness to pay for enhanced water services meaning as the level of education increased by one level, the likelihood of willingness to pay by respondents in Kapingazi catchment increased by 4.4 times. The odds ratio is 4.396 for an additional higher level in education. Therefore, by increasing education by one level the odds of willingness to pay increases by a factor of 4.396. These results may be due to fact that most of the respondents with higher education i.e. high school education and college/tertiary education had more understanding of conservation of the catchment due to implications of water shortage and low water quality than those with lower education i.e. primary level of education or no education in the study area. As a result, they showed higher willingness to pay for enhanced watershed services to secure a reliable water supply for their agricultural activities.

These results correspond to the study conducted by Mezgebo and Ewnetu (2015), who found out that residents with higher levels of education were more likely to pay than those with less education. Amponin *et al.* (2007) also observed that educated people had a better understanding of the future risks of reduced water quantity on crop production and thus better appreciated the significance of payment for watershed services. Rahman *et al.* (2017) revealed that respondents with education up to the secondary level demonstrated a higher willingness to pay for improved water supply compared to respondents with lower level of education. Bogale and Urgessa (2012) also established that education significantly influenced willingness to pay (WTP) for enhanced water services in Eastern Ethiopia.

4.6.3.3 Household size

Household size is positively signed, indicating that larger households have higher probability of willingness to pay (WTP) for improved water services than smaller households. As the number of household members increases, the probability of willingness to pay in the Kapingazi catchment increased by a factor of 1.345. This result can be explained by the higher water demand in bigger households for domestic use and food production. Similar findings were reported by Hundie and Abdisa (2016) in Jigjiga town, Ethiopia. However, Moffat *et al.* (2013) observed the opposite, noting that larger families often face budgetary constraints that reduce their WTP.

Contrary to many previous studies, this research did not establish a significant relationship between household income and willingness to pay (WTP) for enhanced water services among respondents in the Kapingazi catchment. This outcome can be attributed to the correlation between household income and the explanatory variable, education, in the model (Akter, 2013). It further implies that respondents value the natural environment highly, regardless of their income levels (Swai, 2016). This finding challenges the economic theory that household commodity's demand is mainly dependent on income and aligns with Zebilo's (2006) study in Simbu Province, Papua New Guinea, which also reported no significant statistical effect of income in Kegsugl.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

The summary, conclusions and recommendations of the study are highlighted in this chapter.

5.2 Summary of findings

This study established that Kapingazi catchment provides a variety of ecosystem services such as food production, soil erosion control, livestock production, fuel and timber provision, landscape scenery, carbon sequestration, climate regulation whereby the main ecosystem service is water. Being an agricultural landscape there was knowledge of provisional services more than regulatory, supporting and cultural ecosystem services.

The main catchment users in Kapingazi catchment were rural farmers, irrigators, coffee and tea factories, government institutions, HEP producers among others. Lack of coordination among the various catchment user in catchment management, shows there is need to involve all the catchment users in decisions regarding catchment management in Kapingazi catchment.

It was also established that freshwater related ecosystem services, including water quality and supply were affected by perceived catchment user activities that do not incorporate the need for provision of these services by catchment users in Kapingazi catchment. Activities by farmers, for example cultivation within riparian zones, chemical pest and disease management, river washing, deforestation, and the lack of soil and water management practices, stone mining and poor waste management affected the water quality of River Kapingazi. Whereas farmers activities, tea factories through deforestation and coffee factories through water abstraction affected the water quantity of River Kapingazi.

The results indicate that the respondents of Kapingazi catchment were willing to pay for enhanced water services in both water quality and supply. Age, education and household size were the factors that influenced the willingness to pay in Kapingazi catchment which should be considered when designing a conservation project in Kapingazi catchment. A holistic and integrated approach in conservation and management of Kapingazi catchment is required. The demonstrated willingness to pay for enhanced water ecosystem services indicates there is potential for implementing a payment for ecosystem services (PES) scheme to support the restoration of Kapingazi catchment through sustainable land management. There is also capacity to shape public policy regarding payment for ecosystem services schemes in Kenya, which can promote the conservation of water catchments. Therefore, based on results of this study, conclusions can be drawn concerning the specific objectives of the research.

5.3 Conclusions

i. The Kapingazi catchment provides a wide array of ecosystem services such as food production, soil erosion control, and carbon sequestration, but water services stand out as the primary ecosystem service. This highlights the need of managing both water quality and quantity to support ecological health and human welfare within the catchment. Although the catchment provides a range of ecosystem services, local awareness is mainly focused on provisioning services, with less knowledge of regulatory, supporting, and cultural services. This suggests a need for educational initiatives to increase awareness of the broader ecological functions that support long-term sustainability.

ii. Fragmented management and lack of coordination among diverse catchment users such as rural farmers, irrigators, factories, Kapingazi WRUA, KenGen, Irangi CFA, research and government institutions impedes effective catchment management. Involving all stakeholders in catchment management decisions is crucial for a holistic approach to maintaining ecosystem services and promoting sustainable practices.

iii. Perceived negative effects of agricultural and industrial activities on water resources are apparent: Unsustainable agricultural practices by farmers, such as riparian cultivation, use of chemicals, deforestation, quarrying, inadequate soil and water conservation practices and poor waste management, degrade water quality and water quantity. Industrial activities, including water abstraction by coffee fatories and deforestation by tea factories reduced water quantity. Catchment management is essential to mitigate these specific threats in order to sustain the provision of water ecosystem services.

iv. The observed willingness to pay for enhanced water quality and supply reflects significant support for a Payment for Ecosystem Services (PES) program. Demographic factors influencing willingness to pay, including age, education, and household size, should be taken into account when designing and operationalizing a locally tailored PES model. The study reveals an opportunity to leverage PES as a policy tool in Kenya, potentially guiding public policy to incorporate ecosystem service valuation in water catchment conservation.

Implementing such schemes can promote sustainable land management practices, improve water services, and inspire similar conservation efforts across Kenya.

5.4 Recommendations

i. Community workshops and outreach programmes should be conducted emphasizing the significance of supporting, regulating and cultural ecosystem services, in addition to provisioning services to increase awareness on ecosystem services. Farmers and other stakeholders should be educated on sustainable practices that protect soil, water, and biodiversity, ensuring a holistic understanding of how these services support long-term agricultural and ecological health.

ii. A multi-stakeholder platform that includes farmers, industry representatives, government institutions, and other catchment users to coordinate on catchment management initiatives should be established. A catchment management committee to facilitate regular communication, share best practices, and collaboratively develop sustainable land and water management strategies should be developed. Policies promoting inclusive participation in catchment management decision-making should be supported to ensure equitable representation of all stakeholder groups.

iii. Through environmental education, farmers in the Kapingazi catchment can improve water quality and availability by implementing soil and water conservation strategies such as terracing agroforestry, grass strips, integrated pest management, riparian buffer zones, and proper waste management. Reforestation programmes targeting farmers will improve the tree cover in Kapingazi catchment. There should be engagement with coffee factories to manage water use through more efficient technologies, such as water recycling systems and rainwater harvesting. Water abstraction permits by coffee factories should be reviewed in order to regulate the amount of water abstracted for coffee factories thus, will reduce over abstraction of water and improve the amount of water reaching downstream users.

   Alternative sources of energy for tea processing should be considered by tea factories in order to reduce reliance of fuel wood for processing such as solar energy, micro-hydroelectric power, biomass briquettes to supply the energy required for tea processing, This will reduce deforestation and improve water quality and flows in Kapingazi catchment.

Incentives such as subsidies or tax breaks should be provided for industries and farmers that adopt sustainable practices to reduce their environmental impact on water quality and quantity.

iv. During projects design related to the PES participation and payment schemes for improved water services, there should be consideration of the household demographic characteristics such as age, education level and household size to increase accessibility and fairness. Partnerships with governmental and non-governmental organizations should be sought to secure funding and technical support for the PES programme. Engagement between policymakers and stakeholders on the benefits of a PES model for sustainable catchment management should be encouraged to garner support for its implementation at a larger scale.

5.5 Suggestions for further studies

i. Water quality and water quantity of River Kapingazi was not measured in Kapingazi catchment. Additional research should be undertaken to evaluate the physical parameters including temperature, flow, sediment characteristics, and the potential for riverbank erosion are essential. Measurement of chemical condition of water, sediments, and fish tissue, with particular attention to key constituents such as dissolved oxygen, nutrients, heavy metals, oils, and pesticides should be conducted. Biological assessments should be carried out to examine the abundance and diversity of aquatic flora and fauna, as well as the survival rates of test organisms in the sampled water. This should be conducted to characterize and determine the condition of River Kapingazi due to the perceived effects of catchment user activities in Kapingazi catchment.

ii. According to the results of this study, WTP data can inform the designing of environmental policies. For instance, when establishing conservation programs like payment for ecosystem services projects, the WTP information will ensure that the costs of compliance or participation are justified by the perceived benefits. Also, having robust WTP estimates can bolster the case for the project's value and impact. It provides evidence of public support and potential return on investment. WTP data is useful for long-term planning and setting goals for environmental sustainability. The preferences and values of the public are considered by the decision-makers when shaping policies that affect the environment. Therefore, a payment for ecosystem service project should be conducted in Kapingazi catchment.

REFERENCES

Ahtiainen, H. (2007). *The willingness to pay for reducing the harm from future oil spills in the gulf of finland- An application of contingent valuation method. Paper No 18; Environmental Economics.* Finland, University of Helsinki.

Akter, S. (2013). *Farmers' willingness to pay for irrigation water under government managed small scale irrigation projects in bangladesh*. Department of Economics, North South University.

Alavaisha, E. (2020). *Agricultural expansion impacts o wetland ecosystem services from Kilombelo valley, Tanzania*. Sweden, Stockholm University.

Allan, J.D., Erickson, D.L., & Fay, J. (1997). The influence of catchment land use on the stream integrity across multiple spatial scales. *Freshwater Biology*, 37, 149-161.

Amondo, E., Kironchi, G., & Wangia, S. (2013). Willingness to pay for improved water supply due to spring protection in Emuhaya District, Kenya. *International Journal of Education and Research,* 1, 7.

Amponin, J. A., Bennagen, E., Hess, S., & Dela Cruz, J. (2007). *Willingness to pay for watershed protection by domestic water users in tuguegarao city*. *Working paper No. 6.* Philippines, Poverty Reduction and Environmental Management.

Bautista, G. M. (2003). *Lessons in the development of markets for ecosystem services in a watershed context: A survey of different country experiences*. Department of Environment and Natural Resources, Philippines; United States Agency for International Development; Philippine Environmental Governance Project.

Behailu, S., Kume, A., & Biruck, Y. (2012). Household's willingness to pay for improved water service: A case study in Shebedino District, Southern Ethiopia. *Water and Environment Journal,* 26 (3), 429 – 434.

Bishop, R. C., & Heberlein, T. A. (1979). Measuring values of extra market goods: Are indirect measures biased? *American Agricultural Economics Association*, 61, 926 – 930.

Boafo, Y. A., Osamu, S., & Takeuchi, K. (2014). Provisioning ecosystem services in rural savanna landscapes of Northern Ghana: An assessment of supply, utilization and drivers of change. *Journal of Disaster Research*, 9, 501–515.

Bogale, A., & Urgessa, B. (2012). Households' willingness to pay for improved rural water service provision: Application of contigent valuation method in Eastern Ethiopia. *Journal of Human Ecology,* 38 (2), 145 -154.

Bond, I., & Mayers, J. (2010). *Fair deals for watershed services. Lessons from a multi-country action learning project.* Natural resources issues No. 13. London: IIED.

Borisova, T., Racevskis, L., & Searcy, M. J. K. (2012). Stakeholder analysis of a collaborative watershed management process: A Florida case study. *Journal of the American Water Resources Association*, 48 (2), 277 – 296.

Bunn, S. E., Davis, P. M., & Mosisch, T. D. (1999). *Ecosystem measures of river health and their response to riparian and catchment degradation.* Australia, University of Western Australia, Nedland, WA 6907.

Butchart, S. H. M., Walpole, M., Collen, B., Van Strien, A., Scharlemann, J. P.W., & Almond, R. E. A. (2010). Global biodiversity: Indicators of recent declines. *Science*, 328, 1164–1168.

Calderon, M. M., Camacho, L.D.,Carandang, M. G., Dizon, J. T, Rebugio L. L., & Tolentino, N. L. (2006). Willingness to pay for improved watershed management: Evidence from metro manila, Philippines. *Forest Science and Technology*, 2(1), 42-50.

Calderon, M. M., Anit, K., Palao, L. K. M., & Lasco, R. D. (2013). Household willingness to pay for improved watershed services of the Layawan watershed in Oroquieta City, Philipines. *Journal of Sustainable Development,* 6, 1.

Carroll, N. & Jenkins, M. (2010). *The matrix: Mapping ecosystem service markets.* The Katoomba Group; Forest Trends; Ecosystem Marketplace.

Castelle, A. J., & Johnson, A. W. (2000). *Riparian vegetation effectiveness*. Technical bulletin No. 799. Research Triangle Park, NC; National Council for Air and Stream Improvement.

Cavelier, J., Gray, I. M. (2014). *GEF investments on payent for ecosystem services schemes*. Global Environment Facility.

Chutter, F. M. (1996). The effect of silt and sand on the invertebrate fauna of streams and rivers. *Hydrobiology,* 34, 57 – 76.

Cocklin, C., Mautner, N., & Dibden, J. (2007). Public policy, private landholders, perspectives on policy mechanisms for sustainable land management. *Journal of Environmental Management*, 85, 986 – 998.

Constanza, R. Groot, R., Braat, L., Kubiszewske, I., Fioramonti, L., Sutton, P., Farber, S., & Grasso, M. (2016). Twenty years of ecosystem services: How far have we come and how far do we still to go? *Ecosystem Services,* 28, 1-16.

Coster, A. S., & Otufale, G. A. (2014). Households' water-use demand and willingness to pay for improved water services in Ijebu Ode local government area, Ogun State Nigeria. *Journal of Environment and Earth Science*, 4 (17), 1-10.

Cowling, R. M., Egoh, B., Knight, A. T., O'Farrell, P. J., Reyers, B., Rouget, M., Roux, D. J., Welz, A., & Wilhelm-Rechman, A. (2008). An operational model for mainstreaming ecosystem services for implementation. *Proceedings of the National Academy of Sciences*, 105 (28), 9483–9488.

Dagnew, D. C., Guzman, D. C., Zegeye, A. D. Tibebu, T. Y., Getaneh, M., Abate, S., Zemale, F. A. Ayana, E. K., Tilahun, S. A., & Steenhuis T. S. (2015). Impact of conservation practices on runoff and soil loss in the sub-humid Ethiopian highlands: The Debre Mawi watershed. *Journal of Hydrology and Hydromechanics, 63* (3), 210–219.

Davari, M. R., Moola, R. Tewari, J. C. & Kaushish S. (2010). Impact of agricultural practice on ecosystem services. *International Journal of Agronomy and Plant Production* 1 (1), 11 – 23.

Dean, E., Elardo, J., Green, M., Wilson B. & Berger, S. (2020). *Principles of economics: Scarcity and social provision*. (2nd ed.). Rice University.

Dixon, J., A. Gulliver, A., & Gibbon, D. (2001). *Farming systems and poverty: Improving farmers' livelihoods in a changing world*. Rome, Italy, FAO; Washington D.C. U.S.A, World Bank.

Dudgeon, D., Arthington, A. H., & Gessner, M. O. (2006). Freshwater biodiversity: Importance, threats, status and conservation challenges. *Biological Reviews*, 81, 163 – 182.

Eboh, E., Oduh, M., & Ujah, O. (2012). *Drivers and sustainability of agricultural growth in Nigeria. Enugu, Nigeria.* Research Paper 8, African Institute for Applied Economics.

Ekka, A., Pande, S., Jiang, Y., & Zaag, P. (2020). Anthropogenic modifications and river ecosystem services: A landscape perspective. *Water*, 12 (10), 2706.

Embu County Government (2019) *Embu county integrated development plan 2018 – 2022*. Embu County Government.

GOK. (2015). *Enviromental Management and Coordination Act*. Government Printers, Kenya, Nairobi.

Enjebo, I., & Oborn, L. (2012). *A farming system analysis on the slope of Mount Kenya.* Sweden, Uppsala Universitet.

Ericksen, P., Leeuw, J., Said, M., Silvestri, S., & Zaibet, L. (2012). Mapping ecosystem services in Ewasongiro catchment. *International Journal of Biodiversity Science, Ecosystem Services and Management,* 8 (1-2), 122 -134.

Engel, S., Pagiola, S., & Wunder, S. (2008). Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics*, 65, 663-674.

Forest trends, The Katoomba Group, & UNEP (2008). *Payments for Ecosystem Services. Getting Started: A Primer*. Nairobi, Kenya, UNON, Publishing Service Section.

Fripp, E. (2014). *Payments for Ecosystem Services (PES): A practical guide to assessing the feasibility of PES projects*. Bogor, Indonesia, CIFOR.

Fuggle, R. F., & Rabie M. A. (1994). *Environmental management in South Africa.* Juta and Co.

Fujita, Y., Fujii, A., Furukawa, S., & Ogawa, T. (2005). Estimation of willingness-to-pay for water and sanitation services through contingent valuation method. A Case Study in Iquitos City, The Republic of Peru. *Japan Bank for International Cooperation,* 11, 59 – 87.

Gidey, K. M., and Zeleke, E. (2015). Households willingness to pay for improved water services in urban areas: A case study form Nebelet town, Ethiopia. *Journal of Development and Agricultural Economics,* 7(1), 12-19.

Global Water Partnership. (2015). *Integrated water resources management in eastern africa: coping with "complex" hydrology.* Stockholm, Sweden, Global Water Partnership Secretariat.

Global Water Partnership. (2017). *GWP in action*. Stockholm, Sweden, Global water Partnership Secretatiat.

GOK. (2007). *Kenya vision 2030: A globally competitive and prosperous Kenya*. Nairobi, Kenya, Government Printers.

Groot, R. S., Wilson, M. A., & Boumans, R. M. J. (2002). A typology for classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics*, 41 (3), 393 – 403.

Groot, R., Brander, L., Van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, A., Hein, L., Hussain, S., Kumar, P, McVittie, A., Portela, R., Rodriguez, L. C., Brink, P., & Beukering, P. (2012). Global estimates of the value of ecosystems and their services in monitary units. *Ecosystem Services,* 1 (1), 50 -61.

Haines-Young, R., & Potschin, M. (2013). *Common international classification of ecosystem services (CICES) consultation on version 4, August – December 2012. Report to the European Environment Agency.* The University of Nottingham, Centre for Environmental Management.

Heathewaite, A. L. (2010). Multiple stressors on water availability at global catchment scales: understanding human impact on nutrient cycles to protect water quality and water availability in the long term. *Freshwater Biology,* 55 (1), 241 -257.

Hlasny, T., Kocicky, D., & Maretta, M. (2015). Effects of deforestation on watershed balance: Hydrological modelling-based approach. *Forestry Journal*, 61 (2), 89 – 100.

https://www.awa.asn.au/membership-specialist-water-networks/catchment-management. Retrieved on 24/07/2023

Hu, W. (2019). Impacts of human activities in the Hanjiang River basin, China. *Journal of Coastal Research*, 96 (1), 68 -75.

Hundie, S. K., & Abdisa, L. T. (2016). Households' willingness to pay for improved water supply: Application of the contingent valuation method; evidence from Jigjiga Town, Ethiopia. *Romanian Economic Journal,* 62, 191–214.

Hunink, J. E., & Droogers, P. (2015). *Impact assessment of investment portfolios for business case development of the Nairobi Water Fund in the Upper Tana River , Kenya*. The Netherlands, Future Water.

Jara-Rojas, R., Bravo-ureta, B. E., Engler, A., & Díaz, J. (2013). An analysis of the joint adoption of water conservation and soil conservation in Central Chile. *Land Use Policy*, 32, 292–301.

Jarvie, H. P., Whitton, B. A., & Neal, C. (1998). Nitrogen and phosphorus in east coast British rivers: speciation, sources and biological significance. *Science of the Total Environment*, 210, 79–109.

Joo, R. J. (2011). *Public willingness to pay for ecosystem services: Water quality in the Triangle region, North Carolina.* U.S.A, Duke University.

Kagombe, J. K., Cheboiwo, J. K., Gichu, A., Handa, C., & Wamboi, J. (2018). Payment for environmental services: Status and opportunities in Kenya. *Journal of Resources Development and Management*, 40.

Kasomo, D., (2006). *Research Methods in Humanities and Education*. Njoro, Kenya, Egerton University.

Kayaga, S., Calvert, J., & Sansom, K. (2003). Paying for water services: effects of household characteristics. *Utilities Policy*, 11 (3), 123 - 132.

Khan H., Iqbal, F., Saeed, I., & Khan, I. (2010). Estimating willingness to pay for improvements in drinking water quality: Evidence from Peshawar, Northern Pakistan. *Environmental Economics*, 1 (2), 38.

Kombo, K. D., & Tromp, A. L. D. (2006). *Proposal and thesis writing: An introduction.* Nairobi: Pauline's publication.

Knapp, A. K., Caroll, C. J. W., & Fahey, T. J. (2014). Primary production in terrestrial ecosystem: Patterns and contrls in a changing world. *Ecology and the Environment*, (1- 36).

Koppen, B. (2000). *Stakeholder indentification and participation*. Colombo, Sri Lanka, International Water Management Institute.

Kothari, C. R. (2007). *Research methodology: Methods and techniques*. New Delhi: New Age International (P).

Landell-Mills, N. & Porras, I. T. (2002). *Silver bullet or fools' gold? A global review of markets for forest environmental services and their impacts on the poor.* ***.*** *Instruments for sustainable private sector forestry series.* London: International Institute for Environment and Development.

Lindberg, K., Johnson, R. L., & Berrens, R. P. (1997). Contingent valuation for rural tourism development with tests of scope and mode stability. *Journal of Agricultural and Resource Economics,* 22 (1), 44-60.

Loomis, J. B. (2002). *Integrated public lands management: Principles and applications to national forests, parks, wildlife refuges and BLM lands.* New York, U.S.A, Columbia University Press.

Lopa, D., Mwanyoka, I., Jambiya, G., Massoud, T., Harrison, P., Ellis-Jones, M., Blomley, T., Leimona, B., Noordwijk, M., & Burgess, N. D. (2012). Towards operational payment for water ecosystem services in Tanzania: A case study from the Uluguru Mountains. *Fauna and Flora International. Oryx*, 46(1), 34 – 44.

Lopez-Marrero, T., & Hermansen-Báez, L.A. (2011). *Participatory listing, ranking, and scoring ecosystem services and drivers of change*. [Guide]. Gainesville, Florida: USDA Forest Service, Southern Research Station.

Mahoo, H. F., Mkoga, Z. J., Kasele, S. S., Igbadun, H. E., Hatibu, N.. Rao, K. P. C., & Lankford, B. (2007). *Productivity of water in agriculture: Farmers' perceptions and practices.* Colombo, Sri Lanka, International Water Management Institute.

Makenzi, P. M. (2012). *Payment for environmental services approach (PESA) as an innovative financing mechanism for conservation of catchments: A livelihoods case study of Lake Naivasha and River Malewa watershed in Kenya*. Njoro, Kenya, Egerton University.

Mango, L. M., Melesse, A. M., McClain, M .E., Gann, D., & Setegn, S. G. (2011). Land Use and climate change impacts on the hydrology of the upper Mara River Basin, Kenya: resultsof a modelling study to support better resource management. *Hydrology and Earth System Sciences*, 15, 2245–2258.

Masese, F. O., Muchiri, M., & Raburu, P. O. (2009). Macroinvertebrate assemblages as biological indicators of water quality in the Moiben River, Kenya. *African Journal of Aquatic Science*, 34, 15–26.

M.A., Millennium Ecosystem Assessment. (2005). *Ecosystems and human well-being: Synthesis*. Washington D.C: World Resources Institute.

Mehrara, M., Pakdin, J., & Neja, A. (2009). Willingness to Pay for Drinking Water Connections: The Case of Larestan, Iran. *Journal of Academic Research in Economics*, 1(2), 191-203.

Mukeria, W., Haileslassie, A., Tengberg, A., & Zazu, C. (2021). Stakeholder interest and influence and their interactions in managing natural resources in Lake Hawassa catchment, Ethiopia. *Ecosystems and People*, 17 (1), 87 – 107.

Mezgebo, G. K., & Ewnetu, Z. (2015). Household's willingness to pay for improved water services in Urban areas: A case study from Nebelet town, Ethiopia. *Journal of Development and Agricultural Economics,* 7 (1), 12-19.

Millennium Ecosystem Assessment. (2005). Washington D. C.: Island Press.

Mitchell, R., & Carson, R. (1989). *Using surveys to value public goods: The contingent valuation method.* Washington D.C: Resources for the Future.

Moffat, B., Motlaleng, G.R., & Thukuza, A. (2011). Household willingness to pay for improved water quality and reliability of supply in Chobe Ward, Mau. Botswana. *Journal of Economics,* 8(12), 45 – 61.

Moffat, B., Motlaleng, G. R., & Thukuza, A. (2013). *Households willingness to pay for improved water quality and reliability of supply in Chobe Ward, Maun.* Department Of Economics, University of Botswana.

MKEPP. (2009). *Database*. Embu, Miika Mäkelä.

Mshigwa, J. (2014). *Willingness to pay for watershed management by domestic water consumer in Chalinze Town, Bagamoyo District, Tanzania*. Tanzania, Sokoine University of Agriculture.

Musiyiwa, K., Harris, D., Filho, L., Gwenzi, W., & Nyamangara, J. (2016) An assessment of smallholder soil and water conservation practices and perceptions in contrasting agro-ecological regions in Zimbabwe. *Water Resources and Rural Development*, 9, 1-11.

Mwamnyange, A. V. (2008). *Financing agricultural marketing in Tanzania. A case of rice and maize traders in Kyela, Mbozi and Dar es Salaam*. Morogoro, Tanzania, Sokoine University of Agriculture.

Mwando, R. N. (2009). *Assessment of stakeholder participation in water resources management in Machakos sub-county, Machakos county, Kenya*. Kenya, Kenyatta University.

Nassiuma, D. (2000). *Survey sampling: Theory and methods.* Njoro: Egerton University Press.

Ndeteiwo, P. I., Mwakaje, A. G., Mujwahuzi, M., & Ngana, J. (2013). Factors influencing willingness to pay for watershed services in lower Moshi, Pangani basin, Tanzania. *International Journal of Agriculture and Environment,* 2, 57 -75.

Newcome, J., Provins, A., Johns, H., Ozdemiroglu, E., Ghazoul, J., Burgess, D., & Turner, K. (2005). *The economic, social and ecological value of ecosystem services: A literature review*. London, UK, Eftec.

Noor, J., Siddiq, W., & Muhammad, T. (2010). *Estimation of willingness to pay for improvements in drinking water quality in Lahore: A case study of WASA, Lahore*. Munich: Personal RePEc Archive.

Nyongesa, M. J. (2011). Payment for environmental services: An integrated approach to natural resourses management and livelihood improvement a case of lake Naivasha – Malewa river basin sub-catchment, Kenya. *African Crop Science Conference Proceedings*, 10, 479-484.

Omokhua, G.E., & Koyejo, A.O. (2008). Impact of Human Activities on Ecosystem in River State, Nigeria. *Journal of Agriculture and Social Research*, 8, 174-178.

Ozcan, O., Musaoglu, N., & Seker, D. Z. (2012). Environmental impact analysis of quarrying activities established on and near a river bed by using remote sensed data. *Fresenius Environmental Bulletin,* 21 (11), 3147 -3153.

Pagiola, S. Bishop, J., and Landell-Mills, N. (2002). *Selling forest environmental services: Market based mechanisms for conservation and development.* London, UK, Earthsan.

Pagiola, S., Ritter, K., & Bishop, J. (2004). *Assessing the economic value of ecosystem conservation.* Washington D.C, U.S.A, World Bank.

Peters, N. E., & Meybeck, M. (2000). Water quality degradation effects on freshwater availability: Impacts of human activities. *Water International, 25* (2), 185–193.

Petrosillo, I., Valente, D., Scavuzzo, C. M., & Selvan, T. (2023). Land degradation pattern and ecosystem services. *Frontiers in Environmental Sciences* 11.

Periotto, N. A., & Tundisi, J. G. (2018). A characterization of ecosystem services, drivers and values of two watersheds in Sao Paolo State, Brazil. *Brazilian Journal of Biology,* 78 (3), 397 -407.

Perrot-Maître, D. (2006). *The Vittel payments for ecosystem services: A "perfect" PES case?* London, UK, International Institute for Environment and Development.

Pettenella, D., & Portaccio, A. (2017). *Ecosystem services in mountain watersheds: supporting tools for adaptive forest management.* Padova, Italy, Dipartimento Territorio e Sistemi Agro-Forestali (TESAF), Universita di Padova.

Porras, I., Aylward, B., & Dengel, J. (2013). *Monitoring payment for watershed services schemes in developing countries.* London, UK, IIED.

Rahman M. M., Alam, K., Karim, R., & Islam, M. K. (2017). Willingness to pay for improved water supply: A policy implication for future water security. *American Jurnal of Environmental and Resource Economics,* 2 (4), 166 – 122.

Raini, J. A. (2009). Impact of land use changes on water resources and biodiversity of Lake Nakuru catchment basin, Kenya. *African Journal of Ecology,* 47, 39–45.

Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H., & Stringer, L. C. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management,* 90 (5), 1933 -1949.

Salzman, J., Bennett, G., Carroll, N., Goldstein, A., & Jenkins, M. (2018). The global trends of payment for ecosystem services. *Nature Sustainability,* 1, 136-144.

Sedell, J. R., & Beschta, R. L. (1991). Bringing back the "bio" in bioengineering. *American Fisheries Society Symposium,* 10, 160–175.

Soko, M. I. (2014). *A study of the impact of anthropogenic activities in the Crocodile River, Mpumalanga.* University of South Africa.

Sommerville, M. M., Jones, J. P. G., & Milner, G. (2009). A revised conceptual framework for payment for environmental services. *Ecology and Society,* 14, 2.

Swai, E. (2016). *Willingness to pay for watershed services by downstream water users in Babati District, Tanzania.* Morogoro, Tanzania, Sokoine University of Agriculture.

Talley, J. L., Schneider, J., & Lindquist, E. (2016). A simplified approach to stakeholder engagement in natural resource management: The feature framework. *Ecology and Society,* 21 (4), 38.

Tanellari, E. D., Bosch, K., & Mykerezi, E. (2015). On consumer attitudes and willingness to pay for improved drinking water quality and infrastructure. *Water Resources Research,* 51 (10), 4757.

Tapio, P. & Willamo, R. (2008). Developing interdisciplinary environmental frameworks. AMBIO: *A Journal of the Human Environment*, 37(2), 125-133.

Taylor, P., Glennie, P., Bjørnsen, P. K., Bertule, M., Harlin, J., James Dalton, J., & Welling, R. (2018). *Nature based solutions for water management: A primer*. UN Environment-DHI; UN Environment; IUCN.

TEEB (Eds.). (2010). *The economics of ecosystem services and biodiversity. Ecological and economic foundations*. London and Washington: Earthscan.

Tefera, B., & Sterk, G. (2010). Land management, erosion problems and soil and water conservation in Fincha'a watershed, western Ethiopia. *Land Use Policy*, 27 (4), 1027–1037.

GOK. (2002). *The Water Act*. Nairobi, Kenya, Government Printer.

GOK. (2016). *The Water Act*. Nairobi, Kenya, Government Printer.

Turner, R., & Daily, G. (2008). The ecosystem services framework and natural capital conservation. *Environmental and Resource Economics*, 39 (1), 25-35.

Udugama, M., Alotaibi, B. A., Navoda, M., Najim, M. M. M., Udayanga, L., & Traore, A. (2024). Willingness to pay for blue ecosystem services of natural pools in Sri Lanka: A discrete choice experiment. *Water*, 16 (17), 2437.

United Nations. (1992). *Convention on Biological Diversity*. New York.

Venkatachalam, L. (2004). The contingent valuation method: A review. *Environmental Impact Assessment Review,* 24, 89-124.

Wallace, J. (2007) Classification of ecosystem services: Problems and solutions. *Biological Conservation*, 139 (3-4), 235 – 246.

Walling, D. E. (2005). Tracing suspended sediment sources in catchments and river systems. *Science of the Total Environment,* 344, 159-184.

WBWDRT World Bank Water Demand Research Team. (1993). The demand for water in rural areas determinants and policy implications. *World Bank Research Observer*, 18 (1), 47 – 70 .

Wedgwood, A., and Sansom, K. (2003). *Willingness to pay surveys: A streamed approach*. Leicestershire, UK, Water, Engineering and Development Centre, Loughborough University.

Wu, X., Liu, J., Fu, B., Wang, S., & Wei, Y. (2021). Integrating multiple factors in evaluating the socio-economic effects of payment for ecosystem services. *Ecosystem Services.*

Wunder, S. (2005). *Payments for environmental services: Some nuts and bolts.* CIFOR occasional paper No. 42, Center for International Forestry Research.

Wunder, S., Engel, S., & Pagiola, A. (2008). Taking stock: A comparative analysis of payments for environmental services programs in developed and developing countries. *Ecological Economics*, 65, 834-852.

Wunder, S., Brouwer, R., Engel, S., Ezzine-de-Blas, D., Muradian, R., Pascual, U., & Pinto, R. (2018). From principles to practice in paying for nature's services. *Nature Sustainability*, 1, 145-150.

Zebilo, E. E. (2006). *Willingness to Pay for Biological Diversity Conservation in Simbu Province, Papua New Guinea*. Alnarp: Department of Southern Swedish Forest Research Centre.

Zekele, G., Kassie, M., Pender, J., & Yesuf, M. (2006). *Stakeholder analysis for sustainable land management (SLM) in Ethiopia: Assessment of opportunities, strategic constraints information needs and knowledge gaps.* Environmental Economics Policy Forum, Ethiopia; International Food Policy Research Institute (IFPRI).

APPENDICES

Appendix 1: **Summary of negative human activities impacting on water service provision in Kapingazi catchment**

Source	**Activities**	**Responses**	
		N	**Percent**
Farmers	Cultivating at the riparian area	53	12.2%
	Eucalyptus trees at the riparian area	10	2.3%
	Chemical control of pests and weeds	17	3.9%
	Water abstraction	12	2.8%
	Washing clothes in the river	16	3.7%
	Deforestation	19	4.4%
	Quarrying/Mining	8	1.8%
	Lack of soil and water conservation measures	12	2.8%
	Poor waste disposal	6	1.4%
Urban households	Poor waste disposal	9	2.1%
	Blocked drainage leading to flooding	1	0.2%
	Run off	2	0.5%
	Washing clothes in the river	1	0.2%
	Sewage spills	3	0.7%
Coffee factory	Water abstraction	54	12.5%
	Effluent from the factory	26	6.0%
	Poor waste management	1	0.2%
Tea factories	Air pollution	8	1.8%
	Effluent from the factory	4	0.9%
	Deforestation at farm level	34	7.9%
Transport sector	Smoke from exhaust pipes (air pollution)	7	1.6%
	Car washing in the river	28	6.0%
Education institutions	Effluent	2	0.5%
	Poor waste management	3	0.7%
Irrigators	Water abstraction	31	7.2%
	Chemical control of pests, diseases and weeds	7	1.6%
	Soil erosion	7	1.6%
	Water wastage	1	0.2%
Urban/Shopping centres	Poor waste disposal	37	8.5%
	Run off	12	2.8%
	Sewage spills	2	0.5%
	Air pollution from burning of waste	2	0.5%
Total		433	100%

Appendix 2 - Field observation list along River Kapingazi catchment.

1. Observe and take note major land use systems.
2. Identifying and mapping critical natural resources e.g. from Mt. Kenya forest at the source to the confluence. E.g. bogs, forest, Kapingazi river, streams.
3. Observation of major activities with potential impact on ecosystem services in the riparian areas in the catchment.
4. Observe and note socio economic development in Kapingazi catchment e. g towns, factories e t c
5. Identifying hotspots in the catchment for example quarries, dumpsites e.t.c along the river.
6. Observe surface water pollutants sources e g run off, effluent from coffee factories e.t c

Appendix 3 - Questionnaire for households with tap water

Household questionnaire on the assessment of willingness to pay for ecosystem services in conserving Kapingazi River catchment in Embu County, Kenya.

Burnice Karimi Ireri is a Masters student from Egerton University, Njoro conducting a study on the assessment of willingness to pay for ecosystem services in conserving Kapingazi catchment in Embu county, Kenya. She appreciates your VOLUNTARY participation in this survey and the information you disclose will be completely CONFIDENTIAL. Your opinion will be combined with those of others to give a general view and your privacy will be protected to the maximum.

Enumerator ________________________________ Altitude __________________________

Respondent's name __________________________ Latitude __________________________

FDA ____Longitude ________________________

Village ______________________________________Date _____________________________

Start time __________________________________ End time _________________________

Questionnaire for households with tap water

Respondent's demographics and occupation

1. What is the tenure of the household head over the farmland? Tenure [ ]

   1=Owned with title deed 2= Owned without title deed 3=Rented 4=Borrowed 5=Workers on the farm

   ENU = Stop the interview if the answer is not 1 or 2

2. We would like to ask you some personal questions. What is?

ENU: Proceed with the interview if the respondent is a household head, the spouse or a son /daughter who is in charge of the farm.

Relationship to household head*	**Sex 1= Male 2 = Female**	**Age (Yrs)**	**Main Activity****	**Education Level*****	**Household size**		
					Adult Male (>=18)	**Adult Female (>=18)**	**Children (<=18)**
relathead	sex	age	activity	Edu	nrhhmale	nrhhfem	nrchildhh

*1 = Household head 2= Spouse 3 = Son/Daughter 4= Others(Please specify)________________________

** 1=Farmer 2=Off-farm 3=Self-employed 4=Public sector employee 5=Private sector employee 6=Disabled/unable to work 100=Others (Please specify)__________________________

***1=zero education 2=Primary education 3=Secondary education 4= Vocational training 4=Tertiary education 100=Others (Please specify) _________________________

3. What is your household total yearly gross income income in Kenya shillings? Totalincome[_______]

4. Roofing type. 1= Grass 2= Iron sheet 3= Bricks 100=Others (Please specify)_________________

5. Type of wall. 1= Stone 2=Mud 3= Bricks 4= iron sheets 5= Timber 100= Other (Please specify)_____________

6. What is the main source of water for the household?
1= River 2= Tap water 3= Community wells 4= Borehole 5= Rain water 6= spring water 7= Neighbours 100= Others______________________

7. Do you have electricity in your house? [_____] 1= Yes 2= No

8. Can you make decisions on what and when to plant on the farm?
1 = Yes 2= I do decisions together with my spouse 3= No

Land Use and Crops

9. What is the household's total land owned (in acres)? Totland[_____]

10. What are the main crops planted on your farmland?

ENU: List crops starting with the one being planted on the greatest area followed by then second greatest area etc.

Crop **ENU: Use Codes**	**Crop type** **1=Cash crop** **2=Food crop**	**Cropping season** **1=Long rain** **2=Short rain** **3=Permanent**

1=Coffee 2=Tea 3=Maize 4=Beans 5=Arrow roots 6=Leaves vegetables 7=Sorghum 8=Sweet potatoes 9=Irish potatoes 10=Tomatoes 11=Cabbages 12=Cassava 13=Fruits (bananas, mangoes, passion fruits, avocadoes etc) 15=Sugarcane 100=Others (Specify) ____________

11. Do you have riparian area on your farmland? 1=Yes 2=No Riparian[_____]

12. If Yes, What have you planted on the riparian area. Plantrip[_____]
1=Food crops 2=cash crops 3=Fodder 4=Woodlot 5=Bush 6=No vegetation 7=Others (Specify)________________

13. Do you irrigate your crops or trees using water from the river? Irrigation[____]
1=Yes 2=No

14. How much of your crop production is irrigated in a dry season(in %)?
Percirrig[____]

15. Do you have livestock? Livestock[___]
1=Yes 2=No

16. If yes, would you tell us your herd of livestock at present?

Type of livestock	**Animal code**	**Number owned(Present at your farm)**
Oxen/bull	ani01	
Cows/heifer	ani02	
Calves	ani03	
Donkeys	ani04	
Sheep	ani05	
Goats	ani06	

Chicken	ani07	
Pigs	ani08	
Rabbits	ani09	
Ducks	ani10	
Others (Please specify)	ani100	

17. Which year did you start farming? Farmstat[________]

A. Characterization of the status of Ecosystem services in Kapingazi Catchment.

A water catchment is a zone which collects and filters natural water (rain, dew and snow) in which all water drains to a common outlet e.g. a river. These catchments provide ecosystem services which are benefits that human beings derive from the ecosystems e.g. Kapingazi river catchment.

18. Have you heard of a water catchment? (Explain what a catchment is)
    1=Yes 2=No
19. Which ecosystem services are provided in Kapingazi river catchment? (Explain what ecosystem services are)
    1= Fresh water supply 2= Fruit and crop production 3= Livestock production 4= HEP Production 5 = Flood prevention 6 = Soil protection and control of soil erosion 7= Recreation 8= Tourism 9 = Nutrient cycling 10 = Landscape beauty 11 = Regulation of climate 12= Carbon sequestration 100=Others (Please specify)____________

20. Which of the above services do you produce? (ENU: Indicate all) NB
    1= Fresh water supply 2= Fruit and crop production 3= Livestock production 4= HEP Production 5 = Flood prevention 6 = Soil protection and control of soil erosion 7= Recreation 8= Tourism 9 = Nutrient cycling 10 = Landscape beauty 11 = Regulation of climate 12 = Carbon sequestration 100 = Other (Please specify)________________________________

21. Rank the following ecosystem services in the order of importance to you.

Ecosystem service	**Very important (5)**	**More important (4)**	**Important (3)**	**Slightly Important (2)**	**Least important (1)**
Provision services					
Water provision					
Food Production					
Fuel wood provision					
Timber provision					
Fiber					
Genetic Resources					

Regulating services					
Carbon sequestration					
Soil erosion control					
Regulation of climate					
Disease regulation					
Pollination					
Water regulation					
Cultural services					
Education					
Aesthetic value					
Sense of place					
Supporting services					
Air purification					
Nutrient cycling					
Soil formation					
Primary production					

22. Which ecosystem services are highly threatened but highly demanded in Kapingazi catchment according to you? (Start with the ecosystem service that is threatened the highest, to the least threatened ES).
____
____
____
____

23. What do you think is threatening the provision of ecosystem services in Kapingazi catchment?____
____
____
____
____

B. Identification of Catchment Users

24. Who are the catchment users in Kapingazi catchment? (List all catchment users in Kapingazi catchment. (Indicate all)
1= Rural farmers 2= Urban householders 3= Coffee factories
4= Tea factories 5= Educational Establishments 6= Worship establishments
7= Irrigators 8= shopping centres 9= Government entities e.g. KSG, KALRO
10= Urban Centres 11= Water service providers 12= HEP producers

100= Others (Please specify) _______________

25. Are you aware of catchment management?
    1= Yes 2= No
26. In your opinion, is it important to manage and conserve Kapingazi river catchment?
    1= Yes 2= No
27. If yes, Why is it important to manage and conserve Kapingazi catchment? (Indicate all)
    1= It minimizes floods
    2= Improves water quality in the river
    3= It provides sustainable water supply
    4= It improves soil fertility
    5= It helps in controlling soil erosion
    6= Disease regulation.
    100= Others (Please specify) ___________________________

28. How are catchment users organized in managing Kapingazi catchment? (Indicate all)
    1= Water associations and committees (WRUA, FDAC)
    2= Farmers' produce cooperatives.
    3= Municipal councils
    4= Conservation youth groups
    5= Women groups
    6= Forest Associations
    7= Water services authorities/Conservation authorities/ government authorities
    8=Water services providers
    9=Advisory boards
    10=I have not heard of any organized association to manage the catchment.
    100= Others (Please specify) ______________
29. What are the functions of the catchment users in management of Kapingazi catchment? (indicate all)
    1= Maintain water supply in Kapingazi catchment
    2= Distribute water
    3= Collect water charges
    4= Monitoring water use
    5= Making rules on water use
    6= Providing forums for resolving disputes on water use
    7= Maintain communication among catchment users
    8= Conservation activities
    9= Marketing of farmers' produce
    10= Economic empowerment
    100= Others (Please specify) ______________________
30. What are the catchment management challenges that the catchment users in Kapingazi catchment face? (Indicate all).
    1= Poor management and coordination
    2=Lack of funding
    3=Poor leadership
    4= Lack of transparency and accountability
    5= Lack of participation and ownership

6= Low literacy levels
7= Lack of commitment on catchment protection by the catchment users
8= Breaking of regulations/rules by catchment users.
9= Lack of awareness.
10=Lack of enforcement.
11= There are no challenges faced in managing the catchment.
12= I do not know
100= Others (Please specify)____

31. Do you belong to any conservation or social group/organization?
 1= Yes 2= No
32. If Yes, Provide the name of the group or organization.
 ____
33. Which conservation activities do you partake?
 1= Tree planting 2 = Soil and water conservation 3 = Tree nursery management 4 = Waste management 100 =Others (please specify) ____
34. How has been your relationship between the members and leadership?
 1 = Very good 2= Good 3= Not very good 4= Not good at all
 Why? ____
35. How has been your relationships between the members and conservation/government agencies? 1 = Very good 2= Good 3= Not very good 4= Not good at all
 Why? ____
36. How has been your experience with the conservation group or organization?
 1 = Very good 2= Good 3= Not very good 4= Not good at all
 Why? ____
 ____
37. If No in question14, why? ____
 ____
 ____
38. Which conservation organizations and government agencies do you collaborate with in managing Kapingazi catchment?
 ____

C. Human activities impacting on water service provision and utilization in Kapingazi catchment

39. What activities by the catchment users are impacting on provision of water services in Kapingazi Catchment?

Catchment User	**Water provision**	**Utilization impacts**
Farmers	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________
Urban households	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________
Coffee factories (Provide name) ________________ _	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________
Tea factories (Provide Name)__________ _	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________
Transport industry	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________
Educational establishment (Provide name)__________ ____	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________
Irrigators (Provide name)__________ _______	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________	1. ________________ 2. ________________ 3. ________________ 4. ________________ 5. ________________
Urban centres/Shopping	1. ________________ 2. ________________	1. ________________ 2. ________________

centres (Provide name)________ ______	3. ______________ 4. ______________	3. ________________ 4. ________________
HEP producers	1. ______________ 2. _______________ 3. _______________ 4. _______________	1. ________________ 2. ________________ 3. ________________ 4. ________________

40. What has been the general trend of water quality of Kapingazi river over the last 10 years?
    1= Decreased 2= Increased 3= Remained the same
41. If it has decreased, Why? (Indicate all)
    1= Very steep slopes 2= Intensive cultivation 3= Lack of soil and management practices 4= Pollution 5= Deforestation 6= Quarrying 7= Construction activities 8= Overgrazing 9= Car wash 10= Run off 100= Others (Please specify)____
42. What has been the general trend of water quantity in Kapingazi river?
    1= Decreased 2= Increased 3= Remained the same 4= I don't know
43. If It has decreased, Why?
    1= Water Abstraction by upstream users (both legal and illegal)
    2= Poor water management mechanisms.
    3= Increased number of water users (including water tankers)
    4= Deforestation
    5= Drought
    100= Others (Please specify) ________________
44. Do you practice the following? (Indicate all)
    1= Agroforestry 2= Ecotourism 3= Forestry 4= Sustainable agriculture 100= Other (Please specify)__________________________
45. Are the following present in your farm?
    Woodlot 1=Yes 2= No
    Indigenous trees 1= Yes 2= No. if Yes, which ones? ____
    Fruit trees 1= Yes 2= No. If yes, which ones? ____
    Exotic trees 1=Yes 2= No. If yes, which ones? ____

46. Do you practice any of the following soil and water conservation methods (ENU: Indicate all)
    1= Tree planting 2= Napier grass strips 3= Terracing 4 = Contour ploughing 5= Crop rotation 6= Cover cropping 7= Mixed cropping 8 = Roof water harvesting 9= Drought

resistant crop varieties 10= Stone strips 100 = Others (Please specify)____________________

47. What are the land degradation threats in your farm? (Indicate all)
    1= Overstocking and overgrazing 2= Over exploitation of forest 3= Cultivation on steep slopes 4= Loss of soil productivity 5= Loss of biodiversity 6= Effect on hydrological regime 7 = Run off due to heavy rains 8= Wildlife from the forest 100= Others (Please specify) ____
48. Do you experience soil erosion in your farm?
    1 = Yes 2 = No
49. If Yes, where in your farm do you experience most soil erosion?
    1= Unused/Bare area 2= Riparian area 3= Cropping area 4= Homestead 5= Road/paths 6= Steep/slopy areas 100 = Others (Please specify)____
50. What is your main source of energy for cooking?
    1= Firewood 2= Kerosene 3= Gas 4= Charcoal 5= Crop residue 6= Animal dung 7= Electricity 100= Others (Please specify) ____
51. Where do you get the above fuel used? (ENU: Indicate all)
    1= Own farm 2= Own trees 3= Forest 4= Purchased from market/shop 5= Purchased from villagers
52. In your assessment, what has been the general trend of firewood in your village in the last 10 years?
    1= Decreased 2= Increased 3= Remained the same 4 = Don't know
53. If the availability of firewood decreased, how do you cope with it?
    ____
    ____
    ____

54. Please indicate the extent of your agreement or disagreement with the following statements.

Statement	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
Global warming is an environmental problem.					
Temperatures have become more in the recent years.					
There is increasing decline in river flows.					
There is frequent flood incidences.					
There is a relationship between my individual farming activities and					

water quality in my area.					
Water quality is a major problem					
Farming activities at the riparian bank affect water quality.					
More trees lead to increased water quantity.					
There is enough firewood for the next generation.					
I feel obliged to conserve the environment.					
The quality of water I get is affected by the activities of people who are farming upstream.					
Water scarcity is a major problem affecting crop production in this area.					
More trees lead to better water quality.					
The riparian area is more productive.					

D. Willingness to pay for ecosystem services in Kapingazi catchment

55. What is your source of water?
    1= In house piped tap water
    2= On compound/yard piped water
    3= Borehole
    4= Shallow well
    5= Common piped water
    6= River/Stream
    100= Others (Please specify)__________________
56. What is the name of your water supply scheme/water service provider? ____
57. Is your source of water supply adequate? 1= Yes 2= No
58. If no, how do you cope and fulfil your water supply demands?

____
____
____
____

59. What do you think is causing water scarcity problem?

____
____
____
____

60. In your opinion, how do you rate the quality and quantity of water you consume in this household

	Very good	**Good**	**Somewhat good**	**Poor**	**Not sure**
Water Quality					
Water quantity					

61. How would you rate water availability in your household?
    1= Always available 2=Available 3= Some what available 4= Not available 5= Not sure
62. Are you making any payment for provision of water?
    1=Yes 2=No

63. If yes, how much do you pay per month? ___________

64. Would you participate in conservation activities in Kapingazi catchment?
    1= Yes 2= No

65. If yes, Why?
    1= Catchments are the primary source of raw water
    2= Catchments provide other goods like timber, and animal and plant products
    3= Catchments provide other services like hydroelectric power, biodiversity conservation, recreation, and carbon sequestration
    4= Catchments minimize floods during the rainy season
    5= Catchments improve water quality
    6= Provides more sustainable water supply for domestic use.
    100= Others (Please specify)____

66. If no, why?
____

____

____

67. Have you heard about payment for ecosystem services? 1=Yes 2= No

Let us assume that there is an improved water supply scheme in Kapingazi catchment. In order to be improve water supply in your household, you would be required to contribute towards a conservation fund and participate in conservation activities in order to improve water provision service in terms of quantity, quality and frequency as a result of conservation measures within the catchment.

68. Would you be willing to pay to have with the improved water service provision?

    1=Yes 2= No

69. If yes, what is the maximum amount you are willing to pay for improved water service with water connection per annum? KES 200, 300, 400, 500, 600, 700, 800, 1000, 1500 ____________

70. If yes, Please indicate your reasons why you are willing to pay for improved water service provision?
    1= I want clean and more reliable water supply
    2= I want the catchment to continue producing ecosystem services
    3= It is my duty as water user.
    4= I would like the future generations to have reliable water supply
    5= To benefit the local community.
    6= Water availability is a problem in my household.
    7= Security will be enhanced.
    8= The money will be used to conserve the catchment.
    9= Water delivery cost to my household is higher than if I was connected.
    10= Reduced cost of health.
    100= Others (please specify) ____

71. If no, Please indicate your reasons why you are not willing to pay for tap water connection and improved water service provision?

    1= Water should be provided free of charge
    2= I am satisfied with the existing source
    3= I do not have enough money
    4= Money paid will be mismanaged.
    5= I think water is a public good and the government should finance the catchment management activities.
    6= I do not care about the reliability of water supply.
    7= I do not think the additional payment will result to improved catchment management.
    8= I do not think catchment management will lead to improved water supply
    9= I do not trust the institution will manage the fund for conservation of the catchment.
    10= I have other bills to pay for example electricity bill, hospital bill etc.
    11= I am considering buying land elsewhere due to small land size here.
    12= I cannot participate in the activities due to old age

13= Small land size
14= Benefits will take a long time before they are felt.
100= Others (Please specify) ____

Thank you

Appendix 4 - Questionnaire for households without tap water

Household questionnaire on the assessment of willingness to pay for ecosystem services in conserving Kapingazi River catchment in Embu County, Kenya.

Burnice Karimi Ireri is a Masters student from Egerton University, Njoro conducting a study on the assessment of willingness to pay for ecosystem services in conserving Kapingazi catchment in Embu county, Kenya. She appreciates your VOLUNTARY participation in this survey and the information you disclose will be completely CONFIDENTIAL. Your opinion will be combined with those of others to give a general view and your privacy will be protected to the maximum.

Enumerator ________________________ Altitude ________________________
Respondent's name ________________________ Latitude ________________________
FDA ________________________ Longitude ________________________
Village ________________________ Date ________________________
Start time ________________________ End time ________________________

Questionnaire for households without tap water

Respondent's demographics and occupation

3. What is the tenure of the household head over the farmland? Tenure [ ]

   1=Owned with title deed 2= Owned without title deed 3=Rented 4=Borrowed 5=Workers on the farm

   ENU = Stop the interview if the answer is not 1 or 2

4. We would like to ask you some personal questions. What is?

ENU: Proceed with the interview if the respondent is a household head, the spouse or a son /daughter who is in charge of the farm.

Relationship to household head*	**Sex 1= Male 2 = Female**	**Age (Yrs)**	**Main Activity****	**Education Level*****	**Household size**		
					Adult Male (>=18)	**Adult Female (>=18)**	**Children (<=18)**
relathead	sex	age	activity	Edu	nrhhmale	nrhhfem	nrchildhh

*1 = Household head 2= Spouse 3 = Son/Daughter 4= Others(Please specify)________________

** 1=Farmer 2=Off-farm 3=Self-employed 4=Public sector employee 5=Private sector employee 6=Disabled/unable to work 100=Others (Please specify)________________

***1=zero education 2=Primary education 3=Secondary education 4= Vocational training 4=Tertiary education 100=Others (Please specify) ________________

3. What is your household total yearly gross income income in Kenya shillings? Totalincome[_______]

4. Roofing type. 1= Grass 2= Iron sheet 3= Bricks 100=Others (Please specify)________________

5. Type of wall. 1= Stone 2=Mud 3= Bricks 4= iron sheets 5= Timber 100= Other (Please specify)____________

6. What is the main source of water for the household?

1= River 2= Tap water 3= Community wells 4= Borehole 5= Rain water 6= spring water 7= Neighbours 100= Others______________________

7. Do you have electricity in your house? [_____] 1= Yes 2= No

8. Can you make decisions on what and when to plant on the farm?
1 = Yes 2= I do decisions together with my spouse 3= No

Land Use and Crops

9. What is the household's total land owned (in acres)? Totland[_____]

10. What are the main crops planted on your farmland?

ENU: List crops starting with the one being planted on the greatest area followed by then second greatest area etc.

Crop **ENU: Use Codes**	**Crop type** **1=Cash crop** **2=Food crop**	**Cropping season** **1=Long rain** **2=Short rain** **3=Permanent**

1=Coffee 2=Tea 3=Maize 4=Beans 5=Arrow roots 6=Leaves vegetables 7=Sorghum 8=Sweet potatoes 9=Irish potatoes 10=Tomatoes 11=Cabbages 12=Cassava 13=Fruits (bananas, mangoes, passion fruits, avocadoes etc) 15=Sugarcane 100=Others (Specify) ____________

11. Do you have riparian area on your farmland? 1=Yes 2=No Riparian[_____]

12. If Yes, What have you planted on the riparian area. Plantrip[_____]
1=Food crops 2=cash crops 3=Fodder 4=Woodlot 5=Bush 6=Bare 7=Others (Specify)________________

13. Do you irrigate your crops or trees using water from the river? Irrigation[____]
1=Yes 2=No

14. How much of your crop production is irrigated in a dry season(in %)?
Percirrig[____]

15. Do you have livestock? Livestock[___]
1=Yes 2=No

16. If yes, would you tell us your herd of livestock at present?

Type of livestock	**Animal code**	**Number owned(Present at your farm)**
Oxen/bull	ani01	
Cows/heifer	ani02	
Calves	ani03	
Donkeys	ani04	
Sheep	ani05	
Goats	ani06	

Chicken	ani07	
Pigs	ani08	
Rabbits	ani09	
Ducks	ani10	
Others (Please specify)	ani100	

17. Which year did you start farming? Farmstat[________]

E. Characterization of the status of Ecosystem services in Kapingazi Catchment.

A water catchment is a zone which collects and filters natural water (rain, dew and snow) in which all water drains to a common outlet e.g. a river. These catchments provide ecosystem services which are benefits that human beings derive from the ecosystems e.g. Kapingazi river catchment.

72. Have you heard of a water catchment? (Explain what a catchment is)
    1=Yes 2=No
73. Which ecosystem services are provided in Kapingazi river catchment? (Explain what ecosystem services are)
    1= Fresh water supply 2= Fruit and crop production 3= Livestock production 4= HEP Production 5 = Flood prevention 6 = Soil protection and control of soil erosion 7= Recreation 8= Tourism 9 = Nutrient cycling 10 = Landscape beauty 11 = Regulation of climate 12= Carbon sequestration 100=Others (Please specify)______________

74. Which of the above services do you produce? (ENU: Indicate all) NB
    1= Fresh water supply 2= Fruit and crop production 3= Livestock production 4= HEP Production 5 = Flood prevention 6 = Soil protection and control of soil erosion 7= Recreation 8= Tourism 9 = Nutrient cycling 10 = Landscape beauty 11 = Regulation of climate 12 = Carbon sequestration 100 = Other (Please specify)___________________________________

75. Rank the following ecosystem services in the order of importance to you.

Ecosystem service	**Very important (5)**	**More important (4)**	**Important (3)**	**Slightly Important (2)**	**Least important (1)**
Provision services					
Water provision					
Food Production					
Fuel wood provision					
Timber provision					
Fiber					
Genetic Resources					

Regulating services					
Carbon sequestration					
Soil erosion control					
Regulation of climate					
Disease regulation					
Pollination					
Water regulation					
Cultural services					
Education					
Aesthetic value					
Sense of place					
Supporting services					
Air purification					
Nutrient cycling					
Soil formation					
Primary production					

76. Which ecosystem services are highly threatened but highly demanded in Kapingazi catchment according to you? (Start with the ecosystem service that is threatened the highest, to the least threatened ES).
____
____
____
____

77. What do you think is threatening the provision of ecosystem services in Kapingazi catchment?____
____
____
____
____

F. Identification of Catchment Users

78. Who are the catchment users in Kapingazi catchment? (List all catchment users in Kapingazi catchment. (Indicate all)
1= Rural farmers 2= Urban householders 3= Coffee factories
4= Tea factories 5= Educational Establishments 6= Worship establishments
7= Irrigators 8= shopping centres 9= Government entities e.g. KSG, KALRO
10= Urban Centres 11= Water service providers 12= HEP producers

100= Others (Please specify) _______________

79. Are you aware of catchment management?
    1= Yes 2= No
80. In your opinion, is it important to manage and conserve Kapingazi river catchment?
    1= Yes 2= No
81. If yes, Why is it important to manage and conserve Kapingazi catchment? (Indicate all)
    1= It minimizes floods
    2= Improves water quality in the river
    3= It provides sustainable water supply
    4= It improves soil fertility
    5= It helps in controlling soil erosion
    6= Disease regulation.
    100= Others (Please specify) ___________________________

82. How are catchment users organized in managing Kapingazi catchment? (Indicate all)
    1= Water associations and committees (WRUA, FDAC)
    2= Farmers' produce cooperatives.
    3= Municipal councils
    4= Conservation youth groups
    5= Women groups
    6= Forest Associations
    7= Water services authorities/Conservation authorities/ government authorities
    8=Water services providers
    9=Advisory boards
    10=I have not heard of any organized association to manage the catchment.
    100= Others (Please specify) ______________
83. What are the functions of the catchment users in management of Kapingazi catchment? (indicate all)
    1= Maintain water supply in Kapingazi catchment
    2= Distribute water
    3= Collect water charges
    4= Monitoring water use
    5= Making rules on water use
    6= Providing forums for resolving disputes on water use
    7= Maintain communication among catchment users
    8= Conservation activities
    9= Marketing of farmers' produce
    10= Economic empowerment
    100= Others (Please specify) _______________________
84. What are the catchment management challenges that the catchment users in Kapingazi catchment face? (Indicate all).
    1= Poor management and coordination
    2=Lack of funding
    3=Poor leadership
    4= Lack of transparency and accountability
    5= Lack of participation and ownership

6= Low literacy levels
7= Lack of commitment on catchment protection by the catchment users
8= Breaking of regulations/rules by catchment users.
9= Lack of awareness.
10=Lack of enforcement.
11= There are no challenges faced in managing the catchment.
12= I do not know
100= Others (Please specify)____

85. Do you belong to any conservation or social group/organization?
1= Yes 2= No
86. If Yes, Provide the name of the group or organization.
____
87. Which conservation activities do you partake?
1= Tree planting 2 = Soil and water conservation 3 = Tree nursery management 4 = Waste management 100 =Others (please specify)
____
88. How has been your relationship between the members and leadership?
1 = Very good 2= Good 3= Not very good 4= Not good at all
Why?
____
89. How has been your relationships between the members and conservation/government agencies? 1 = Very good 2= Good 3= Not very good 4= Not good at all
Why?
____
90. How has been your experience with the conservation group or organization?
1 = Very good 2= Good 3= Not very good 4= Not good at all
Why?
____
91. If No in question14, why?
____
92. Which conservation organizations and government agencies do you collaborate with in managing Kapingazi catchment?
____

G. Human activities impacting on water service provision and utilization in Kapingazi catchment

93. What activities by the catchment users are impacting on provision of water services in Kapingazi Catchment?

Catchment User	Water provision	Utilization impacts
Farmers	6. ________ 7. ________ 8. ________ 9. ________ 10. ________	6. ________ 7. ________ 8. ________ 9. ________ 10. ________
Urban households	6. ________ 7. ________ 8. ________ 9. ________ 10. ________	6. ________ 7. ________ 8. ________ 9. ________ 10. ________
Coffee factories (Provide name) ________________	5. ________ 6. ________ 7. ________ 8. ________ 5. ________	1. ________ 2. ________ 3. ________ 4. ________ 5. ________
Tea factories (Provide Name)___________	6. ________ 7. ________ 8. ________ 9. ________ 10. ________	1. ________ 2. ________ 3. ________ 4. ________ 5. ________
Transport industry	6. ________ 7. ________ 8. ________ 9. ________ 10. ________	1. ________ 2. ________ 3. ________ 4. ________ 5. ________
Educational establishment (Provide name)______________	6. ________ 7. ________ 8. ________ 9. ________ 10. ________	1. ________ 2. ________ 3. ________ 4. ________ 5. ________
Irrigators (Provide name)________________	6. ________ 7. ________ 8. ________ 9. ________	1. ________ 2. ________ 3. ________ 4. ________

	10. ______________	5. ________________
Urban centres/Shopping centres (Provide name)__________ _______	5. ______________ 6. ______________ 7. ______________ 8. ______________	1. ________________ 2. ________________ 3. ________________ 4. ________________
HEP producers	5. ______________ 6. _______________ 7. _______________ 8. _______________	1. ________________ 2. ________________ 3. ________________ 4. ________________

94. What has been the general trend of water quality of Kapingazi river over the last 10 years?
    1= Decreased 2= Increased 3= Remained the same
95. If it has decreased, Why? (Indicate all)
    1= Very steep slopes 2= Intensive cultivation 3= Lack of soil and management practices 4= Pollution 5= Deforestation 6= Quarrying 7= Construction activities 8= Overgrazing 9= Car wash 10= Run off 100= Others (Please specify)____
96. What has been the general trend of water quantity in Kapingazi river?
    1= Decreased 2= Increased 3= Remained the same 4= I don't know
97. If It has decreased, Why?
    1= Water Abstraction by upstream users (both legal and illegal)
    2= Poor water management mechanisms.
    3= Increased number of water users (including water tankers)
    4= Deforestation
    5= Drought
    100= Others (Please specify) _________________
98. Do you practice the following? (Indicate all)
    1= Agroforestry 2= Ecotourism 3= Forestry 4= Sustainable agriculture 100= Other (Please specify)____________________________
99. Are the following present in your farm?
    Woodlot 1=Yes 2= No
    Indigenous trees 1= Yes 2= No. if Yes, which ones? ____
    Fruit trees 1= Yes 2= No. If yes, which ones? ____
    Exotic trees 1=Yes 2= No. If yes, which ones? ____

100. Do you practice any of the following soil and water conservation methods (ENU: Indicate all)

1= Tree planting 2= Napier grass strips 3= Terracing 4 = Contour ploughing 5= Crop rotation 6= Cover cropping 7= Mixed cropping 8 = Roof water harvesting 9= Drought resistant crop varieties 10= Stone strips 100 = Others (Please specify)____________________

101. What are the land degradation threats in your farm? (Indicate all)

1= Overstocking and overgrazing 2= Over exploitation of forest 3= Cultivation on steep slopes 4= Loss of soil productivity 5= Loss of biodiversity 6= Effect on hydrological regime 7 = Run off due to heavy rains 8= Wildlife from the forest 100= Others (Please specify) ____

102. Do you experience soil erosion in your farm?

1 = Yes 2 = No

103. If Yes, where in your farm do you experience most soil erosion?

1= Unused/Bare area 2= Riparian area 3= Cropping area 4= Homestead 5= Road/paths 6= Steep/slopy areas 100 = Others (Please specify)____

104. What is your main source of energy for cooking?

1= Firewood 2= Kerosene 3= Gas 4= Charcoal 5= Crop residue 6= Animal dung 7= Electricity 100= Others (Please specify) ____

105. Where do you get the above fuel used? (ENU: Indicate all)

1= Own farm 2= Own trees 3= Forest 4= Purchased from market/shop 5= Purchased from villagers

106. In your assessment, what has been the general trend of firewood in your village in the last 10 years?

1= Decreased 2= Increased 3= Remained the same 4 = Don't know

107. If the availability of firewood decreased, how do you cope with it?

____

____

____

108. Please indicate the extent of your agreement or disagreement with the following statements.

Statement	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Global warming is an environmental problem.					
Temperatures have become more in the recent years.					
There is increasing decline in river flows.					

There is frequent flood incidences.					
There is a relationship between my individual farming activities and water quality in my area.					
Water quality is a major problem					
Farming activities at the riparian bank affect water quality.					
More trees lead to increased water quantity.					
There is enough firewood for the next generation.					
I feel obliged to conserve the environment.					
The quality of water I get is affected by the activities of people who are farming upstream.					
Water scarcity is a major problem affecting crop production in this area.					
More trees lead to better water quality.					
The riparian area is more productive.					

H. Willingness to pay for water provision ecosystem service in Kapingazi catchment

109. What is your source of water?

1= In house piped tap water
2= On compound/yard piped water
3= Borehole
4= Shallow well
5= Common piped water
6= River/Stream
100= Others (Please specify)________________________

110. Is your source of water supply adequate? 1= Yes 2= No

111. If no, how do you cope and fulfil your water supply demands?

____

112. What do you think is causing water scarcity problem?

____

113. In your opinion, how do you rate the quality and quantity of water you consume in this household

	Very good	**Good**	**Somewhat good**	**Poor**	**Not sure**
Water Quality					
Water quantity					

114. Why are you not connected to piped water?

1= Water is a public good and it is government's responsibility
2= I am unemployed therefore I cannot afford tap water
3= I live in a temporary house.
4= Never asked to pay.
5= I was disconnected because I could not afford to pay the water bill.
6= The water service provider is far therefore I cannot be connected.
100= Others (Please specify) ______________________________

115. In your opinion, do you think you should pay for water provision?

1= Yes 2= No

116. If yes, why should you pay for water?

1= It is a service and hence I am obliged to pay
2= Only if I own a permanent house
3= Only if water tap is in-house or in my compound.
4= Never asked to pay
5=It is convenient to have tap water in the compound
6=It saves time and one can do other things other than fetching water
7=It improves your security.

100= Others (Please specify) ______________________________

117. If no, why should you not pay for water provision service?

1= Water is a public good and it is government's responsibility
2= Unemployed therefore I cannot afford tap water
3= I live in a temporary house.
4= Never asked to pay.
5= Others (Please specify) ____________________________

118. Would you participate in conservation activities in Kapingazi catchment?

1= Yes 2= No

119. If yes, Why?

1= Catchments are the primary source of raw water
2= Catchments provide other goods like timber, and animal and plant products
3= Catchments provide other services like hydroelectric power, biodiversity conservation, recreation, and carbon sequestration
4= Catchments minimize floods during the rainy season
5= Catchments improve water quality
6= Provides more sustainable water supply for domestic use.
100= Others (Please specify) ____

120. If no, why? ____
____
____

121. Have you heard about payment for ecosystem services? 1=Yes 2= No

Let us assume that there is an improved water supply scheme in Kapingazi catchment. In order to be connected to tap water supply in your household, you would be required to contribute towards a conservation fund and participate in conservation activities in order to improve water provision service in terms of water quantity, quality and frequency once connected as a result of conservation measures within the catchment.

122. Would you be willing to pay to have with the improved water service provision?

1=Yes 2= No

123. If yes, what is the maximum amount you are willing to pay for improved water service with water connection per annum? KES 200, 300, 400, 500, 600, 700, 800, 1000, 1500 ____________

124. If yes, Please indicate your reasons why you are willing to pay for improved water service provision?

1= I want clean and more reliable water supply

2= I want the catchment to continue producing ecosystem services
3= It is my duty as water user.
4= I would like the future generations to have reliable water supply
5= To benefit the local community.
6= Water availability is a problem in my household.
7= Security will be enhanced.
8= The money will be used to conserve the catchment.
9= Water delivery cost to my household is higher than if I was connected.
10= Reduced cost of health.
100= Others (please specify) ____

125. If no, Please indicate your reasons why you are not willing to pay for tap water connection and improved water service provision?

1= Water should be provided free of charge
2= I am satisfied with the existing source
3= I do not have enough money
4= Money paid will be mismanaged.
5= I think water is a public good and the government should finance the catchment management activities.
6= I don't care about the reliability of water supply.
7= I do not think the additional payment will result to improved catchment management.
8= I don't think catchment management will lead to improved water supply
9= I do not trust the institution will manage the fund for conservation of the catchment.
10= I have other bills to pay for example electricity bill, hospital bill etc.
11= I am considering buying land elsewhere due to small land size here.
12= I cannot participate in the activities due to old age
13= Small land size
14= Benefits will take a long time before they are felt.
100= Others (Please specify) ____________________________________

Thank you

Appendix 5- Focus group discussions (Kapingazi WRUA, Kapingazi FDAC, Irangi CFA)

1. How do you assess water situation in Kapingazi catchment?
2. How are the catchment users organized in managing Kapingazi catchment?
3. What is your group doing to promote conservation in Kapingazi catchment?
4. Do you involve community members in catchment management?
5. If Yes, Explain how
6. If No, Why
7. How does your group reach community members?
8. Has your group been successful in promoting environmental conservation activities/catchment management activities in Kapingazi catchment?
9. If yes, what activities have you been involved in?
10. What challenges do you encounter in promoting catchment management activities in Kapingazi catchment?
11. In your opinion, what can be done to address these challenges?
12. What is currently being done to address these challenges?
13. What is the primary source of your water in Kapingazi catchment?
14. Are the present supplies adequate?
15. If no, how do the catchment users cope and fulfil their demands? How many litres you buy and how much it cost?
16. Why do you think that water scarcity problem is increasing?
17. Do you think people who live upstream are responsible for decrease in water supply in Kapingazi catchment?
18. If yes, what do you think they could do to increase the water supply? If no, who are responsible?
19. What could be the possible ways to increase the water supply and can you help for it? How?
20. If the people of upstream are ready to work in conservation of the catchment for increase in water supply. Would you like to help? How?
21. How could you minimize scarcity in water supply?
22. Is there any group in the catchment who looks into the water supply and demand? Any program conducted?
23. How is water regulated/managed in the catchment?
24. What are the water access/use rights in Kapingazi catchment?
25. What are the major water issues in Kapingazi catchment?
26. Have you heard about payment for ecosystem services? If yes, do you believe it will help to improve watershed supply in your place?
27. What is the maximum amount that you are willing to pay for improved water services per annum? KES 200, 400, 600, 1000, 2000____________________________

Appendix 6 - Key informant schedule for EWASCO, NEMA, WRA

1. What is the coverage area of the institution? ____________________________________
2. In which ways has the institution contributed to catchment management activities in Kapingazi catchment?
   ____
   ____
   ____
3. Does your organization partner with community based committees/groups in managing Kapingazi catchment? 1= Yes 2= No
4. If yes, Please name the groups____
   ____
   __
5. How does the institution partner with community groups and other stakeholder institutions?
   1= Community development 2= Conservation 3= Funding 4 = Capacity development/trainings 5= Others(Please specify)___________________________________
   ____
   __
6. If no, why?
   ____
   ___
7. How do you assess the water quality and quantity in Kapingazi river?
   1= Increased 2=Decreased 3= Remained
   ____
   __
   ____
   __
8. Why has it decreased?
   ____
   ____
   ____
9. What activities are you involved in?
   1= Eco tourism 2= Education and awareness 3= Capacity building 4= Environmental conservation 5= Others (Please specify)
   ____
10. Which projects have been/are/will be conducted in your institution?
    1= Eco tourism 2= Education and awareness 3= Capacity building 4= Environment conservation 5= Others (Please specify)
    ____

11. Do you have local and international institutions that you collaborate with? 1= Yes 2= No
12. In which areas do you collaborate?
    1= Community development 2= Conservation 3= Funding 4 = Others (Please specify) ____
13. Do you know of any markets for ecosystem services? 1= Yes 2= No
14. Would you be willing to pay or contribute towards a conservation fund to support farmers/communities providing ecosystem services through conservation activities?

    1= Yes 2= No
15. Which organizations would you recommend to lead or initiate the PES schemes?
    1= HEP Production companies 2= Water service providers 3= Government 4= Private sector 5= NGOs 6= Others (Please specify)

    ____
16. Do you think there is potential in Kapingazi river catchment for Payment for Ecosystem services?
    1= Totally agree 2= Partially agree 3= Undecided 4= Partially disagree 5 = Totally disagree

Appendix 7 - Key informant schedule for KENGEN

Burnice Karimi Ireri is a Masters student from Egerton University, Njoro conducting a study on the assessment of willingness to pay for ecosystem services in conserving Kapingazi catchment in Embu County, Kenya. She appreciates your VOLUNTARY participation in this survey and the information you disclose will be completely CONFIDENTIAL. Your opinion will be combined with those of others to give a general view and your privacy will be protected to the maximum.

Name of Organization Officer: ____

Position of Organization Officer: ____

1. What is the coverage area of the institution? ________________________________
2. In which ways has the institution contributed to catchment management activities in Kapingazi catchment?
   ____
   ____
3. Does your organization partner with community based committees/groups in managing Kapingazi catchment? 1= Yes 2= No
4. If yes, Please name the groups____
   ____
5. How does the institution partner with community groups and other stakeholder institutions?
   1= Community development 2= Conservation 3= Funding 4 = Capacity development/trainings 5= Others (Please specify)_______________________________
   ____
6. If no, why?
   ____
7. How do you assess the water quality and quantity in Kapingazi River?
   1= Increased 2=Decreased 3= Remained
   ____
8. Why has it decreased?

____
__

9. What activities are you involved in?
   1= Eco tourism 2= Education and awareness 3= Capacity building 4= Environmental conservation 5= Others (Please specify)
   ____

10. Which projects have been/are/will be conducted in your institution?
   1= Eco tourism 2= Education and awareness 3= Capacity building 4= Environment conservation 5= Others (Please specify)
   ____

11. Do you have local and international institutions that you collaborate with? 1= Yes 2= No
12. Which organizations do you collaborate with?_____________________________________
____
__
13. In which areas do you collaborate?
   1= Community development 2= Conservation 3= Funding 4 = Others (Please specify) ____
14. Which is the primary sources of water for KenGen?
   ____
   ____
15. Are the present supplies adequate? 1=Yes 2= No
16. If No, how do you fulfil your demand?
   ____
   ____
   ____
17. What do you think is causing water scarcity?
   ____
   ____
   ____
18. Do you think people who live upstream in Kapingazi catchment are responsible for declining water supply? 1= Yes 2=No If yes, why and what could they do to increase the water supply?____
   ____
   ____
   ____
19. What would be the possible ways to increase water supply and would you be involved in it?
   How?____

____

20. If the people who live upstream are ready to work to conserve the catchment in order to increase water supply, would you be willing to help? 1= Yes 2= No How? ____

21. How would the communities minimize water shortage? ____

22. Have you heard about payment for ecosystem services (PES)? 1= Yes 2= No If yes, Do you believe it can help to improve watershed services supply in Kapingazi catchment? 1= Yes 2= No
23. Would you be willing to pay or contribute towards a conservation fund to support farmers/communities in Kapingazi catchment providing watershed services through conservation activities 1= Yes 2= No
24. Which organizations would you recommend to lead or initiate the scheme?
    1= HEP Production companies 2= Water service providers 3= Government 4= Private sector 5= NGOs 6= Others (Please specify) ____

Thank you

Appendix 8 – Research authorization

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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Ref No **NACOSTI/P/17/28875/19806**

Date: **3rd November, 2017**

Burnice Karimi Ireri
Egerton University
P.O. Box 536-20115
EGERTON.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Assessment of willingness to pay for ecosystem services in conserving Kapingazi Catchment in Embu County, Kenya"*** I am pleased to inform you that you have been authorized to undertake research in **Embu County** for the period ending **3rd November, 2018.**

You are advised to report to the **County Commissioner and the County Director of Education, Embu County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GKalerwa

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Embu County.

The County Director of Education
Embu County.

Appendix 9 – Research publication

WATER INTERNATIONAL
https://doi.org/10.1080/02508060.2024.2321819

Routledge
Taylor & Francis Group

CASE STUDY

Check for updates

Provisioning of water ecosystem services in the Kapingazi River Basin in Kenya: can prospects of willingness to pay improve water quality and quantity?

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ABSTRACT

The Kapingazi River Basin in Kenya is home to a range of ecosystem services. Agricultural and industrial activities have negatively impacted water quality and flows. This study assesses the willingness to pay for improving water service provision. Two-thirds of the respondents are willing to pay for improved water quality and quantity. The respondents were willing to pay an average of US $9.10 per annum for improved water services, not counting water connection fees. Logistic regression analysis revealed that age, education and household size were factors influencing respondents' willingness to pay.

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KEYWORDS
Ecosystem services; willingness to pay; Kenya

Introduction

Payment for ecosystem services is an emerging practice that deals with a financial support scheme that aims to conserve ecosystem services by providing incentives to those who contribute to conservation, mainly by managing ecosystem services by adopting land-use practices that lead to ecosystem services – for example, enhanced carbon sequestration, improved water quality and quantity. The payment for ecosystem services (PES) approach is based on a theoretically straightforward proposition: pay individuals or communities to undertake actions that increase levels of desired ecosystem services. It helps to achieve environmental outcomes by providing a way to internalize economic externalities, a problem that has long been recognized and studied in the environmental economics (and broader economics) literature (Turner & Daily, 2008).

Mount Kenya is one of the five water towers in Kenya whose water yield contributes close to 49% of the flow of river Tana. The river supports hydroelectric power generated in Kenya, irrigated agriculture, fisheries, livestock production and biodiversity conservation in the lower Tana, which is strategic to Kenya's economic development. River Kapingazi is located in the upper Tana river basin area and originates from Mount Kenya forest and joins with the river Rupingazi at the confluence in the lower part of the

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