PAYMENT FOR ENVIRONMENTAL SERVICES: LAND USE PRACTICES INFLUENCE ON LIVELIHOOD- ENVIRONMENT NEXUS AND ENVIRONMENTAL SERVICES VALUE IN LAKE NAIVASHA WATERSHED, KENYA

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A thesis submitted to Graduate School in partial fulfillment for the requirements of the Doctor of Philosophy Degree in Agricultural Economics of Egerton University

EGERTON UNIVERSITY

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DECLARATION AND RECOMMENDATION

DECLARATION

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

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DEDICATION

I dedicate this work to my late parents, Samuel Nyongesa and Idah Nyongesa.

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ABSTRACT

Nature provides ecosystem services (ESs) which benefit humans for socio-economic development. However, ecosystems degradation has impacted negatively on people's livelihood leading to increasing global concern to rethink on sustainable conservation-livelihood mechanisms. Lake Naivasha basin has been undergoing ecosystem degradation threatening ecological functional capacity to provide ESs. As a result, it has increased food insecurity, poverty levels, decreased income and destabilized ESs-dependent commercial investments. Payment for Environmental Services (PES) scheme was initiated by the Non-Governmental Organizations (WWF and CARE-Kenya) in partnership with government agencies, local communities and private sector. The purpose was to rehabilitate and manage Lake Naivasha watershed through financial incentives for smallholder farmers. The objective of this study was to evaluate the influence of PES on farmer's livelihoods and environment. The study covered 2 community Water Resource Users Associations (Upper Turasha Kinja and Wanjohi) in Nyandarua South, Kinangop and Kipipiri sub-counties of Nyandarua County. Primary data was collected from selected PES households using semi-structured questionnaires. Total of 200 farmers were randomly sampled from 9 purposively selected PES zones. Data was analyzed through qualitative and quantitative description using computer generated STATA and SPSS softwares. Results revealed over 93 percent of farmers were influenced to practice PES overall and 61.5 percent preferred particular PES practices. Average monthly household gross on-farm income without PES was KES 6,891.96 but increased to KES. 11,011.48 with PES interventions. Specifically, monthly revenue increased by KES 3, 333.44 for crop and KES 3, 085.60 for livestock enterprises. Average Willingness to Accept Pay (WTA) to conserve 1 acre of land was KES. 21,902.50 annually. The lowest and highest annual WTA for specific PES farm practices were KES. 7,428.00 for grass strips and KES. 21,847.50 for fallowing. The significant determinants of WTA were gender, age, farm size, acquired skills/knowledge, land use system, conservation interest, income and education. Consequently, 84 percent and 99 percent of farmers perceived that PES improved water quality and soil fertility correspondingly. By inference, findings demonstrate PES as a successful policy tool to enhance environmental conservation and livelihood improvement nexus for sustainable agro-ecosystem management and provision of ESs. There's need to institutionalize PES as national integrated natural resource management policy to conserve ecosystems for livelihoods benefits through developed market for ESs considering household socio-economic WTA determinants. Findings are useful to policy, development and conservation stakeholders.

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ACRONYMS AND ABBREVIATIONS

CARE-KENYA	Cooperative for Assistance and Relief Everywhere-Kenya
CBD	Cost Benefit Analysis
CPI	Consumer Price Index
DEFRA	Department for Environment, Food and Rural Affairs
ES	Ecosystem/Environmental Services
EPWS	Equitable Payment for Watershed Services
FAO	Food and Agriculture Organization of the United Nations
GoK	Government of Kenya
IUCN	International Union for Conservation of Nature, IUCN
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KES	Kenya Shillings
LANAWRUA	Lake Naivasha Water Resource Users Association
NGO	Non-Governmental Organization
TEV	Total Economic Value
m a.s.l	Meters above sea level
MEA	Millennium Ecosystem Assessment
NR	Natural Resource
PES	Payment for Environmental Services
WRMA	Water Resource Management Authority
WRUA	Water Resource Users Association
WTA	Willingness to Accept Payment
WTP	Willingness to Pay
WWF	World Wide Fund for Nature

CHAPTER ONE

INTRODUCTION

1.1. Background information

Natural resources provide humans with different ecosystem goods and services including food, medicinal plants, fiber and energy, climate and water regulation, soil formation and nutrients cycling, erosion control and socio-cultural attachment. Human wellbeing depends mainly on these ecosystem services and biodiversity for sustainability (Mugwedi *et al.,* 2018; Brancalion *et al.,* 2014). However, natural resources are mostly regarded as "natural given" or public goods with limited realization of their natural intrinsic value leading to lack of direct market for ecosystem services (Gustafsson, 1998). Public good or service means their consumption by one individual does not decrease the amount or level of same good or service available to another individual (non-rivalry), and that nobody can be effectively excluded from using the good or service, that is they are non-excludable (Pechey *et al.,* 2013). Low recognition of natural resources economic value has therefore led to increasing unsustainable mining resulting to environmental degradation and resources scarcity which threatens global economic growth including agriculture sector (Najam *et al*., 2007).

Socio-economic development globally mainly depends on natural resources whose increasing loss accelerates poverty levels especially in rural areas. Specifically, Africa is endowed with rich natural resources base which contribute to the continent's economic development and support the human population's livelihood. Over 30 percent of the continent's Gross Domestic Product (GDP) is linked to mining of natural resources (AFDB *et al.,* 2011; McKinsey Global Institute, 2010). Destruction of natural resources is mostly driven by anthropogenic factors (Yihdego *et al.,* 2017), mainly human population growth, poverty, overuse, weak policy enforcement, social, human and capital limitations, land use changes (Grima *et al.,* 2018) and exacerbated by external factors including climate change (Gebretsadik, 2016).

The Millennium Ecosystem Assessment (MEA) defines ecosystem services as benefits obtained from nature that satisfies human needs and simultaneously fulfill other species requirements (Costanza, 1997; MEA, 2005). Realization of importance of ecosystem services to both humans and biological diversity has rekindled universal attention to focus on valuing Ecosystem/Environmental Services (ES) for sustainable management of ecosystems. Ecosystem valuation has been recognized as key information tool to guide and inform on policy decisions related to socio-economic wellbeing and natural resource management strategies (Folkersen, 2018).

Several ecosystem management approaches including Payment for Environmental Services (PES) that link local community wellbeing with natural resources conservation are implemented worldwide. The PES schemes have gained global recognition as a potential market based policy tools to internalize negative environmental externalities (Wang *et al*., 2017; Schwilch *et al.,* 2016) to contribute to the increasing call to address human wellbeing concerns in ecosystem services governance (Cruz-Garcia *et al.,* 2016; Suich *et al.,* 2015). However, this global acknowledgement of PES schemes has been challenged by Silvertown (2015) who has argued that PES is not yet universally applied as conservation and human wellbeing enhancement tool. Human wellbeing has been defined differently by different scholars and this study adopted MEA (2003) and Narayan *et al.* (1999) versions of human wellbeing in relation to five components: basic material for a good life; security; health; good social relations; freedom of choice and action. Consequently, poverty and derivatives including 'poor' are defined as the deprivation of wellbeing.

Payment for Environmental Service schemes have as well been recognized and gained importance in Sub-Saharan Africa (SSA) as potential mechanism for ecosystems restoration, management, conservation and source of sustainable socio-economic wellbeing. This recognition is mainly linked to the fact that over 67 percent of Africa's land is degraded and soil degradation is attributed to anthropogenic factors including overgrazing, unsustainable agricultural management practices, vegetation destruction and overexploitation of natural resources exacerbated by climate change (Liniger *et al.*, 2011).

Payment for ecosystem services is as well recognized as essential tool to mobilize funding sources for sustainable conservation for Africa as it relates to private sector (Wunder, 2006). Although it is implemented in few countries, PES scheme is popular among local communities, policy makers, conservation/development organizations and private sector (FAO, 2016). The introduction of PES interventions are envisaged to contribute to ecosystem services provision, sustainable livelihoods, build institutional capacity in socio-ecological production landscapes, create markets for ecosystem services and conserve Africa's ecologically rich biodiversity (UNU-IAS, 2016), which is under degradation threat.

Contrary to global PES potential recognition, Cook *et al*. (2017) have argued that PES schemes are still underdeveloped in most countries. However, some of the selected examples of PES schemes implemented around the world are listed in Table 1.

Table 1: Examples of payment for environmental services schemes

Policy context	Examples
Agri-environment	Equitable Payment for Watershed Services in Naivasha Kenya and Uluguru Tanzania, England Environmental Stewardship, US Conservation Reserve Program, Australia Bush Tender, Kenya-Cash for Assets programme
Watershed protection	Equitable Payment for Watershed Services in Naivasha Kenya and Uluguru Tanzania, Lesotho Highlands project (South Africa), Guatemala Motagua-Polochic River and Peru Piura River Basins PES projects, US Wetlands Reserve Program, UK SCAMP, French Vittel, New York City water supply
Carbon sequestration	Kasigau Corridor REDD+ project-Kenya, Voluntary Agriculture, Forestry & Land Use (AFOLU) Carbon Market (for instance Noel Kempff Mercado Climate Action Project in Latin America), Carbon Sequestration and Sustainable Agriculture in Senegal
Habitat/Biodiversity/wildlife conservation	Costa Rica payments for ecosystem services, Voluntary biodiversity offsets, Kenya Kasigau Corridor REDD+ project

Source: Nyongesa (2018).

In Kenya, PES scheme in Lake Naivasha basin was initiated by two NGOs: the World Wide Fund for Nature (WWF) and CARE-Kenya in partnership with government agencies, local community and private sector. This was a mechanism to mitigate watershed degradation trend and diminishing livelihood challenges. The Lake Naivasha Equitable Payment for Watershed Services (EPWS) is a market-based scheme whose concept is modelled on the premise that those who provide environmental services (ES managers, stewards or sellers-upstream) by conserving natural ecosystems are paid by those who benefit from the ecosystem services. Payments for Watershed Services generally engage multiple users of the same watershed in co-investment in ecosystem services through mutual contractual agreement commonly between upstream land owners as sellers and downstream beneficiaries as buyers of ecosystem services (Bottazzi *et al.,* 2018).

The core of PES is to promote sustainable ecosystem conservation through compensatory or incentive scheme (Van Noordwijk and Leimona, 2010). However, Wunder (2005) and Engel *et al*. (2008) posit that a PES mechanism should fit five sets of conditions; a *voluntary* transaction where, a well-defined *environmental service* (or land use likely to secure that service), is being "bought" by at least one *buyer*, from environmental *service provider*, if, and only if, the environmental service provider secures environmental *service provision* (conditionality). However, critics of this definition have increasingly raised concern on whether all these sets of conditions should exist for ecosystem conservation-livelihood enhancement intervention to qualify as Payment for Environmental Services (PES) scheme (Sattler and Matzdorf, 2013; Kumar *et al.,* 2014; Wunder, 2015) or economic incentive and ecological outcomes could be applied to characterize a PES scheme (van Noordwijk *et al.,* 2012; Muradian *et al.,* 2010).

Being a comparatively new concept, different approaches to PES have been suggested. Although Wunder (2005) is a widely acceptable definition and the conditions that defines a PES scheme, Pechey *et al.* (2013) have shown that DEFRA Best Practice Guide on Payments for Ecosystem (Smith *et al.,* 2013), identifies seven key guiding principles which should define any PES scheme: [1] Voluntary: stakeholders especially buyers and sellers of ecosystem services sign a mutual PES contract on a voluntary basis; [2] Beneficiary pays: payment is made by the beneficiaries of ecosystem services who could be individuals, communities and private sector-businesses or governments acting on their behalf; [3] Direct payment: payments are made directly to ecosystem service providers (in practice mainly through an intermediary organization) and mode of payment is included in the mutual agreement; [4] Additionality: payments are made for actions over-and-above those which land owners or resource managers would generally be expected to undertake for provision of ecosystem services. These actions could be implemented through communal or private land use interventions or on individual farms. However, the actions that would result to additionality usually vary with PES designs in different geographical PES case scheme sites; [5] Conditionality: payments are dependent on the delivery of ecosystem service benefits agreed in the contract. Though from experience in practice, due to uncertainty and variability in many natural ecosystem services, most PES payments are based on the implementation of management practices agreed between sellers and buyers of ecosystem services for example presence of soil and water conservation interventions such as grass strips or planted agroforestry trees; [6] Ensuring permanence: management interventions paid for by beneficiaries should not be readily reversible, thus providing continued sustainable provision of ecosystem services and [7] Avoiding leakage: PES schemes should be set up to avoid leakage, whereby securing an ecosystem service in one location does not lead to the loss or degradation of ecosystem services elsewhere.

However, literature indicates that some PES schemes do not fulfil all these principles in practice and therefore achieving or implementing a ‘perfect’ PES scheme may not be realistic always (Pechey *et al.*, 2013). Many successful PES schemes around the world including Lake Naivasha watershed PES scheme are generally designed around these seven principles and Wunder (2005) five condition sets for PES with flexibility to incorporate stakeholder’s expectations and related social variability aimed to promote its sustainability.

Proponents of PES concept agree that considering market economic settings, compensation for ecological management are effective tools for conservation of ecosystems (Shen *et al.*, 2010) to sustain provision of ecosystem services. Compensation for conservation of ecosystem services and voluntary engagement of stakeholders are some of the attributes which differentiates PES from other conventional regulatory natural resource conservation interventions.

The PES schemes are regarded as alternative market-based policy instruments that are more flexible and cost-effective compared to command-and-control policy instruments designed to address livelihoods and environmental challenges (Goldman *et al.*, 2008). The schemes develop hypothetical market opportunities for ecosystem services which are mainly public goods estimated through different techniques including revealed preference methods (Baker and Ruting (2014).

Given its versatility, PES schemes have been applied in different watershed globally to conserve ecosystems that sustain living and non-living biodiversity in provision of different ecosystems services that support socio-economic-ecological development (Wunder *et al.*, 2008). Exceptional examples of models of local level PES schemes among many globally include Vittel (Nestlé Waters) water bottling company in north-eastern France which is a private buyer of ecosystem services (water) provided by farmers, the sellers of ecosystem services in the upstream catchment area for the company's water springs sources at the foot of the Vosges Mountains (Wunder & Wertz-Kanounnikoff, 2009). The Vittel PES is a sustainable working example similar to Lake Naivasha PES which involves upstream ecosystems service sellers and downstream private sector commercial ecosystem buyers.

In Costa Rica Alix-Garcia (2014) identifies Payment for Ecosystem Services (forest-PES) programs developed to pay for avoided deforestation as national-level PES program. The Reduced Emissions from Deforestation and forest Degradation conservation and sustainable management of forests and enhancement of carbon stock (REDD+) in developing countries to address climate change (O'Connor, 2008 and Arriagada, 2009) is as an example of global level large scale forest-PES program. The link between PES and REDD+ has been observed as complementary schemes especially in cases when both apply conservation and management practices in landscapes to contribute towards socio-economic and environmental outcomes (Trædal, 2017). The PES scheme has specifically been observed to offer potential improvement for REDD+ program to pay developing countries for protecting and management of natural resources to reduce global carbon emissions (UN, 2010; UN, 2014) and to address fundamental drivers of deforestation (Pfaff *et al.*, 2013). Research reveals that there is increasing number of similar REDD+ carbon off set projects in East Africa which mainly focus on afforestation, reforestation or forest conservation (Bond *et al.*, 2008; Huxham *et al.*, 2012; Namirembe *et al.*, 2014)

Trees for Global Benefit programme managed by the Environmental Conservation Trust of Uganda (ECOTRUST-Uganda) aims to generate long-term verifiable emission reductions sold at the voluntary market and improve rural community's livelihood through carbon payments in Western Uganda's Albertine Rift, which is considered a biodiversity hotspot area (ECOTRUST, 2012; Nantongo, Personal communication, December 9, 2014).

Land Leases Program in the Amboseli Ecosystem in Kenya is a PES project initiated by the African Wildlife Foundation (AWF) around Amboseli National Park to mitigate conservation threat in the Kimana group ranch. The PES scheme engages landowners organized in local community associations to adopt wildlife compatible land practices in exchange for payments.

In Tanzania, Equitable Payments for Watershed Services in the East Uluguru Mountains is a global scheme initiated by World Wide Fund for Nature (WWF) Tanzania and Cooperative for Assistance and Relief Everywhere (CARE) International. The PES scheme focus on ecosystem restoration-conservation and livelihoods improvement for local farming communities and to conserve the Ruvu River's water supplies to Dar es Salaam in Tanzania (Lopa and Mwanyoka 2011). Similar to Naivasha PES scheme, Uluguru PES project is designed to achieve sustainable land management practices through fair and equitable distribution of benefits to smallholder farmers upstream for the sale of ecosystem services to downstream users mainly the two main private sector water users, the Dar es Salaam Water and Sanitation Company (DAWASCO) and Coca Cola Ltd (Lopa *et al.*, 2012).

1.2. The PES project in Lake Naivasha watershed

The Lake Naivasha watershed is an important landscape in Kenya where 46.3% of people in the watershed are below the poverty line and depend on ecosystem services for their livelihood (GoK 2013a). Lake Naivasha landscape socio-economic development, livelihoods and natural resources are interlinked and degradation of the ecosystem has significant impact on socio-economic and environmental outcomes. The increasing land use change including deforestation and intensification of small-scale agriculture on smallholder farms in the upper catchment have impacted on water quality and quantity inflows into the Lake Naivasha which support commercial horticulture investment downstream. The increasing environmental degradation in the watershed mainly by human related activities and exacerbated by effects of climate change contributes to increasing destruction of natural resources which support rural communities livelihoods and private sector nature depended investments. The upper catchment smallholder farms experience low farm productivity due to decreasing soil fertility and the lower catchment commercial investment is affected by increasing degradation in ecological status of Lake Naivasha.

Unsustainable agricultural practices in the upper catchment of Lake Naivasha watershed are a major cause of watershed degradation, siltation, pollution of water ecosystems and declining water flows downstream. The PES scheme was initiated to address the Lake Naivasha watershed challenges and envisaged a developed mechanism of payments for watershed services which contribute to sustainable natural resource management and improved livelihoods. The overall goal of the Naivasha PES project was to improve the livelihoods of target households in the river Malewa catchment and secure sustainable commercial investment downstream through development of viable payments for watershed services incentive mechanism that delivers sustainable natural resource management and improved livelihoods. The PES scheme was envisaged to benefit farmers by delivering on objectives of food security, natural resources management and securing commercial investment therefore balancing environmental conservation and economic development.

Lake Naivasha watershed degradation was the main factor which compelled the intermediary organizations (WWF and CARE-Kenya) to initiate the PES conservation-livelihood improvement project in collaboration with multi-stakeholders including upstream local communities and downstream commercial private sector that depend on Lake Naivasha to sustain their horticulture commercial businesses. The PES scheme was introduced as a tool to offer mitigation solution to continuous environmental degradation, increasing poverty levels and diminishing communities' livelihoods.

Literature on PES schemes has shown that ccompensation and reward for environmental services (CRES) in PES schemes envisages efficient equitable use and conservation of NRs through contingent contracts (Swallow *et al.,* 2007). Many recent studies have suggested the need to understand the interaction between agricultural practices and ecosystem services production, which influence farm productivity and socio-economic wellbeing (Dale and Polasky, 2007). This suggestion has been supported in literature as key for informed environmental policy decision making to mitigate practices that contribute to environmental degradation (Landis, 2017). Though there's increasing worldwide recognition and interest to use Payment for ecosystem services to stimulate changes in the sustainable use of natural capital, Zheng *et al.* (2013) have argued that there are few assessments on analyses of impacts of payment for ecosystem services programs on ecosystem service provision, program cost, and changes in livelihoods.

This research attempted to fill this gap and aimed to determine the influence of PES scheme land use practices on environment and smallholder PES farmer's livelihood as well value ecosystem services in Lake Naivasha watershed. Specifically, the study focused on ecosystem seller's Willingness to Accept Pay (WTA) to implement PES land use practices, characterized factors influencing WTA and conversely quantified time series changes in farm yield and income before and after PES interventions.

1.3. Statement of the problem

Lake Naivasha watershed has rich natural resource base which drives socio-economic development at local and national levels through subsistence and commercial agriculture, fishing, geothermal power generation and tourism as the main economic sectors. The natural resources provide primary foundation of livelihood sources for smallholder indigenous farming communities. However, unsustainable land use practices within the upper catchment over years have led to agro-ecosystem degradation resulting in increasing poverty levels, diminishing farm household livelihoods, decreasing farm productivity, decreasing household income, increasing food insecurity, siltation and pollution of water ecosystems. The ecological function breakdown as well affects green economic commercial investment downstream which depend on water in Lake Naivasha recharged from upper catchment sources. Although efforts have been made to restore degraded ecosystems in the watershed through PES, the influence of the PES scheme practices on socio-economic benefits, environment and ecosystem services value as related positive externalities have not been empirically studied as part of the already existing literature framework in Lake Naivasha basin. This study attempts to fill this knowledge gap.

1.4. Objectives of the study

1.4.1. General objective

The general objective of the study was to generate knowledge on the influence of Payment for Environmental Services land use practices on smallholder farmer's livelihoods and achievement of environmental conservation.

1.4.2. Specific objectives

Specific study objectives were to;

i. Determine socio-economic attributes which influence farmer's preferences for land use PES conservation practices

ii. Asses productivity changes for crop and livestock enterprises as a result of PES interventions,
iii. Estimate farmers Willingness to Accept Pay (WTA) to provide ecosystem services,
iv. Determine socio-economic factors influencing farmer's WTA to implement PES practices.

1.5. Hypotheses

i. There are no significant socio-economic attributes which influence farmer's preferences for land use PES conservation practices,
ii. There are no productivity changes in crop and livestock enterprises as a result of PES interventions,
iii. Willingness to Accept Pay (WTA) to provide ecosystem services is insignificant, and
iv. There are no socio-economic factors influencing farmers' WTA to implement PES practices.

1.6. Justification of the study

The importance of this study arises from the need to understand if PES scheme was making any contribution to environmental degradation reduction and livelihoods enhancement in agricultural landscapes under PES project sites. Agro-ecosystem degradation has led to decreasing livelihoods opportunities mainly low farm productivity, food insecurity, limited household income, reduction in employment sources due to diminishing provision of ecosystem services and increased silt load in river water sources. Rehabilitation of degraded natural ecosystems through PES incentive scheme is essential for supply of ecosystem services for instance smallholder's household food security, enough clean water, provision of rural employment, strengthened socio-economic opportunities and conservation of biological diversity.

The findings of this study are important for future natural resource management policy formulation and designing similar PES programs, on-farm informed decision making on resource allocation, adoption of sustainable conservation farm practices and promotion of green economy. Characterizing socio-economic factors influencing WTA and valuing ecosystem services is a prerequisite to formulation of strategies for sustainable natural resources management and livelihoods enhancement. The study contributes to increasing literature on PES schemes, therefore the need for this study.

1.7. Limitation and scope

This study focused on valuation of ecosystem services and how land use practice generated from PES influenced environment-livelihood conservation nexus in Lake Naivasha watershed. It was limited only to PES implementing farmers within two WRUAs (PES sites) in three administrative sites of Nyandarua South, Kinangop and Kipipiri sub-counties. Targeted farmers were those whose farms were identified under different sub-basins in PES feasibility studies as highly degraded and prioritized for conservation to restore watershed ecosystem services (Figure 3). This research did not assess change in water quality which was hypothetically estimated to be realized after 14 years (WWF-CARE-Kenya, 2007) of implementing land use PES practices initiated in the year 2008. Consequently, the study did not estimate Willingness to Pay (WTP) but focused on Willingness to Accept Pay (WTA) and did not attempt to compare WTP and WTA therefore leaving gap for future hydrological water quality assessment and WTP studies.

1.8. Definition of terms

Direct use value: Actual or planned use of an ecosystem service (DEFRA, 2007).

Ecosystem: Natural unit of living things (flora and fauna, micro-organisms) and their physical environment (DEFRA, 2007).

Externality: Cost (negative) or benefit (positive) effect from an economic activity transaction that affects parties not directly involved in the transaction.

Green economy: Economy that results in "improved human well-being and social equity, while significantly reducing environmental/ecological scarcities" (FAO, 2012).

Indirect use value: Benefit from Ecosystem Services supported by a resource, rather than by using it directly (DEFRA, 2007), for instance soil retention and climate regulation,

Total Economic Value (TEV): The total gain in wellbeing from a policy measured by the net sum of the WTP or WTA (DEFRA, 2007). It is the value derived from natural resource.

Use value: Value derived from using or having the potential to use a resource (net sum of direct, indirect, and option values). It is the value that people place on having the option to use a resource in the future even if they are not current users (DEFRA, 2007).

Water Resource Users Associations: Legal community-based organizations formed under Kenya's WRMA in line with Water Act and mandated to conserve watersheds (GoK, 2002 and WWF, 2012).

Watershed: Area of land that feeds water into a river, by the process of precipitation draining through the landscape, into tributaries and into the main river channel. Watersheds are also called "catchments", "drainage basins or river basins" (Smith *et al*., 2006).

Willingness to Accept Pay (WTA): Monetary measure of the value of forgoing an environmental gain or allowing a loss (DEFRA, 2007).

Willingness to Pay (WTP): Monetary measure of the value of obtaining an environmental gain or avoiding a loss (DEFRA, 2007).

CHAPTER TWO

LITERATURE REVIEW

2.1. Valuation of ecosystem services

Natural resources produce different ecosystem services (ESs) as positive externalities not directly priced in markets (Goulder *et al*., 2009). Market imperfection for ESs is exacerbated by human's assumptive characterization of natural resources (NRs) as common-pool or public goods (Rolf, 2012) overlooking the intrinsic rent of natural ecosystem goods and services leading to unsustainable mining. Payment for environmental services provide an opportunity to price un-priced common pool ecosystem services such as climate regulation, water quality, soil erosion control, flood control, soil formation and nutrient cycling, regulation and the provision of habitat for wildlife and thus inform on policy decision to include such services into wider economy (Pechey *et al.*, 2013). Though natural ecosystems provide services to society, literature on valuation of ecosystem services is still limited.

Valuation of ecosystem services has been identified by several scholars as essential process to support decision-makers incorporate environmental, social and economic concerns into policy and natural resources management strategies (Daily *et al.*, 2009). Simpson (2011) argued that the economic values of ecosystem services have not yet been estimated with any generality or precision. However, Kremen *et al*. (2000) and Odour *et al*. (2018) have shown that eecosystem services have been valued differently in relation to cost and benefits linked to conservation of ecosystem's ecological functions and the benefits people gain from natural resource ecosystem services. Several authors have argued that ecosystem assessment takes two main approaches: non-monetary and monetary valuation. Monetary estimates give the value and marginal change of ecosystem services in monetary terms and has been shown to be a useful tool for policy decision making and for provision of incentives to public and private for ecosystems protection and poverty alleviation mainly in developing countries (Christie *et al.*, 2012).

Monetary valuation is equally useful to attach economic value to non-market public ecosystem goods and services and researchers have widely argued that monetary valuation directly links the ecosystems and the societies, providing economic numerical measures of ecosystem services (Campbell and Tilley, 2014; Ruckelshaus *et al.*, 2015). Economic (mainly monetary reference to this study) valuation mainly estimates price attached to ESs as public goods since human preferences or choices are at times not altruistic but based on self-interest motive (Navarro, 2010). However, Ernesto *et al.* (2007) and De Groot (1992) established that in line with ecosystem services framework, ecosystem functions provide a wide range of services with significant value. Interestingly, Folkersen (2018) found monetary valuation to be inappropriate to elicit ecosystem value in South Pacific Island countries. This argument could be accepted as one of isolated case studies or challenged and debated based on understanding that different societies have different perceptions of how ecosystem services can be valued at individual level.

Non-monetary valuation methods estimate ecosystem services changes and value qualitatively and quantitatively (for instance number of households or people affected by change in provision of ecosystem services). Kenter *et al.* (2015) have argued that non-monetary and the social valuation of ecosystem services provides an inclusive approach for assessing and understanding the values of natural ecosystem services to human well-being. This argument can as well be contested given that some scholars have shown that valuation technique can be influenced by type of ecosystem service to be valued (DEFRA, 2007).

Available literature indicates recent studies done by researchers who concur that ecosystem value involves assessment and economic valuation to make plausible conclusion on ecosystem value estimate (Sagoff, 2008; Turnhout *et al.* 2013). Contrary to these studies, it has been contested by some scholars that payment for ecosystem services schemes rarely use economic valuation but generally depend on buyer-seller negotiations to deliver on conservation objectives (Wunder, 2013). However, Wunder's argument does not consider the empirical evidence of the PES business case studies, livelihoods and opportunity cost analyses which are key preliminary feasibility components important to inform stakeholders before design and initiation of PES programmes. The components directly or indirectly attach proxy economic value to ecosystem services, especially the opportunity cost and benefits in PES programmes. Other authors have suggested production function approach to estimate ecosystem service values (Daily *et al.,* 2009), though this approach has been criticized by some economists to be challenging in context of ecosystem services valuation (Simpson, 2011).

There is general agreement in literature that ecosystem valuation is an important fundamental instrument for the ecosystem management policy decision-making especially tradeoffs between different strategies (Groot *et al.*, 2012; Toman *et al.*, 1998). Several researchers have as well valued ecosystem services to estimate the level of sustaining the human wellbeing and the ecosystem service contribution to climate change to sustain human livelihood and improve social and ecological resilience to effects of climate variability (Jones *et al.,* 2012). Other authors have suggested for a holistic wider review of best practices for integrated ecosystem services valuation to guide for future further scientific research that would improve decision making for ecosystem services management (Dendoncker *et al.,* 2018).

Capodaglio and Callegari (2018) have suggested six optional general approached for valuing ecosystem services in monetary forms: [1] Avoided costs; which enables society to avoid costs that they would incur, in the absence of those natural services for example soil erosion control cost that could be incurred in the absence of natural mechanisms such as land vegetation cover especially on high gradient and riparian land prone to soil erosion; [2] Replacement costs; the method consider ecosystem services as services that could be replaced with human-made services, at a cost. Replacement technique assess the cost of replacing or restoring degraded services asset as estimated measure of the benefit of restoration; [3] Missed income; focus on opportunities ecosystem services could provide for improvement of income to landowners whose livelihood depends on environmental resources for instance improved farm productivity and diversification of farm enterprises; (4) Travel costs; involves ecosystem service used through demand satisfaction visit to ecotourism destinations, and the travel cost used to imply the value of the ecosystem service visitors derive utility from as an implied value of the service (for instance the amount individual visitor would be willing to pay to access the ecotourism service); [5] Hedonic pricing; estimate economic values for ecosystem services that directly influence market prices for the services or products that reveal the value of local environmental attributes for instance estimates economic benefits or costs of goods and services related to environmental quality, including air pollution, water pollution, or noise and environmental amenities, including aesthetic views or proximity to recreational sites and [6] Contingent valuation; which is survey based approach applied to elicit individual's hypothetical cost or value for specific ecosystem goods or services. These approaches are applied to attach economic value to ecosystem services which are mainly public goods to elicit public inference estimates for changes in the state of the environment in monetary terms (DEFRA 2007).

Market and nonmarket or combination of both monetary and non-monetary valuation techniques for NRs depends on how the resource is used (Koteen *et al.,* 2002). For instance, as food, industry raw material, recreation among others, and WTA/WTP are the most fundamental measures of economic value of costs and benefits for market and nonmarket use/nonuse values. Willingness to Accept Pay for provision of environmental services is important factor in PES schemes establishment and Tetra Tech, & LTS Africa Limited (2018) report on willingness to accept payment recognize the need to assess land owner's willingness to be paid for allowing farm practice restriction or modifying their land use and resource practices to secure ecosystem services.

Willingness to Accept Pay underscores business relationship between sellers and buyers of ecosystem services. By postulation, the derivation of econometric model assumes that if respondent's true WTA is higher than the opportunity cost, then the respondent is likely to choose 'yes', and 'no' for otherwise, when presented with option to accept or reject pay for PES watershed conservation practices (Daniel *et al.*, 2009). Related to WTA, Zilberman *et al.* (2008) found that potential WTP by buyers of ESs strengthen further sustainability of PES schemes as an additional source of income from new farming technologies.

Kissenger *et al*. (2018) however argue that the value of ecosystem services can be challenging and not easily determined. This argument has been supported by Ainscough *et al.* (2018) who agree that though the ecosystem services concept is increasingly recognized for integration into natural resource management and environmental policy frameworks, the ecosystem assessments have mainly been characterized with uncertainty. In literature, the PES scheme proponents have proposed that markets should define ecosystem services value on the basis of willing sellers and willing buyers of ecosystem services. This proposal is supported by Wunder (2005) who concur that under Payment for environmental services, the ecosystem service beneficiaries (buyers) agree to make direct contractual payment to ecosystem managers (the producers and sellers of ecosystem services) to sustain ecosystem conservation.

There is general agreement however in literature that valuation of ecosystem services is important to inform on level of payment offered to providers of ecosystem services in PES schemes. For example, Gross-Camp *et al.* (2012) have shown that ecosystem services valuation was applied to determine standard payment levels based on estimated opportunity costs for Rwanda Re-Direct project. Despite this approach, many PES projects have different payment levels depending on the PES design, opportunity cost and negotiation between buyers and sellers of ecosystem services as evidenced in East Usambara Mountains PES scheme where payment amounts varied among landholders, the sellers of ecosystem services (Jaimbya, 2013; Kaczan *et al.* 2012).

Consequently, nonmarket valuation utilizes inferential methodology to analyze goods and services not bought or sold in a formal market. Brown and Adger (1994) suggests that ecosystem goods and services should be valued broadly by multiple stakeholders located in multiple geographical areas from local, regional and global levels. Conversely, some studies have applied monetary and conditional final bonus choice models to estimate WTA (Kuhfuss *et al*., 2016). In this study, ecosystem services were considered as environmental goods at local level and revealed preference (RP) and stated preference (SP) valuation techniques were applied.

Revealed preference technique require individuals to indirectly reveal their WTA to implement PES practices for provision of environmental goods and services as market and surrogate market prices while in SP (based on contingent valuation method), respondents are directly subjected to two binary choice options and asked what their WTA is using survey questionnaire instrument (Bett *et al.*, 2009) based on the direct elicitation of individual's preference as well as the amount they are willing to pay for certain non-market goods (Bengochea-Morancho *et al.*, 2005; Kong *et al.*, 2014). Revealed Preference (RP) and Stated Preference (SP) approaches have been applied widely to value non-market ecosystem services and their impact to human well-being (Costanza *et al.,* 2017; Jadhav *et al.,* 2017; D'Amato *et al.,* 2016). Globally, comparable studies have applied contingent valuation (CVM) techniques to estimate the economic value of ecosystem services based on willingness to accept pay (WTA). Example of these studies include estimation of rural households' willingness to accept two PES programs and ecosystem service valuation in the Miyun reservoir catchment, China (Li *et al.*, 2018) and the analysis influencing factors of willingness to accept pay for ecological compensation of Poyang Lake Wetland in China (Xiong and Kong, 2017).

Valuation based on WTA estimation for Naivasha study was premised on producer surplus concept whereby producer gets the benefits above the production cost. Purposely, the value for regulating services such as soil erosion control, pest and flood management were estimated as surrogate prices for instance how much a farmer gets from the farm with or without soil conservation technologies.

However, to draw “accurate” WTA without hypothetical bias is a known challenge faced in CVM approaches (Loomis, 2013). Having recognized this challenge, *ex ante* techniques were applied to reduce expected bias; first, the enumerators were trained to engage respondents in brief discussion and explanation to understand the need to have realistic estimates based on assumption they (respondents) were selling goods and services in the common market. These approaches have been found by other researchers to reduce hypothetical bias linked to CVM technique (Cummings and Taylor, 1999). Equally, Vásquez-Lavín *et al.* (2016) noted the hypothetical bias a challenge in precise evaluation on willingness to pay for ecosystem services and applied numerical certainty scale technique to reduce the bias.

2.2. Community livelihoods

Although there have been concerted efforts to achieve millennium and sustainable development goal to reduce poverty and hunger, over 1 billion people globally still live on less than 1 dollar per day for consumption. Majority of this population are in African countries living in the rural areas as smallholder farmers (Guerry *et al.,* 2015; UNIDO, 2010 FAO, 2009). Livelihoods enhancement is an essential incentive in encouraging community ownership and sustainability of development projects. Livelihood is a generalized term with varied definitions from different scholars. Oxford University dictionary defines livelihoods as a set of economic activities, that involves self-employment or wage employment by using one’s endowments (both human and material) to generate adequate resources for meeting the requirements of the self and household in a sustainable basis with dignity (Oxford, 2015).

Livelihood encompasses household’s capabilities, materials and social assets and activities required to achieve means of living (Ashley and Carney, 1999). Available literature indicates that Sustainable Livelihood Approach (SLA) approach has been applied to achieve socio-economic development since the late 1990s. The SLA combines multiple capital/assets approach where livelihood sustainability is considered in terms of available capitals; natural, human, social, physical and financial (Morse *et al.,* 2009).

Livelihood is sustainable if it is resilient to stress and shock stimulus to sustain its current and future assets and has adaptive capacity, without destabilizing the natural resource functional base. Generally, livelihood is about people's welfare, therefore the need to integrate physical, social, natural, financial and human capital assets (FAO, 2009) in designing rural community's livelihoods development and conservation projects.

Payment for environmental services schemes have been recognized to have pro-poor potential to reduce farmers' poverty levels by increasing farm productivity (Bond and Mayers, 2010, Van Noordwijk and Leimona, 2010) and livelihoods through restoration and sustainable production of ecosystem services which contribute to global human wellbeing (Constanza *et al.*, 1997). For instance, PES schemes have been implemented to alleviate poverty among smallholder farmers and restore clean water flow in Rwanda (Karangwa, 2011).

Studies have shown that ecosystem services have potential to contribute to varying combinations of livelihood improvement and poverty alleviation (Suich *et al.*, 2015; Willemen *et al*., 2013; Milder, 2010) among millions of people mainly in developing countries (Lau *et al.*, 2018). Other authors agree with this argument, and that PES schemes have potential to provide pathways for poverty alleviation though provision of additional income and implementation of alternative sustainable land use practices which are significant incentives for providers of ecosystem services to participate in land use changes especially in rural community areas (Jack, 2008; Lipper and Cavatassi, 2004). There's increasing interest for PES schemes due to its potential to restore ecosystem services which contribute to global poor local community's wellbeing (Daw *et al.*, 2011; Fisher *et al.*, 2014).

Rural community livelihood mainly depends on natural resources for sustainability, however, though PES schemes have been generally recognized to promote conservation of ecosystems for sustainable provision of ecosystem services, some researchers have argued that there's still limited evidence to show whether PES improves the livelihood of local communities participating in PES scheme (Lima, 2014). Contrary to Lima's findings, Hejnowicz *et al.* (2014) found that PES schemes can internalize environmental externalities to provide positive conservation and socio-economic development outcomes relative to livelihoods, land-use change, rural community household incomes and governance. Hejnowicz *et al.* (2014) have shown further that PES can contribute to livelihood capital/assets; natural, physical, human, social, and financial to improve socio-economic and environmental outcomes. These outcomes have been confirmed to support community household needs and national economy (Narloch *et al.*, 2011).

Other scholars found that PES programs when designed based on sustainable livelihood framework (which combines livelihood capitals to generate livelihood outcomes), the income of PES participating ecosystem service providers increased and their poverty relieved (Wang, 2009).

In Ecuador PES program study, Echavarria *et al.* (2002) have shown the increasing popularity of integrating sustainable livelihood approach to widen PES schemes to recognize natural, physical, human, social, and financial assets. Further, Kwayu *et al.* (2017) have argued that the livelihood impacts of the Equitable Payments for Watershed Services Program (EPWS) in Morogoro, Tanzania contributed to smallholder farmer's livelihood from direct payment incentives and indirect benefits including increased crop yields and on-farm employment opportunities.

Other studies have indicated improved human capacity and knowledge of participants through training, technical support and extension services as indirect livelihood benefits to smallholder farmers participating in PES programmes (Tacconi *et al*., 2010). Positive PES impact on livelihood of communities participating in PES has been demonstrated by Blundo-Canto *et al.* (2018) who reviewed 46 PES livelihood impacts assessment studies. Similarly, Clements and Milner-Gulland (2015) PES study in Cambodia further revealed that communities enrolled in PES scheme derived multiple livelihood benefits including increased income, agricultural productivity, and improved food security.

Payment for Environmental Services in Lake Naivasha basin focused on watershed management for water quality, quantity demanded downstream as ecosystem service and upstream soil and water conservation practices to restore and conserve agro-ecosystems to improve land owner's livelihood through increased productivity mainly food as provisioning services. Smallholder farmers enrolled in PES scheme benefit from direct payment incentives from buyers, capacity building and in-situ benefits from improved farm productivity. Other than direct payments, the Naivasha PES implementation framework was designed to integrate all the four livelihood capitals.

2.3. Alternative PES land use practices and ecosystem service concept

Agro-ecosystems provide a wide range of ecosystem goods and services essential for human wellbeing (DEFRA, 2007; Groot *et al*., 2012) for instance supporting services notably soil formation and retention, provision of habitat, nutrient cycling, water cycling and provisioning services such as food production and water. Soil nutrients are key factors of production associated with agriculture practices. Land use practices determine the soil nutrient cycling capacity which bears significant influence on agricultural ecosystems. Changes in land use practices in rural areas are multifaceted, but largely driven by farmers seeking to increase economic returns, resulting to human induced ecosystem degradation (Minang *et al*., 2008).

Recent research has shown that the concept of ecosystem service has gained interest globally as potential approach to soil management (Cord *et al.,* 2017) and as a way of understanding ecosystem service benefits and trade-offs from changes in land use (Lazos-Chavero *et al.,* 2016). The ecosystem services model establishes the natural resources value to human wellbeing to encourage conservation of ecosystems through incentive mechanisms such as Payment for environmental services (Díaz *et al.*, 2018; Haines-Young & Potschin, 2013).

These studies have identified soils not only as key supporting services for production of other ecosystem services but also its main contribution to agricultural production. For instance, crop production directly depends on soil fertility provided by soil supporting service, biodiversity conservation and sustenance benefits for human well-being (Baveye, *et al.,* 2016; Schwilch *et al.,* 2016; Alston and Mueller. 2008). Helming *et al.* (2018) concur with these studies and have argued that soil management influence farm production and related ecosystem services provision.

Several past researchers have widely studied the essential role of soil in relation to terrestrial ecosystem services provided by agro-ecosystems (Bünemann *et al.,* 2018; Adhikari & Hartemink, 2016; Keesstra *et al.,* 2016; Bouma, 2014) and have shown the importance of soil function management to sustain ecosystem services provision (Schulte *et al.,* 2014; Breure *et al.,* 2012) through application of tools such as payment for environmental services.

Some of the human related poor land use practices that contribute to agro-ecosystems degradation include clearing of land vegetation cover, cultivating slope areas exposing soil to erosion, salinization, nutrient depletion through continuous over-cultivation of land, cultivating riparian land and pollution from overuse of agro-chemicals. In rural areas, most farmers own land through family inheritance and majority of land ownership is under male household members. Other land ownership is by lease agreement. Land tenure by family inheritance through subdivision increasingly reduces land size for agricultural enterprises leading to encroachment on protected areas. Land ownership has significant effects on conservation such that farmers who lease land may not be motivated to practice long-term conservation activities.

Studies have established that land tenure for smallholder farmers influence farm productivity and conservation sustainability with significant improvement on resources allocation for on-farm investment (FAO, 2009).

In Lake Naivasha basin PES project sites, most land owners are smallholder farmers whose land has been degraded through long years of over cultivation. The prioritized PES land use practices to rehabilitate degraded farms included; rehabilitation and maintenance of riparian zones through tree planting, grass strips, terracing along steep slopes, fallowing, agro-forestry, crop rotation, contour cropping and reduction in agrochemicals. The PES practices aim at restoring ecosystems for continuous supply of ecosystem services (Namirembe *et al*., 2017) through envisaged reduction in soil erosion, sediment load and environmental pollution in water ecosystems (Gathenya and Jones, 2007).

In related studies, the PES practices have been proven to have positive impact on agriculture through increased farm productivity by restoring degraded agro-ecosystems (Wang *et al.,* 2018). Significant provision of net benefits in a theoretical PES context is essential for achievement of PES goals as pro-poor mechanism (Kissinger, 2013; Van Noordwijk and Leimona, 2010; Harrison *et al.*, 2010). Hydrological study in Lake Naivasha basin using landsat and Aster images between 1973 and 2005 has shown that land especially in the upper catchment areas has undergone tremendous change in terms of land subdivision, degradation, vegetation clearing and encroachment into forest reserves for agriculture land expansion (Gathenya, 2007).

2.3.1. Payment for environmental services in Agriculture sector

Studies have recognized agriculture as the main land use activity globally and human dependence on agricultural land continue increasing relative to human population increase.

Agriculture is perceived to be the key driver of competitiveness among other activities in agro-ecosystems (Schaller *et al.,* 2018). Research findings confirms agriculture's demand for land increase conversion of natural habitats, increase demand for ecosystem services and leads to environmental degradation (Tanentzap *et al.,* 2015; Ramankutt *et al.,* 2008).

Literature has shown further that agriculture though supports the human wellbeing, it also contributes to some forms of environmental degradation than any other economic sector including global greenhouse gas (GHG) emissions, eutrophication of water ecosystems from increased over use of agro-chemicals, soil degradation and environmental pollution (Foley *et al.,* 2011; Tilman *et al.,* 2011).

Studies have shown that trade-offs exists between agriculture and environmental conservation and can be reconciled through policy frameworks that promote habitats and nature conservation, while encouraging intensive agricultural production (Merckx, 2015; Lastra-Bravo, 2015; Hodgson, *et al.*, 2010).

Most developing countries' economies are driven by agriculture sector and majority of local communities depend on small-scale agricultural enterprises for their socio-economic development. Different mechanisms including sustainable land management (SLM) have been recognized in Africa to contribute to sustainable management of natural resources in Agro-ecosystems. However, the SLP potential benefits, have not yet been widely realized across the African continent (AFDB, 2015). Rural subsistence agriculture is mainly sustained by agro-ecosystems and agricultural land use practices determines the productivity of smallholder farms. Other scholars have recommended agriculture activities that protects, regenerates and benefit from ecosystem services to achieve socio-ecological outcomes that promote human wellbeing and environmental sustainability in agro-ecosystems (Gill *et al.,* 2012; Henry *et al.,* 2012).

Agro-ecosystems natural resources provide ecosystem services essential to human's socio-economic-cultural wellbeing (Power, 2018). Agro-ecosystems ecosystem services including supporting services such as soil formation, nutrient cycling and fertility (Zhang *et al*., 2007) influence provision of other ecosystem services for example regulating and provisioning services (Table 2). Though agro-ecosystems provide vital ecosystem services, increasing demand of these ecosystems services has led to degradation in many rural areas and impact on human wellbeing. Increasing human population and poverty have been associated with increasing agro-ecosystem degradation due to demand for ecosystem services to sustain human livelihoods. The Ten Brink (2009) report has acknowledged the linkage between poverty and ecosystems and biodiversity loss.

Literature has shown that smallholder rural poor land owners mainly depend on marginal lands that are prone to land degradation influenced by poverty as major driver of natural resource and ecosystem services exploitation exacerbated by natural factors for instance soil erosion (Bulte *et al.*, 2008).

Conversely, using matching and panel data analysis, Alix-Garcia *et al.* (2013) found close relationship between environmental degradation and poverty. Interestingly, Trædal, (2017) applied a livelihood framework to assess links between livelihoods and land use amongst small-scale coffee farmers in Lam Dong Province in Vietnam communities and found no clear linkages between poverty levels, unsustainable practices and environmental degradation contrary to most forest policy dialogues assumptions about the drivers of forest cover change in a Payments for Environmental Services and Reduced Emissions from Deforestation and Degradation (REDD+) that link deforestation to poverty and unsustainable practices such as agricultural land expansion into forest areas.

Despite these study variations, there is increasing global popularity and recognition of Payment for Ecosystem Services (PES) schemes to restore, conserve and sustain provision of ecosystem services for livelihood and conservation improvement in the agro-ecosystems in developing and developed countries (Scales, 2015; Branca *et al.*, 2011; Sommerville *et al*., 2009).

Studies in literature have demonstrated that managed agro-ecosystems provide ecosystem services which directly or indirectly impact on ecological functions to support human populations (Groenfeldt, 2006; Bills and Gross, 2005). Other scholars have shown that agroecology has been suggested to have potential of nurturing agro-ecosystems resilience and sustainability in rural areas through implementation of practices that enhance ecosystem services (ES) production at ecosystem wide level (Dendoncker *et al.*, 2018a). Agroecology concept combines science and different practices (including efficiency in farm input use optimization and minimized environmental impacts) with social dimension in sustainable farming to improve biodiversity and ecosystem service provision in agro-ecosystems (Duru and Thérond, 2015).

Thus, agroecology and ecosystem service concepts complement, they both address social-ecological-economic interactive outcomes. Conversely, Farber *et al*. (2006) have shown that managed agro-ecosystems have potential to increase production of provisioning services such as crop production, regulating services cultural and supporting services and sustained biodiversity conservation. Other researchers have argued that ecological characteristics of the agro-ecosystem are linked to crop and animal management which contribute to community household livelihood strategies (Somarriba, 1992) and that integrating ecological management concept into agricultural practices has potential to increase food production and related ecosystem services (Garbach *et al.* 2017; Ponisio *et al.,* 2014).

Most PES schemes are designed to provide incentives to farmers to motivate adoption of sustainable farm agricultural practices. Recent literature has shown other scholars agree that payment for environmental services implementation framework depend on the beneficiary-pays principle for its financing based on contractual incentives to producers of ecosystem services for conservation (Legrand, 2013). It has been demonstrated that agro-enterprises that depend on agro-ecosystems for supply of ecosystem services have benefitted from payment for environmental services schemes to enhance and sustain supply of agro-based goods and services. This potential has been recognized and implemented by some countries such as Mozambique which apply PES as an option tool to finance protected areas and biodiversity conservation (Honwana, 2014).

Payment for ecosystem services schemes have been applied as a tool to restore and manage agro-ecosystem to improve agricultural productivity. In their research, Garbach *et al.* (2012) argued that Payment for Ecosystem Services schemes are applied to agro-ecosystems to provide multiple service benefits and sustain food production. The linkage between PES and agriculture production activities has been demonstrated by several studies which reveals that combination of agriculture production activities with PES conservation interventions improve landowners' needs and motivate farmers to conserve agro-ecosystems (Miranda *et al.,* 2003). Such activities include conservation farming practices; reduction or optimal use of agro-chemical inputs, grass stripping on high gradient farms, fallowing, agro-forestry, land tillage practices that enhance soil retention and reduce soil erosion, cover crops, protection of riparian land, indigenous trees and fruit trees planting among others to stimulate extensive sustainable agricultural production and environmental conservation. These on-farm management activities can promote improved ecological functions and significantly improve sustainable provision of ecosystem services in agro-ecosystems to sustain agricultural productivity.

Some scholars have analyzed tradeoffs between these PES practices and agriculture as source of ecosystem services including tradeoffs observed within ecosystem services mainly between provisioning services and other services such as regulating and supporting services, cultural services and conservation of biodiversity (MEA, 2005; Pereira *et al.,* 2005), environmental and social outcomes, targeting both poverty alleviation and conservation (Pascual *et al.,* 2010; Tuna *et al.,* 2007), agriculture food production and ecosystem services production (Raudsepp-Hearne, 2010) among others. On contrary, Gauvin *et al. (*2010) study has shown less tradeoffs between environmental and development goals in China's Sloped Land Conversion PES Program.

2.3.2. Payment for environmental services potential to mitigate climate change

Many countries around the world including African continent are affected by increasing effects of climate change (Boko *et al.,* 2007a; Hope, 2009). Adaptation to climate change under increasing degradation of natural resources has been identified as one of the main global socio-ecological-economic challenges (Pecl, *et al.,* 2017). Studies have shown that rural communities mainly depend on rain-fed agriculture which is supported by ecosystem services that are highly vulnerable to effects of climate change variability impacts (Midgley *et al.,* 2012).

The climate variability directly or indirectly affects sustainable provision of ecosystem goods and services. Climate change impact on the ecosystem services equally impacts on the human wellbeing which depends mainly on ecosystem services. Midgley *et al.* (2012) have further argued that market-based payment for ecosystem services schemes have potential contribution to climate change adaptation strategies to improve local communities and ecosystems resilience to climatic shocks.

In recent literature, there’s increasing interest and proposal to apply ecosystem-based adaptation (EBA) approach to mitigate effects of climate change (Pecl *et al.,* 2017).

Promoters of this suggestion define EBA as the adaptation policies and measures that considers the role of ecosystem services in reducing the vulnerability of society to climate change, in a multi-sectoral and multi-scale approach (Vignola *et al.,* 2009). However, this definition has been simplified by the Convention on Biological Diversity (CBD) which defines EBA as the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change. The definition recognizes the potential of ecosystem services contribution to sustainable management, conservation and restoration of ecosystems to deliver on multiple social, economic and cultural co-benefits for local communities through application of EBA for co-investment in the natural capital (Naumann *et al.,* 2011)

Agriculture sector is affected by effects of increasing climate change manifested through floods, extreme temperature variations, increased pests and disease prevalence, low precipitation and unpredicted seasonality among others. Different strategies have been applied to mitigate climate change effects to improve ecological and human resilience to climate change. A case study from Sasumua a rural watershed in Kenya has shown that payments for ecosystem services has potential role in climate change mitigation (Sand *et al.,* 2014). The posited that climate change impacts on social-ecological systems including practices implemented under PES and participating stakeholders as well.

Most of the PES conservation interventions contribute to effects of climate change mitigation thus the link between PES and climate adaptation. For instance, agro-forestry, terracing, fallowing and contour cropping can contribute to flood control and carbon sequestration (agro-forestry) which are linked to climate change. Pedrono *et al.* (2016) found that biological diversity are disappearing due to climate change combined with other anthropogenic pressures, affecting the functionality of ecosystems. Based on this concern, Balvanera *et al.* (2012) have suggested for ecosystem services delivery evaluation and assessment of the potential trade-offs in future payment for environmental projects schemes under situations of climate and land use changes.

Past research by Sand (2012) recognize Payment for Environmental Services potential to contribute to climate change adaptation in several ways including: enhancements in the provision of ecosystem services, improvement of ecosystems adaptive capacity relative to PES interventions design and implementation, and incentive provision mechanism to motivate farmer’s adoption of PES practices for adaptation to climate change. Through these approaches, Payment for environmental services contributes to improved human and ecosystem resilience to climate change.

2.3.3. Payment for ecosystem services policy implication

Payment for ecosystem services schemes have been applied globally as effective policy mechanism to develop markets for public ecosystem goods and services through incentive payments framework to individual and community stewards of natural resources for the opportunities forgone (Li *et al.,* 2011). The incentives aim to motivate communities to rehabilitate and conserve ecosystems for sustainable provision of ecosystem services which sustain human wellbeing and biodiversity habitats. Though PES schemes have these potentials, they are limited of clear policy for their operationalization and as well as less studies on ecosystem service valuation. The increasing popularity of PES programmes as a tool to create market for ecosystem services and link landscapes environmental conservation with livelihoods necessitates the need to review the existing local, national and international natural resource use policies for integration (Pirard, 2012; Pokorny *et al.*, 2012).

Evaluation studies on Payment for Ecosystem Services outcomes indicate that PES has potential opportunity to expand globally but other researchers suggest that such opportunities should be linked to other natural resource management and poverty alleviation policy instruments (Hejnowicz *et al.*, 2014) since PES schemes are now preferred as alternative policy solution to address ecosystem environmental challenges and promotes integration of the private and social benefits (Arriagada, 2009; Jack, 2008). Though PES schemes are mainly voluntary, they involve participating farmers to undertake conservation interventions in agro-ecosystems and such intervention practices require supportive policy environment to sustain PES scheme for viable provision of ecosystem services.

Börner *et al.* (2017) have argued that payment for environmental schemes are mainly initiated along with other policy instruments as complementary to achieve conservation and socio-economic outcomes. However, this policy integration with PES schemes in many cases is not formal to institutionalize PES programs. Related studies have demonstrated that policy framework can strengthen Payments for Ecosystem Services to mitigate catchment management challenges to sustainably implement conservation interventions for provision of ecosystem services (Cook *et al.*, 2017). However, experience from available literature indicate that policy solutions for wider integrated ecosystem management can be feasible if

PES key stakeholders including policy institutions collaborate under forms of contractual agreement (Benson *et al.*, 2013).

Payments for Ecosystem Services may not solve all environmental and livelihood challenges. Integration of PES schemes with other natural resource management policy tools to contribute significantly towards better natural resource conservation has been proposed by various scholars (Reed, 2013). Though PES is voluntary in design, other researchers have proposed the need for supportive regulatory and institutional framework for PES operationalization and that PES could be integrated with the existing national policy, legal and institutional frameworks to strengthen the enabling environment of PES scheme implementation (Biryahwaho *et al.,* 2011). The AFDB (2015) report identifies promotion of integrated water resources management (IWRM) policy as one example of such integration. The IWRM policy promote coordinated development and management of water, land and related resources to maximize economic and social welfare equitably without compromising the sustainability of vital ecosystems. The IWRM approach has been adopted in Lake Naivasha watershed to complement Payments for Ecosystem Services sites.

2.3.4. Policy framework for Lake Naivasha watershed PES project

This section briefly covers key conservation-livelihood policy issues and reviews selected natural resource based policies relevant to Payment for Environmental Services in Lake Naivasha watershed. Some of the key conservation-livelihood Policy issues include: [1] Low Agricultural productivity and the increasing food insecurity influenced by unsustainable farm practices contribute to increasing soil infertility; [2] Increasing human population and poverty levels which increase demand for ecosystem services to sustain human wellbeing; [3] Soil erosion and pollution including overuse of agro-chemicals which increase silt load and eutrophication in water ecosystems and [4] Weak policy enforcement related to natural resource management among other policy issues. Lake Naivasha Payment for Ecosystem Services can be integrated within several relevant policy framework in Kenya including the following:

The National Water Policy Act (2012) was formulated in line with Kenya’s 2010 new constitution and recognizes that water towers in the country are faced with degradation due to anthropogenic activities. The Policy directs on the need to conserve the water towers for sustainable provision of ecosystem services to support economic development. Emphasis is on government and water sector stakeholders' commitment to achieve watershed resource management. The act provides that environmental conservation, water and sanitation services should be a major function of the national and decentralized governments whereas mmanagement of water resources be based on Integrated Water Resource Management-IWRM framework.

Further, the act recommends establishment of Payment for Ecosystem Services (PES) to conserve ecosystems for provision of ecosystem services benefitting both landowners and water users as well as development of community conservation projects.

Forest Act (2005) guides on management, conservation and rational utilization of forest resources for the socio-economic development of the country. It recognizes the role forest ecosystems play in supporting other ecosystems for provision of ecosystem services including regulating services for instance stabilization of soils and soil erosion control as well as climate moderation and provisioning services mainly ground water recharge, food and medicinal plants, supporting services through provision of organic matter important for soil nutrient cycling and cultural services for communities that live in and adjacent the forests.

The forest ecosystems are important as well through their potential to complement and support biodiversity by provision of habitats and supports other cross-cutting issues including agriculture, water, ecotourism and genetic resource for research. The act provides for creation and management of forests and community participation in joint forest management through legal formation of community forest associations. This makes it ideal for incorporating PES scheme as incentive mechanism for sustainable management of forests and watersheds.

Forest Policy Sessional Paper (2007) further identifies forest as important sector for provision of environmental goods and services for economic development, social and cultural values. This recognition supplements provisions of forest Act (2005). Both sessional paper and the Act are ideal legal frameworks for incorporation of PES scheme as watershed management policy tool.

The Environmental Management and Co-ordination Act (EMCA) (1999) provides for establishment of an appropriate legal and institutional framework for the management of the environment. It guides on protection and conservation of the environment, specifies environmental conservation and restoration orders. The Act legalizes principles of sustainable development as the basis for managing environment and provides for public participation in the development of policies, plans and processes for the management of the environment. Though PES is a voluntary rather than command driven scheme, the restoration orders of the Act provides appropriate legal framework especially the policy enforcement important for PES to strengthen ecosystem service conservation.

Land Act (2012) directs on land laws and provides in part for the sustainable administration and management of land and land based resources for connected purposes. It provides for conservation of both private and public land for provision of ecosystem goods and services to support socio-economic development through PES schemes. Land managers are incentivized to adopt sustainable land use practices to conserve the watersheds for sustainable provision of ecosystem goods and services important to sustain social wellbeing. The PES soil and water conservation practices are important interventions for restoring degraded land and therefore PES policy is important land management tool for both sellers and buyers of ecosystem services. The Land Act is linked to the Constitution of Kenya (2010).

National Environment Policy - NEP (2013) identifies environment and natural resources as important assets that must be sustainably managed for provision of ecosystem goods and services which support economic development and livelihoods at local and national levels. The policy identifies drivers of environmental degradation including high rates of population growth, inappropriate technologies, unsustainable consumption and production patterns, and increased incidences of poverty and climate change. The Policy further recognizes the linkage between socio-economic wellbeing and environmental conservation which requires conservation to achieve sustainable mutual integration. The NEP identifies PES as one of the important market based tools which allows for establishment of business relationship between land managers as sellers of ecosystem services and buyers as beneficiaries of ecosystem services. The PES scheme can be institutionalized under NEP policy as implementation framework instrument to support both environmental conservation and livelihoods enhancement at local and national level.

Agriculture policies

The local economy is supported mainly by agriculture which contributes to poverty reduction and average of 25 percent of the GDP (Alila, 2006). Agriculture sector potential is sustained by ecosystem services in agro-ecosystem to contribute to socio-economic development. Agricultural policy in Kenya mainly focuses on increasing farm productivity and income, particularly for smallholder farmers and available literature has indicated several policies and legislations related to agriculture sector in Kenya. Ng'endo *et al.* (2013) have illustrated for example 6 agriculture policies (Agriculture Act, Agriculture-Basic Land Usage Rules, Agriculture- farm forestry Rules, Forests Act 2005, National Land Policy and Agricultural Sector Development Strategy) related to conservation agriculture with trees (CAWT). Specifically, the Agriculture Act revised edition 2012 aims at promoting and maintenance of sustainable stable agriculture, provision for the conservation of the soil and its fertility and to stimulate the development of agricultural land in accordance with the accepted practices of good land management and good husbandry. Agriculture Act is important legal framework which PES could be incorporated for national promotion and adoption of its sustainable land use practices to rehabilitate degraded land and sustain farm practices for provision of ecosystem goods and services.

2.4. Theoretical framework

2.4.1. Relevant theories related to the study

People benefit and derive satisfaction from ecosystem goods and services as natural capital for socio-economic development. Increasing demand for ESs to satisfy human needs exert pressure on sustainability of the ecosystem services leading to degradation of ecological functions and reduced natural resilience (Steffen *et al.*, 2015). Resource economists have related increasing price of some provisioning services such as food, water and timber to natural resources scarcity. This concern has led to universal thinking to develop markets for environmental goods and services for instance regulatory and voluntary carbon markets through PES schemes to give value to ESs including, flood and soil erosion control and clean water flows.

However, most ecosystem services are not directly tradable in the markets or lack direct markets making it difficult to estimate their value and develop payment framework for both providers and beneficiaries of ES (Rohit and John, 2007). Where there are no direct markets for ecosystem services, economists have applied alternative non-market approaches to value the services. This includes survey related methods such as revealed preference (RP), hedonic, travel cost, and replacement cost techniques (Rolf, 2012). Equally, stated preference (SP) economic valuation methods are used to estimate Willingness to Pay (WTP) and Willingness to Accept Pay (WTA) as surrogate price values attached to the ecosystem services and has been widely applied to estimate non-use values which relates to TEV for most natural resources (Soto *et al.,* 2018; Giergiczny and Kronenberg, 2014; Wang, 2013).

Common SP approaches include contingent valuation method which is survey-based economic technique for the valuation of nonmarket resources (Seong-Hoon *et al.,* 2008) and choice modeling methods based on random utility theory. Comparable studies have used contingent valuation technique to elicit compensation to farmers as incentive to change land use practices under Payment for environmental services schemes such as in carbon emission control projects (Freeman, 1994).

Tao *et al.* (2012) and Venkatachalam, (2004) have argued that contingent valuation method creates a hypothetical market environment and get the value of the respondents for public goods not traded directly in market. It has been argued in literature that contingent valuation technique can be useful to estimate the economic value of ecosystem goods or services not directly traded or lack defined market prices such as non-use or bequest values (O'Garra, 2012). Contingent valuation technique has been widely applied in multi-disciplinary research including economic valuation of forest and forest ecosystem services (Oduor *et al.,* 2018; Tao *et al.,* 2012; Jørgensen, 2003).

Koteen *et al.* (2002) have argued that producer and consumer surplus theories are measures of benefits, which WTA and WTP by producers and consumers of ecosystem services respectively can quantify. Assessment of ecosystem sellers WTA is related to producer surplus theory which reflects higher benefits farmers expect to receive from their farms above expected pay from buyers of ecosystem service. Unsustainable land use practices are major sources of negative externalities in agro- ecosystems including biodiversity loss, soil erosion and nutrient loading from overuse of agrochemicals.

Most economic development activities are based on understanding of natural resources shortage related to Ricardian neoclassical law on resources scarcity especially diminishing returns on land, and to Malthusian concerns on population growth (Turner *et al.,* 1994). David Ricardo observed nature as a force resisting labour to produce commodities such that the higher quality of a natural resource, the less labour required to produce needed commodity, notwithstanding human related environmental degradation activities. Malthus theorized the arithmetic food growth versus simultaneous geometric human population growth predicting natural resources degradation in the long run to undermine sustainable human wellbeing (Malthus, 1798).

In two sector economies, production involves mining and use of natural resources with objective function of profit maximization while consumption sector involves people consuming products to satisfy their needs. The two sectors have important implication on ecosystem services. They depend on use of natural resources whose efficient sustainable mining is overlooked leading to degradation (Fedotenkov, 2014; Marsiglio, 2012). Rehabilitation of degraded ecosystem requires implementation of integrated conservation practices aimed at increasing productivity and restoring ecosystem. Reference to Pareto improvement-optimality theory (Hammond, 1997), there is need to allocate resources to activities which will not undermine environmental quality despite change in land use to increase productivity. Therefore, the economy becomes Pareto optimal if individual farmers will be better off in terms of productivity and livelihood enhancement without harming either one another, the environment or otherwise.

In economics, demand and supply theory defines market transaction between producer and consumer of goods and services. However, classical Keynesian macro-economic theory economists believed in free markets, that the economy would always achieve full employment through forces of demand and supply by total spending in the economy considering effects on output. The classical economists however, did not consider effect of scarcity and degradation of ESs that drives the economy as well as lack of direct market for ecosystem goods and services which are mostly non-excludable and non-rivalry. Though one underlying issue of Keynesian economists is that those with income will demand for goods and services, the economists did not consider environmental goods and services scarcity and thus failed to consider sustainability of the natural resources (Chick, 1983).

Payment for Environmental Service involves business relationship between buyers and sellers of ESs and therefore demand-supply theory was relevant to this study. Ehrlich (1981) argued that the value of nature started gathering interest by neoclassical economists in 1860s, the argument which has been supported by Wegner and Pascual (2011) that under neoclassical economic theory, individual utility can be used to measure the value of ecosystem goods and services. Most micro-economic models have basis on theory of consumer behaviour in trying to maximize utility subject to a budget constraint (Francisco, 2001). This is associated with consumer making rational choice of ranked bundles of commodities in order of preference from characteristics of goods other than goods and services themselves (Lancaster, 1996) such as PES farm practices.

The axiom of comparison is applied in revealed and stated preference methods in estimating WTA analyses with close relation to PES conservation practice bundles. For better understanding of the theoretical relations in this study, revealed preference (RP) theory pioneered by American economist Paul Samuelson was linked to demand and supply theory. The assumption is that consumers make consumption decisions to maximize their utility functions which RP method defines through consumer behaviour based on individual motives and incentives (Khaled, 2008). Proponents of this assumption in literature equally argue that farmers implicitly maximize utility based upon consumption of market goods and non-market ecosystem goods and services produced in agro-ecosystems subject to the budget constraints (Dupraz *et al.,* 2003). This study adopted hybridized theoretical approach as modification of the discussed theories.

2.4.2. Overview of payment for environmental services

Modern understanding of ecosystem services (ES) concept can be traced from late 1970-1980s (Erik *et al.*, 2009) with framing of beneficial ecosystem functions as services to increase public interest in biological diversity conservation. Since then, ES concept has gathered global interest (Waylen, 2018; LaNotte *et al.*, 2017) including recommendation for its incorporation in socio-economic decision making through increasing innovative market-based conservation tools including PES schemes (De Groote, 1987).

Martin and Mazzotta (2018) have shown that significant research work on ES has focused mainly on ecological studies to assess how ecosystems provide useful goods and services, and socio-economic dimension of valuation of ecosystem services and how ecosystem goods and services benefit humans. However, literature on PES impact on environment and livelihood outcomes and its integration in policy is still limited in Africa and Kenya in particular.

The term environmental services is sometimes used interchangeably with ecosystem services when in reference to payment for environmental services concept (Capodaglio and Callegari, 2018). The terms have no standardized definition but have been broadly used to mean services provided by the natural environment that benefit people (MEA, 2005; DEFRA, 2007; Smith *et al*., 2013). Other scholars have defined ecosystem services concept to mean multiple benefits humans obtain from natural resource capital (Table 2) that deliver on socio-economic and conservation objectives to sustain human life (Capodaglio and Callegari, 2018).

Ecosystem services are recognized in literature as essential for human existence and social-economic development around the world (Fu *et al.,* 2018). Recent literature has shown that ecosystem services concept has gained wide recognition and is influencing how environmental and development stakeholders pursue dual conservation and community development goals linkages (Chaudhary *et al*, 2018). The concept is widely applied to offer important context for the systematic assessment of the multiple benefits ecosystems deliver to society and biodiversity (Raum, 2018).

Ecosystem service concept has been applied to link society with ecosystems management, underscore humanity's wellbeing dependence on nature and to contribute to biodiversity conservation (Schr¨oter *et al.*, 2014). The linkages is important to attach economic value on ecosystem services as an incentive to motivate environmental conservation. Other scholars have recognized the importance of ecosystem services and have suggested the need to strengthen linkage among ecosystem services (ES) supply, social demand and human well-being to achieve sustainable mutual human and nature co-existence (Wei *et al.,* 2018). Conversely, Ehara *et al.* (2018) agree that there's strong relationship between human wellbeing and ecosystem services and have suggested that it is essential to understand this linkage for conservation-livelihood policy formulation relative to societal groups affected by changes in provision of ecosystem services.

Achieving the human well-being while protecting the environment is a key idea in the United Nations Sustainable Development Goals (SDGs) which some researchers in literature have proposed can be achieved through integrating ecosystem services, the benefits nature provides to humans, into strategies designed to attain the Sustainable Development Goals (Wood *et al.,* 2018). Under the SDGs, global governments agree to develop strategies to achieve their national goals that integrate social, economic and environmental dimensions of sustainability for poverty reduction, which are as well relevant to biodiversity and ecosystem service concept to deliver on socio-economic-ecological outcomes (Naeem *et al.,* 2012). Several studies have shown that valuation of past and present ecosystem services enables investigation into how different scenarios impact the SDGs including economic growth, poverty and equitable distribution of ecosystem benefits within societies (Ward *et al.,* 2018).

Tresierra (2009) and DEFRA (2007) reports, identifies four forms of Payments for Ecosystem Services acceptable universally; [1] carbon sequestration: which enhances sequestration and long-term storage of carbon in plant biomass and soil organic matter, for climate change mitigation; [2] watershed services: focus on water quality improvement through nutrient and chemical load management and erosion reduction, reducing the risk of landslides, floods and increased groundwater recharge by better rainwater infiltration; [3] biodiversity conservation: aim at maintenance of biodiversity at all levels(including landscape, species and genes) supporting protection of areas important for wild biodiversity or enhancing the quality of on-farm habitats and agro-biodiversity and [4] landscape beauty or aesthetic features: involving maintenance of landscapes creating source of inspiration, culture and spiritual nourishment; protection or enhancement of landscape features, like tropical forests, agricultural activities mosaic valued for commercial form of ecotourism. Consequently, Millennium Ecosystem Assessment-MEA framework (MEA, 2005; DEFRA, 2007) identifies four broad categories of ecosystem services; provisioning, regulating, cultural and supporting services.

Examples of these ecosystem services are provided in Table 2. In most cases, ecosystem services have been assumed to be freely provided by nature therefore, characterized as public goods leading to *Laissez-faire* societal behaviour of unsustainable use.

Payment for environmental service schemes have been initiated around the world and mainly implemented among the local rural communities to incentivize them adopt conservation practices that enhance provision of ecosystem services (Muradian *et al.,* 2013). However, the PES schemes have been faced with some critique, risks and uncertainties concerning key issues such as who to pay, PES efficiency, effectiveness and equity/ fairness in compensation to benefit the poor smallholder ecosystem stewards, the sellers of ecosystem services (Wunder, 2005).

Table 2: Broad categories of ecosystem services

Provisioning Services	Regulating Services	Cultural Services
Products acquired from Ecosystems	**Benefits got from regulation of ecosystem process**	**Non material obtained from ecosystems**
Food; fruits, fish, crops	Climate regulation	Spiritual and religious
Fresh water	Disease regulation	Recreation and ecotourism
Fibre and fuel wood	Water regulation; timing run-off and floods	Aesthetic values; beauty in ecosystem aspects
Bio-chemicals; for instance, natural medicines	Erosion control	Inspirational
Genetic resources	Water purification; such as waste decomposition	Social relations; such as fishing communities
Ornamentals; such as flowers	Pollination	Cultural heritage
Supporting services		
Service necessary for production of all other services		
Soil formation and retention		
Nutrient cycling		
Primary Production		
Habitat provision		
Production of atmospheric oxygen		

Source: Nyongesa, J.M (2018).

Some researchers have argued that PES uncertainties arise due to limited knowledge on ecosystem services, the PES concepts as well as socio-economic and ecological linkages (Wells *et al.,* 2018; De Lima e*t al.,* 2018). Further criticism has been recorded over the argument in literature that PES is market based incentive mechanism. The market-based concept has been critiqued for inadequacy to address social and institutional determinants that control land use and management decision making and that market is the solution to ecological challenges (Frame, 2011; Robertson, 2004). This criticism is however debatable since the critiques overlooked the socio-economic-ecological dimensions that are key issues most PES schemes focus on.

The critics' generalized assumption on social and institutional determinants also contradicts overall general PES scheme principle requirements which recognize the issues of land ownership markets and voluntary participation in PES schemes involving producers and buyers (beneficiaries) of ecosystem services. Jack (2008) has argued that the compensation component in Payments for ecosystem services (PES) policies incentivise the ecosystem managers including the land owners to motivate them implement interventions that sustain the provision of ecosystem services such as flow of water quality and quantity and thus compensation payment under seller-buyer agreement recognizes PES schemes as potential market-based mechanisms for environmental policy.

Other scholars have raised concerns on PES program's long-term sustainability and impact when payments are discontinued Börner *et al.* (2017). These concerns however did not consider other underlying PES design framework such as mutual market based agreement between buyers and sellers of ecosystem. For instance, Lake Naivasha watershed presents an example of engagement between upstream local communities and downstream private sector through co-investment in ecosystem services to achieve long term socio-economic and environmental outcomes for sustainable payment for environmental services scheme beyond PES project duration.

The Naivasha PES project other than direct payment, provides other in-kind incentives including capacity building of local communities on various conservation practices, linkage to extension services for technical support, introduction of high value fruit trees as well as soil and water conservation planting materials among other services to ensure PES sustainability.

In Zambia, a discrete choice experiment study on preferences of smallholder farmers for PES contracts revealed farmers valued in-kind agricultural inputs more highly than cash payments. The study emphasized that PES has to conserve ecosystems and improve smallholder agriculture (Vorlaufer *et al.,* 2017) for sustainability. Conversely, Pagiola, *et al*. (2016) found that in Colombia, the PES land use changes (adoption of silvopastoral practices to enhance biodiversity benefits) were still maintained by ranchers even after end of payment after 4 years PES program. In some watersheds, integrated catchment management (ICM) programmes have been used to manage natural resources and improve social wellbeing in landscapes (Cook *et al.,* 2017). Though ICM has been applied at ecosystem level to manage natural resources, some researchers have criticized its effectiveness and argued that it is characterized by both technical and societal uncertainty (Smith, 2010). The ICM challenges have been related to its limitation to mitigate increasing ecological degradation in many rivers and lakes (EFRA, 2016).

Despite these critical concerns, PES schemes have been applied as alternative sustainable incentive mechanisms for ecosystem management to improve social and environmental outcomes by promoting sustainable land management practices that secures ecosystem conservation and restoration (Arriagada *et al.,* 2018). Suich *et al.* (2016) equally recognized the global recognition of Payments for ecosystem services schemes to have the potential to internalize environmental externalities and contribute to positive biodiversity and ecosystem service and social outcomes. To the contrary, Muradian *et al.* (2013) argued that though PES schemes have the potential to internalize environmental externalities to achieve environmental-socio-economic outcomes, the design of PES schemes could be exposed to politicization, by powerful groups at local level at the disadvantage of the vulnerable poor groups at community level.

In related studies, other authors have raised the concern about the shift PES induced from a polluter pays principle to a beneficiary-pays principle (Pirard *et al.,* 2010). Though these concerns are valid, they have been contested by other scholars. The PES schemes for example the Naivasha project are designed as a co-investment framework which involve both sellers and buyers of ecosystem services to address common watershed challenges that affect both sides.

Further, contrary to Pirard *et al*.(2010) criticism, Pechey *et al.* (2013) have argued that what distinguishes PES from the other market-based tools is the PES focus on the payment by beneficiary of ecosystem services (rather than polluter of ecosystem pays) concept and that PES financial incentives (paid by ecosystem service beneficiaries) to land owners to adopt conservation practices have been proven to motivate participation in conservation practices that increase ecosystem service provision compared to other conservation instruments.

Other critical thinking on whole concept of ecosystem services framework under PES has been illustrated by other researches in literature (Schaubroeck, 2017). They have argued that ecosystem services context mainly focuses on the benefits people derive from ecosystems and tend to overlook services that people could perceive to undermine societal wellbeing by producing ecosystem disservices or negative externalities which are unwanted or socio-economically harmful. Some of these disservices could include pollen allergens, increased pests prevalence and unpleasant smells from rotting organic matter (Lyytimäki *et al.*, 2008). However, whether ecosystem function is termed a services or disservice has remained debatable, and Scholte *et al.* (2015) found that it mainly depends on the individual perception, values and characterization, that is how the individual view and interact with environment and the specific ecosystem functional products (goods and service)

In literature, other scholars have as well raised concerns on PES conflicts with the concept of biodiversity and argued that payment for ecosystem service could be used as a conservation goal at the expense of biodiversity-based conservation for instance implementing PES conservation strategies based on ecosystem service provision might not safeguard biodiversity (Vira & Adams, 2009). Cardinale *et al.* (2006) and Norgaard 2010) argue that empirical proof of relationships between ecosystem services provision and biodiversity conservation is perceived as weak. However, this criticism fails to consider the PES concept and its underlying implementation framework that defines specific interventions to address specific ecological challenges which equally impact on biodiversity. For instance, PES practices including agro-forestry for instance that restore ecosystems functions to provide ecosystem services directly or indirectly protects biodiversity. Thompson & Starzomski (2007) as well provides evidence in literature for ecosystem service and biodiversity protection of win-win relationship.

Overlaps between biodiversity and ecosystem services through inclusion of biodiversity aspects within the habitat, supporting, provisioning, regulating and cultural service categories has been recognized in the Millennium Ecosystem Assessment (MEA) and The Economics of Ecosystems and Biodiversity-TEEB) frameworks (MEA 2005; De Groot *et al.*, 2010; Reyers *et al.* 2012). Sandifer *et al.* (2015) found strong evidence connecting biodiversity with production of ecosystem services and between nature and human livelihoods.

Other recent studies have established that biodiversity supports essential ecosystem services which provide benefits to humans to sustain their livelihoods (Loreau and de Mazancourt, 2013) and this biodiversity-ecosystem services and livelihood linkage has influenced wide support for biodiversity conservation to sustain human well-being (Sandifer and Sutton-Grier, 2014; Bernstein, 2014). Further evidence that ecosystem services concept support biodiversity conservation has been studied by Armsworth *et al. (*2007) and Benayas *et al.* (2009) who argue that restoring degraded ecosystems can have positive effects on biodiversity and ES provision.

In literature, biodiversity, ecosystems and the ecosystems services they provide support human societal, cultural and economic wellbeing though, generally human economic and social development have led to the unsustainable exploitation of ecosystems (Folke *et al.,* 2016; Naeem *et al.*, 2012) which impact negatively on sustainable provision of ecosystem services. Realization of exploitation threat to ecosystems has generated debate on best and sustainable approach ecosystem services concept knowledge can be applied in practice for integration into environmental governance (Russel *et al.,* 2016; Guerry *et al.,* 2015).

The PES voluntary incentive schemes are regarded as an improvement over other landscape management approaches that apply legal restrictions and investment subsidies associated with development projects to deliver on social and environmental outcomes (Kerr, 2014).

Available literature has demonstrated that PES as voluntary market-based ecosystem service mechanisms generally are more efficient compared to command and control non-market based environmental policy measures (Arriagada, 2009; Pagiola, 2006; Wertz-Kanounnikoff, 2006). Delivery on socio-economic and environmental benefits defines the sustainable working of PES schemes (Yang *et al.,* 2018) and mitigation of market failure for ecosystem services. The ecological, economic, and social outcomes are key building blocks in PES programs. However, PES ecological effectiveness, economic efficiency, and social equity have been least studied as the main determinants of the PES sustainability (Yang, 2018).

Distribution of multiple benefits derived from the sale of environmental services among stakeholders participating in PES programs can be a challenge. For PES scheme to be attractive to stakeholders, mainly buyers and sellers of Ecosystem services, it should exhibit the attributes of effectiveness, efficiency and equity (3Es) in its implementation framework.

The 3Es attributes have been shown to stimulate stakeholders willingness to participate in PES practice implementation relative to the content of mutual contractual agreement between sellers and buyers of ecosystem services (Li *et al*., 2017). Studies have shown 3Es to have close relationship in PES schemes (Pascual *et al.,* 2010). Payment for environmental services has been derived partly from Coasean economics as an approach to improve economic efficiency (Engel *et al*., 2008) even though Coasean policy methodologies tend to disregard equity concerns which are important attributes in PES schemes (Li *et al*., 2017).

Proponents of Payment of environmental services have argued that payment incentives under PES framework directly or indirectly change the land-use and management practice. This argument supported by Coasean economic theory in which environmental externalities are internalized through development of markets for ecosystem public goods and services for land owners with property rights ownership (Engel *et al.,* 2008). The PES scheme incentivizes holders of such property rights to adopt PES land use management practices for sustainable provision of ecosystem services (Norgaard, 2010). However, Frank (2010) argued that equity in PES is essential based on moral argument that rural community ecosystem service managers implementing PES interventions for provision of ES have a right to a fair share of the resulting benefits to ensure PES interventions under implementation are effective and sustainable (practical argument).

Nevertheless, trade-offs arise in seeking to achieve *equitable* PES outcomes along *effectively* achieving ecosystem service (ES) objectives in an *efficient* (i.e. cost-effective) manner. There is still limited knowledge and practice which seeks to optimize the trade-offs both between the interests of ES provider and buyer and related social groups who contribute to ES provision. It is envisaged that PES pro-poor approach can contribute to poverty reduction and improved ecological functions.

Literature on PES programs has indicated that land use practices, for example avoided deforestation under PES programs have potential to benefit the poor smallholder farmers through increased agricultural productivity and income (Zilberman *et al.,* 2008). But, there are concerns that the change in natural resource management brought about by PES could in many situations result in negative social impacts, especially for poorer, vulnerable social groups who have fewer options to adjust their livelihood strategies to accommodate change (Landell-Mills and Porras, 2002).

Perceived fairness in distribution of the costs and benefits defines the equity component and influence adoption and success of community-based PES interventions (Sommerville, 2010), though Kagata *et al.* (2018) have argued that equally, socioeconomic characteristics, agricultural extension services and incentives initially provided to farmers are as well key factors that influence smallholder farmers to adopt of PES land use interventions.

Thematic areas of focus to enhance equity within PES business schemes include; fair distribution of benefits, costs and risks to ES sellers and buyers, supporting factors that enable more equitable outcomes, balancing PES objectives with equity-efficiency-effectiveness trade-offs, participatory development of mutual benefit-cost sharing framework, governance and policy framework, monitoring, measuring and verification of PES social impacts (McDermott *et al.,* 2013). Though equity is associated with fairness, humans perceive it differently and therefore it is not easy to achieve general societal satisfaction on equitable distribution and sharing of the costs and benefits under PES schemes (Konow, 2001; Pascual *et al.,* 2010).

Equity in distribution and sharing of benefits in particular has been identified as a challenge to achieve in PES mechanisms designs (Di Gregorio *et al.,* 2013; Ghazoul *et al.,* 2010). Nevertheless, Griffiths (2008) and Peskett *et al.* (2008) have suggested that equitable benefit sharing among stakeholders under PES schemes need to depend on the degree of local participation in the process of developing and implementing PES interventions to deliver on benefits. However, Corbera *et al.* (2007) suggest that equity in society can be achieved if it is linked to the distribution of socio-economic factors and goods characterized by distribution of costs and benefits related to agreed criteria relative to PES programs contractual agreement.

Corbera's suggestion is relevant to PES Naivasha design which targets WRUAs as legal institutions whose members are buyers and sellers of ecosystem services. However, the suggestion does not consider variation to satisfy different individual tastes and preferences to maximize utility subject to a budget constraint (Kragt *et al.,* 2009). Consequently, in Norbu (2012) report, it is argued that sustainable management of the natural ecosystems can be achieved if the benefits of ecosystem services are shared equitably and impartially with the local communities who provide these services.

Equitable cost and benefit sharing lacks global standard criteria, but it can take two dimensions depending on the PES design framework (Frank, 2010; Watson, 2010); [1] Vertical sharing- equitable sharing between local, national and international levels for instance in PES carbon sequestration schemes and [2] Horizontal sharing- equitable sharing of benefits, costs and risks between communities, and within communities and households (applicable in Naivasha Payment for watershed services PES scheme). The two dimensions in provision of ecosystem services are guided by different equity approaches such as equity based on egalitarian-uniformity in payment of incentives to ecosystem service providers, proportionality payment in relation to cost and benefits, equity based on contribution to ES conservation/ improvement, equity in access to ecosystem services market created by PES, equity in decision making for PES participating stakeholders or equity based on PES scheme socio-economic-environmental impact.

The decision on which equity model to use depends on PES design and stakeholders agreement. Some PES programs have applied hybridized approach combining different equity approaches. Equitable cost and benefits sharing has been supported by Yang *et al*. (2015) who observed that local communities' perceptions on equity is key fundamental factor that motivate decision making on cost and benefits sharing distribution model under PES schemes for accountability.

The correlation between the environment and economic improvement place efficiency and effectiveness as key components in PES schemes. The PES interventions that improve ecological function to increase ecosystem services provision to stimulate and sustain socio-economic development improvement is thus regarded efficient (Pascual *et al.,* 2010). Efficiency is essential to both buyers and sellers in terms of ecosystem services delivery. For buyers of ecosystem services to achieve beneficial return on investment, PES interventions need to be efficient relative to cost incurred as payment incentives to sellers of ecosystem services.

Research has shown that evaluation of PES efficiency to deliver on environmental outcomes can be a challenge, whereas other available literature has indicated possibility of determining

PES efficiency through comparison cost invested to achieve envisaged outcomes (Ferraro, 2002). Some authors have proposed implementation of participatory processes at the early stages of PES schemes to achieve efficiency (Grima *et al.,* 2017; Reed *et al.,* 2017; Sarkki *et al.,* 2017). These findings can be summarized to three main efficiency indicators; transaction costs, opportunity costs and risks.

Many PES schemes mainly target rural communities as managers of the ecosystems that provide ecosystem services. This implies effectiveness of PES in watershed conservation will appeal to ecosystem service providers and motivate them to sustainably implement PES farm practice interventions. Effectiveness for instance would relate to impact of PES conservation interventions to achieve environmental and livelihood outcomes. For example, farm PES practices that would restore degraded agro-ecosystems, improve farm productivity and restore water quality and quantity flow on wider ecosystem level scale (geographical coverage) would be regarded effective under PES schemes.

Valuation of ecosystem of ecosystem services has been applied to attach economic value to ecosystem services and directly or indirectly evaluate the effectiveness of the PES outcomes. Literature has shown that cost-effectiveness of PES schemes is designed to achieve a specific level of ecosystem services, while development of market for ecosystem services benefit through consideration of efficiency design. (FAO, 2007). Many PES scheme designs including Naivasha PES project combine the equity, efficiency and effectiveness to achieve the PES livelihoods and environmental additionality outcomes.

However, available literature indicate efficiency to be least studied among the 3Es related to ecological effectiveness, economic efficiency and social equity (Yang, 2018). Contrary to Yang, it has been argued in other related studies that economic efficiency in PES schemes can be improved through well designed framework to deliver on three dimension of PES sustainability of ecological effectiveness, economic efficiency, and social equity outcomes (Viña *et al*., 2013; Chen *et al*., 2010; Uchida, *et al.,* 2005).

Payment for environmental services land use conservation practices have been applied in watersheds to improve ecosystem services including water quality and quantity flows especially from upstream areas (Wunsher *et al.,* 2008). Implementation of most PES programs is premised that environmental challenges are as a result of market failure to recognize the value of positive externalities provided by natural ecosystems (Kosoy *et al.,* 2007). Market failure occurs due to nature of most environmental services as public goods. Markets fail to compensate producers of positive externalities by the beneficiaries of ecosystem services and thus reward or PES schemes provide market-based solution to the market failure for environmental services (Puttaswamaiah, 2018). Payment for environmental services schemes attempt to bridge the gap between lack of tradable market and monetary value for the ecosystem services considered public goods (Bell *et al.,* 2018; Nguyen *et al.,* 2016).

However, Kosoy (2009) argued that PES ignores complex heterogeneity of ecosystems which undermines smooth market transactions, while Arild (2010) distinguished between generalizing PES and theory on market for ES as link to the ES niche market leading to widely acceptable theoretical PES definition by Wunder (2005). Wunder's definition is supported by Brendan *et al.* (2010) who concurs that PES is a mechanism linking conservation outcomes to market-based incentive approaches. This characterization is subsequently supported by Van Noordwijk and Leimona (2010) who distinguish PES or compensation reward for environmental services (CRE) based on three paradigms; [1] commoditized Environmental Service (CES); which focus on procurement with conditionality based on actual service delivery and marketability; [2] compensating for opportunities skipped (COS); involves paying land owners for accepting restrictions on their use of land. These restrictions may be voluntary or mandatory; [3] co-investment and shared responsibility in stewardship (CIS)**;** of landscapes for enhancing ES.

Lake Naivasha basin PES design is a hybridized approach modifying combination of the three models to co-benefit both ES stewards upstream and private sector ES beneficiaries downstream. This hybridized approach has been supported by other scholars for its flexibility to achieve sustainable socioeconomic, ecological, and institutional outcomes in specific ecological areas under PES projects (Muradian *et al.,* 2010)

Lake Naivasha watershed PES scheme links upstream smallholder farmers and downstream commercial private investors as providers and beneficiaries of ecosystem services respectively. The scheme involves two Water Resource Users Associations-WRUAs as sellers (located in the Turasha and Wanjohi sub-catchments of the Malewa River) at the western foothills of the Aberdare Mountains in Kenya the main catchment area of the

Malewa River crucial for both Kenya's horticulture and tourism industry around Lake Naivasha (Harrison *et al.*, 2010). The two WRUAs represent land managers (sellers) while buyers are represented by Lake Naivasha Water Resources Users Association-LANAWRUA downstream.

The PES scheme was initiated in Naivasha basin through WWF and CARE-Kenya partnership as the main intermediary NGOs in collaboration with government agencies, private sector and local communities. The intermediary organizations were interested to conserve the natural resources, restore ecological function for protection of biodiversity habitats and sustainable socio-economic development. Key government agencies involved included Water Resources Management Authority (WRMA), Kenya Forest Services (KFS), Ministry of Agriculture and local administration.

The government agencies involvement was important for provision of technical, policy and social (such as smallholder farmer's mobilization and training) support. Main actors and beneficiaries of the PES scheme included; two Water Resources Associations (WRUAs-Upper Turasha/Kinja and Wanjohi) as sellers and one WRUA (Lake Naivasha Water Resources Users Association-LANAWRUA representing water users) as buyer of ecosystem service downstream. The ecosystem service sellers, mainly rural community smallholder farmers have a role to sustainably rehabilitate and manage their degraded farms by adopting PES conservation farm practices.

The PES practices were envisaged to increase farm productivity to improve farmer's livelihoods; increase income and food security (provisioning services) through restored soil fertility and soil retention (regulating/supporting services). The Naivasha PES scheme was initiated to benefit upstream farmers through incentives inform of cash (voucher system) from buyers as a source of income. The voucher enables land managers to access farm inputs to improve farm productivity.

There are other different forms of payment for ecosystem services around the world. For example Costa Rica PES program offers direct cash payments while Los Negros PES in Bolivia offers payments in kind through distribution of beehives and community capacity building in apiculture (Asquith *et al.*, 2008). Similar in kind incentives have been reported in a study by Bottazzi *et al.* (2018) in Rio Grande catchment in the eastern Bolivian Andes.

Upstream farmers enrolled in PES watershed conservation incentive programme and selected their in-kind incentive preference from bundle of five incentives: bee-keeping materials; water infrastructure (irrigation tanks or tubing); construction material (cement, tin roofing); fruit trees; or barbed wire to motivate allowing restrictions on their farms to implement alternative land use PES conservation practices.
Other PES program have combined direct cash with in kind payments for example the largest PES programs in the world, Chinese national sloping land conservation program and Brazilian Bolsa Floresta Program in Amazonas state (Viana, 2010).

Choice decision on type of payment for the provision of ecosystem services is a challenge but generally preference for the form of payment is made through participatory negotiations of main stakeholders (buyers and sellers of ecosystem services). Naivasha PES scheme visualized to benefit the commercial investors downstream through provision and use of quality and enough water from upstream sources for their horticultural business investments. The buyers of ecosystem services (quality water) are commercial private sector downstream. The rich biodiversity especially wildlife attracts a lot of tourists in the basin. Hotels downstream depend on water for their vibrant business and wildlife similarly depend on Lake Naivasha for water thus PES interventions were envisaged to benefit biodiversity and the tourism sector as well. The geo-thermal power generation depends on clean water for green power production around Lake Naivasha which is recharged from River Malewa flowing from the upper catchment.

The Naivasha PES scheme is expected to contribute to economic recovery and livelihoods resilience for wealth and employment creation related to Kenya's 2009-2020 Agriculture Sector Development Strategy as well to contribute to the government of Kenya's 2030 development goals though conservation of natural resources for citizen's improved livelihoods.

2.4.3. Key lessons learnt from payment for environmental services schemes

Payment for Environmental Services Schemes have been implemented in different parts of the world and some lessons documented. Experiences and lessons from PES schemes are important to inform on future successful PES scheme design, implementation and policy decisions. Generally, successes in PES schemes programs depends on both their design and implementation.

Corbera *et al.* (2008) found that PES schemes should be linked to the scale of the ecosystem services provision while other studies have shown the need for stakeholder analysis to identify the key providers and beneficiaries of ecosystem services, stakeholder sensitization on ecosystem services degradation risks and livelihood outcomes to necessitate co-investment invest in PES scheme to sustain demand for improved watershed services sustainability (Smith *et al.*, 2013; Talberth *et al.*, 2012).

Lessons from studies on implementation of community-based Payment for environmental services projects across Sub-Saharan Africa (SSA) have shown that strengthened local institutions, land tenure, community control of land management decision-making and flexible payment schemes are important for PES schemes sustainability (Dougil *et al.*, 2012).

Lessons from watershed PES schemes in Africa have indicated high cost related to PES design and implementation and few private sector willingness to engage in PES schemes as buyers of ecosystem services are regarded as some of barriers in development of watershed PES schemes (Sand *et al*., 2014; Stanton *et al*. 2010).

Lessons from Vittel (Nestlé Waters) PES project indicate that initiating PES can be challenging as it requires concise consideration of scientific, social, economic, political, institutional, and power interactions (Perrot-Maître, 2006). Vittel PES study further demonstrates that PES presents a strong business case for public community and private sector participation in PES schemes which especially address water quality, quantity and agricultural practices connected to ecosystem watershed management. Lessons from other Payment for environmental services schemes have shown that financial intermediary organizations are important to support engagement between buyers and sellers of ecosystem services especially when benefits and costs accrue at different local, national and global scales especially Payments for Ecosystem Services for REDD+ Benefit-Sharing schemes (Loft *et al.*, 2014).

Other lessons in literature indicate that when PES schemes are financed by beneficiaries of ecosystem services rather than government or other external donors they are more likely to be sustainable (Farley and Costanza, 2010). Success of PES scheme is vital for sustainability and research has shown that engagement of multi-stakeholders and community participation in all stages of PES development is essential for motivating individual and community empowerment, supporting access to resources and information, strengthening support networks in conservation initiatives, increased access to markets especially for ecosystem services, securing socio-economic sustainability and improved land practices reform (Fisher *et al.,* 2008). The Pro-poor PES strategies that address livelihood development have been found to be equally critical to promote stakeholder participation at local smallholder community farm level (Bremer *et al.*, 2014).

Lake Naivasha Payment for Environmental Services present some key lessons learnt for successful design, implementation and sustainability of PES scheme. These lessons include; feasibility studies are essential to establish business case, develop market mechanisms for ES and build trust and PES concept understanding between buyers and sellers of ecosystem services. Kagombe *et al*. (2018) equally found that trust building and feasibility studies form key components in establishment of Payment for Environmental Services. Identification, sensitization and involvement of key multi-stakeholders including buyers and sellers of ecosystem services and technical extension support in all stages of PES scheme ensures ownership and sustainability.

The PES design that increase in-situ benefits to ecosystem sellers motivates sustainable adoption of PES practices. Equitable and transparent payment to sellers of ecosystem services as incentives from buyers strengthens trust and business relationship between the ecosystem's stewards and ecosystem service beneficiaries while effectiveness of PES schemes programs depends on design and implementation, socio-economic-political and environmental perspective of the PES program (Arriagada, 2009). Flexibility in PES seller-buyer contracts including negotiated payments based on cost benefit assessment for sellers opportunity cost and trade-offs between conservation and livelihoods initiatives have proven key in PES designs sustainability (Grieg-Gran *et al*., 2006). Other studies have shown flexibility in PES program design to be effective in addressing individual expectations and (Cheatum *et al*., 2011).

2.4.4. Lake Naivasha PES project design

Designing is important process in PES scheme development. The design process determines the sustainability of PES project (Arriagada, 2009). Lake Naivasha PES was initiated to promote land use conservation practices in the upper catchment smallholder farms through incentive contractual agreement between buyers and sellers of ecosystem services. The PES scheme was established through multi-stakeholder engagement process in a three phased design; [1] Feasibility assessments, [2] Implementation, [3] Monitoring, evaluation and scale-up.

Feasibility studies aimed to provide baseline information to establish viability of PES scheme, business case for buyers and sellers prior to project initiation. Feasibility studies contacted included, cost benefit analysis, hydrological studies, legal framework and livelihood. The studies are important in PES projects to inform on the current land use practices, watershed environmental externalities and socio-economic benefits versus provision of ES (Tresierra, 2009). The feasibility studies contacted in Naivasha PES project included;

Hydrological assessment based on watershed Soil Water Assessment Tool (SWAT) model. The SWAT simulates amount of soil erosion with a basis on hydrologic response unit (Gassman *et al.,* 2007). The hydrological analysis assessed land management practices and its influence on water quality, sedimentation level and agricultural chemical yields in the upper catchment smallholder farms. The study aimed to identify and prioritize degraded sub-basins for PES conservation interventions (Gathenya, 2007). The sub-basins selection was based on several factors including: [1] Water yield- areas with significant high water yield especially groundwater discharge. These were areas which contributed to high water flow demanded by commercial investors downstream especially during dry seasons; [2] Sediment yield-sub-basins with high sediment yield, which increased sediment load in Lake Naivasha downstream through rivers flowing from upper catchment; [3] Pollution threat- sub-basins with high sources of pollutants including over-use of agro-chemicals which increased pollution in water ecosystems; [4] Land use/land cover change- areas with high land use changes over time including sites that had experienced increasing forest cover reduction through agricultural land expansion, areas with steep slopes continuously cultivated leading to increased soil erosion and sub-basins with high number of riparian land cultivation which reduced the buffering capacity to reduce erosion and silt loading in rivers the main sources of Lake Naivasha; [5] Population density- sub-basins with high population density which increased demand for natural resources leading to overuse and degradation of ecosystem services with significant impact specifically on agro-ecosystem and changes in water quantity and quality; [6] Water use-sub-basins with high water demand especially for irrigation which reduced the water flow downstream. Information on water use would be useful in designing PES soil and water conservation management practices; [g] Poverty-areas with high poverty levels which if PES was initiated would contribute to livelihood improvement for the poor smallholder farmers and general social and environmental outcomes; [7] Potential sellers-buyers; sub-catchments where potential sellers and buyers of ecosystem services existed. These were the main stakeholders in the PES schemes. They would be key to establishment of business case for ecosystem services.

Based on critical level of degradation, 5 sub-basins were identified and 2 prioritized as most significant to hydrological problem (Figure 3). Selection of the smallholder farms for PES intervention was done through stakeholder participatory approach based on the following criteria; private land owner, high gradient (steep) land under cultivation along the rivers, steep and bare land without vegetation cover, farms with riparian land under cultivation, farms with high water consuming tree species such as *Eucalyptus grandis* and *Eucalyptus camaldulensis)* planted close to the rivers and farms without conservation structures.

Socioeconomic study aimed to assess legal status of land tenureship and critical local livelihood as baseline condition, identify alternative land use practices with potential to promote conservation agriculture in the watershed and establish PES business case for buyers and sellers (Makenzi *et al*., 2007). Livelihoods assessment in PES schemes is important to identify and indicate willingness of local communities to participate in the PES scheme to improve their livelihood and willingness of the buyers to pay for ecosystem services as an investment. The buyers and sellers willingness is essential for co-investment in ecosystem services through PES schemes. From socioeconomic study findings, over 60 % of the farmers owned legal titles for their land and study results further indicated feasible business case viable for PES initiative (Makenzi *et al*., 2007). Socioeconomic study is particularly key to PES schemes to inform on property rights, stakeholders relevant to PES project and poverty prevalence’s in sites identified for PES projects.

Cost and benefit analysis aimed to assess opportunity cost, estimate expected loss and gains of PES interventions (Gamba *et al.,* 2007). Cost and benefit analysis is key to estimate costs of changing from current land-uses to proposed PES conservation practices and evaluate the benefits and costs of such land-use changes. The analysis is important in designing PES schemes to inform on the amount buyers would pay the sellers of ecosystem services for the farm economic opportunities foregone to adopt PES conservation interventions and the feasibility of adopting PES scheme as incentive instrument for adoption of PES watershed conservation practices.

The implementation phase involved a series of PES activities including buyers-sellers mobilization, sensitization, contract negotiation and signing facilitated by legal expert and implementation of the PES interventions including mapping and layout of PES conservation interventions, community capacity building involving technical and managerial aspects (on soil and water conservation, livestock management, water quality monitoring) and annual payment of sellers (smallholder farmers) for ecosystem service provision.

Available literature reveals the important role of intermediaries in transfer of knowledge, skills and guiding on contract negotiations between buyers and sellers of ecosystem services under PES programmes (Laurans *et al.,* 2012). Equally, informed participation of all stakeholders in negotiation process is essential to secure comprehensive agreement among buyers and sellers of ecosystem services and strengthen business relationship and trust amongst themselves (Kwayu *et al.,* 2013).

The PES mechanism being a business case required seller-buyer entities which could enter into legal contractual agreement. The smallholder farmers and commercial investors organized in WRUAs institutions provided formal entry point to initiate the Lake Naivasha watershed PES scheme. Several planting materials were selected for implementation of different PES interventions. The initial stock of the planting material was procured by supporting intermediary organizations to allow participating PES farmers to bulk their own materials for future PES expansion programme. Some of the conservation materials used included; Grass (Napier grass; Kakamega 1 variety (*Pennisetum purpureum*), Elmba Rhodes (*Chloris gayana*) and cock's foot (*Dactylis glomerata*}; Tree seedlings; Cedar *(Juniperus procera*), rosewood (*Dalbergia spp.*), *Prunas Africana, Dombeya torrid, Grevellia spp.);* Fruit tree seedlings including Olives (*Olea europaea*), Tamarillo or tree tomato (*Cyphomandra betacea*) and apples (*Malus pumila*) and crops/fodder such as Potatoes (*Solanum tuberosum*) including *Kenya Karibu and Kenya Sifa* varieties, Livestock fodder: Lucerne (*Medicago sativa*), Desmodium (*Desmodium intortum*).

Monitoring and evaluation is important stage in PES projects to assess and verify progress on PES practice adoption level on individual PES farms to qualify for payment based on the contractual agreement between sellers and buyers of ecosystem services. Monitoring and evaluation phase for provision of the ecosystem service attached to conditional payment of revenues has been recognized as key component of performance-based benefit-sharing in PES schemes (Engel *et al.*, 2008; OECD 2010).

Monitoring and evaluation for Lake Naivasha PES scheme was organized jointly involving representatives of buyers and sellers WRUA groups, intermediate NGOs supporting PES scheme and government agencies engaged in the PES project as key stakeholders. The trained WRUA management personnel monitored water quality and quantity flowing downstream by using turbid meters and river gauges installed along rivers.

Other parameters monitored included soil retention on farms by trained land owners using simple calibrated pegs (Annex 15) and Water samples taken from rivers to WRMA for turbidity analysis. Studies have found that monitoring and evaluation is essential phase and complement payment to determine adoption of PES land use practices by land owners (Garbach *et al*., 2012).

Scale-up phase and exit strategy

Initially, 565 farmers in 2 WRUAs were enrolled in 2008 to participate in PES. The PES project stakeholders continued to engage more farmers within the first pilot PES sites and other sub-basins identified in the feasibility studies. By the time of this study, over 700 farmers in two upstream, Upper Turasha and Wanjohi WRUAs were enrolled and participating in the PES project (Annex 2). The scale-up phase aimed to engage more farmers whose farms were identified as degraded and targeted for restoration to improve farm productivity and sustain ecosystem service production. During scale-up and exit phase, the intermediate NGOs which initiated and supported the PES mechanism handed over (after 4 years project period) the project to the key stakeholders, the ecosystem buyers and sellers organized under the WRUAs for full management and control of the PES scheme. Government agencies including WRMA, KFS and Ministry of Agriculture continue with technical backstopping support.

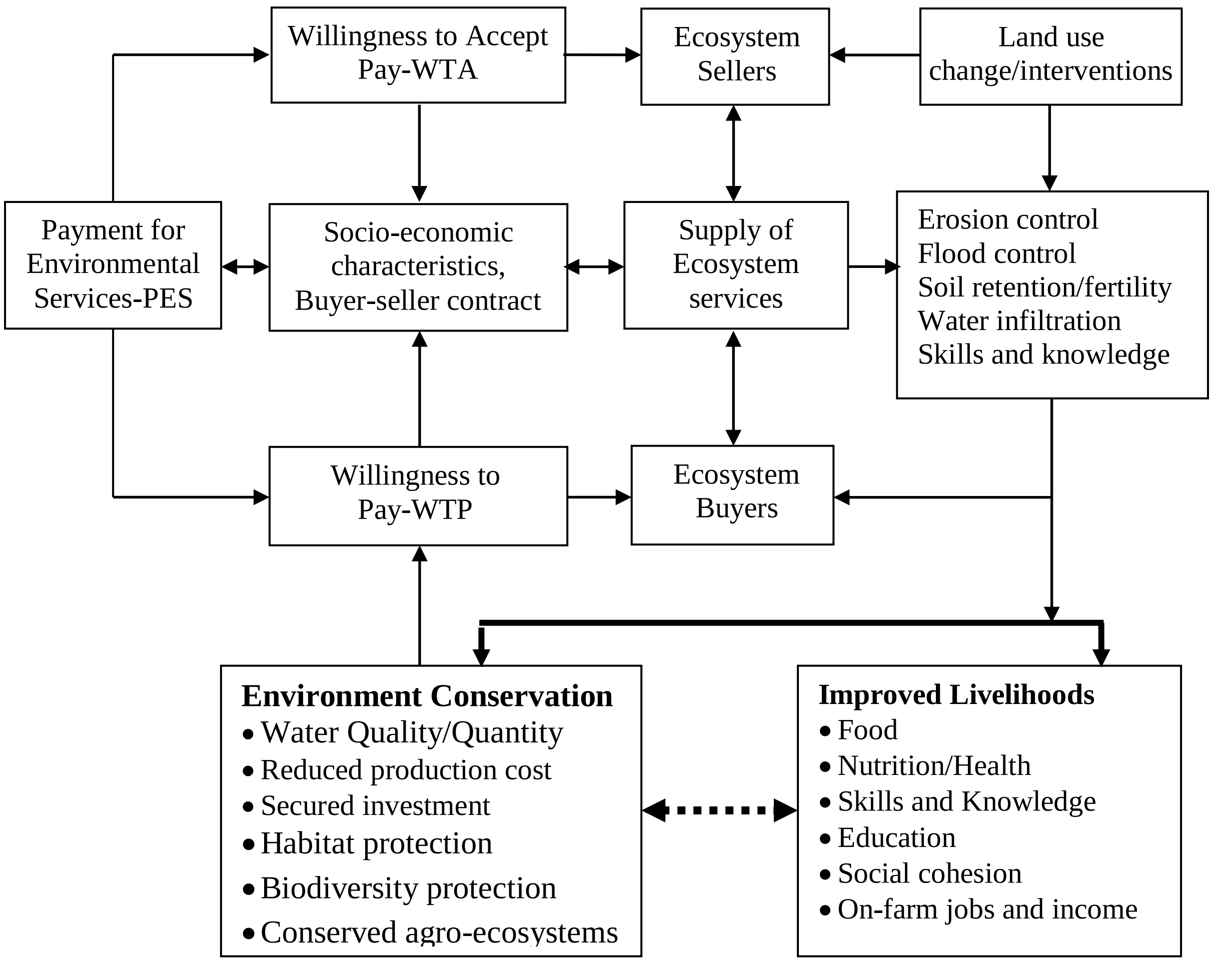
The PES scheme in Naivasha is visualized to benefit upstream communities directly through incentives from private sector downstream and indirectly from *in-situ* on-farm benefits. In-situ benefits for instance include; increased farm productivity, income from sale of farm produce, on-farm employment and community empowered with skills and knowledge to conserve ecosystems as the natural base for enhanced rural livelihoods. Payment for environmental services in Naivasha was envisaged to have potential to rehabilitate degraded ecosystems and restore provision of ES which benefits humans and biodiversity (WWF-CARE Kenya, 2007).

2.4.5. Conceptual framework

Figure 1 shows hypothetical conceptual framework for envisaged influence of PES land use change on upstream farms, downstream private sector investment and environmental conservation. Based on PES definition, the concept works in business scenario if and only if there is WTP -WTA for demand and supply of ecosystem services. This is possible through voluntary binding business contract between buyers and sellers of the ecosystem services to achieve envisaged PES intervention impacts on livelihoods and conservation.

Production of provisioning services like food (plants and animals) and non-food products such as timber and medicinal herbs can be premeditated as their production can be controlled for both sale and consumption. The end users can influence their supply through markets demand-supply forces. However, most of other natural ES including regulating, supporting and cultural services are produced as non-excludable positive externalities and are not easily priced in the markets. Ecosystem service providers implement soil and water conservation technologies designed to improve soil retention on farms, reduce soil erosion and agro-chemical overuse, control flood and increased water infiltration. Achievement of these services is envisaged to improve related provisioning services such as increased water flow and recharge of water sources, improved water quality as result of reduced nutrient load and siltation in river water sources.

Ecosystem service sellers are anticipated to realize increased farm productivity and accept direct income from buyers as incentives to implement PES conservation practices. Buyers on other hand are expected to benefit from constant flow of enough quality water key to sustain their commercial investments downstream. Willingness to Accept Pay is a function of land use practices influenced by household farm characteristics including age, gender, occupation, source of income, increase in productivity, soil fertility, soil erosion control, food security and acquired skills among others. Biodiversity is hypothesized to benefit from the conservation activities through secured habitats protecting genetic resources and enhancing biological diversity resilience through reduced unsustainable anthropogenic related activities.



Lines: ——— Linkages ▬▬▬ Envisaged end results

◂••••••▸ Environment-livelihood linkages

Figure 1: Conceptual framework for the PES Land Use Practice Change Influence on Community Livelihood and Environmental Conservation

Source: Nyongesa, J.M (2018

Figure 2 further expands the interaction between ecosystem transformation and human well-being. Supporting services form the foundation of other ecosystem services; provisioning, regulating and cultural. Supporting services impact on humans is indirect as the services destruction is rarely noticed directly until significant change in other three services is realized.

Deduction from Figures 1 and 2 is that ecosystem services have potential economic value. They provide economic goods and services which benefit humans and related biodiversity. Payment for Ecosystem Services is thus conceptualized as an innovative tool which incentivizes ecosystem services managers to conserve environment for provision of ecosystem services demanded by buyers through a negotiated business contract. The PES interventions in Lake Naivasha watershed focuses on restoring ecosystems for enhanced production of supporting services which forms the foundation for provisioning, regulating and cultural services, important for the human well-being.

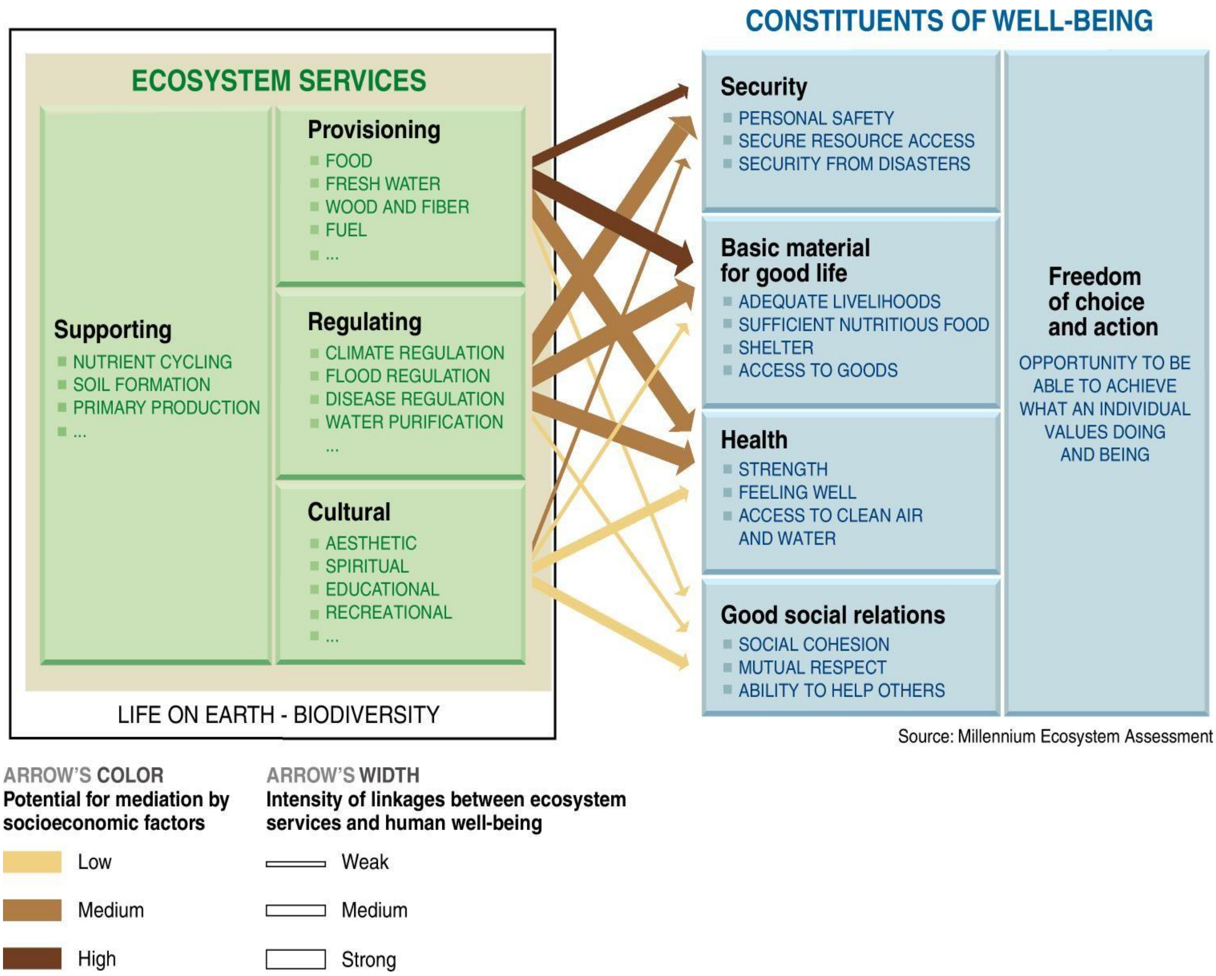


Figure 2: Interaction between Ecosystem Transformation and Human Well-being within Ecosystem Framework

Source: Millennium Ecosystem Assessment 2005

CHAPTER THREE
METHODOLOGY

3.1. Introduction

Lake Naivasha basin is located between 0° 08´ to 0° 46´ S and 36° 14´ to 36° 43´ E (Njiru, *et al.,* 2015) covering catchment average area of 3,400 km^2 (Kuhn *et al.*, 2015). The basin covers six administrative units; Kinangop, Nyandarua South, Gilgil, Naivasha, Kipipiri and a section of Narok North sub-counties. Lake Naivasha basin has upland forests which forms essential watershed catchments providing water that supports diverse ecological habitats, livelihoods and economic development. The upland forests are important water towers for Lake Naivasha in Rift Valley; Ewaso Ngiro, Tana and Athi basins. Main rivers draining into Lake Naivasha are; Malewa, Gilgil, Karati (seasonal) and their tributaries. The PES scheme is located at the western foothills of the Aberdare ranges, the main catchment area of the Malewa River important for both Kenya's horticulture and tourism industry around Lake Naivasha (WWF and CARE-Kenya, 2007).

3.2. The study area

Figure 3 illustrates the study area which covered two WRUAs; Upper Turasha Kinja located in Nyandarua South, Kinangop, sub-counties and Wanjohi WRUA located in Kipipiri sub-county. The WRUAs cover main sub-basins of 639 hectares Tulaga area (Rivers Turasha and Kinja) and 4,680 hectares Geta (River Wanjohi), areas selected and prioritized sites in PES Naivasha three feasibility studies; hydrological (Gathenya, 2007), livelihoods-legal (Makenzi *et al.*, 2007) and cost benefit analysis (WWF and CARE-Kenya, 2007) surveys prior to PES project initiation in Lake Naivasha basin.

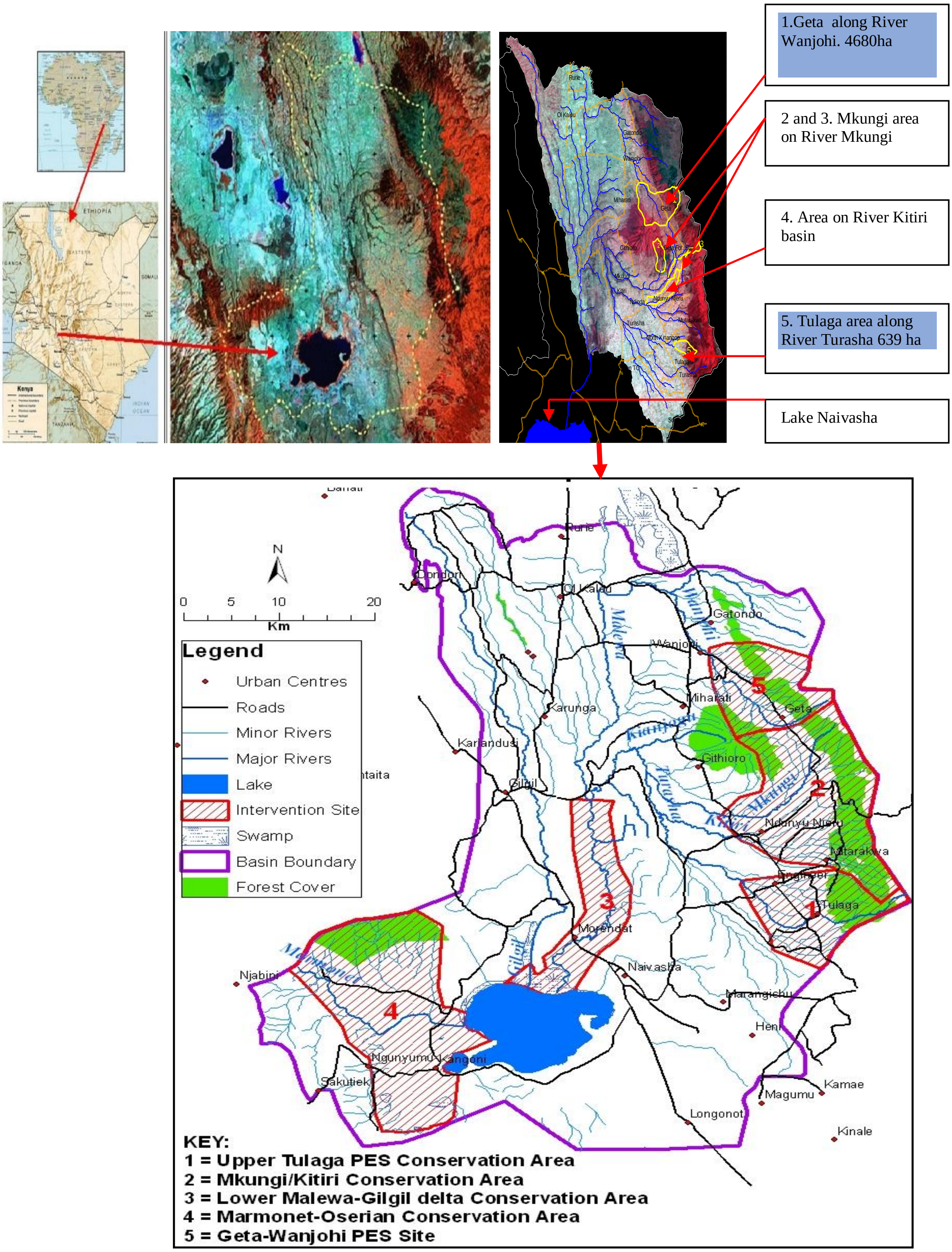


Figure 3: The PES Intervention sites within Lake Naivasha basin study sites are numbered 1 and 5

Source: Gathenya (2007); WWF (2007)

3.2.1. Topography and climate

Topography range from higher areas in the upper catchment on the slopes of Aberdares and Kipipiri ranges where altitude raises to 3,360 meters above sea level on top of Kipipiri and 3,990 meters above sea level near Ol Donyo Lesatima peak on the Aberdares. In the lower catchment around Lake Naivasha, average elevation is 1,890 meters above sea level (Njiru, *et al.,* 2015). Lake Naivasha basin is characterized by two climatic conditions varying from wet cold in the highlands and dry semi-arid in the lower areas around Lake Naivasha. Soils type varies from volcanic, sandy loam to clay with high phosphorus, calcium, magnesium and potassium and sandy-pumice. Temperature varies between $2^{o}C$-$25^{o}C$ in the upper catchment and between $26^{o}C$-$29^{o}C$ around Lake Naivasha. Rainfall is bimodal ranging between 700-1500mm annually in the upper catchment and between 500-700mm per year in the lower catchment.

3.2.2. Demography

Human population in Naivasha basin varies from rural, peri-urban and urban areas.

Table 3: Initial enrolled number of farmers in PES intervention sites

WRUAS	PES zone area	Total number of farmers
Upper Turasha WRUA		
	Mutamaiyu	24
	Kianguyo	26
	Mutarakwa	15
	Tulaga	220
Sub-Total		**285**
Wanjohi WRUA		
	Geta	14
	Gitei-Gatondo	52
	Kiamboga	40
	Mikeu	58
	Rayeta	27
Sub-Total		**191**
Grand Total (285+191)	Upper Turasha and Wanjohi	**476**

Source: Nyongesa, J.M (2018)

In the rural areas, population is composed primarily of smallholder subsistence farmers while in urban and peri-urban areas population is mostly cosmopolitan consisting of indigenous people and immigrants attracted by employment and business opportunities. From Kenya population census records (GoK, 2009), population in PES study site locations in three sub-counties is indicated in Annex 2. Table 3 shows initial number of farmers enrolled in PES in the year 2008. These were PES farmers targeted for sampling.

3.2.3. Economic activities and natural resource base

Lake Naivasha basin covers diverse ecology supporting unique habitats and biological resources that drives socio-economic development in the landscape and the country at national level. The basin supports important biodiversity conservation areas; Aberdare National Park, Aberdare and Kipipiri forest reserves, Oserian sanctuary, Hells Gate National Park, Lake Naivasha (145 Km^2) Ramsar site (Harper, et al., 2011) and associated riparian land. Commercial horticulture business dominates the area around Lake Naivasha and contributes to over 10 percent of Kenya’s agricultural export, generating more than €350 million annually. Commercial floriculture investment contributes to more than 35 percent of all flower sales in European Union (EAC-EU, 2015). Horticulture creates direct employment opportunities for over 30,000 people directly as well as benefits above 350, 000 people indirectly (WWF, 2012).

Other socio-economic activities in the basin include fishing, geothermal power generation, subsistence and large-scale agriculture, tourism, timber industry and off-farm employment. The study sites in the upper catchment are mainly occupied by indigenous smallholder subsistence farmers who primarily depend on agro-ecosystems for their livelihood. The sites have undergone transformation over years of continuous cultivation and clearing of vegetation cover to expand agricultural land. Though Naivasha basin has enormous economic potential, unsustainable land use practices in the upper catchment have been the major source of ecosystems degradation. Degradation poses major threat to sustainability of the upstream livelihoods, biodiversity, commercial investment and employment opportunities downstream.

3.3. Research methodology and design

3.3.1. Scope and design

This research was conducted among 200 households, members of two WRUAs spread out in three sub-counties (Nyandarua South, Kinagop and Kipipiri) of Nyandarua County. The 200 respondents were sampled from initial source list of 476 PES farmers who were initially enrolled in PES scheme implementation in 2008 (Table 3). However, the two WRUAs had increased the membership to 785 smallholder PES farmers implementing PES land use practices to restore degraded farms by the year 2013 (Annex 2). The study targeted only the initial PES farmers and focused on collection and assessment of data that assessed PES contribution to objectives of restoring agro-ecological state of upstream degraded farms to sustain ecosystem services including food security and water quality and quantity improvement demanded by private investors to secure commercial investment downstream in Naivasha Sub-county of Nakuru County.

3.3.2. Data collection

Secondary data was collected by reviewing existing literature relevant to the study. Sample size was empirically determined using the Kothari (2004) formula based on marginal error of 5 percent, thus;

$$n = \frac{Z^2 PqN}{e^2(N-1) + Z^2 Pq} \quad \text{………………………………………………………………………….1}$$

Where;

n = sample size

N =population size (Number of PES households) = 476

P = population reliability (frequency estimated for a sample of size n)

q = 0.5 taken for all developing countries population and p + q= 1 (where q=1- p = 0.5)

e = 0.05 error margin considered in this study

$Z\alpha/_2$= normal reduced variable at 0.05 level of significance/confidence level and z is 1.96

From the formula 1, the sample size n considered was determined as follows;

$$n = \frac{1.96^2(0.5*0.5*476)}{0.05^2(476-1)+1.96^2*0.5*0.5} = \frac{457.15}{2.15} = 213.63$$

The sample size n across the two WRUAs was rounded to 214 respondents. First, 9 sites (four in Upper Turasha Kinja WRUA; Mutamaiyu, Kianguyo, Mutarakwa/Kinja, Tulaga and five in Wanjohi WRUA; Geta, Gitei-Gatondo, Kiamboga, Mikeu, Rayeta) were purposively selected from twelve PES zoned village sites. The second stage involved proportional to size random selection of household heads from verified source list of 476 farmers in 9 sites, giving a total of 214 sample size (109 farmers from Upper Turasha Kinja WRUA and 105 farmers from Wanjohi WRUA).

The sample frame was PES farmers and source list of farmers was provided by WWF and WRUAs. Primary data was collected from randomly selected PES farm households heads through questionnaires written in English which was administered by local trained enumerators. The enumerators translated in either Swahili or local dialect for easier understanding and response. The questionnaires were supplemented with transect walks to verify farmer's responses and PES technologies on farms.

3.3.3. Data analysis

After data collection, 14 questionnaires were detected as spoilt and therefore discarded while 200 questionnaires were used for further analysis. Data was analyzed using descriptive techniques (including means, standard deviations, range and mode presented in form of graphs, pie charts and tables), STATA version 12.0 and statistical package for social sciences-SPSS version 17.0 software were applied.

Objective i: Determine socio-economic attributes which influence farmer's preferences for land use PES conservation practices

Payment for Environmental Services practices implemented in study sites included; rehabilitation and maintenance of riparian zones through tree planting, grass strips, terracing along steep slopes, contour cropping, agro-forestry, improved seed varieties, crop rotation, fallowing and reduction in agrochemicals use. Different disciplines including economics and environmental economics have widely used choice experiments to assess individual's preferences (Swait and Adamowicz, 2001; Hanley *et al*., 1998) including different types of ecosystem goods and services under hypothetical options presented to the individual for choice decision (Bennett and Birol, 2010). Choice experiments are regarded important valuation tools for non-market goods and services studies for example the ecological value of ESs and therefore applicable to determine farmers' preferences for PES conservation measures (Chapika and Andreas, 2009).

Different studies have applied choice model to determine farmer's preference based on random utility theory (Jordan *et al.,* 2007) developed by Thurston (1927) to analyze respondent's utility function. Random utility theory (RUT) is equally useful in modelling individual's preferences, and because of heterogeneity amongst farmer's taste and preference for utility satisfaction, it was essential to model individual farmer's choices for easy estimation of parameters. Choice experiments as reported by Alpizar *et al.* (2001) were inspired by the Lancasterian microeconomic approach (Lancaster, 1966) which recognized that individuals derive utility from the characteristics of the goods rather than directly from the goods themselves.

Objective i was analyzed through choice modelling related to stated preference (SP) techniques. Respondents were asked to make choice of their preferred conservation technology(s) from a set of PES alternative technology bundles with specific characteristic features giving reasons for their preferences. The ecosystem seller's preference for particular set of optional practice(s) were established and attributes linked to preferred choice of conservation technology determined. Choice was assumed to be guided by farmer's expected utility satisfaction derived from each choice in terms of each intervention attribute's influence on socio-economic and environmental conservation benefits.

The economic model presented for this objective in this study is based on random utility maximization decision as equally studied by Hanemann (2007). Random utility model adds stochastic terms to the deterministic utility of each alternative in the choice set Y (Cappelen *et al.*, 2010). Based on respondents utility function under RUT (McFadden, 1974), it was assumed the individual utility function U_i takes the form;

$$U_{i(y)} = V_{i(y)} + \varepsilon_{yi} \text{ for all } y \in Y \ldots\ldots\ldots 2$$

Where V_i *(y)* is the deterministic utility the *ith* individual associates with a particular choice y and εyi is the stochastic term for individual choice mostly assumed to be extreme value distributed independently and identically (IID) and the choice set Y of conservation technologies typically assumed to be discrete. From equation 2, if alternative j is chosen then $U_j > U_y$ for all $y \neq j$ and if individual maximize U_i *(y)*, this gives rise to choice probability expressed as;

$$P(y) = P(V_i + \varepsilon_i) > (V_y + \varepsilon_y) \text{ for all } y \in Y \ldots\ldots\ldots 3$$

Where, Y is a set of possible conservation technology(s) choices. Since PES technologies are not directly marketed or consumption products, farmers derive satisfaction from technology attributes and therefore the farmer's utility function takes the form;

$$U_{ij} = V(a_j, z_j) + \varepsilon_i \ldots\ldots\ldots 4$$

Where selected *ith* respondent utility is related to *jth* PES alternative conservation technology. From Hanemann (2007), consumer utility is also influenced by *y's* attributes.

This implies that utility derived from any of technology alternatives depends on the attributes a_j of technology (for instance income, soil retention, control flood, erosion control, control pets and diseases, improve soil fertility, food, climate regulation and soil conservation) and farm/farmer's own characteristics z_i for instance (age, gender, land tenure, poverty reduction,) both denoted by $a_1 \ldots\ldots, a_n$ and $z_{1 \ldots\ldots}, z_f$ respectively. The utility function of individual farmer can then be stated as;

$$U_{ij} - v(a_j, z_j) + \varepsilon(a_j, z_j) \ldots\ldots 5$$

With probability that an individual chooses the alternative which maximizes the deterministic utility is decreasing in the deterministic utility of the other alternatives. Based on the conditional logit model-CLM modified from Cappelen *et al.* (2010), the equation is written as;

$$P_{ij} = \frac{e^{v(a_{ij}, z_i)}}{\sum_{y \in Y} e^{V(a_{ij}, z_i)}} \text{ for all } y \in Y \ldots\ldots 6$$

Where *y* is one of the probable PES conservation alternative practices in data choice set Y. Therefore the individual indirect utility function is generally estimated as follows;

$$V_{ij} = \beta_0 + \beta_{1a_1} + \beta_{2a_2} + \ldots \beta_{na_n} + \delta_{1z_1} + \ldots \delta_{fz_f} + \varepsilon_i \ldots\ldots 7$$

Where;

V_{ij} = is the deterministic utility of *ith* individual associates with a particular *jth* choice or y

β_o= Constant (intercept)

β_i and δ_i = Vector of coefficient β_1 to β_n and δ_1 to δ_f of unknown parameters to be estimated (where; *is* = 0, 1, 2…n; 0, 1, 2,…*f* respectively), β_1 to β_n and δ_1 to δ_f are attached to vectors of technology attributes *a* and farmers socio-economic interacting characteristics *z* which could influence utility

n = number of PES conservation technologies with specific attributes

f=number of farmers own characteristics

ε_i =is the stochastic term

Objective ii: Assess productivity changes for crop and livestock enterprises as a result of PES interventions.

Based on farm productivity historical trends overtime, objective ii was analyzed by asking farmers their farm time series productivity changes for both crops and livestock products on same piece of land before and after PES interventions. Crops and livestock production was analyzed holding other factors constant, for instance farmers did not use inorganic fertilizers and that fodder planted under PES interventions was only acquired from own farm. For succinct analysis, productivity was computed in terms of income (by inference) changes farmers realized from their farms before and after PES initiation taking 2008 as base and 2013 as current years concurrently.

Objective iii: Estimate farmer's willingness to accept pay to provide ecosystem services

In this study, natural inputs such as flood control, soil erosion control, nutrient recycling, water filtration were assumed as natural capital input with potential to influence farm productivity. The approach to measure their value was to estimate the additional income or profit they provided on consumptive goods. The approach involves choice experiments application to elicit resource steward's WTA to implement environment conservation agricultural practices (Chapika and Andreas, 2009). Likewise, soil lacks direct market, but soil fertility is a production input. To value soil fertility for investment in conservation, it was implicitly assumed as input in production function to assess the impact of soil degradation on farm productivity.

Estimates for WTA can be alternatively computed through cost benefit analysis. However, cost benefit analysis is based on aggregated values of gains and costs and fails to precisely consider how benefits and sacrifices are distributed across members of society. This weakness explains variations in results between cost benefit analysis and Total Economic Value-TEV approaches. This study applied TEV which economically elicits preferences for changes in the state of environment in monetary terms.

The TEV technique has been applied widely in other studies including costs and value measurement of forest ecosystem services (Gren and Amuakwa-Mensah 2018). Similarly, it has been suggested by some scholars that to achieve PES scheme efficiency, the price paid to the ecosystem service sellers should be greater than their opportunity cost but less than negative externalities which would result from land conversion (Pagiola *et al.,* 2005; Kosoy *et al.,* 2007; Wunder, 2007). That is, profit foregone from abandoning one farm practice for alternative land-use practices (service provider's WTA for PES, plus transaction costs).

Comparable researchers have applied Willingness to Accept Pay (WTA) approach to estimate farmers' willingness to participate in a PES programs relative to scale of the change in farmers expected utility. The WTA estimates reflect monitory proxy price payment a household would accept to implement PES land use practices to provide specified ecosystem service (Shan *et al.,* 2012; Jack *et al.,* 2008).

In this study, individual's WTA was maximum incentive the ES producer accepted to derive utility from implementation of PES farm practices to provide ESs versus foregone land use practices. Modifying farmer's WTP estimation technique for agricultural services to increase productivity Ulimwengu and Prabuddha (2011), WTA was modeled as opportunity cost to allow for farm restriction to maintain or increase agricultural productivity and improve environment for provision of ESs by farmers. Based on Holden and Shiferaw (2002) approach, to achieve the initial utility level, the equation is written as;

$$V(I, EU_0, A_0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 8$$

Where, I is the vector of income, EU_O is the current expected utility level, and A_0 is the set of agricultural farm practices and farm characteristics before PES scheme. It follows that WTA in order to sustain current productivity is stated as;

$$WTA_i = V(I, EU_0, A_0) - V(I, EU_0, A_1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 9$$

From equation 9, WTA is the sum that leaves the household indifferent between the expected marginal utility under the farm practices before PES initiation and the discounted expected marginal utility from change in future incomes as a result of the new set of PES conservation technology(s) A_1. Change in expected utility relative to the adoption of PES farming practices is heterogeneous among individual farmers as individual farmer perceive different the change in utility for different bundles of PES practices. Thus, the individual's maximization of expected utility in the long run is presented as;

$$E\left\{-U_{i0}(C_{i0}) + U_{i0}(C_{i0} - WTA_i) + \sum_{j=1}^{\infty}(1+\delta_i)^{-j} U_{ij}(C_{1ij} - C_{0ij})\right\} = 0 \ldots\ldots\ldots\ldots 10$$

Where δi is the constant rate of household time preference, C is the household consumption, and U_{ij} $(C_{1ij}$-$C_{0ij})$ is the utility level available to the *ith* household from the difference in land productivity induced by new *jth* conservation technology(s). The WTA_i is the probability of the *ith* farmer's WTA for A_1 PES technology. Equation 10 is then written as;

$$U_{i0'}(C_{i0})(WTA_i) = \sum_{j=1}^{\infty}(1+\delta_i)^{-j} EU'(C_{ij})\partial C_{ij} \ldots\ldots\ldots\ldots\ldots\ldots 11$$

From equation 11, it implies that;

$$WTA_i = \sum_{j=1}^{\infty} (1+\delta_i)^{-j} \left[EU^{'}(C_{ij}) / U_{i0}(C_{i0})^{'} \right] \partial C_{ij} \ldots\ldots 12$$

Where C_{ij} is the consumption of the *ith* household practicing the *jth* PES related conservation technology(s) and ∂ is the derivative change in WTA when income increases. In many cases WTA is almost always higher than WTP (Horowitz and McConnell 2003; Bett *et al.,* 2009) and therefore not always equal such that;

$WTA \approx WTP + WTA \frac{\partial WTP}{\partial y}$ leading to WTA and WTP relationship as derived by Sugden, (1999),thus;

$$\frac{\partial WTP}{\partial Y} \approx 1 - \frac{WTP}{WTA} \ldots\ldots 13$$

From equation 13, WTA estimation for this study objective iii was generalized following adoption from Bett *et al. (*2009) as;

$$WTA_{ij} = \alpha + \beta_i \chi_i + \cdots + \beta_n \chi_n + \varepsilon_{ij} \; for \;\; is = 1 \cdots n \ldots\ldots 14$$

Where WTA_{ij} is the probability that the *ith* household will accept pay to implement *jth* PES conservation technology(s) influenced by socio-economic characteristics, *n* is the number of technologies while α and β are parameters to be estimated.

Revealed preference (RP) method was applied to estimate direct use surrogate values of consumptive resources derived from land ecosystem for ecosystem services providers. Revealed preference method focused on change in on-farm productivity over time resulting from land use practice transformation through PES program. Rolf (2012) found that RP approach traces impact of change in environmental services on produced goods. The approach quantifies marginal change in provisioning services such as food, both crop and livestock production before (without) and after (with) PES intervention.

Data on net value of produced marketable provisioning goods was analyzed to infer on change in environmental services because of PES conservation technologies under implementation. By the time of this research, water quality the main ecosystem service demanded downstream had not been analyzed to determine significant change in quality. It was exciting to infer from seller's responses on their WTA to provide ESs to buyers downstream, and equally remarkable to determine factors influencing farmer's WTA.

Objective v: Determine socio-economic factors influencing farmer's WTA to implement PES practices.

Binary Logit regression was applied to analyze factors influencing farmers to practice alternative PES practices. The Binary Logit model was used to determine the relationship between the willingness to accept pay (WTA) as dependent variable and the socio-demographic independent variables. The model uses standard logistic probability distribution providing modelling framework that integrates bio-economic, socio-economic and biophysical databases. The model integrates farm enterprises including crops, livestock, soil fertility, conservation practices and market forces that are highly interactive and heterogeneous. Nonlinearity aspect of Logit model allows maximum likelihood (ML) procedure to estimate parameters. The ML procedure has several desirable attributes for instance consistency of all parameter estimators and asymptotic efficiency for large samples, which enhance the *t* – test regression analysis.

Farmer's WTA to implement PES practices was taken as dependent variables while the socio-economic factors as independent variables. The dependent variable is discrete (involving multinomial ordered choices) and hence, probit model has been used in comparable research and could be ideal for analytical framework (Bosch *et al.,* 1995; Sidibe, 2005; Davey and Furtan, 2008).

However, multinomial probit (MNP) is prone to assumption of independent irrelevant alternatives (IIA), is equally expensive and its estimation difficult (Rubinfeld, 1997), although if choice options can be ordered then calculations can be less difficult (Negatu and Parikh, 1999; Judge *et al.,* 1982), thus the preference to apply logit model. Given the heterogeneity of farmer's choice for different PES practices, Logit model application was essential to relax the assumption of independent irrelevant alternatives (IIA) associated with other models especially multinomial. Likewise, dependent variable, WTA to provide ecosystem services or otherwise is dichotomous allowing Logit model to be used as key tool for analysis.

In literature other researchers have widely applied multinomial logit to model farmer's willingness to participate in conservation programs (Zbinden and Lee, 2005; Wu and Babcock, 1998). Similarly, Logit model was useful in this study because of the mainly dichotomous nature of data (binary variable which cannot take more than two alternate values) of the dependent variable. For instance, prefer or otherwise, influenced or not influenced, WTA or otherwise. The WTA determinants were expressed as a function of farm-farmer socio-economic factors such as gender (ge), education (edu), family size (fs), income(icn), access to extension services (axs), erosion control (ec), soil fertility (sf) such that;

$$WTA = f(ge, edu, fs, inc, axs, ec, .sf...n) \qquad (15)$$

Following Pindyck and Rubinfeld (1981), the Logit model was specified as;

$$\frac{LogP_i}{1-P_i} = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \ldots\beta_n\beta_n + \varepsilon_i \qquad (16)$$

Where;

P_i = Latent (Unobservable or unmeasurable) probability that a given *ith* household is practicing particular PES conservation technology.

1– Pi = Probability that a household is not implementing particular PES conservation technology and hence Pi/ 1- Pi are odds of implementing conservation technology

β_o = Constant (intercept).

β_i = Vector of unknown parameters to be estimated (where; i = 0, 1, 2, 3…n).

X_i = Vector of socio-economic variables (explanatory) of household *i* for the probability (*Pi*) which assumes the *ith* household implements technology, that is, alternative 1 (where *i*=0, 1, 2, 3…n)

ε_i = Error term

The X_1 to X_n are independent variables with descriptions given in Table 4. Running Logistic Regression model started with its evaluation and check of goodness-of-fit determination. The Common measures of fit included; coefficient of multiple determination R^2 and sample result likelihood. The higher the values for two measures the better the model. The model is perfect if the values are exactly 1.

Table 4: Description of variables

Variable	Description	Units	Expected coefficient sign
Dependent			
PES_pracchoice	Preference for PES practices: 0=No, 1=Yes		$\pm$
Inf_practPES	Influenced to practice PES Practices: 0=No, 1=Yes	Binary	$\pm$
WTA_cpay	Willingness to Accept Pay for provision ES: 0=No, 1=Yes	Binary	$\pm$

Independent			
X_1 = FM_size	Household farm size	Acres	+
X_2 = L_tenu	Land tenure: 0=Not owned; 1=Owned	Categorical	+
X_3 = HH_gender	Gender of household head, 0 = Male, 1= female	Binary	$\pm$
X_4 = HH_age	Age of household head	Years	+
X_5 = HH_educ	Education level of household head: No formal education (0=No, 1=Yes); Primary (0=No, 1=Yes); Secondary(0=No, 1=Yes); College/University(0=No, 1=Yes)	Discrete	+
X_6 = HH_occ	Occupation of household head; 0 = farmer; 1 = off-farm employed; 2= farmer/ off-farm employed	categorical	$\pm$
X_7 = HH_size	Household family size	Number	+
X_8=Conserv_PES	Implement PES for conservation; 0=No, 1=Yes	Binary	+
X_9 =Askil_legPES	Acquired skill under PES; 0=No, 1=Yes	Binary	+
X_{10}=PES_IMPPICE	PES impact on produce price 0=none,1=reduced, 2=Increased	Categorical	+
X_{11} =HH_EXT	Household access to extension services;0=No, 1=Yes	Binary	+
X_{12} = PES_INCENT	PES incentives; 0=Not important, 1=Important	Binary	+
X_{13} = Food_sPES	PES impact on food security 0= No; 1=Yes	Binary	+
X_{14}=AQ_SKI	Acquired skills and knowledge, 0=No important, 1=Yes	Binary	+
X_{15}=Famprodty_PES	PES impact on farm productivity; 0= No; 1= Yes	Binary	+
X_{16}=Income_PES	Income influence; 0= No; 1= Yes	Binary	+
X_{17} = GMI_BPES	Monthly Gross income earned by household from off-farm activities and sale of farm produce output before PES introduction	KES	-
X_{18} = GMI_PAPES	Gross monthly income earned from off-farm activities and sale of farm after PES introduction	KES	+
X_{19} = Poverty_PES	Poverty reduction; 0=No, 1=Yes	Binary	-
X_{20}=A_MRKTS	Availability of markets for farm produce; 0=No, 1=Yes	Binary	$\pm$
X_{21}=Ld_use	Land use system; 0=Not farming; 1=farming	Binary	
X_{22}=Retainsoil_choice	Soil Retention;0=No, 1=Yes	Binary	+

X_{23}=Pestdses_choice	Prevent pests and Diseases;0=No, 1=Yes	Binary	+
X_{24}=Floodr_choice	Flood control/reduction; 0=No, 1=Yes	Binary	+
X_{25}= Food_sPES	Food Security; 0=No, 1=Yes	Binary	+
X_{26}= Acash_WTA	Influence of cash received from PES; 0=No, 1=Yes	Binary	+
X_{27}= Exp_CSEROSN	Cost to control soil erosion	KES	+
E_i	Error term normally distributed and independent across observations with constant variance		

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1. Introduction

This chapter consists of three sections: the first section presents descriptive results and the second empirical results while the third provides the conclusion and recommendations. The results include: household socio-economic characterization, farmer's revealed preferences for land use PES conservation practices, productivity changes for crops and livestock enterprises under PES interventions, estimated farmers Willingness to Accept Pay (WTA) for ecosystem services and socio-economic factors influencing farmer's implementation of PES interventions.

4.2. Descriptive statistics

Descriptive results of the households are presented in Tables 5, 6, and 7. Table 7 profiles demographic as well as socio-economic characteristics of the households using means and percentages. Results indicate that PES farmers interviewed comprised 67 percent males and 33 percent females. The age for household heads ranged between 27-98 years with mean of 54 years and the mode was 40 years. Age has significant implication to PES scheme given that some PES interventions such as terracing are physically demanding and pose a challenge to the aged farmers. Level of literacy was high because 62.5 percent had acquired primary education, 18.5 percent had achieved high school education and 1.5 percent college/University level of education while 17.5 percent had not received formal education. Findings closely corroborate government statistics (GoK, 2013), which has shown that 48 percent and 27 percent of Kenya's population have acquired primary and secondary education correspondingly. It was expected that the higher the education level the better understanding of PES scheme and interventions adoption among farmers.

By contrast, Robertson *et al.* (2014) found that incentive was essential in provision of ecosystem services in agro-ecosystem and level of farmers education was not significant factor in adoption of conservation practices as majority of farmers were aware of the environmental benefits of alternative practices in USA. Robertson's conclusions may not however be applicable in most developing countries including Kenya's Naivasha watershed where literacy level was varied.

Over 90 percent of households practiced farming while others were engaged in off-farm and employment activities, to supplement on-farm income. Occupationally, those who were mainly farmers likely allocated more time and willingness to accept PES activities implementation compared to those employed or engaged in off-farm activities. However, this can be influenced by the individual farmer's expected utility satisfaction derived from different bundles of PES practices. The mean family size was 6 members. Memberships to other community-based groups possibly indicate farmers' understanding of socio-economic benefits realized through economies of scale when in groups compared to individual farming.

Table 5: Households demographic profiles in Lake Naivasha watershed

Variable Description	Statistic				
	Count	Percent	Range	Mean	Mode
Gender of household head					
0=Male	134	67			
1=Female	66	33			
Household head age (years)			27-98	54.19	40
Household head education level					
0=None	35	17.5			
1=Primary	125	62.5			
2=High school	37	18.5			
3=College/University	3	1.5			
Household head occupation					
0=Farmer	186	93.0			
1=Off-farm employment	7	3.5			
2=Farmer/off-farm employment	7	3.5			
Household family size (number)			1-17	5.76	5
Household farm size(acres) :					
<1	36	18			
1-2.5	77	38.5			
2.6-5	56	28			
5.5-10	20	10			
Valid N (Listwise)=200					

The farm characteristics of the households are presented in Table 6. Over 88 percent of farmers practiced both crop production and livestock keeping. Enterprise combination is an on-farm strategy to spread-out farm risks and improve household resilience from effects of natural calamities like floods and other climate change related effects on farm enterprises. However, 3 percent and 8.5 percent of farmers practiced only livestock keeping and crop production respectively. Combination of food security and income generation was the main farming goal reported by 71.5 percent of the households. Other farmers indicated farming goals as food security and to earn income revealed by 12.5 and 16 percent correspondingly. Complex land tenure system through inheritance by sub-dividing same land parcel between family members can be an impediment to PES interventions. New landowners may not be willing to participate in PES scheme and could be lacking skills to implement alternative conservation technologies on their farms.

Table 6: Land use practices and main farming goals in Lake Naivasha watershed

Variable description	Frequency	Percent
Land Use		
Crop Farming	17	8.5
Livestock keeping	6	3
Farming and Livestock	177	88.5
Total	200	100
Main Farming Goals		
Food security	25	12.5
Earn income	32	16
Food security and income	143	71.5
Total	200	100

Farmers faced several challenges in the course of their agricultural activities before PES interventions. The main challenges are presented in Table 7 and they varied in their frequencies from the most to the least severe. Soil erosion was the main environment related challenge reported by 36.5 of percent of farmers. The consequences of degraded soils were evident through low yields observed by 35.5 percent. Other studies, for instance by Bymolt and Delnoye (2012) revealed that farmers experience declining farm productivity due to unsustainable conservation farm practices. Third in the hierarchy of challenges was the increased incidence of pests and diseases (10.5 percent) associated with effects of climate change as predisposing factor.

Table 7: Land Use Challenges in Lake Naivasha Watershed

Land use challenges	Frequency	Valid Percent
Low yields	71	35.5
Pests and diseases	21	10.5
Soil Erosion	73	36.5
Decreasing land use size	7	3.5
Pollution of water sources	4	2.0
Floods	2	1.0
Lack of financial capital	8	4.0
Lack of water for irrigation	1	.5
Lack of market for farm produce	2	1.0
Human-wildlife conflict	1	.5
Frost	3	1.5
Poor roads	1	.5
Water scarcity	6	3.0
Total	200	100.0

4.3. Empirical Results

4.3.1. Influence of socio-economic attributes on farmer's preferences for land use PES conservation practices

Table 8 present results for factors influencing farmer's preference for PES practices. Gender was significant ($P>z=0.088$) at 10 percent level. However, gender had negative coefficient compared to predicted coefficient which implies variation in PES practice preference among respondents. Variations in PES interventions preference across gender are explained with reference to labour requirement. Some interventions such as terracing are physically and time demanding therefore less preferred by women and aged farmers. Fruit trees, grass strips and agro-forestry require less labour to establish and maintain and are implemented across the gender divide. Villamor and van Noordwijk (2016) in their study have similarly shown that gender significantly influence ecosystem services preferences and determines choice for land use interventions that could contribute to sustainable provision of ecosystem services.

Table 8: Socio-Economic attributes influencing farmers' preferences for land use PES conservation practices

Variable description	Statistic		
	Coef.	Std. Err.	P>z
Dependent variable:			
Preference for PES practice choice			
(0=No; 1=Yes)			
Independent variables			
Household Gender; (0=Male; 1=Female)	-.880	.516	0.088*
Household head age (years)	-.047	.020	0.016**
Land Tenure (0=Not owned; 1=Owned)	.845	.254	0.001***
Soil Retention;0=No, 1=Yes	1.475	.626	0.018**
Prevent pests and Diseases;0=No, 1=Yes	-2.303	.873	0.008***
Flood control/reduction; 0=No, 1=Yes	1.933	.699	0.006***
Cost to control soil erosion (KES)	.00007	.00003	0.013**
PES impact on soil fertility; 0=No, 1=Yes	4.734711	1.869	0.011**
Income from PES practices; 0=No, 1=Yes	2.15043	.667	0.001***
Food security; 0=No, 1=Yes	1.025732	.666	0.123
Influence of cash received from PES; 0=No, 1=Yes	1.17551	.559	0.035**
Availability of markets for farm produce; 0=No, 1=Yes	-.464296	.506	0.358
_cons	-8.269	2.780	0.003
Logistic regression. Number of observations =200			
LR chi2(12) = 39.04; Prob > chi2=0.0001			
Log likelihood = -59.6349; Pseudo R^2=0.3680			

Source: Nyongesa, J.M. (2018)

(***) significance at 1%, (**) significance at 5%, (*) significance at 10%

Age was significant (P>z =0.016) at 5 percent level, and an equally important driving factor for farmer's preference for PES practices. Age had negative coefficient which implies that if increased by one unit (year) then the preference PES practice factor will decrease by 0.047. The mean age was 54.19 years and at this age, farmers would consider selecting less strenuous PES farm practices. In related study, Kisaka and Ajuruchukwu (2015) found that gender and age have a positive influence on choice for PES practices.

When tenure status is secured, it influences the type of PES farm practices preferred. Interventions requiring long term to establish such as terracing and tree planting would be associated with private land ownership as opposed to practices that required short time to establish for instance grass strips. The PES mechanism design is market based and requires seller-buyer negotiations to voluntarily accept to sell and buy environmental services respectively. To make such decisions, the farmer must own the land as a requirement to join PES scheme. Consequently, high significance attached to land tenure relates to preference for interventions which correspond to the tenure status. Land tenure was significant (P>z =0.001) at 1 percent level.

Related studies have shown that scenarios where payment for ecosystem services incentives are conditionally tied to land-use change practices and socio-economic-ecological outcomes, land tenure security is essential to influence smallholder landowners in decision-making (Robinson *et al*., 2011).

Soil retention was significant (P>z =0.018) at 5 percent level. Soil erosion was identified as a major on-farm challenge. Interventions with soil retention attributes were preferred to improve soil fertility and increase farm productivity as provisioning service. Soil retention on farms would result in reduced silt load in rivers and improve clean water flow as a product demanded by buyers of environmental services downstream.

These results corroborate Shan *et al.* (2010) findings that decision to implement PES practices is influenced by expected farm benefits. Previous studies have equally identified soil retention as key component in agro-ecosystems. Bartkowsk *et al.* (2018) applied New Institutional Economics and the ecosystem service concept to analyze the Institutional Economics of Agricultural Soil Ecosystem Services in Wiesenena Germany. Their findings have shown that soil is a vital component of most ecosystems which support terrestrial biodiversity, and unsustainable anthropogenic land use change that degrade soil availability and soil health impact negatively on provision of ecosystem services that sustain human wellbeing.

Bartkowsk *et al.* (2018) finding has been supported by Nkonya, *et al.* (2016) and Juerges *et al.* (2018) who argue that soil degradation influenced by human activities, climate change and exacerbated by limited governance structures for sustainable soil management remains a global challenge, a concern they suggest that needs to be addressed to restore agro-ecological functions for sustainable ecosystem service provision.

Reduction in agro-chemical use was one of the key factors that influenced initiation of PES scheme. It was envisaged that reduced pollution of water bodies would ensure clean water flow required by buyers of ecosystem services downstream. High cost of agrochemicals influenced choice of practice that would reduce their use. This explains why prevention of pests and diseases as regulating service was significant ($P>z = 0.008$) at 1 percent determining farmer's PES intervention preference.

Flood control is important regulating ecosystem service. Flood reduction was significant ($P>z = 0.006$), preference determinant at 1 percent level. Farmers chose PES interventions which could mitigate against natural externalities, notably, flood control. This could lead to reduction of silt load in river ecosystems enhancing clean water as an important service demanded by ES buyers. There was need to safeguard against loss of livelihoods from destruction of crops and livestock enterprises, infrastructure and other non-agricultural enterprises and interventions from floods.

The PES interventions with potential attributes to control floods on farms would thus influence farmer's preference. In similar study, Boko *et al.* (2007) observed that farmers are concerned with strengthening their resilience against effects of climate change manifested through floods, and interventions which strengthen the resilience are preferred for implementation.

Cost to control soil erosion attribute was significance ($P>z = 0.013$) at 1 percent level. The PES practice that control soil erosion would reduce the cost a farmer could incur to control erosion on farm without conservation practices and therefore such attribute influenced farmer's preference for PES practice. Erosion control ensured soil retention on farms an important attribute that contributes to soil nutrient cycling and fertility as supporting services. The impact of PES practice on soil fertility significance ($P>z = 0.011$) at 5 percent level suggests that it is an important attribute to consider when choosing PES interventions for implementation in agro-ecosystems. The PES positive impact on soil fertility is linked to food security and farm yields improvement.

A study on payment for environmental services application in conservation agriculture among smallholders farmers in three upstream riparian districts (Balaka, Machinga and Zomba) in the Shire River in Southern Malawi revealed that interventions that improved soil structure and fertility motivated famers to adopt sustainable PES land management practices, with or without other incentives (Bell *et al.*, 2018). In a similar research, Robertson *et al.* (2014) found that through PES schemes, farms could be readily managed to contribute to clean water, bio-control and other ecosystem benefits. These benefits include climate stabilization and long-term soil fertility, thereby supporting to meet society's need for agriculture that is economically and environmentally sustainable.

Farmers would adopt any PES intervention that will increase their incomes opportunities. The alternative PES practices with such possibilities influenced farmer's preference. This is explained by income source significance ($P>z = 0.001$) at 1 percent level and influence of cash received from PES as incentive from buyers of ecosystem services significance ($P>z = 0.035$) at 5 percent level. However, extension training received before and during PES implementation on benefits expected from each PES intervention could have influenced individual farmer's preferences.

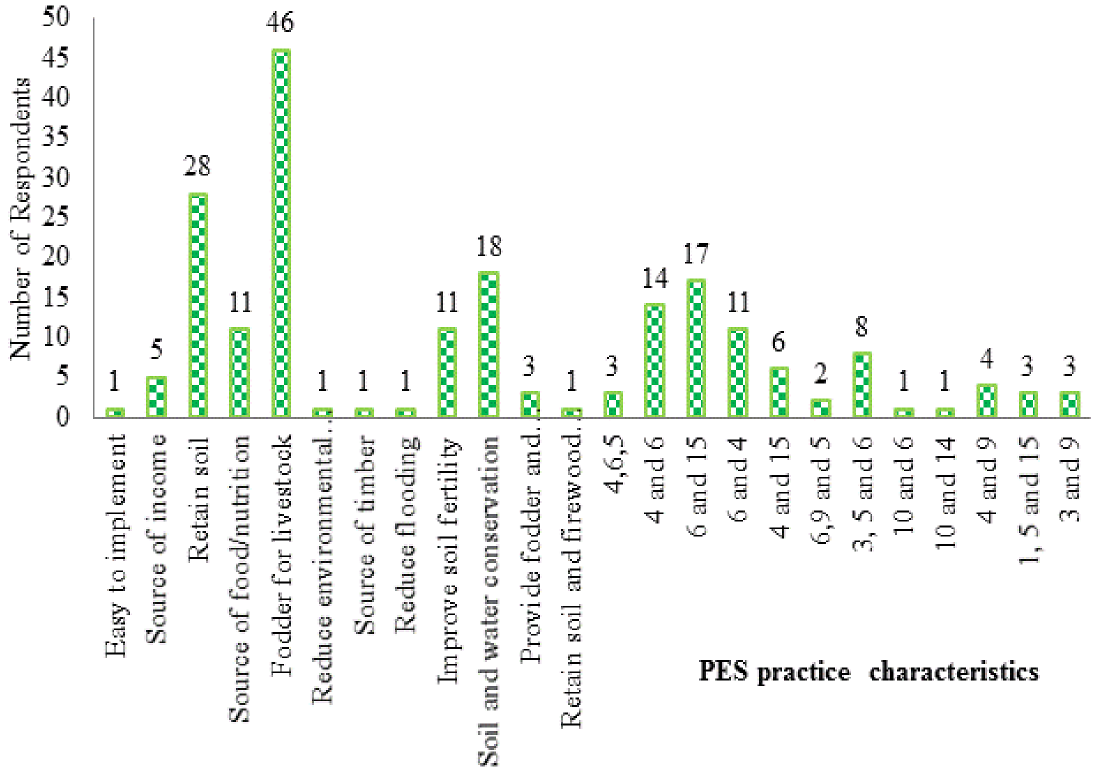
Table 9 shows results of whether farmers were influenced to practice PES or otherwise and if they had personal preference for particular PES practices. Over 90 percent were influenced to practice PES technologies. It is evident that farmers had individual choice for PES practices indicated by 87 percent who reported to have preference for particular PES practices. Given the heterogeneous nature of households, varied preferences is an indicator of individual farmer's expected maximum utility derived from specific PES practices in terms of socio-economic and environmental benefits. Preference may have as well been influenced by nature of land degradation versus suitable PES interventions to rehabilitate degraded farms, gender and age factors.

In related socio-cultural valuation of ecosystem services study of Posidonia oceanica ecosystem services in North Western Mediterranean, Ruiz-Frau (2018) found that public preferences for particular ecosystem management interventions were influenced by environmental perceptions related to individual knowledge on environmental, ecosystem services and human wellbeing linkages. In their study, Dick *et al.* (2017) have proposed that knowledge on these linkages can be enhanced through awareness creation.

Table 9: Influenced and preference of PES practices

Variable description	Frequency	
	No	Yes
Influenced to practice PES; (0=No; 1=Yes)	14	186 (93%
Preference for PES practice; (0=No; 1=Yes)	27	123 (87%)

Figure 4 characterizes PES intervention attributes hypothesized to influence farmer's choice for particular practices. The figure shows the number of respondents who identified different attributes they considered important for PES practices. Provision of fodder for livestock, soil retention, soil and water conservation were most common attributes reported by 23 percent, 14 percent and 9 percent of farmers in that order. These attributes form the basis of farm agricultural production and their availability means farmers could improve farm productivity including increase of livestock feeds. The need to rehabilitate degraded land to retain soil and reduce siltation for enhanced clean water flow downstream influenced farmer's choice for PES practices indicated by soil and water conservation attribute of 18 percent. Desire to increase farm productivity was guided by the preference for practice that could retain soil attributed by 28 percent of farmers.



Key: *1=Easy to implement; 2=Less expensive; 3=Source of income; 4=Retain soil; 5=Source of food/Nutrition; 6= Fodder for livestock; 7=Reduce environmental pollution; 8= Source of timber; 9= Source of firewood; 10=Reduce flooding; 11=Manage frost; 12= Prevent pests and diseases; 13=Wind break; 15=Soil and water conservation; 16=Provide fodder and firewood; 17=Retain soil and firewood source*

Figure 4: Attributes for preferred PES practices

The PES interventions which ensured attainment of household food security and maintain environmental conservation were highly preferred. This is indicated by 11 percent of farmers. However, farmers preferred PES interventions with combination of attributes that would provide multiple benefits. From Figure 4, combination of fodder for livestock as well as soil and water conservation were preferred attributes influencing choice of PES interventions revealed by 17 percent. Kuhfuss *et al.* (2016) however, empirically found that socio-economic characteristics are correlated with preferences and ES buyer-seller contractual attributes.

Table 10 summarises farmer's perception on influence of PES interventions on various environmental and socio-economic farm characteristics. Over 50 percent of farmers observed change in farm produce price after PES scheme initiation. This can be explained in two ways;

first, increased productivity linked to soil fertility improvement led to high yields and surplus lowering local market demand and price for farm produce. Second, rise in price was related to increase in demand for organic produce arising from reduced and/or optimal use of in-organic fertilizers.

Table 10: Perceived impact of PES on environment and socio-economic farm characteristics

Variable description	Statistic		
(0=No; 1=Yes; 2=Don't know)	No	Yes	Don't know
PES impact on farm produce prices	93(46%)	107 (54%)	
PES impact on local human labour(0=No; 1=Yes; 2=Don't know)	53 (26.5%)	114(57%)	33 (16.6%)
PES impact on livelihood	2(1%)	198(99%)	
PES potential to mitigate climate change	60(30%)	140(70%)	
PES impact on soil fertility	2(1%)	198(99%)	
PES impact on water quality	32(16%)	168(84%)	
PES impact on productivity	4(2%)	196(98%)	
Valid N =200			

A research in Kellogg Biological Station at Michigan State University revealed that farmer's perceived expectation on increased production as a result of nature conservation determined their willingness to adopt new land use practices in their cropping systems including reduced agro-chemical use (Shan *et al.*, 2012). Likewise, 57 percent of farmers observed that PES had influence on distribution of farm human labour. This perception is associated with increased demand for labour to implement PES technologies. Consequently, non-PES farmers were engaged on PES farms as casual workers to implement PES farm practices. Also, 99 percent perceived PES scheme had improved their livelihoods depending on the interventions envisaged to restore sustainable provision of ecosystem services. Similar results were found by Cole (2010) in Buenos Aires County in southern Costa Rica among farmers who perceived PES programme had a positive impact on their socioeconomic situation. Other studies have indicated livelihoods- wellbeing of the poor to be key foundation attributes for adoption of PES conservation practices for provision of ecosystem services (Lehmann *et al.*, 2018).

Climate change is manifested in the study area in form of extreme temperatures, floods leading to soil erosion, changes in rainfall patterns and seasonality (GoK, 2012), and 70 percent perceived that PES had potential to mitigate effects of climate change. Over 90 percent perceived PES had impact on soil fertility and farm productivity (98 percent) while 84 percent qualitatively perceived PES had improved water quality. However, empirical analysis to confirm qualitative perception on water quality change under PES would give higher bargaining power for sellers of ecosystem services with buyers downstream. Empirical hydrological survey was beyond this research leaving gap for future study.

Perceived PES impact on productivity is related to soil fertility improvement under PES farm practices. Wambugu *et al.* (2009) in their study demonstrated that rural poverty is marked by its connection to unsustainable land use practices in agriculture sector. These findings confirm that productivity increase is interlinked with sustainable management of agro-ecosystems to provide provisioning services. This is essential to cushion farmers against increasing poverty levels which confirm significant 98 percent perception attached on PES impact on productivity. Consistent with previous studies, Wei *et al.* (2009) in their research found that perceived increment in productivity as ecosystem services benefits to individual farmers and the society in general influenced the participation and adoption of conservation practices.

4.3.2. Productivity changes for crop and livestock enterprises as a result of PES interventions.

This section addresses the second objective, and Table 11 presents the results of farm enterprise revenue changes as a result of PES interventions (without/before PES in the year 2008 and with/after PES in the year 2013). A comparison of income was made before and after the interventions were initiated.

Table 11: Household monthly revenue profile with and without PES scheme

Variable	Range	Mean	Std.Dev
Gross monthly income (farm produce sources) without PES	500- 42,167	6,891.96	5,101.12
Gross monthly income (farm produce sources) with PES	1*-194*	11,011.48 (10,310.37)	14,719.42
Monthly crop revenue without PES	0-100*	5,046.54	7,790.85
Monthly crop revenue with PES	0-180*	8,379.98 (12,536.45)	14,568.32
Total Monthly livestock revenue without PES	0-31*	3,532.43	3,597.74
Total Monthly livestock revenue with PES	0-35*	6,618.03 (9,900.57)	5,147.55

* Kenya shillings (KES) in 1,000s; Without PES (base year 2008) and with PES (current year 2013);

All values are nominal except figures in parenthesis which are Real values adjusted to eliminate effect of inflation using the formula;

Real income = (Nominal income $_{\text{base year}}$) x ($CPI_{\text{current year}}$ / $CPI_{\text{base year}}$). The CPI Source (World Data, 2010)

$$Real\ Income = (Nominal\ Income_{2008}) \times (CPI_{2013} \div CPI_{2008}) \qquad 17$$

For example,

Real Gross monthly income from farm produce sources with PES= (6,891.96) x (131.8/ 88.1)

Gross monthly income (real) from farm produce sources with PES= (6,891.96) x (131.8/ 88.1)

= (6,891.96) x (1.496)

Real Gross monthly income from farm produce sources with PES = KES. 10,310.37

In terms of real purchasing power comparing base and real income, it implies farmers are 49.60 percent better off with PES than without PES (that is KES. 10,310.37-6,891.96= 3.418.41). Similarly, farmers were 49.60 percent better off with PES for income from crop and livestock revenue of KES. 4,156.47 and KES. 3,282.54 correspondingly.

The income change was assesed to infer change in productivity, that is, evenue indicated in Kenya shillings was analysed to infer to change in productivity. The mean gross monthly income from on-farm activities before PES scheme was KES. 6,891.96, which closely relate to the national average household income range of between KES. 3,000-7,492 (GoK, 2009). However, the mean gross monthly income of KES. 11,011.48 was realized after PES interventions. This is an indicator of PES influence on farm household income (59.77 percent increase). Increase in income is related to increase in productivity following improved soil fertility as a result of PES interventions. Results corroborates FAO report that increase in productivity and farm income as a result of adopting conservation practices enhance ecosystem services (Aerni *et al.,* 2013). Similarly, a study conducted on PES watershed program in Hebei Province (upstream landowners) and Beijing City (downstream water beneficiaries) communities in China showed doubled farm income and improved livelihood for upstream smallholder land owners participating in PES watershed programme (Zheng *et al.,* 2013). Contrary to these results, Arriagada *et al.* (2015) found no significant PES effect on income increase and well-being for households enrolled in the Costa Rica's PES program. Their contrary findings could be attributed to possible PES program selection bias towards participants especially selection of those who had economic influence with a relatively better socio-economic profile. This bias was equally reported by Zbinden and Lee (2005) as a challenge in assessing PES impact.

Results further specifically indicate KES. 5,046.54 and KES. 8,379.98 monthly revenue from crop enterprise without and with PES interventions congruently, an increase of 66.05 percent. The mean income from livestock enterprises was KES. 3,532.43 and KES. 6,618.03 in 2008 and 2013 without and with PES scheme correspondingly. Revenue increase of 87.35 percent from livestock products enterprise has two explanations; it is attributed to increased availability of fodder which influenced increased milk production and also associated with improved livestock management skills acquired during PES training sessions by the ministry of livestock extension staff.

4.3.3. Estimated farmers' Willingness to Accept Pay to provide ecosystem services

As results in Table 12 reveal, individual WTA as maximum incentive ES producer accepts to derive utility from implementation of alternative PES farm practices versus foregone land use practices. It also shows the estimated cost to restore natural ecosystem services on one acre of land. The estimated values reflect WTA as the sum that leaves the household indifferent between the expected marginal utility under the foregone farm practices and the discounted expected marginal utility from change in future incomes because of the new set of PES interventions.

The average WTA to conserve 1 acre of land was estimated at KES. 21,902.50. This value was the mean proxy price for opportunity cost accepted to set aside 1 acre of land for conservation only without agricultural practices other than restricted activities such as controlled grazing. Findings corroborate Ndetewio *et al.* (2013) findings that WTA could vary with farm size as significant determinant with positive influence on WTA-WTP for watershed services.

Table 12: Estimated Willingness to Accept Pay to implement PES interventions

Variable Description	**Statistic**			
Estimated WTA (KES.) (1US$=100KES.)	Min.	Max.	Mean	Std. Dev
WTA to conserve 1 acre*	0.00	50,000.00	21,902.50	110,03.39
WTA for rehabilitation of Riparian Zones	0.00	18,000.00	6,648.00	3,305.73
WTA for Grass Strips	1,200.00	20,000.00	7,428.00	2,442.096
WTA for terracing	3,500.00	55,000.00	17,466.00	8022.384
WTA contour cropping	2,000.00	45,000.00	11,838.00	6783.223
WTA for Agro-forestry	1,500.00	35,000.00	9,821.500	5,783.13
WTA for improved seed varieties	1,200.00	80,000.00	16,878.00	13,674.56
WTA for fallowing**	5,000.00	45,000.00	21,847.50	10,232.01
WTA for crop Rotation	1,500.00	85,000.00	7,470.50	6,499.00
WTA for reduction in Agrochemical use	1,000.00	90,000	7,451.50	8,701.11
Estimated cost to restore natural ecosystem services on 1 acre without PES (KES.)				
Cost to control soil erosion	1,000.00	100,000.00	12,965.00	13239.72
Cost to improve soil fertility	1,000.000	100,000.00	11,815.00	11116.59
Cost to control flooding	1,000.00	90,000.00	11,215.00	8060.935
Cost to control pests and diseases	1,000.00	15,000.00	3,801.00	2323.617
Valid N =200				

*Land for conservation only without agricultural practices

**Restricted agricultural activities-no ploughing but limited activities like grazing allowed

The mean annual WTA estimates to implement specific PES practices were as follows: rehabilitation and maintenance of riparian land KES. 6,648.00; grass strips KES. 7,428.00; terracing KES. 17,466.00; contour cropping KES. 11,838.00; agro-forestry KES. 9,821.500;

improved seed varieties KES. 16,878.00; fallowing KES. 21,847.5; crop rotation KES. 7,470.50 and reduction in agrochemical use KES. 7,451.50. The estimates reflect the value farmers are willing to accept as opportunity cost to adopt PES farm practices for environmental conservation and livelihoods improvement.

Rehabilitation of the riparian land was mainly through planting grass, indigenous and fruit trees. These were the preferred soil and water conservation measures along riparian land to prevent silt load in water sources. Similarly, riparian land's proximity to water sources provides provisioning services such as food especially during dry season. Such attribute influenced low WTA estimates to restore degraded riparian land as strategy to adopt rehabilitation of the riparian land to enhance resilience to effects of drought.

Improved water quality and quantity were the main selling points in the agreement between buyers and sellers of ecosystem services and riparian land protection was therefore conditional for farmers to improve water quality. Lower WTA for grass strips is explained by farmer's expectation that the practice would significantly contribute to soil retention and provide fodder for livestock. However, the cost to implement the practice was low in terms of labour requirement, time taken to establish grass strips and planting materials which explains the attached low WTA value (KES. 7,428.00).

High WTA for terracing and contour cropping combined (KES. 29,304.00) relates to high skills required to map and mark contours and terraces along the sloping land. Considering the two practices, terracing is labour intensive and could not be favoured by aged and female gender farmers. Willingness to accept pay estimate for improved crops seed varieties was determined by the cost and accessibility. Initial improved seeds for selected crops were provided by the PES intermediary organizations. Perceived sustainability of improved seeds after exit of PES intermediaries influenced WTA estimate of KES 7,451.50. However, WTA for the practice could reduce over time as farmers continued realizing in-situ benefits especially higher farm productivity, increased income from use of certified seeds and incentives from ecosystem service buyers.

It was remarkable to note close correlation in WTA between fallowing (KES. 21,847.50) and conserving (KES. 21,902.50) one acre of land under restricted agricultural practices. The WTA for the two practices confirms trade-offs between foregone farm practices and alternative PES conservation practices. Comparative research has shown trade-offs between provisioning and regulating services, or between provisioning and cultural services to be common occurrence in PES schemes (Fu *et al.,* 2018) though interaction between and within these ecosystem services has been considered to create synergy in PES schemes (Felipe-Lucia *et al.,* 2014). Fallowing was highly priced because of the value attached to land as source of livelihood. The PES practice that requires leaving the land fallow will therefore attract high WTA rate as opportunity cost. The WTA payment reflects best opportunity foregone if the farmers had to set aside one acre for only conservation or fallowing. The estimate represents the economic value attached to the two interventions.

Crop rotation had moderately low WTA (KES. 7,470.50). The intervention requires minimal technical skills, is less costly and with low agricultural activity restrictions. The attributes explain low WTA value attached to the practice. Farmers can benefit from provisioning, regulating and supporting services mainly increased productivity and maintained soil fertility from nutrient recycling enhanced by crop rotation. Reduction in agro-chemicals use was required to prevent pollution of water sources to improve water quality demanded downstream by ecosystem service buyers. The WTA estimate was KES. 7,451.50.This estimate can be explained in two ways. First, this amount is low because it was already a requirement in mutual ecosystem buyer-seller agreement to adopt practice to prevent pollution. Second, without the agreement, it implies that farmers lack alternative methods for pests and disease challenge such as integrated pest management (IPM) approaches.

Low WTA for PES interventions imply more farmers' willingness to implement PES farm practices considering opportunity cost as trade-off between PES and foregone farm practices. Results corroborate with Pagiola *et al.* (2002) study that where upstream opportunity costs are high and downstream benefits are low, PES schemes tend to be unsustainable. Likewise, Ndetewio *et al.* (2013) found that PES scheme becomes sustainable and feasible if downstream benefits are high and upstream opportunity costs are low.

Table 12 further shows farmers estimated cost attached to rehabilitation of degraded land in absence of PES technologies. These are costs farmers bided to internalize negative externalities to ecosystems without PES. Considering Total Economic value-TEV (the total gain in wellbeing from a policy measured by the net sum of the WTP or WTA) framework, the estimates reflect avoidance cost. These are the cost farmers will avoid if they practised

PES technologies or the amount in economic terms farmers could spend to replace or restore degraded ecosystems in absence of PES practices. The cost represents the proxy value attached to the regulating and supporting ecosystem services including natural soil erosion and flood control, soil fertility restoration and nutrient recycling.

Without PES scheme, soil erosion control, improved soil fertility, flood control and land rehabilitation costs were estimated above KES. 11,000 annually. The bids reveal the average amount a farmer would save or the avoided cost if ecosystems are conserved to offer the same natural services. The value attached to rehabilitation practices indicate surrogate market price estimates linked to environmental services. The services include regulating and supporting services which directly or indirectly contribute to provisioning services. The cost to control pests and diseases was estimated at annual KES. 3,801 per acre. The cost was dependent upon the different crop and livestock enterprises raised by individual farmers. Training on reduction of agro-chemicals under PES scheme influenced farmers to apply good agricultural practices to lower pollution levels in agro-ecosystems with significant influence on WTA estimates for pests and disease control.

For sustainability of PES project, it was important to explore its continuity especially the implementation of PES practice in the long-run. Table 13 presents WTA to continue implementing PES practices for watershed conservation to provide ecosystem services. Results shows 97 percent of farmers were willing to accept pay to continue implementing PES scheme irrespective of the PES practice type. For specific PES practices, over 30 percent were willing to accept pay to continue implementing rehabilitation and maintenance of riparian zones, 95 percent were for grass strips, 15 percent for terracing, 32 percent for contour cropping, 96 percent for agro-forestry, 62 percent for clean improved seed varieties, 37 percent for fallowing, 53 percent were willing to continue practicing crop rotation technologies and 70 percent for reduction in agrochemical use.

Riparian land is important to farmers due to its proximity to water sources, and was among the interventions with lowest number of farmers WTA to implement (39 percent). Due to land scarcity, there is rampant encroachment on riparian land which provides provisioning ecosystem services especially food during dry season. Although riparian land acts as a buffer for water sources from siltation during rainy season, encroachment for provisioning services influenced household’s low willingness to restriction for riparian activities. Conversely, Rafuse (2013) found riparian land to be vital for provision of services and significant in maintaining water quality which influence the smallholder farmers in decision making on change of riparian farm practices.

Grass stripping was highly favoured (95 percent) due to its dual purpose of soil and water conservation as well as provision of fodder for livestock. Adopting the practice directly contributes to land restoration and supporting services such soil retention on farms and fodder availability for livestock which translate to increased milk production. These attributes motivated farmers to continue implementing the practice. Results corroborate Kagombe (2015) and Yves *et al.* (2004) who found that grass strips conservation practice is more attractive among farmers because the practice significantly reduce farm runoff and retain soil on farms.

Table 13: Willingness to continue implementing PES practices

Variable description	**Statistic**	
	Mean	Std. Error
Willingness to continue implementing all PES practices (0=No; 1=Yes)	0.970	.013
Willingness to Continue Implementing Specific PES Practices		
Rehabilitation and Maintenance of Riparian Zones (0=No; 1=Yes)	0.390	.035
Grass Strips (0=No; 1=Yes)	0.950	.015
Terracing (0=No; 1=Yes)	0.150	.025
Contour cropping (0=No; 1=Yes)	0.320	.033
Agro-forestry (0=No; 1=Yes)	0.960	.014
Improved certified seed varieties (0=No; 1=Yes)	0.620	.034
Fallowing (0=No; 1=Yes)	0.370	.034
Crop Rotation (0=No; 1=Yes)	0.530	.035
Reduction in Agrochemical use (0=No; 1=Yes)	0.700	.032
Valid N =200		

Low number (15 percent) of farmer’s willingness to implement terracing is related to different reasons ranging from high physical labour demand for mapping and digging terraces. High labour demand for terracing discourages female gender and older farmers due to drudgery. Similarly, contour cropping was not highly favoured (32 percent) because it requires high skills to implement. The practice is preceded by marking out contours on the farm using an extension expert. Likewise, due to the cost involved, few farmers would be willing adopt the practice.

Depending on type and species, agroforestry is a source of food, livestock feeds, and firewood for households. Farm wood fuel energy provision is important in reduction of pressure on natural forests. Agroforestry also contributes to regulating services especially those linked to soil and water conservation (mainly flood and soil erosion control) as well as climate moderation. This made it attractive to more farmers (96 percent) willing to continue its implementation.

In comparable research in Southern Costa Rica, Cole (2010) found that agroforestry under PES programme on smallholder farms had potential to provide important ecological services, such as carbon sequestration and maintenance of biological diversity in addition to on-farm ecosystem goods and services and contribution to increased reforestation which motivated farmers to continue with its implementation. These findings are further supported by Lee *et al*. (2018) that agroforestry contributes to forest ecosystems to provide important ecosystem services including provisioning, regulating, habitat or supporting, and cultural services.

Certified seeds for crop varieties is a strategy to increase productivity through use of high yielding planting materials and resistance to adverse weather conditions, pests and disease. This explains high number of farmers (62 percent) willingness to continue planting certified seeds. It was remarkable, however, to find a low proportion of household's willingness to continue fallowing (37 percent). Result is related to small land parcels which could significantly affect food security if fallowing was practiced. However, crop rotation was preferred to reduce pest and disease prevalence associated with climatic changes and improved soil fertility. Crop rotation improves soil structure and nutrient cycling which are important supporting environmental services and therefore attractive to 53 percent of farmers. Reduction in use of agrochemicals (70 percent) was accepted to avoid cost for purchasing inorganic agrochemicals and as an approach to reduce environment pollution mainly in agro-ecosystems and water bodies.

High farmer's WTA to implement different PES interventions imply acceptance of PES practices and recognition for practices ability to have positive influence on environmental conservation and household livelihoods improvement. Other studies have as well shown that high willingness to restore ecological functions is an indicator that PES can work in agriculture sector where ecosystem services are under threat and the opportunity costs for alternatives are not very high (FAO, 2011). Conversely, a study by Swinton *et al.* (2014) revealed that willingness of farmers to adopt new farm management practices that improve sustainable provision of ecosystem services is as well influenced by other factor including awareness creation, personal attitudes, available resources to implement the practices and incentives to motivate and compensate farmers for the opportunity cost.

4.3.4. Socio-economic factors influencing farmer's WTA to implement PES practices.

Table 14 presents Logit model regression estimates results for socio-economic factors hypothesized to influence farmers' WTA to implement PES practices for provision of ESs demanded by downstream commercial buyers. The R^2 value of 53.37 percent implies that the variability in WTA is well explained by the model. Total of nine independent variables significantly determined farmer's Willingness to Accept Pay. Gender and age of household head were correlated and both were significant (P>z = 0.032) at 5 percent level. Gender significance influence on WTA results corroborates with other past related studies (Kadigi and Mlasi, 2013; Priyambodo *et al*., 2016).

Household age mode was 40 years which implies the respondents were adults of age to make informed decision and therefore influenced WTA on their farms. Farmers gain farming experience over time and the aged would recognize the benefits of farm conservation practices and are likely to be influenced in WTA decision compared to younger farmers. Comparable results have been obtained in WTP studies (Abdulkarim *et al.*, 2016) farmers. Similarly, a total of 134 (67 percent) males and 66 (33 percent) females were interviewed. The higher number of male respondents therefore influenced the WTA compared to female gender.

Farm size was significant (P>z= 0.077) at 10 percent level. Because farms were degraded with low productivity observed, PES practices and incentives was a solution to enhance productivity and income therefore influenced WTA to implement PES practices for provision of environmental services. The mean farm size was 2.47. If land size decreased by one unit (acre) then the WTA factor will increase by 0.077

Table 14: Socio-economic factors influencing farmers' WTA to provide ecosystem services.

Variable description	Statistic		
Dependent variable:			
Willingness to Accept Pay (WTA) (0=No; 1=Yes)			
Independent variables	Coef.	Std. Err.	P>z
Gender of household head (0=Male; 1=Female):	4.240	1.978	0.032**
Age of household head (years)	.1341	.062	0.032**
Farm size (acres)	1.665	.941	0.077*
Household family size (number)	-.291	.221	0.188
Acquired skills/knowledge through PES (0=No; 1=Yes)	6.506	2.536	0.010***
Access to extension services (0=No; 1=Yes)	-1.744	1.364	0.201
Land use system (0= Not farming; 1= farming)	3.392	1.481	0.022**
Income from PES (0=No;1=Yes)	3.567	1.584	0.024**
Conservation interest (0=No; 1=Yes)	-5.329	2.079	0.010***
Gross monthly income before PES (KSHS)	-.0003	.0003	0.224
Occupation of Household head (0=Farmer; 1=off-farm employment, 2=Farmer/off-farm employment)	-1.437	1.043	0.168
Gross monthly income After PES (KSHS)	.0005	.0002	0.063*
Education level of household head: No formal education (0=No, 1=Yes); Secondary (0=No, 1=Yes); College/University (0=No, 1=Yes)	7.236	2.965	0.015**
_cons	-26.875	10.896	0.014
LR chi2(13) = 32.39; Prob > chi2 =0.0021			
Log likelihood=-14.1478; Pseudo R^2=0.5337; N=200			

(***) significance at 1percent, (**) significance at 5percent, (*) significance at 10 percent
Source: Nyongesa, J.M. (2018)

Skills and knowledge empowerment of farmers was conducted by government extension staff under the PES program before implementing the technologies. This added an impetus to accept pay given that farmers were able to understand conservation and economic development linkages.

Acquired skills and knowledge was significant (P>z=0.010) at 1 percent level. In absence of PES scheme, farmers could have paid for soil and water conservation capacity empowerment services. Related studies have shown adoption of sustainable land management practices to be determined by the information and farmer's participation in conservation program design and the change in the farm management similar to PES scheme (Kwayu *et al*., 2014). Consistent to these findings, other researchers in past studies equally found that social motivation including training to exchange and impart skills and knowledge influenced farmer's willingness to participate in Payment for Ecosystem Services program in Nicaragua (Van Hecken and Bastianensen, 2010).

The PES interventions aimed at increasing farm productivity for both livestock and crop enterprises as expected benefits. Land use system was significant (P>z= 0.022) at 5 percent level. Total of 177 farmers (88.5 percent) practiced mixed farming (crop and livestock). The expected pay from alternative PES practices as *in-situ* benefit and incentives from buyers of ES influenced farmer's WTA to implement the PES practices as change in land use activities. The incentive as the expected increased additional income (payment from buyers) attached to PES scheme was significant (P>z = 0.024) at 5 percent level and was related to gross monthly income after (with) PES interventions significant at (P>z = 0.063) at 10 percent level. Expected income was mainly from two sources; buyers of ecosystem services and from *in-situ* sources through increase in productivity as a result of implementing alternative PES practices.

Farm income was correctly predicted to have affirmative influence on WTA. Incremental change in income under PES interventions motivated farmers to accept pay to implement PES interventions. In similar past studies, it has been shown that farm and off-farm income have influence on farmer's decisions to invest in agricultural technologies like PES interventions (Pender and Kerr, 1998). Other studies have shown positive relationships between income and adoption of agricultural technologies (Faye and Deininger, 2005) and PES incentives to be directly connected to the income of ES sellers.

These findings are supported by Priyambodo *et al*. (2016) who have shown that lower incomes increase the WTA for extra revenues to cover the farm opportunity cost and satisfy other household socio-economic needs. Further comparable studies in literature have shown that income from PES schemes has significant influence on the local Willingness to Accept Pay (Doris and Wang, 2018; Li *et al.*, 2018). Consistent to these findings, Jiaran *et al.* (2018) analyzed factors affecting the willingness of farmers to accept eco-compensation in the Qianxi chestnut agroforestry system of Hebei China and found that household income was one of significant factors that influenced farmer's willingness to accept pay.

Interest to conserve ecosystems in the watershed was significant (P>z= 0.010) at 1 percent. The PES scheme design aimed at rehabilitating degraded agro-ecosystems to restore provision of environmental services such as food and enough clean water for sellers and buyers of the ES respectively. Farmers were motivated by PES practices that would positively contribute to livelihoods-environmental conservation nexus. Farmers would readily accept payments that relate to farm enterprise productivity improvement. With improved productivity, farmer's livelihoods will be enhanced contributing to improved household food security, income and poverty reduction.

Comparable studies in literature have indicated that farmers are motivated to adopt farm practice that conserve ecosystem if such practices create markets for ecosystem services, reduce socioeconomic costs and directly increase their benefits at farm level (Lastra-Bravo, 2015; Wilson and Hart, 2000). However, interest to conserve had negative coefficient value of -5.329265 contrary to the positive prediction. This implies that if the number of farmers with interest to conserve increased by 1 unit (number) then level of WTA will decrease by the coefficient value. This could be related to the increased level of restored farmland which by inference would contribute to increased; productivity, soil retention, income and water quality and quantity therefore influence WTA for PES practices. Contrary to this findings, Feng *et al.* (2018) found positive correlation between environmental conservation and WTA such that respondents that valued conservation required higher compensation therefore regulated Willingness to Accept Pay.

Related previous studies have shown that interest to conserve is a significant factor to influence willingness to participate in conservation farm practices among farmers who perceived their farm benefits could increase from nature conservation (Sheikh *et al.,* 2003). In agreement to these studies, Kenter *et al, (*2015) found that moral commitment to nature conservation generally motivated people to participate in farm practices when they value ecosystems for provision of ecosystem services.

Education was significant (P>z =0.015) at 5 percent level. Education was predicted to have positive influence on WTA. Results revealed that if education increased by 5 percent, the WTA to adopt PES practices increased. This influence relates to literate farmers better understanding of PES concept compared to farmers without formal education. Literate farmers as well are likely to give near precise WTA estimates than those with low education level. This outcome corresponds with findings by Ulimwengu and Prabuddha (2011), Chapika and Andreas (2009), Asrat *et al.* (2004) and Aura (2016) that education has significant influence on willingness decisions among smallholder farmers.

Conversely, available literature has shown education to have positive correlation with land owner's participation in PES schemes that involve changes to land management practices. For instance a study by Shan *et al,* (2012) to understand farmer's willingness to participate in Payment for Environmental Services programmes in Michigan, USA revealed education had significant influence on farmer's willingness to participate. Shans's findings corroborates previous similar studies in literature which indicate significant influence of education on farmer's willingness to adopt conservation farm practices for provision of ecosystem services (Warriner and Moul, 1992; Rahm and Huffman, 1984).

Xiong and Kong (2017) applied contingent valuation method (CVM) and Ordinal Logistic model to study the farmers' willingness to accept pay and its influencing factors for ecological compensation of Poyang Lake Wetland in Chian and equally found that several socio-economic characteristics including education and source of income were significant determinants for willingness to accept pay. Interestingly, contrary to these findings, Bonnieux *et al.* (1998) argued that measures of formal education is not always a measure of informed land management techniques adoption and is not significant in participation of Payment for Environmental Services.

However, PES scheme in the study sites could be interwoven with Kenya's water policy framework as watershed-based policy therefore to institutionalize PES as important conservation-livelihoods policy tool (GoK, 2002). As policy instrument, PES can strengthen management of natural resource use, conflicts resolution over natural resources and degradation in watersheds (Daniel *et al.,* 2009).

Significant determinants for WTA were however interrelated directly or indirectly. They are linked to trade-offs associated with PES activities as well as livelihood-environment guild. Addition of more variables in the model yielded insignificant results including household head family size and access to government extension services variables. Access to extension was insignificant for instance as it correlates with acquired skills and knowledge which was gained through farmer's training by extensions staff. This is explained by skills for PES practice implementation farmers acquired through training of para-professionals selected among PES farmers. This result is consistent with similar past research findings by Ulimwengu and Prabuddha (2011). Contrary to Naivasha study results, (Xiong and Kong, 2017) found number of family members to have significant influence on farmers willingness to accept pay. Contrary results could be explained by variations in social-cultural-demographics and PES design.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

This study examined PES influence on environmental conservation and farmer's livelihood in Naivasha watered, Kenya. The study was conducted among 200 PES implementing farmers, the members of the Upper Turasha Kinja WRUA located in Nyandarua South, Kinangop sub-counties and Wanjohi WRUA located in Kipipiri sub-county. This section provides brief conclusion of the study.

5.2. Summary

Payment for Environmental Services schemes have been initiated to restore degraded watersheds around the world. The PES payment concept relates to compensation for opportunity foregone and is an incentive aimed to motivate farmers implement alternative sustainable PES practices that contributes to livelihoods and environmental conservation in the watershed. The PES concept therefore creates substitution market for ecosystem services between farmers as sellers and private sectors as buyers and beneficiaries of ecosystem services.

The PES scheme in Lake Naivasha watershed links smallholder farmers in the upper catchment with commercial private sector farmers downstream. Study results have shown increase in income from farm produce sales after introduction of PES scheme that relates to increased productivity which by inference is linked to PES influence on environmental conservation improvement to sustain ecosystem services provision in comparison to degradation trend that would have increased without PES interventions. Success of PES scheme depends among others factors including preference for PES practice attributes, adoption and willingness to accept pay by farmers the sellers of ecosystems services.

Willingness to Accept Pay was estimated for different PES practices as economic value attached to ecosystem services. The WTA was however influenced by social economic factors. Positive influence on ecosystem restoration validates PES scheme as potential policy tool to conserve and rehabilitate degraded agro-ecosystems to improve local community smallholder farmer's livelihoods.

Payment for Ecosystem Services schemes have potential role to contribute to ecological management for sustainable production of ecosystem services which support socio-economic development. This study generates information which contributes to existing knowledge on Payment for Ecosystem Services and important for policy decision making on natural resource management and societal wellbeing.

5.3. Conclusion

5.3.1. Influence of socio-economic attributes on farmer's preferences for land use PES conservation practices

Different PES interventions were implemented as sustainable farm practices to mitigate watershed negative externalities. This study aimed to establish if PES practice attributes had influence on farmer's preference for particular PES practices. Findings have established variation in farmers' preference for PES interventions to have been influenced by the socio-economic attributes for specific PES technologies. Preferences for PES practices are as well linked to the utility satisfaction farmers expected to derive from the PES practice attributes and the payment from buyers of ecosystem services.

5.3.2. Productivity changes for crop and livestock enterprises as a result of PES interventions

Results have shown increase in income from sale of crop and livestock farm produce after introduction of PES practices. Increase in income relates to high sales from increased farm productivity which by inference characterizes improvement in agro-ecosystem condition. Improvement in ecological function relates to influence of PES scheme on rehabilitation of degraded farms for sustainable supply of ecosystem services important to sustain social wellbeing.

5.3.3. Farmers Willingness to Accept Pay to provide ecosystem services

Results have revealed that farmers were willing to accept certain average amount of incentive in monetary form to implement PES farm practices to restore degraded farms for provision of ecosystem services. The Willingness to Accept Pay (WTA) estimates were the opportunity cost for the foregone or restricted unsustainable practices in favour of alternative PES practices. The WTA estimates reflect economic values attached to ecosystem services. Recognition of economic value for ecosystem services creates and strengthen market for ecosystem services which are mainly public goods and services that lack direct market or price. The economic value attachment is an incentive to motivate natural resource stewards, development and conservation stakeholders to influence policy decisions to improve management of ecosystems to sustain provision of ecosystem services which are essential natural capital that sustain biodiversity and benefits humans socio-economic development.

5.3.4. Socio-economic factors influencing farmers' WTA to implement PES practices.

Significant socio-economic variables which determined farmer's WTA to implement PES interventions included: household head gender, age, farm size, acquired skills, land use system, income and education level. Willingness to implement PES practices implies farmer's acceptance to adopt the alternative PES farm practices envisaged to rehabilitate degraded farms in the upper catchment and restore ecological function to sustain provision of ecosystem services in Lake Naivasha watershed. Results have demonstrated that financial incentives only is not sufficient to influence farmers to make individual informed choice to implement PES practices. Findings contributes to understanding that other household farm-farmer's characteristics are equally significant in determining the land owner's willingness and informed decision choice to implement PES practices.

5.4. Recommendations

Ecosystem services contribute towards achievement of national objectives of food security, poverty reduction and biodiversity conservation. Sustainable provision of ecosystem services can be achieved when ecosystems including agro-ecosystem are conserved through sustainable farm practices in the watersheds. The following are recommendations based on study results;

5.4.1. Institutionalize PES and strengthen intuitional capacity building

It is recommended that policy and decision makers institutionalize PES scheme as a national policy framework to conserve agro-production landscapes for sustainable provisions of ecosystem services. Payment for ecosystem services may not provide all solutions to ecological and socio-economic challenges. In addition to legalizing the PES scheme, it is recommended that PES scheme be applied as complementary integrated instrument alongside other policy tools to strengthen natural resource management and livelihood initiatives. This will strengthen national recognition of PES schemes and contribute to its replication to restore degraded watersheds countrywide.

To strengthen recommended PES policy operational framework, there's need to enhance local technical and institutional governance such as WRUAs, government agency staff supporting PES schemes and research organizations that conduct research work on PES projects. This can be done through building their capacity to buttress conservation-livelihoods initiatives under PES scheme while considering farmers preference for PES practices. The need to institutionalize PES scheme will also commit the national government and the public to recognize PES as regulatory framework which will standardize the scheme implementation structure considering the geographical-socio-ecological and cultural variations.

Policy makers need to collaborate with other stakeholders including private sector, public, development, research and conservation institutions. Experience and lessons learned from PES schemes need to be disseminated and integrated into policy for future PES schemes design and sustainability. Payment for environmental services incentive schemes have potential to address challenges related to sustainable Natural resources management and improved livelihoods for local community smallholder farmers and therefore it is recommended to develop institutional PES framework for PES implementation on scale.

5.4.2. Sensitization and training of farmers and scale-out of PES practices

Increasing farm productivity motivates farmers to practice PES interventions. Adoption of PES practices need to be enhanced through sensitization and training of more farmers as sellers of ecosystem services thus communicating to farmers on conservation benefits. Training to build capacity especially of the local communities implementing PES projects is important for sustainability particularly those supported by conservation, development and non-governmental organizations in terms of management and implementation. Relevant multi-stakeholder's engagement needs to be strengthened in watershed management decision making in all stages of PES scheme development. Landscape wide integrated natural resource management approach to scale-out PES interventions and enrollment of more farmers in the watersheds countrywide is recommended.

It is important for PES project stakeholders to develop monitoring and evaluation system to assess PES long-term impact on farm productivity in watersheds. Engagement of multi-stakeholders from initial stage of PES project is recommended to build trust, confidence and local ownership of PES scheme. Although cash money is one of the key components in PES scheme to motivate land owners accept implementation of conservation practices to provide ecosystem services, it is recommended to assess other farmers' individual needs and preferences including payment in kind such as knowledge and skills transfer that will stimulate farmers to sustainably adopt PES practices to manage their natural resources. Lessons and experiences learned from successful Payment for ecosystem services are important for scale-up or design of similar PES schemes in other areas. Such lessons and experiences need to be documented, disseminated and integrated into natural resource management policy making decisions and knowledge exchange.

5.4.3. Need to value ecosystem services

Valuation of ecosystem services based on TEV framework needs to be enhanced. This will strengthen public private partnerships understanding of ecosystem services intrinsic economic value to reinforce conservation-livelihoods strategies. In literature, scholars have generally argued that three valuation disciplines: ecological, economic and sociocultural are associated with valuation of ecosystem services. They describe the contribution of particular ecosystem services to the maintenance and functioning of the ecosystem (ecological) and economic and sociocultural for characterization of the value of ecosystem services to humans wellbeing (Ruiz-Frau, 2018; Kennedy *et al.*, 2010). Based on this general valuation approach, Jacobs *et al.* (2016) have proposed that sustainable environmental management should be based on reliable scientific socio-economic and biophysical information coupled with integrated ecosystems services valuation approaches to assess natural values and benefits.

The WTA estimation for PES practices is recommended to determine the opportunity cost for the sellers of ecosystem services and inform the buyers on price to pay for ecosystem services demanded thus ensuring fair equitable buyer-seller business relationships. The future PES designers need to consider robust baseline studies to establish PES conservation interventions with positive impact on ecosystem restoration and farmers socio-economic expectations. Non-financial, in-kind incentives for sellers of ecosystem services are recommended in future PES designs to augment financial payments.

Global recognition of PES schemes to contribute to socio-economic-ecological outcomes requires inter-disciplinary researchers coordination with other stakeholders including local community smallholder farmers and other natural resources stewards. This will contribute to existing knowledge on linkages between economic development and environmental conservation outcomes. Payment for environmental services has been recognized globally as a tool with potential to deliver on environmental conservation and socio-economic outcomes.

This study recommends more private sector engagement and participation in PES schemes. The PES scheme could be applied by commercial private sector to market their specific nature depended products linked to ecosystems or habitats such as horticulture produce marketed as eco-products to earn premium price which other than increasing the return on investment for the private sector, part of it could be re-allocated and invested back to conservation and incentive for the ecosystem stewards.

5.4.4. Establish WTA and integration of PES with extension services

Socio-economic factors influencing farmer's WTA to implement PES practices are important consideration in designing PES schemes. It is recommended that socio-economic factors are analyzed as they influence PES practices adoption and community ownership of PES schemes for sustainability.

This study further recommends application of PES mechanism as incentive tool to conserve watersheds in rural areas where PES is applicable. This will contribute to rural community's livelihood and ecosystem resilience against disaster risks mainly related to climate change and anthropogenic factors as well as strengthen market linkages for ESs between smallholder farmers and commercial private sector. It is further recommended that PES is integrated within extension services to enhance farmer's access to knowledge, skills and information on alternative sustainable on-farm technologies. Building capacity of selected farmers from community as para-professionals in PES practices is recommended to supplement government extension services mainly in rural areas.

To enhance sustainable long-term motivation to implement PES practices, it is recommended that payment models should consider multiple benefits for instance in-situ farm benefits to complement cash payments for suitability beyond PES project period. The PES scheme should be designed to increase benefits to the poor local farmers who provide ecosystem services. Payment for Environmental Services should be designed to be sustainable in the long-run in relation to payment for opportunity cost incurred by land owners and the willingness of beneficiaries to pay for ecosystem services supplied. Payment for Ecosystem Services design can be challenging and involvement of intermediary organization with technical expertise is recommended. Other than providing initial PES project development support, the intermediary organizations could assume important role of independent neutral mediation or negotiation between sellers and buyers of ecosystem services and other stakeholders involved in PES projects.

5.5. Areas for further research

Correlation between improved agro-ecological status and ecosystem service buyers Willingness to Pay (WTP) for improved ecosystem services production in the PES study sites is imperative. This study did not assess WTP and impact of PES on change in water quality. It is recommended that these gaps are filled in future through assessment of buyers WTP for ecosystem services and hydrological studies to empirically determine water quality improvement because of PES farm practices as qualitatively observed by farmers in this study. Further research is needed to understand effect of PES farm practices on provision of different ecosystem services in other PES intervention areas for comparison and informed policy decision making in future. Finally, this study did not assess the influence of PES scheme on non PES implementing farmers or how such farmers influence the PES project under implementation. These are other interesting gaps for future studies.

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APPENDICES

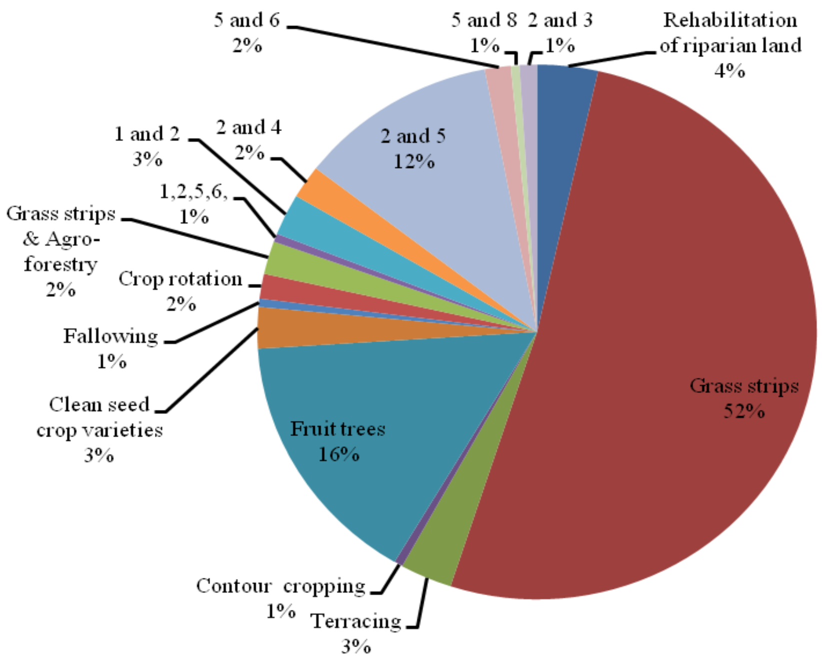
Annex 1: List of ecosystem services buyers at the time of study

Sno.	Farm Name	Address (Naivasha)
1.	De-Ruiters	209
2.	Goldsmiths seeds	928
3.	Hamer/Florensis	1896
4.	Homegrown all farms	530
5.	Hortitec	520
6.	Kenya Nut ltd (Morindat)	510
7.	Kijabe	358
8.	Lake Flowers	17
9.	Lamorna ltd	1913
10.	Longonot Farm	86
11.	Longonot Hort	1271
12.	Nini Farm	
13.	Noraflora	460
14.	Ol njorowa	879
15.	Oserian flowers	209
16.	Blooming Oasia/Florema	226
17.	Blooming Oasis/Lex	1739
18.	Plantation Plants	1909
19.	Red Fox	
20.	Savanna Plants	
21.	Shalimar	781
22.	Stokman Rozen Roses	2029
23.	Wildfire Flowers	379

**Over 72 commercial Horticulture farms were recorded around the Lake by the time of study*

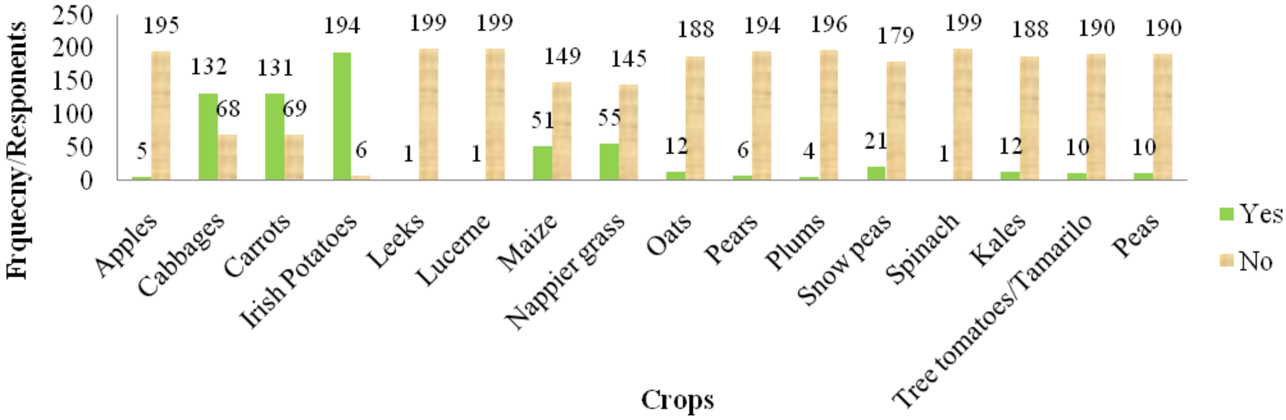
Annex 2: Population, households and cumulative number of farmers in PES intervention sites by 2013

Sno.	WRUA		Sub-county	Divisions	Locations	No. of PES farmers	No of households	Population	Villages	No. of PES farmers
1	Upper Kinja	Turasha	Nyandarua South	Central	Gathaara	345	2399	10262	Tulaga settlement	253
									Kianguyo	38
									Mutamaiyu	54
				North Kinangop	Kinja	30	2151	8514	Kinja	30
			Kinangop	Njabini	Tulaga	10	1767	7880	Tulaga(Kwa Nguruka)	10
2	Wanjohi		Kipipiri	Geta	Geta	75	1441	6215	Geta	21
									Kianjogu	54
					Kiambogo	75	975	4558	Kiambogo	75
					Mikeu	77	1152	4807	Mikeu	77
				Wanjohi	Wanjohi	173	3204	13848	Gitei	101
									Rayetta	27
									Kiamboga	45
						785	13089	56084		785
3	LANAWRUA*		Naivasha	Naivasha	Naivasha					

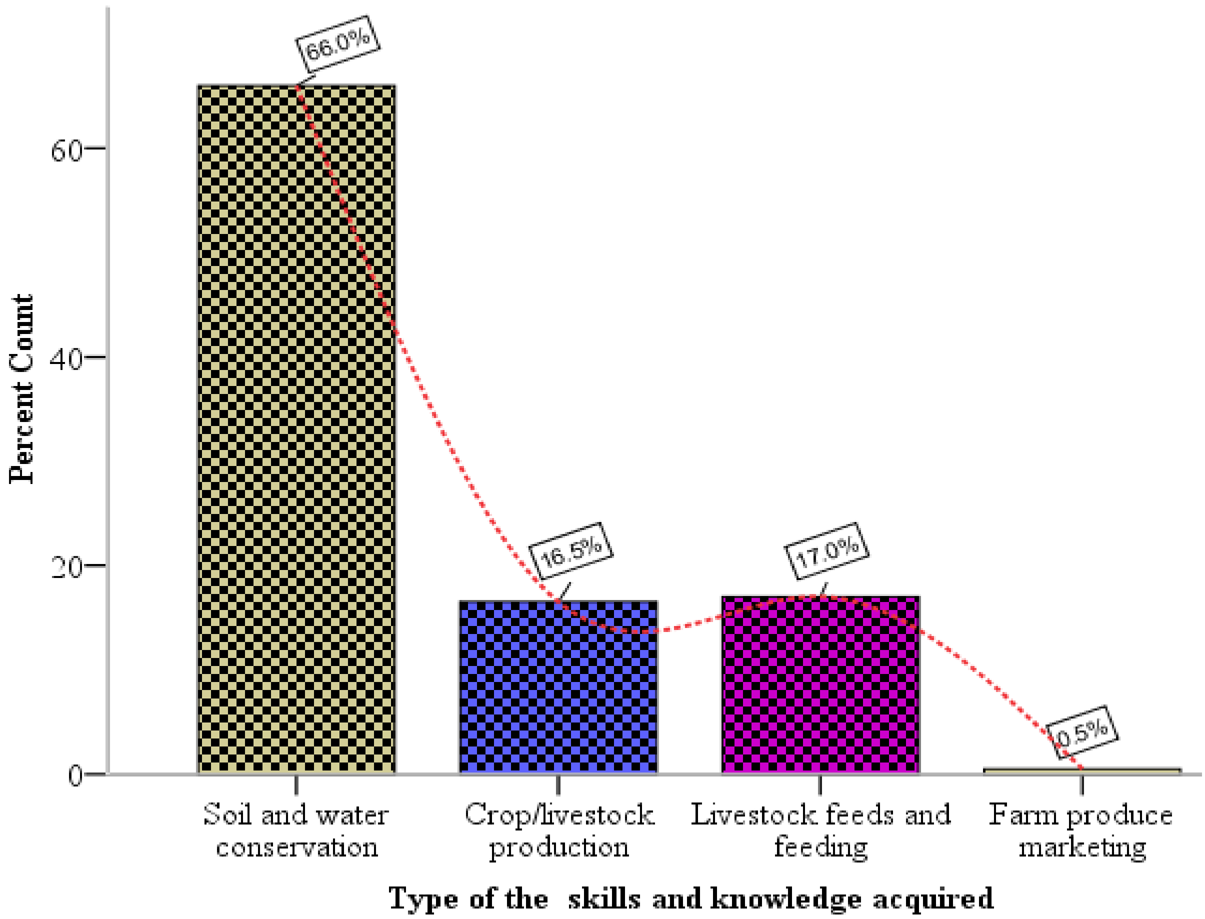


Legend: *1=Rehabilitation of riparian land; 2= Grass strips; 3=Terracing; 4= Contour cropping; 5= Fruit trees; 6= Clean seed crop varieties; 7= Fallowing; 8= Crop rotation; 9= Grass strips and Agro-forestry*

Annex 3: Preferred PES farm practices



Annex 4: Common crops and conservation plants grown in study sites



Annex 5: Type of skills and knowledge acquired through PES trainings

Annex 6: Perceived PES sustainability determinants

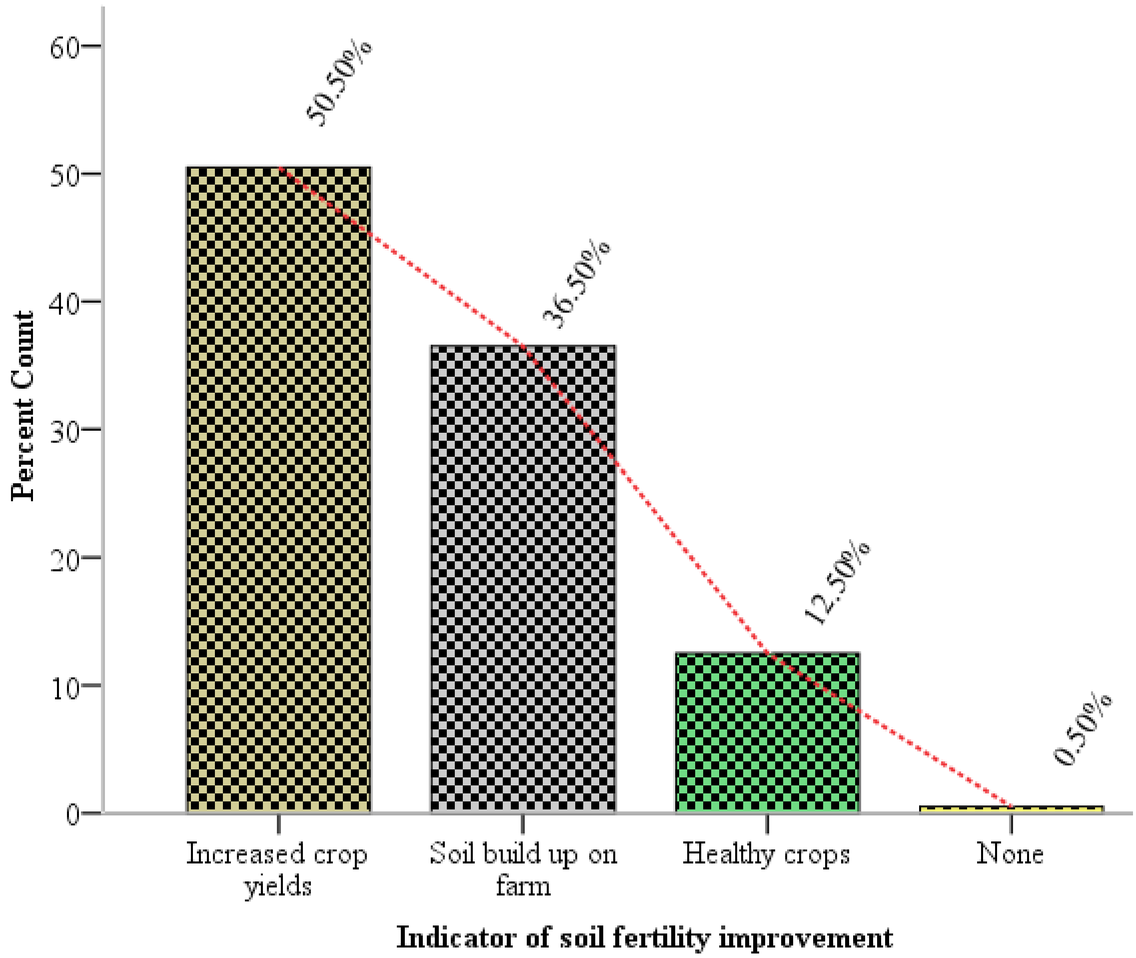
Variable Code	Variable description	Frequency	Percent
1	Incentives	32	16.0
2	WRUAs membership	15	7.5
3	Government agencies	17	8.5
4	On farm benefits	24	12.0
5	Acquired conservation skills and knowledge	85	42.5
6	Alternative income generating farm enterprises	26	13.0
7	More PES farmers	1	.5
	Total	200	100.0

Annex 7: The PES practices under implementation

Variable description	Frequency		
	No	Yes	Mean
Rehabilitation and Maintenance of Riparian Zones (0=No; 1=Yes)	122	78	0.39
Grass Strips(0=No; 1=Yes)	9	191	0.96
Terracing(0=No; 1=Yes)	170	30	0.15
Contour cropping(0=No; 1=Yes)	136	64	0.32
Agro-forestry(0=No; 1=Yes)	8	192	0.96
Clean improved seed varieties(0=No; 1=Yes)	107	93	0.47
Fallowing(0=No; 1=Yes)	179	21	0.11
Crop rotation(0=No; 1=Yes)	121	79	0.40

Annex 8: Access to Natural Resources

Variable	Statistic	
	Yes =1	No = 0
Access to Natural Resources	196	4
Access to Land	200	0
Access to water	200	0
Access to Fuel wood	200	0
Access to fiber and timber	1	199
Access to medicinal plants	200	0
Access to ornamentals	200	0
Access to social-cultural sites	200	0
N=200		

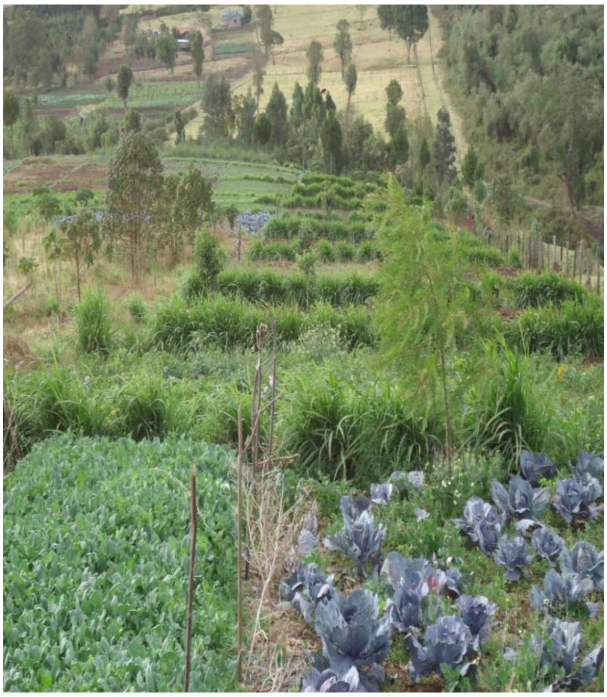


Annex 9: Perceived indicators of PES influence on soil fertility improvement

Annex 10: Poor farm practice. Slash, burn and cultivation on inclined or high gradient ground. Photo: WWF, 2008

Annex 11: Siltation of Lake Naivasha (Left) and floriculture farms around Lake Naivasha (Right). Photos: WWF, 2008.

Annex 12: Inside a greenhouse around Lake Naivasha. Photo: Nyongesa, 2012



Annex 13: Illustration of two farms under PES interventions. Grass strips along contours (Left) and combination of grass strips and Agroforestry (Right). Photos: Nyongesa, 2013.

Wanjohi WRUA (top left) and Upper Turasha Kinja WRUA (top right and bottom) officials display their dummy cheques received from buyers of ecosystem during two annual events, 2010 and 2012 respectively. Photos by Nyongesa, 2010 and 2012

Annex 14: Payment for ecosystem services events

Left and centre; Upper Turasha WRUA staff takes water sample for quality/turbidity assessment. Right: a farm in Wanjohi WRUA with installed graduated/marked staff to monitor soil retention by grass strips on contours (Photos by WWF, 2012)

Annex 15: Monitoring of selected PES parameters

Annex 16: Questionnaire-Survey Interview Schedule

Questionnaire Serial Number………………

Questionnaire for Payment for Payment for Environmental Services: Land Use Practices Influence on Livelihood- Environment Nexus and Environmental Services Value in Lake Naivasha Watershed, Kenya.

(2014)

INTRODUCTION

My name is Josephat Mukele Nyongesa and I'm part of the team from Naivasha studying issues related to Payment for Environmental Services project (PES) which joins Upper Turasha Kinja, Wanjohi WRUAs and LANAWRUA in environmental conservation and livelihood improvement. The objective of PES initiated through WWF and CARE-Kenya collaboration is to develop a viable mechanism for compensation of watershed services to sustain natural resources management and improved livelihoods of farmers in Malewa-Naivasha catchment. **The main aim of this study is to evaluate realized influence of change in Land use practices on farmer's livelihoods and environment under PES project between 2008 and 2013**. Your participation by answering our questions is very important and much appreciated. Your responses will be **COMPLETELY CONFIDENTIAL** and will be part of other 200 PES farmers participating in this survey. Research findings will help in future improvement of PES project design. If you have any questions or comments after this survey, you may contact **Nyongesa Mukele Josephat; Tel: 0722 990670; email: nyongesajm@yahoo.com**

Module 1: GENERAL INFORMATION: ENUMERATOR'S VISIT.

1.1. Enumerator's identification.

Questionnaire Number	
Date	…./…/.2014
Enumerators Names and Tel.	
Time interview starts	
Time interview ends	

1.2. Identification of Household Head (mark/tick appropriately where applicable)

Name of Household head	***Contact (Mobile)…………………***
WRUA **(W_rua)**	*1=Wanjohi; 2= Upper Turasha Kinja*
District **(D_strict)**	*1=Kipipiri; 2=Kinangop; 3= Nyandarua South 4=Other(specify)……………….*
Division **(D_vision)**	*1= Wanjohi; 2= Geta; 3=Njabini ;4= North Kinangop; 5= Central; 6=Other(specify)……………….*
Location **(L_ocation)**	*1=Wanjohi; 2=Mikeu; 3=Kiambogo; 4=Geta; 5=Tulaga; 6=Gathaara; 7=Kinja; 8=Other (specify)…………………………………………………*
Sub-location **(S_loc)**	
Village **(V_llage)**	*[ ] -code appropriately; Other specify…………………….*
Sex***(interviewer's observation)***	*1=Female; 2= Male*
PES zone**(PES_zon)**	
Age of household head	*…. Years*
Education level	0=Informal 1=Formal
Occupation	(0=Farmer; 1=Farmer/off-farm employment)

Village codes: 1=Tulaga settlement; 2=Kianguyo; 3=Mutamaiyo; 4=Kinja; 5=Tulaga(Kwa nguruka); 6=Geta; 7=Kianjogu; 8=Kiambogo; 9=Mikeu; 10=Gitei; 11=Rayetta; 12=Kiamboga

Education; No. of years in school: 0= Informal(None) 1=Formal (1-12)

PES Zones: *1=Mutamaiyu; 2=Kianguyo; 3=Mutarakwa; 4=Tulaga; 5=Geta; 6=Gitei-Gatondo; 7=Kiamboga; 8=Mikeu; 9=Rayeta*

Employed: Refers to formal employment

Module 2: Household/Farm Characteristics.

2.1. What are your main goals of farming (**Mf_goals**)(select first response from the list below)
1=Food security; 2=Earn income; 3=both food security and income; 4=Social status (prestige; 5=As a hobby; 6-Other (specify)…………………………………………………………………………….

2.1a. Do you own this land? **(L_own)** ***1=Yes, 0=No***

2.1.b. Do you own land title deed for your farm? ***1=Yes, 0=No***

2.2. How many years have you settled on this farm **(S_dland)**? Mark appropriately:
1= <5years; 2=5-10years; 3=11-20 years; 4= >20 years; 5=don't know

2.3. Land Tenure: How did you acquire your land? **(L_tenu)**
1=Inherited; 2=bought; 3=Leased; 4=Issued by government; 5=Care taker

2.4. What is the size of your land **(FM_size)?** ***1= <1 acre; 2= 1-2.5 acres; 3= 2.6-5acres; 4= 5.5-10acres; 5= >10 acres; 6= don't know***

2.5. How many family members live in this household **(HHF_size)**?..

2.6. QUALITY OF HOUSING **(qh_lty)** *(enumerator's own observation)*

2.7. Floor **(f_lor);** ***1=Earthen….; 2=Cement….., 3=Wood….; 4=Other (specify)…….***

2.8. Roof **(r_oof)** ***; 1=Iron sheet… 2=Tiled….; 3=Grass Thatch….; 4=Other (specify)……***

2.8a. Wall**(w_al);** ***1=Mud….; 2=Wood….; 3=Stones/bricks….; 4=Other (specify)…..***

2.8b. What is your source of Water**? (ms_water)**
1=Tapped water; 2=Borehole/well; 3=Roof harvesting; 4=River; 5=Other(specify)

2.8c. What is the main source of energy? **(ms_energy)**
1=Electricity; 2=Firewood; 3=Gas; 4=Fuel; 5=other (specify)

2.8d. What type of sanitation do you have?**(t_san)**
1=Private toilet "flush"; 2= Public toilets/Latrine; 3=none; 4=other (specify)…..

2.9. HOUSEHOLD USE OF NATURAL RESOURCES

2.9a. Do you have access to Natural resources? **(Acc_NRS)** ***0=No, 1=Yes***
If No skip to 3.1
2.9b. If Yes, which ones **?**
1=Land (0=No, 1=Yes), 2=Water (0=No, 1=Yes), 3=Fuel wood(1=0, Yes=No), 4=Fiber and Timber (0=No, 1=Yes), 5=Medicinal plants(0=No, 1=Yes), 6=Ornamentals (0=No, 1=Yes), 7=Social-cultural sites (0=No, 1=Yes)

MODULE 3: HOUSEHOLD HEAD SOCIAL CAPITAL

3.1. Other than WRUA, do you belong to other community group? **(CBO_MBER*) (0=No, 1=Yes)*** If yes, which group**?**

Code	**Organization** (Org-type)	***Position in the group(1=Member; 2=Official)***
1.	Producers group	
2.	Agriculture Cooperative	
3.	Livestock Cooperative	
4.	Micro-credit users	
5.	Religious organization	
6.	NGO	
7.	Self help group	
8.	others (specify)	

3.2. How do you benefit from the group?**(ben_ftg)**
1=information/experience sharing; 2=source of credit; 3=skills and knowledge; 4=other (specify)

3.3 Have you acquired any new skills/knowledge under PES project?**(aski_pes)** ***0=No, 1=Yes***
If Yes which one **(typ_aqskk);** ***1=soil and water conservation; 2=crop/livestock production; 3=livestock feeds and feeding; 4=farm produce marketing; 6=other (specify)***

3.4. How important is the acquired skills/knowledge to you? **(AQ_SKI)**
0=Not important, 1=Important; 2=very important

MODULE 4: LAND USE AND LAND DEGRADATION

4.1. How have you been using your land since you first settled on this farm?**(ld_use)**
1=farming; 2=Livestock keeping; 3=farming and livestock; 4=Leasing; 5=quarry; 6=other (specify)……………………………………………………….

4.2. From the time you settled on this farm, which main challenge have you faced related to your land use? **(L_useclange)**
1=Low yields; 2=pests and diseases..; 3=soil erosion..; 4=decreasing land size;5=pollution of water sources; 6=floods; 7=water logging; 8=other (specify)………………………………

4.3. Do you receive government agricultural extension service **(HH_EXT**)? ***0=No, 1=Yes***

4.4. If yes, which main information/service do you get?**(inf_typ)** ***1=agriculture; 2=livestock production; 3=produce markets; 4=group formation/leadership; 5=soil and water conservation; 6=other (specify)……………………………………………………………………….***

4.5. How would you rate the extension service you receive?**(ex_infor)**
1=Not important; 2=less important; 3=important; 4=very important

MODULE 5: PAYMENT FOR ENVIRONMENTAL SERVICES

5. Do you have choice for particular PES technology **(PES_pracchoice)?** ***0=No, 1=Yes***

5.1. If ***yes*** which conservation technologies are you practicing on your farm**(Pestech_pract)?**

Conservation Practices	Mark ***0=No, 1=Yes***	Please choose the best practices you prefer (rank 1=good; 2=better; 3=best technologies under practice) **p-pref**	What are reasons for choosing your preferred practice (**r_pref**)? (Code not more than 2)
1=rehabilitation & maintenance of riparian zones*(Rehab_mrianz)*			
2=grass strips* (*Gras_strips)*			
3=terracing along steep slopes *(Terr_assing)*			
4=Contour cropping*(Contor_cropng)*			
5=Agro-forestry) *(Agro_forestry)*			

6=clean improved seed crop varieties *(Clin_impseed)*			
7=fallowing *(Fall_owing)*			
8=crop rotation *(Crop_rot)*			

Note*combination of different grass species also used as fodder; Nappier *(Pennisetum purpureum),* Elmba Rhodes grass *(Chloris gayana)*, Cock's foot *(Dactylis glomerata),* Lucerne *(Medicago sativa),* desmodium *(Desmodium spp mainly triflorum)*

Agro forestry: all tree species planted (including fruit trees and common indigenous trees)

Coded reason for choice; *1=Easy to implement/practice-Ease_choice* ***(0=No, 1=Yes)****; 2=less expensive-*/cost effective-*costeff_choice)* ***(0=No, 1=Yes)****; 3=source of income-Income_choicee****(0=No, 1=Yes)****; 4=retain soil-Retainsoil_choice* ***(0=No, 1=Yes)****; 5=source of food security/nutrition-Foodsec_choice* ***(0=No, 1=Yes)****; 6=fodder for livestock-FodderL_choice****(0=No, 1=Yes)****; 7=reduce environmental pollution-Polution_choice* ***(0=No, 1=Yes)****; 8=source of timber-****(0=No, 1=Yes)****; 9=source of firewood-Fwood_choice* ***(0=No, 1=Yes)****; 10=reduce flooding-Floodr_choice* ***(0=No, 1=Yes)****; 11.manage frost-Frostmgt_choice* ***(0=No, 1=Yes)****; 12=prevent pests and diseases-Pestdses_choice* ***(0=No, 1=Yes)****; 13=wind break(****-0=No, 1=Yes)****; 14=improve soil fertilitySoilfert_choice* ***(0=No, 1=Yes)****;15=Soil and water conservation-Soilconsv_choice* ***(0=No, 1=Yes)***

5.2. PES CONSERVATION PRACTICES IMPACT ON SOIL FERTILITY

5.2a. Do you think PES has impact on soil fertility **(pes_impsfert**)? ***0=No, 1=Yes***
If no skip to **5.5d**

5.2b. If yes, how would you perceive/rate the impact? (**PPES_IMPSFERT**) ***1=reduced; 2=improved***

5.2c. What would you say is the indicator of soil fertility improvement (**Ind_fert**)?
1=High crop yields; 2=Soil build up on farm; 3=Healthy crops; 4=don't know;
5=other (specify)……………………………………………………………………………………………..

***5.2.*d.** Has PES conservation activities had any impact on water quality in rivers (**pes_impwqty**)?
0=No, 1=Yes

5.2e. If yes, how would you rate the impact? **(r_impwqty)** ***1=low; 2=moderate; 3=high; 4=very high***

5.3. Productivity. Do you think PES land use practices have impact on farm yields/productivity **(PESIMP_PROD)**? ***0=No, 1=Yes.*** If yes how would rate it? (**Rimp_prod**)
1=reduced; 2=increased

5.4. Which **MAIN** crops **(M_crops)** have you been growing from the time you settled on this farm up to 2012? **TICK main crops using codes as per the table below**; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20=Other (specify)…………………………………………………………………….

5.4.a Please estimate the main crops grown below

Code	**Crop**	**Tick**
1.	Apple	
2.	Cabbage	
3.	Carrots	
4.	Cauliflower	
5.	Coriander/Dhania	
6.	Flowers	
7.	Irish Potatoes	
8.	Leeks	
9.	Lucerne	
10.	Maize,	
11.	Nappier Grass	
12.	Oats	
13.	Pears	
14.	Plums	
15.	Snow Peas	
16.	Spinach	
17.	Stinging Nettle	
18.	Sukuma Wiki/Kales	
19.	Tree Tomato (Tamarilo)	
Other		

5.5. Do you keep livestock?(**k_lvsk**) ***0=No, 1=Yes***

5.6. If yes, which ones? (tick main ones) **(M_lv)*; 1=Cattle, 2=Chicken 3=Donkeys; 4=Sheep, 5=Goats, 6=Bees, 7=Horses, 8=Geese, 9=Ducks, 10=Guinea fowls, 11=Pigs; 12=Other specify)………………***

5.7. For what reason do you keep livestock?(**re_lvestock**):
1=Incomes; 2=saving/capitalization; 3=animal traction 4.manure 5=Food; 6=Other (specify)…………

5.7.a. Have you increased the number of livestock on your farm between **2008** and **2013**? (**in_lvstck**) ***0=No, 1=Yes***
If yes, please give reasons for increasing stock **(r_instck)**
1=availability of fodder; 2=increased income; 3=provide manure; 4=increase milk; 5= prestige; 6=other (specify)…………………………………………………………………..

5.7b. If, No why have you reduced on maintained the number of stock you have? (***M_stock) 1=Efficient management, 2=Lack of farm space, 3=Improve production; 4=Increased fodder; 5=Other (specify)***

5.7c. Do you think PES has had any changes on price of common farm produce in this community? (**PES_IMPPICE)** ***0=No, 1=Yes***

5.7d. If yes, how would you describe the price impact on farm produce **(PES_impprice)**? ***1=reduced; 2=Increased***

5.7e. Are markets available for increased farm produce? (**A_MRKTS**) ***0=No, 1=Yes***

5.8. Do you think PES project has had effect on local human labour? **(PES_IMPLHL)**
0=No, 1=Yes, **2=don't know**
If yes how would you describe the effect (**Per_PESimpLHL**)? ***1=none; 2=reduced; 3=increased***

5.9a. In the year 2008 **without/before** PES **(GMI_BPES**), what was your average monthly income earned from sale of all farm produce (crops and livestock) and off farm activities ***(tick appropriately and fill in actual figures in spaces provided)***

(a).Income from sales of farm produce (ksh)	**(b). Off-farm source of income (ksh).**
0- 500 …………………..	0- 500 …………………………….
501-1,000…………………	501-1,000…………………………..
1,001-1,500…………………	1,001-1,500…………………………..
1,501-2,500…………………	1.501-2,500…………………………...
2,501-3,000…………………	2,501-10,000………………………….
Over-3,000…………………	Over-10, 000…………………………

Total income ((a +b) –Ksh. ………………

5.9b. In the year 2013 **with/after** PES **(GMI_APES)**what was your average monthly income earned from sale of all farm produce (crops and livestock) and off farm activities***(tick appropriately and fill in actual figures in spaces provided)***

(a).Income from sales of farm produce (ksh)	**(b). Off-farm source of income (ksh).**
0- 500 …………………..	0- 500 …………………………….
501-1,000…………………	501-1,000…………………………..
1,001-1,500…………………	1,001-1,500…………………………..
1,501-2,500…………………	1.501-2,500…………………………...
2,501-3,000…………………	2,501-10,000………………………….
Over-3,000…………………	Over-10, 000…………………………

Total income (a +b) –Ksh. ………………

5.9. c. What was your average gross monthly expenditure in the year 2008 (**G_MEXPE**) in KES?
1=500-2,500; 2=2,501-7,500; 3=7,501-10,500; 4=>10,000; 5=don't know

***5.9.* d.** What was your average gross monthly expenditure in the year 2012 (**G_MEXP**) in KES
1=500-2,500; 2=2,501-7,500; 3=7,501-10,500; 4=>20,000; 5=don't know

5.9. c. Has PES project improved your livelihoods? (**PES_impvhood**) ***0=No, 1=Yes***

5.9. d. If yes how would describe the improvement? **(PES_perlivhood)**
1=Low; 2=moderate; 3=High; 4=very high;

5.9. e. On what has PES had MAIN impact on livelihood? **(QLOOD_IMPACT)**
1=Increased income; 2=Food secure; 3=Community cohesion; 4=Acquired skills and knowledge; 5=Access to health facilities; 6=Education for children; 7=Other(qualify)…………………………….

5.9.f. Have you experienced any problems/challenges implementing PES practices?**(C_PESIMPL)** ***0=No, 1=Yes***
If Yes which one has been the MAIN challange in PES implementation? **(MPES_chall)**
1=time consuming; 2=lack of income; 3=labour demanding; 4=land subdivision; 5=lack skills and knowledge; 5=Lab our intensive, 6=Pests and diseases; 7=other (specify)…………………………

5.9a. Is your spouse (wife or husband- note respondent being interviewed) involved in PES activities?**(Sp_invPES)** ***0=No, 1=Yes***

5.9b. Do you think women can be involved in PES activities **(Wmen_PES)**? ***0=No, 1=Yes***

5.9c. Are you familiar with climate change issues **(F_cc)?** ***0=No, 1=Yes***

If Yes, what is the main climate manifestation in this area **(M_ccma)?** ***1=Floods; 2=Frost; 3=Increased temperature; 4=Increased pests and disease incidences; 5=Unpredicted rainfall/seasons; 6=Other (specify)...***

5.9d. Do you think PES activities can reduce impact of climate change?**(PES_impcc)** ***0=No, 1=Yes***

If Yes, which is the main farm practices under PES that can mitigate climate change **(MFPPES_MCC)**?
1=rehabilitation & maintenance of riparian zones;2=grass strips; 3=terracing along steep slopes; 4=Contour cropping; 5=Fruit trees; 6=clean improved seed crop varieties;7=fallowing; 8=crop rotation; 9=other specify)………………………………………………………………………………

6. MODULE 6: WILLINGNESS TO ACCEPT PAY (WTA)

6.1. As a member of WRUA you receive USD 17 (about KES.1,300 flat rate) /year for conservation practices on your farm. Are you still willing to accept this incentive in future? **(WTA_cpay)** ***0=No, 1=Yes***

6.2. If Yes why **(Rson_WTA)**?
*1=it is enough (**0=No, 1=Yes)**; 2= i get more money from farm produce/practices(**0=No, 1=Yes)**; 3=WRUA will negotiate new incentive(**0=No, 1=Yes)**; 4= I still utilize my land(**0=No, 1=Yes)**; 5= Poverty reduction(**0=No, 1=Yes)**; 6=Reduce farm cost(**0=No, 1=Yes)**; 7=Related practices conserve soil **(0=No, 1=Yes)**, **8**=other (specify)……*

6.3. If No, how much (KES/year) would you suggest to be incentivized to implement current PES land use practices in future? (**EWTACONSERV)** can indicate exact figure if given; KES…………….
1=0; 2=5,000-10,000; 3=10,001-15,000; 4=15,001-20,000; 5=20,001-40,000; 6=>40,001

6.3. Are you willing to forego 1 acre for conservation only? **(WTA)** ***0=No, 1=Yes***
6.3b. What is WTA estimates for the following PES practices in KES?; WTA to conserve 1 acre-*WTA_Conserve*; WTA for rehabilitation and Maintenance of Riparian Zones-*WTA_RehabR;* WTA for Grass Strips-*WTA_grasstrip;* WTA for terracing-*WTA_terracing;* WTA contour cropping-*WTA_contcrop;* WTA for Agro-forestry-*WTA_Agrofores;* WTA for Clean improved seed varieties-*WTA_cleansidV;*
6.4. Assuming you were to completely forego (leave) your 1 acre land for conservation, how much will you be willing to accept as incentive from LANAWRUA/LNGG per year (KES)?-**WTA_CCONSRVE**
1=0; 2=5,000-10,000; 3=10,001-15,000; 4=15,001-20,000; 5=20,001-40,000; 6=>40,001

6.4a. Are there reasons which influence you to implement PES **(Inf_practPES)? 0=No, 1=Yes**

6.4b. What influence you to continue implementing PES conservation practices (**fac_inPES**)?
Source of income ***1=Yes, 2=No***; incentive from LANAWRUA/LNGG ***1=Yes, 2=No***; Food security ***1=Yes, 2=No***; Land size ***1=Yes, 2=No***; family size ***1=Yes, 2=No***; education ***1=Yes, 2=No***; acquired skills and knowledge ***1=Yes, 2=No***; age ***1=Yes, 2=No***; impact on soil fertility ***1=Yes, 2=No***; impact on productivity ***1=Yes, 2=No***; Interest to conserve environment ***1=Yes, 2=No***; Poverty ***1=Yes, 2=No*** Other (specify)…………………..

6.5. If WWF Kenya-CARE Kenya were to stop distributing PES conservation materials to you, would you be able to provide yourself**?(SP_convm)** ***0=No, 1=Yes***
6.6. If No, why **(R_notpur)**? ***1=Expensive; 2=Materials not available; 3=Lack income; 4=other (specify)…***

6.7. Would you agree or disagree to the following statement regarding your farm?

Statement	Response ***0=No, 1=Yes***
Soil erosion has been a major farm problem (**so_ero**)	
Soil infertility has reduced productivity(**so_infert**)	
Conservation practices can improve water quality & land fertility (**C_wqltyLfert**)	
You can continue doing/implementing conservation practices even without incentives (**co_wincent**)	

6.8. If there was no PES project, how much on average would you spend on the following activities to restore your 1 acre farm original productivity condition?***(only fill in cost against activity applicable to the farmer)***

Activity	**KES.**
1=Control soil erosion **(Exp_CSEROSN)**	
2=Improve soil fertility **(Exp_isoilfert)**	
3=Control flooding **(Exp_cflood)**	
4=Control crop/livestock pests and diseases **(Exp_cPDs)**	
5=Rehabilitate riparian land (**Exp_RRL)**	

6.9. Which is your preferred method to pay/incentivize farmers? (PES-ICENTV**)** ***1=cash; 2=In-kind; 3=Voucher; 4=both cash and in-kind***

6.9a: What is the main reason for your preferred choice***?(R_choice)1=Enables buy farm inputs; 2=Transparent; 3=Gender friendly; 4=Easy; 5=Avoids funds misuse;***

6.9b. Are you willing to continue implementing PES conservation practices? **(WC_PES)** ***0=No, 1=Yes***

6.9c. Do you think PES incentive you receive from LANAWRUA/LNGG is important?**(PES_INCENT*)*** ***0=No, 1=Yes***

6.9d. What is your commend on affordability of conservation material (cost)? **(CM_COST)** ***1=None; 2=Affordable; 3=High***

6.9e. How important are government Natural Resources Agents to PES? **(Gov_NRPES)** ***0=Not important; 1=important; 3=Very important***

6.9g. Do you think PES will be sustainable in future? (**PES_SUST*) 0=No, 1=Yes***

6.9h. What do you think can sustain PES project?**(WOT_SUSTPES)** ***1=Incentives; 2=WRUAs; 3=Government agencies; 4=On farm benefits; 5=Acquired conservation skills and knowledge; 6=Alternative income generating farm enterprises; 7=More PES farmers; 8=Other (specify)……………***
6.9i. Are willing to continue with PES without incentive from LANAWRUA/LNGG (W_CPESWINCENT) ***0=No, 1=Yes***
SURVEY FOLLOW-UP

6.9J. Would you allow the investigator to come for follow-up and verification of information you have given after this interview? ***0=No, 1=Yes***
Thank you for participating in this survey and more so for your time and contribution to conservation efforts through PES project implementation.

Annex 17: List of candidate's publications

Nyongesa, J, M., Bett, H.K., Lagat, J.K, Ayuya., O.I. (2016). Estimating farmers' stated willingness to accept pay for ecosystem services: case of Lake Naivasha watershed Payment for Ecosystem Services scheme-Kenya. *Springer Ecological Process Journal*, https://link.springer.com/article/10.1186/s13717-016-0059-z DOI 10.1186/s13717-016-0059-z

Nyongesa, J.M (2017). Determining farmer's preferences for land use practices under payment for environmental services in Lake Naivasha basin-Kenya. *African Journal of Rural Development*, ISSN 2415-2838, July-September 2017, 2 (3):389-402. http://www.afjrd.org/jos/index.php/afjrd/article/view/195

Nyongesa, J.M., & Beria, L. (2017). From payment to co-investment for ecosystem services: Stewardship and livelihood improvement in the Lake Naivasha agro-production landscape, Kenya. UNU-IAS and IGES (eds.) 2017, Sustainable livelihoods in socio-ecological production landscapes and seascapes (Satoyama Initiative Thematic Review vol. 3), United Nations University Institute for the Advanced Study of Sustainability, Tokyo. http://www.unuias-isi.org/activities/research/ipsi-pubication-series/, 3:124:137. http://collections.unu.edu/eserv/UNU:6444/SITR_vol3.pdf.

Sang J., Mwanyoka I., Nyongesa, J.M, Lopa, D, & Mwangi, J. (2017). Case studies of water-related PES schemes in East Africa. Namirembe S, Leimona B, van Noordwijk M, Minang P, eds. Co-investment in ecosystem services: global lessons from payment and incentive schemes. Nairobi: World Agroforestry Centre (ICRAF). http://www.worldagroforestry.org/sd/environmental-services/PES/chapter6-9 http://www.worldagroforestry.org/sites/default/files/Ch8%20Case%20studies%20of%20Water_ebook-Done.pdf.