EVALUATING PAYMENT POTENTIAL FORENVIRONMENTALSERVICES AND WATERSHED CONSERVATION OF THIKA DAM, MURANG'A COUNTY, KENYA

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DECLARATION

This thesis is my original work and has not been presented in any other university or for any other award. No part of this thesis may be reproduced without prior permission of the author or Kenyatta University.

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DEDICATION

To my wife Beatrice, children; Edna, Ephraim and Sidney for prayers, encouragement and support during the study.

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ACRONYMS AND ABBREVIATIONS

ADB	Africa Development Bank
ARIMA	Auto Regressive Integrated Moving Average
CBO	Community Based organization
CDF	ConstituencyDevelopment Fund
CES	Compensation for Environnemental Services.
CFA	Community Forest Association
CIA	Conservation Incentive Agreement
CMPs	Catchment Management Plans
DENR	Department of Environment and Natural Resources
DN	Digital Numbers
DRSRS	Department of Resource Surveys and Remote Sensing
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act
ES	Environmental Services
ETM+	Enhanced Thematic Mapper plus
FAO	Food Agriculture Organization
FCC	Forest Cover Change
FGD	Focus Group Discussions
GBM	Green Belt Movement
GIS	Geographical Information Services
GLCF	Global Land Cover Facility
HEP	Hydro Electric Power
IIRR	International Institute for Rural Reconstruction

KEBS	Kenya Bureau of Standards
KEFRI	Kenya Forestry Research Institute
KENGEN	Kenya Electricity Generation
KFS	Kenya Forest Service
KFWG	Kenya Forest Working Group
KNBS	Kenya National Bureau of Statistics
KTDA	Kenya Tea Development Agency
KWS	Kenya Wildlife Service
KWTA	Kenya Water Towers Agency
LANAWRUA	LakeNaivasha Water Resource Users Association
MDG	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
MSS	Multi-spectral Scanner
NCCRS	National Climate Change Response Strategy
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organization
NLC	National Land Commission
NWSC	Nairobi Water and Sewerage Company
NDEKA	NdakainiEnvironnemental Conservation Association
PES	Payment for Environmental Services
PRESA	Pro Poor Reward for Ecosystem Service in Africa
PWS	Payment for Water Services
PWS	Payment for Water Services
REDD+	Reducing Emission from Deforestation and Forest Degradation plus
RUPES	Rewarding Upland Poor for Environmental Services

THIWASCO	Thika Water and Sewerage Company
TM	Thematic Mapper
TNC	The Nature Conservancy
UN	United Nations
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WCA	Water Catchment Area
WHO	World Health Organization
WRA	Water Resource Authority
WRUA	Water Resource Users Association
WSRB	Water Service Regulatory Board
WSTF	Water Services Trust Fund
WTA	Willingness-To-Accept
WTC	Willingness-To-Compensate
WTP	Willingness-To- Pay
WWF	World Wide Fund

ABSTRACT

Payment for Environmental Services is a concept that is increasingly being adopted as anincentive-basedapproach in natural resource management. It links the suppliers and consumers of environmental goods and services in a way that both parties can contribute to improved delivery. The main environmental goods and services traded are carbon, biodiversity, aesthetics and water. The predominant attitude towards watershed management in many parts of the world is that water will always flow from the catchment for free and there is therefore no urgency or incentive to institute sustainable use of land and water resources. As a result, farmers lack inadequate knowledge, incentives and recognition of their role in provision of water to the rivers. Nairobi City has been experiencing serious water shortages in the past years resulting in water rationing. Thikadam supplies 80% of water to Nairobi city but few of the users of water are able to link availability of clean water in their pipes to conservation of water catchments areas. The objective of the study was to find out how land owners and users of water from Thika dam can participate in watershed protection scheme through Payment for Environmental Services. Specifically, the study identified land use changes in the catchment area for the last 30 years and its effects on water quality and quantity;factors that could influence willingness of water users to pay for the environment services; environmental services the farmers are willing to adopt; economic incentives the buyers were willing to give to farmers in return for their conservation efforts and policies and institutional framework that are necessary for PES. Primary and secondary data were collected based on baseline survey and qualitative research approaches, interview schedules, questionnaires, focus group discussions and analysis of satellite imagery followed by ground truthing. Both parametric and non-parametric methods of data analysis were used. Results showed that land use practiceshave changed over time with tea coverage increasing by 11% at the expense of woodlots. Chemicals used in water treatment hasincreased with increasing rainfall. Farmers are also willing to accept improved farming practices in return to incentives though their expected incentives were far above what the users are willing to give. Incentives in kind were most preferred (50%) followed by community projects (33%) and cash incentive (17%). Consumers preferred giving community projects (48%), support in kind (38%) and cash incentives (15%). There was a significant relationship between consumers source of water and willingness to pay. Consumers who are connected with water from the Ndaka-ini catchment area werewilling to give more. However, there was no framework in which consumers willing to pay could use to provide incentives to the providers of environment services. Further results showed a gap in institutional framework for PES and lack of supporting legal institutions. The findings of this study can lead to better management and conservation of catchments areas leading to improved water quantity and quality of Thika dam. The findings of the study can be used by the government to develop a payment of environment service model for Thika dam and other water catchments areas in the country.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Forests worldwide form vital catchments for rivers that provide water for irrigation, domestic, industrial and power generation thus contributing to growth of the world economies. The Millennium Development Goals (MDGs) had set the agenda for global world growth up to year 2015 (MDG, 2008). Goal number seven aimed at ensuring environmental sustainability with the set targets of integrating principles of sustainable development into country's policies and programme, reversing the loss of the environmental resource, reducing biodiversity loss, and reducing by halfthe proportion of the population without sustainable access to safe drinking water and basic sanitation by 2015. The MDG (2008) report noted that 1.2 billion people in the world lived under conditions of physical water scarcity whose symptoms include, environmental degradation and competition for water. Though access to improved drinking water has expanded, nearly one billion people do without it and its use has grown at more than twice the rate of the population for the past century. The NCCRS (2010), noted that failure to recognize the economic value of water has led to its unsustainable use and degradation of its natural base in many regions of the world.

The MDGs were replaced with Sustainable Development Goals (SDG) that will guide world development up to 2050. Goal number six aims at ensuring water and sanitation for all(Universal Sustainable Goals, 2015). It recognizes that clean and accessible water for all is an essential part of the world we live in and though there is sufficient fresh water on the planet to achieve this, bad economics or poor infrastructure

lead to death of millions of people every year most of them children from diseases associated with inadequate water supply, sanitation and hygiene (Universal Sustainable Goals, 2015). The SDG aims at achieving universal and equitable access to safe and affordable drinking water for all;provide access to adequate and equitable sanitation and hygiene, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials. In addition, it aims to half the proportion of untreated wastewater, substantially increase recycling and safe reuse of water globally, substantially increase water-use efficiency across all sectors, ensure sustainable withdrawals and supply of freshwater to address water scarcity, substantially reduce the number of people suffering from water scarcity by 2030 and protect and refurbish water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes by 2020 (UN SDG, 2015).

Millennium development and sustainable development goals in Kenya were operationalized through government blue print contained in Vision 2030, which set a road map for the country's development. It aims at making Kenya a newly industrialized middle-income country with high quality of life for all citizens by 2030 (Vision 2030, 2007). Conservation of water catchments and development of water resources is covered under the Water Act(2016) and the ForestsConservation and Management Act(2016). The Water Actprovides a framework for development of water sector in the country with clear institutions for water providers, users and regulators. The Forests Act, providea framework forinvolvement of the communities next to a forest resource in conservation and management while addressing the society needs.

The main sources of water in Kenya are the commonly referred tofive water towers namely; the Aberdares, Mt. Kenya, Mau, Cherangani and Mt. Elgon. In 2012, the water towers were increased from 5 to 18 based on the need to capture other key water towers that supply water in the country(Kenya Water Towers Agency order, 2012).According to Kenya Water Master Plan (2013), the main challenges facing conservation and protection of water catchment areas include:weak institutional relations and collaborations, conflicting institutional mandates,lack of clear funding mechanisms for Water Catchment Areas (WCA), inadequate flow of information on WCAs, lack of integrated WCA monitoring and evaluation systems, low levels of awareness and capacity of stakeholders, land degradation (and soil erosion) in WCA, poor management of water resources and waste, water insecurity, livelihood insecurity, over-dependence on biomass energy and limited involvement of women and youth in WCA activities.

The major threats to water towers are degradation, change in land use and unsustainable management practices (KFWG & DRSRS, 2009). Degradation has resulted in reduced water supply making Kenya to be classified as water scarce country, with water endowment at $647m^3$ per capita, which is far below the global UN benchmark of 1000 m^3 per capital (MEMR (2012). By year 2012, the water supply in Nairobi was 580,000 m^3 per day against a demand of 750,000 m^3/day and this demand was projected to increase to 860,000 m^3/day by 2017 and 1.2million m^3/day by 2035, requiring large and sustained investments in expanding water supply to meet the growing water needs (Nairobi Water Master plan, 2012). Many dams and water-pans were dug to supply water for farming, domestic and industrial use at independence.

Over time, these have become degraded, silted and even inhabited. Rapid population growth has exerted immense pressure on the quality and quantity of water(Ministry of Environment and Mineral Resources, 2012). Provision of adequate water to Nairobi residents calls for concerted efforts to increase the water sources by maintaining existing sources while opening new ones.

To ensure sustainable conservation of water catchments areas, it is important to link the providers of environmental goods and services with the users. This link is provided by Payment for Ecosystem Services (PES). Payments for Environmental Services is the practices of offering incentives to communities, farmers or landowners in exchange for managing their land and resources in a way that contribute to improved provision of environmental services(MEMR, 2012). The programs are voluntary and mutually beneficial contracts between consumers of environmental services and the suppliers of these services. The party supplying the environmental services holds the property rights over an environmental good that provides a flow of benefits to the demanding party in return for compensation. The beneficiaries of the Environmental Services (ES) are willing to pay a price that is lower than their welfare gain due to the services. The providers of the ES are willing to accept a payment that is greater than the cost of providing the services. An important component of PES scheme is that the targeted service is threatened and in short supply thus making them subject of trade. Payment of Ecosystem Services is a direct and efficient way to promote conservation of biodiversity by bridging the interest of the local people and external actors (Wunder, 2006).The PES concept has gained importance as incentive in environmental conservation.

The National Forest Program (2017), identified opportunity to apply PES schemes to protect and conserve forest ecosystems noting that government institutions have responsibility to promote PES and support partnerships as well as ensure enabling legal framework is in place (Ministry of Environment and Natural Resources, 2016).

1.2 Problem Statement

Water supply and sanitation in Kenya is characterized by low levels of access, in urban slums and rural areas, as well as poor service quality in the form of intermittent water supply. Only 9 out of 55 water service providers in Kenya provide continuous water supply. Seasonal and regional water scarcity exacerbates the difficulty to improve water supply (National Water Conference, 2012). Nairobi City residents have witnessed serious water shortage in recent years due to reduced inflow mainly occasioned by degradation of the catchments areas and the dry spell. In the year 2009, Thika dam(commonly referred to as Ndaka-ini dam) which supplies 80% of water to Nairobi City reached its lowest water level since its construction, a level of 28 million cubic metres compared to its filled capacity of 70 million cubic metres(Nairobi Water & Sewerage Company, 2010). Conserving natural forests in the Aberdares watersheds and reducing pollutant loads in the runoff from the farms in the catchment areas, can be cost- effective-method of providing reliable supplies of clean water. Water provision in cities depends on reservoirs having adequate water throughout the year that is in turn affected by weather pattern and conservation efforts in the dam catchment area. Unfortunately, many water consumers are not able to link the conservation efforts and land use changes, with water quality and quantity they consume in their houses. The

predominant attitude toward watershed management is that water will always flow from the catchments for free and so there is no urgency or the incentive to institute sustainable land and water use. As a result, farmers lack knowledge, incentives and recognition of their role in the provision of water to the rivers(National Water Conference, 2012).The purpose of this study was to provide the vital link, where the producers of environmental services would link with consumers with an aim of producing regular and clean water services for the fast growing population of Nairobi City and its environs. The study provides guidelines on how PES can be pooled together and used to improve the conservation of water catchments areas of the dam as well as rewarding the farmers for adopting environmentally friendly farming practices.

1.3 Objectives

The main objective of this study was to evaluate how PES could be applied in Thika dam catchment to enhance supply. Specifically, the study tried to:

i. Identify land use and socio-economic changes in Thika dam watershed for the last 30 years (1984-2004) and their effects on water flow and quality.
ii. Find out the willingness of the downstream buyers to pay for watershed protection services and socio-economic factors influencing their ability.
iii. Identify the environmental services farmers in Ndaka-ini area were willing to offer for conservation of the watershed and their willingness to accept incentives.
iv. Identify economic incentives consumers are willing to pay and socio-economic issues influencing the willingness to pay for watershed protection.

v. Evaluate, existing Policies, legal and institution framework required for PES implementation in Kenya.

1.4 Research Questions

The study was guided by the following research questions:

i. To what extent had land use changes in areas around Thika dam affected water flow, quality and farming practices of the farmers in the last 30 years?

ii. Are downstream water consumers able to link water they consume to conservation of watersheds and are they willing to pay for management of watershed areas?

iii. Which are the catchments conservation activities are the farmers in the catchment areas of Thika dam willing to adopt and be paid to improve water quantity and quality?

iv. Which are the economic incentives are the consumers willing to provide farmers with to support watershed protection?

v. How are the current policies, legal and institution framework are in place able to support PES work in Kenya?

1.5 Research Hypothesis

i. The changes in land use in Thika dam watershed area have significantly affected farming practices resulting to changes in water flow and quality for the last 30 years.

ii. Water consumers are willing to pay for conservation of Thika dam watershed in return for continued provision of water.

iii. Farmers in Thika dam catchment areas would accept environmentally friendly conservation practices in exchange to incentives provided by water providers and consumers.

iv. The current policies and institutions in place in Kenya support implementation of PES.

1.6 Significant and Anticipated Outputs

The results of this study provide land use cover changes in Ndaka-ini and how it has affected water flow and quality. This is related to the willingness of farmers to practise conservation friendly activities that would enhance water flow and quality. Feasibility for using water for purpose of PES was explored targeting the upstream and downstream users. Finally, the study explored policies, institutional framework in place and how they support PES system in Kenya. Results showed the potential for PES within Ndaka-ini area with a view of establishing pilot project. In addition, it gives case study of PES that can be shared in other areas. Further, results can be used to influence policy change of PES in Kenya.

1.7 Conceptual Framework

Payment for environmental services is a form of compensation paid by those who appropriate the benefits generated to those that preserve or conserve resources, ecosystems and environmental services related to the benefits. The principle guiding this relation is known as “protector – recipient” and the concept is based on the utilitarian approach in economics, specifically in the concept of “externality”

(Cornes&Sandler, 1996).To achieve optimum forest cover, consumers of these services must compensate the producers of the positive externalities. To maintain forest cover, a mechanism in which all beneficiaries compensate producers of the services must be instituted. The forest conservation benefits national and international consumers, by carbon sequestration and biodiversity preservation, while the local and regional economy benefits through hydrological services and ecotourism benefits (Chomitz et al., 1998).

Land use system in place affects ecosystem service providers positively or negatively which in turn affects ecosystem service provision.Payment for environmental services by consumers may have a positive impact on service providers leading to better land use and improved ecosystem service. However, this payment is affected by the socio-economic status of the consumers of the service (Figure 1.1).

Land use changes occasioned by changing socio-economic, environmental and infrastructure have had an impact on water flow and quality within the main rivers in the catchment. This has "in turn" resulted to farmers and other stakeholders adopting various farming and conservation practices that have had a positive or negative effect on water flow and quality. Payment for environmental services aims at influencing the adoption of friendly conservation practices by giving incentives to those contributing to conservation. It is important then to gauge the willingness of farmers to accept the incentives provided aimed at enhancing the conservation. On the other hand, the users of water services should be willing to pay for these incentives. This will link the provider and user of environmental services. The adoption of Environmental Services (ES), Willingness –To-

Accept (WTA) and Willingness-To Pay (WTP)are all affected by the policies and legislation in place for the water and environmental sector.

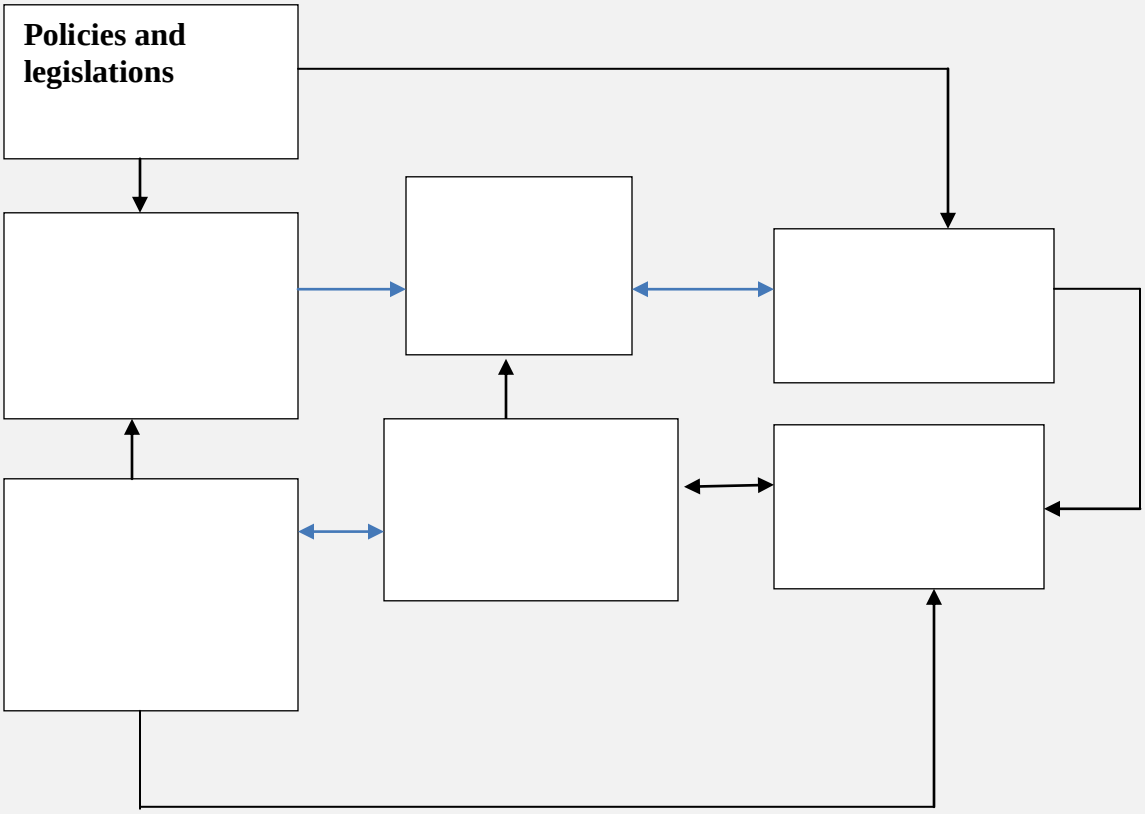

Figure 1.1: Conceptual Framework

1.8 Limitations and Scope of Work

The study focused on representative consumers of water in the Gatanga Sub-County in Murang'a County and Thika Sub-County in Kiambu County as the water consumers are many and the time available and funds could not cover all the consumers. On theother hand, the study had an assumption that persons answering the questionnaires would provide correct information that will guide the study. This may

not always be the caseand so triangulation was used to verify some of the information. For the institutions and companies that availed the data, the study assumed that access was allowed for all the data required for the research. Due to budget constraint, the study did not capture consumers from Nairobi but concentrated on areas around lower side of the dam. However, it made reference to earlier study done for WTP for Nairobi residents using water from Sasumua dam.

1.9 Definitions of key terms

Ecosystem services are outputs, conditions, or processes of natural systems that directly or indirectly benefit humans or enhance social welfare.

Payment for environmental services refer to voluntary transaction where a service provider is paid by or on behalf of service beneficiaries for land, coastal or marine activities that are expected to result to continued or improved service provision.

Willingness -To –Accept is the minimum amount of money that a person is willing to accept to abandon a good or to put up with something negative, such as pollution. It is equivalent to the minimum monetary amount required for sale of a good or acquisition of something undesirable to be accepted by an individual.

Willingness-To -Pay is the maximum amount an individual is willing to sacrifice to procure a good or avoid something undesirable. The price of any goods transaction will thus be any point between a buyer's willingness to pay and a seller's willingness to accept.

Watershed is the area of land where all of the water that falls in it and drains off of it goes to a common outlet It is also an area or ridge of land that separates waters flowing to different rivers, basins, or seas., an event or period marking a turning.

Demand for ecosystem services is the sum of all ecosystem goods and services currently consumed or used in a particular area over a given time period.

Ecosystem service supply-Supply of ecosystem services refers to the capacity of a particular area to provide a specific bundle of ecosystem goods and services within a given time period.

Additionality is the change in land use generated by the PES payment, which can be compared with what would have happened if no scheme were in place.

Conditionality – payment is dependent on delivery of ecosystem service benefits.

Buyers –beneficiary of ecosystem services who are willing to pay for them to be safeguarded, enhanced or restored.

Sellers –land or resource managers whose actions can be potentially secure supply of the beneficial service.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Payment for Environmental Services

Ecosystems provide valuable services to local, regional and international community (Costanza et al., 1997; Millennium Ecosystem Assessment (MEA), 2005). However, traditional markets are underdeveloped or lacking in many environmental services such as watershed benefits, biodiversity conservation and carbon sequestration and hence decision to convert or alter the habitat fail to take into account the total service loss (Hanley, 1992; Loomis et al., 2000). When taken into account, these services may tip the scale in favor of environmental service particularly if the competing resource use such as agriculture and timber are only marginally profitable (Pearce &Moran, 1994; Pagiola et al., 2004). In cognizance of the worth of ecosystem services, 'Payment for Environmental Services" (PES) (also called ecosystem or ecological services) has emerged over the last decade as an approach that provides positive incentives to manageecosystems (Simpson &Sedjo, 1996; Landel-Mills &Porras, 2002). The incentives under PES may be used to compensate those presently providing an environmental service or those who have foregone some of their land use practices that are detrimental to provision of ecosystem service.

The key characteristic of PES deal is the focus to maintain flow of a specified ecosystem "service" such as clean water, biodiversity habitat, or carbon sequestration capabilities in exchange for something of economic value. The critical and defining factor of what constitutes a PES transaction, however, is not just that money changes hands and an environmental service is either delivered or maintained. Rather, the key is

that payment causes the benefit to occur where it would not have otherwise thus becoming an "additional" to "business as usual," or at the very least, the service can be quantified and tied to the payment (Namirembe et al., 2014). The payment or incentive can take different forms such as; conservation easements (owner is paid to use and managedefined piece of land only for conservation purposes), conservation land lease (owner is paid to use and manage land for conservation purposes for a definedperiod of time), conservation concession (public forest agency is paid to maintain a defined area under conservation uses only), community concession in public protected areas (individuals or communities are allocated use rights to a defined area offorest or grassland in return for a commitment to protect the area from practices that harm biodiversity), management contracts for habitat or species conservation on private farms, forests, or grazing lands (contract that detailsbiodiversity management activities) and payments linked to the achievement of specified objectives(Katoomba, 2008).

The ecosystem services traded include; purification of air and water, regulation of water flow, detoxification and decomposition of wastes, generation and renewal of soil and itsfertility, pollination of crops and natural vegetation, control of agricultural pests, dispersal of seeds, translocation of nutrients, maintenance of biodiversity, partial climatic stabilization, moderation of temperature extremes, wind breaks, support from diverse human cultures, aesthetic beauty and landscape enrichment (Daily Gretchen, 1997). These ecosystem services can be categorized into four broad types:

(1) Public payment schemes to private land and forest owners to maintain or enhance ecosystem services;

(2) Open trading between buyers and sellers under a regulatory cap or floor on the level of ecosystem services to be provided;

(3) Self-organized private deals in which individual beneficiaries of ecosystem services contract directly with providers of those services; and

(4) Eco-labelling of products that assures buyers that production processes involved have a neutral or positive effect on ecosystem services.

Payment for environmental service concept has evolved over time as the discipline develops. The definition by Wunder(2005, 2006, and 2007) has received widespread acceptance amongst scholars as well as practitioners (Sommerville et al., 2009). Wunder (2007) classifies PES as (1) voluntary transaction where (2) a well-defined environmental service (ES) is (3) being bought by a minimum of one buyer (4) from a minimum of one ES provider, (5) if the ES provider secures the ES provision. Recent evaluation of PES has shown that it is difficult to meet all the above criteria. Swallow et al.(2007) have redefined PES as approaches that aim to (1) transfer a positive incentive to the environmental service providers that are (2) conditional on the provision of the service, where successful implementation is based on consideration of additionality under varying institutional contexts.Additionalityis the change in land use generated by the PES payment, which can be compared with what would have happened if no scheme were in place. Use of positive incentives, including and not limited to payment is the core ideology of PES.

Ecosystem service payments include both monetary and non-monetary transactions between an individual who offers services (“sellers”) and an individual (or a group) who pays for maintenance of demanded services (“buyers”). The

maincharacteristic of these seller/buyer transactions is the focus on upholding a flow of a specified ecological "service," such as maintaining clean water, biodiversity and carbon sequestration capabilities. The transactions require regular, independent verification of sellers' actions and effects on the resources as a way of ensuring that the ecological service is indeed maintained—as buyers expect for their money(Katoomba, 2008). Payment of ecosystem services is identified as a direct and efficient way to promote conservation of biodiversity by bridging the interest of the local people and external actors (Wunder, 2006).

According to Galvin & Haller (2008), there are three main strategies for conserving protected areas, and these depend on the decision-making framework; the populist approach adopts a bottom-up strategy where decisions on suitable actions rest with the local community, who are also in charge for providing leadership in the implementation of conservation activities. The second approach, which considers poverty as the root cause of environmental degradation, seeks to provide alternate livelihoods to communities that depend on the natural resource that is to be conserved. In this case, conservation efforts could be in conflict with development aspirations, necessitating the use of prohibition mechanisms to bar communities from accessing the conserved resources.The third approach is founded on the principles of cost-benefit analysis, and here conservation takes a business model that necessitates action to be taken on the basis of perceived costs and benefits. However, quantifying and attributing value to abstract benefits of conservation such as clean air is a challenge that plagues the cost-benefit method, which is also hinged on principles of rational choice. The three approaches are appropriate to any conservation program but require the articulation of

the role of the private sector beyond corporate social responsibility; furthermore, the assumption that poverty is the root cause of environmental degradation is inaccurate.Payment for ecosystem service is founded on the third approach, one of cost benefit analysis but also borrows from first and second as it's important to get community support and also works in a framework where issues of poverty have to be mainstreamed for the intervention to be successful (Galvin & Haller, 2008).

One of the conditions under PES is conditionality. This has taken different approaches leading to different paradigm shifts. Study on synthesis of PES lessons in Asia categorized PES into three paradigms: "Commoditization" of Environmental Services, 'Compensation' for Opportunities Skipped and 'Co-investment' in Stewardship" (Van Noordwijk et al., 2010).Commoditization' entails recurrent payments for actual delivery of a specified ES conforming to market-based mechanisms. 'Compensation' entails payment for acceptance of restrictions or achievement of a condition or proxy to specified environmental outcomes. 'Co-investment' entails conditional rewards that are not market-driven, involving flexible contracts entrusting resource management and monitoring with local communities, with broad performance sanctions. Co-investment rewards were based on either proxy trusted to deliver a specific ES, a set of best-bet practices trusted to deliver an unspecified set of ES or permits for actions trusted to generate positive ES externalities. In these projects, mostly financed from public or donor sources due to lack of ES demand, emphasis is not placed on measuring out comes but rather, on motivating actions or 'good land use practices' for ecosystem health as a public good. In Africa, many tree-based PES projects fall within the 'softer' PES paradigm with characteristics

of ‘co-investment’ and without explicit frameworks for monitoring and evaluating environmental service outcomes. As a result, this makes them less efficient and not much different from past Integrated Conservation and Development Projects (Wunder,2007). A desk study review of the ‘state-of-the-art’ in 50 tree-based PES projects in Africa, showed how variations in conditionality with land owners affects fairness and efficiency in delivering ES outcomes. Levels of conditionality with land owners were not always clear-cut, but fell into thefollowing categories: 30% ‘commoditization’, 12% ‘compensation’ and 58% ‘co- investment (Namirembe et al., 2014).

2.2 Land use and land cover changes

Land cover change information at different spatial and time-scales is critical in evaluating ecosystem conditions and environmental trends(Alphan et al., 2009). Knowledge about the kind and the rate of change in the use of land resource is essential for proper planning, management and to regulate the use of such resources (Sreenivasulu et al., 2010). The information is also critical in resource economics as land cover change is attributed to dynamics of proximal livelihood options as well as externalities related to economic activities and resources. Indeed, as noted by Sreenivasulu et al. (2010) and Mas (1999), land use change has direct bearing on various hydrological phenomena such as interception, infiltration, surface flow, evaporation with related problems including rainfall-runoff modeling and sedimentation, being well understood if information on land use/land-cover change is available for respective catchment. Thus, as underscored by Alphan et al. (2009), better

understanding of these impacts would allow accurate estimation, modeling and forecasting of such dynamics from local to regional levels.

Remote sensing offers a cost-effective alternative of mapping landscape resources and analyzing changes over the traditional ground-based surveying methods. While the latter methods will continue to be important in ground-truthing exercises for validation and calibration of remotely sensed data, it is generally agreed that application of remote sensing technologies for mapping of resources over large areas and with need for temporal replication is far much economical in comparison to traditional methods. They provide effective tool for analyzing the land use dynamics of a region, as well as for monitoring, mapping and management of natural resources, (Sreenivasulu et al., 2010 and Mas, 1999). Remote sensing approach employing the moderate resolution satellite imageries like Landsat Thematic Mapper, Landsat Enhanced Thematic Mapper Plus, SPOT Vegetation among others has widely been accepted (Alphan et al., 2009). It has gained prominence in wide range of application such as landscape resource assessment, resource monitoring, land cover change analysis, drought monitoring, and biomass estimation among others. In environmental monitoring for instance, information from satellite remote sensing can play a useful role in understanding the nature of changes in land cover/use, where they are occurring, and projecting possible or likely future change (Nori et al., 2008).

Successful application of remote sensing technology hinges on the understanding of the interaction between electromagnetic spectrum and the target land surface materials and subsequent matching of this knowledge with the application at hand. Generally, the spectral properties of the surface material as sensed by the detector is one of the most

important piece of information gathered through remote sensing, besides others like viewing and illumination geometry. Depending on the nature of the target surface material as well as the path of illumination to and from the sensor, it becomes possible or not, to gather information that may infer about the properties of the target surface (Xie et al., 2008).

2.3 Experiences on Development of PES Programme

Some PES programme like Rewarding Upland Poor for Environmental Services (RUPES) in Indonesia, have focused on mechanisms and modalities for poverty reduction through rewards for verifiable environmental services to the global and national communities (Leimona etal., 2008).In the area, aquick assessment of hydrological functions of the Singkarak watershed was made, comparing the perspectives of local people, government officials and scientists (Farida et al., 2005). The study concluded that the watershed needed to balance three objectives: to maintain a clean lake, to produce electricity for the two provinces and, most importantly, to meet expectations of the large population residing upland and downstream for productive landscapes on hills and irrigated plains. Based on national regulations, the local government in West Sumatra issued its own regulation on the deployment of tax money derived from the use of surface and subsurface water. Such income, derived from the Hydro Electric Power (HEP)was shared among provincial governments (30%), the district that produces the tax (35%) and other districts of West Sumatra (35%).

Watersheds in Kenyaare managed through a public structure involving Water Management Authority (WMA) that builds capacity of land users organized in Water Resource Users Association (WRUA) to develop and implement Catchment

Management Plans (CMPs). This structure mainly financed by Water Services Trust Fund (WSTF) has achieved community organization and restoration of publicly owned land but its potential to reverse land degradation in privately owned land is low (Namirembe et al., 2013). Studies conducted by Pro-poor Reward for Ecosystem Services Approach (PRESA) in Sasumua showed that Nairobi Water and Sewerage Company (NWSC) spends US$50,000 a year in clearing silt and flushing water intakes and a further US$187,500 on alum, a coagulant to clean water (Mwangi et al., 2011). A reward/payment for environmental services scheme was shown to have potential to contribute to improved catchment management practices by promoting appropriate land management practices that would reduce soil erosion from privately owned farmlands (Namirembe et al., 2013).

Studies conducted in Upper Tana Basin and other parts of the world showed that local communities are a component of the ecosystem. Rewards based approach that incorporates these resident communities has potential to reverse degradation of the upper Tana landscapeto reduce costs of water treatment and de-siltation of dams (PRESA, 2010). Payment for environmental services was piloted in Naivasha by WRUAs, CARE Kenya, WWF and WRMA. The scheme provided options for practising sustainable and environmentally friendly land use practices by farmers in the catchment andin returnreceived support from the downstream flower growers. Sellers of ES were the Upper Turasha-Kinja WRUA and Wanjohi WRUA while the buyer wasLake Naivasha Water Resource Users Association (LANAWRUA). Report by Ndetei (2012), showed that uptake of the PES initiative by year 2012 was remarkable,

with 784 farmers participating who received incentives in form of conservation materials.

In addition, farmers received cash payment through payment vouchers. In total, an area of 360,000m^2 was set for conservation. The buyers included; economic entities, small- scale flower farmers,large-scale flower farmers, tourism establishment, government departmentsand ranchers.The PES required that the WRUA'S involved in the process enter a contractual one-year agreement renewable annually between the sellers and buyers making the concept legal business entity.Pilot PES scheme provided opportunity for linkage between upstream and downstream users, reduction of soil erosion, increased production due to retention of top soil, received incentives to generate additional income and improvement of local livelihood. Challenges faced included; harnessing potential buyers, absentee land owners, complex land ownership, inadequate law enforcement, unpredictable weather patterns, attitude change and inadequate knowledge on PES among stakeholders, among others.

A recent study assessed the business case for setting up an Upper Tana Nairobi water fund that was aimed at bringing together partners to support conservation efforts. The initiative led by The Nature Conservancy (TNC) showed that positive conservation efforts resulted to 50% reduction in sediment load in rivers, 18% decrease in sedimentation in Masinga dam, up to 15% increase in annual water yields, US $ 3 million per year increase in agriculture yields, US $ 600,000 increased annual revenue for Kenya Electricity Generation (KENGEN) and US $ 250,000 cost saving per year to NWSC. The business case showed an overall US $ 10million investment in water fund was expected to give a return of US 21.5 million in economic benefits over a 30 year

timeframe (TNC, 2015). The water fund was launched in March 2015 and it is expected to immensely contribute to PES interventions in Upper Tana.

Successful PES schemes in Costa Rica shows how the scheme can be used to finance environmental conservation by allowing landholders to be compensated for the ES they provide. The approach was that of delinking environmental services from financing of these services. The services of carbon sequestration and watershed protection were marketed to domestic and international buyers and proceeds ploughed back to finance the provision of the services (Chomitz et al., 1998). A study by Stanton et al., (2010) indicatedthat PESprograms are still at initial stages with 288 programs globally while in Africa,there were only 20programs while Latin America had the highest programs. Payment for Water services programme was either demand or supply - driven with main players as sellers, administrators and buyers. The sellers were the upstream landowners either as individual groups or rural community or in a few cases managers of protected areas. The buyers were municipal governments, drinking water companies, power generation companies and Non-Governmental Organizations (NGOs). The role of administrator of the ES scheme was to help in design, promotion, lead in negotiation, and carry out tracking and monitoring.

Payment varied depending on land management requirement, whether program was local, national or regional and whether programme was incorporating poverty alleviation goals. The study showed a growing trend in Payment for Water Services (PWS)programme with transactions not strictly limited to cash payment but also included other types of kind compensations that supported a range of activities such as adjusting land management practices, improving and protecting water qualityand flow,

storage, poverty alleviation, institutional capacity building, technical assistance, overall social concerns and community development activities. Government implemented programme at all levels in conjunction with private sector, NGOs, and community groups or combination of these players. The role of government was critical in developing policies and regulations in Payment for Water Services (Stanton et al., 2010). An evaluation of PES experiences and lessons learnt by OECD (2010) led to development of key criteria that are needed to enhance PES effectiveness. These include; removing perverse incentives, clearly defining property rights, clearly defining PES goals and objectives, developing a robust monitoring and reporting framework, identifying buyers and ensure sufficient and long-term sources of financing, identifying sellers and target ecosystem service benefits, establishing baselines and target payments to ecosystem services that are at risk of loss, or to enhance their provision, differentiating payments based on the opportunity costs of ecosystem service provision and considering bundling or layering multiple ecosystem services

Studies conducted by Pro-Poor Rewards for Environmental Services in Africa (PRESA) in Kapingaziriver-rine basin in Mt. Kenya, showed that land use decision and agricultural management practices adopted upstream, affect water quantity and quality available to beneficiaries downstream. However upstream landowners, have no or little incentives to take these impacts into account in their decision, making processes (PRESA, 2010).Several community leaders in different parts of Kenya have increasingly demanded to be rewarded, even in kind, for protecting environmental goods from those who derive economic or consumptive benefits of such services. This scenario is expected to improve with the Constitution ofKenya (2010), in which, Article

69 (1) and (2) elaborately spells out that the people of Kenya should benefit equitably from the sustainable exploitation, utilization and management of natural resources and at the same time, work to conserve and protect these resources. It is expected that costs and benefits in managing natural resources should be shared among the state natural resources managers and the citizens (Constitution of Kenya, 2010). The constitution also introduces devolved governance in form of counties and calls for public participation in decision making.

2.4 Process of Water Abstraction and Treatment for Nairobi City

Water destined for Nairobi is abstracted from three main sources, namely;Sasumua, Ruiru and Thika dams. This water is treated before it's piped to Nairobi residents for distribution by Nairobi Water and Sewerage Company (NWSC).Sasumua dam, located in NyandaruaCountyprovides11.6 % of water in Nairobi. It has storage capacity of 15.9 million cubicmetrewith a design yield of 59,000m^3 per day but a current yield of 52,800 m^3 per day. Its water is treated inSasumua and then piped 60 km to Kabete storage. Ruiru dam, located in Githunguri Sub-County, KiambuCounty has a storage capacity of 2.9 million cubic metres with a yield of 22,800 m^3 per day translating to 5% of water provision. Water is piped 25 km away to Kabete storage. However, the main source of water for Nairobi is Thika dam also referred as Thika dam, located in Gatanga Sub-County, Murang'aCounty, with a storage capacity of 77 million cubicmetre. It is linked to ChaniaRiver through a four-kilometre tunnel and then to Ngethu treatment works. Ngethu treatmentworks located in Gatundu North Sub-County, KiambuCounty has three phases of treatment with capacities of 37,000, 127,000 and 220,000 m^3 per day respectively. Treated water is

piped 36 km to Gigiri storage with pipes whose design capacity is 440,000 m^3 per day but current capacity is 379,200 m^3per day. Thika dam provides 83.3% of water requirement in Nairobi. Water has to be treated to conform to World Health Organization (WHO) standards before it can be piped to Nairobi(Nairobi Water Masterplan, 2012).

Water drawn from rivers and dam is treated in stages to the level accepted by World Health Organization. It firstruns through intake tunnels into a distribution chamber in the plant's raw water building. Vertical pumps draw the water through a series of screens, which prevent large debris, such as fish and seaweed, from entering the system. It is then pumped to the main treatment plant to begin the treatment process.

Water then flows through rapid mixers where poly-aluminium chloride is added whose chemical reaction causes dirt, clay, and bacteria to form a product known as floc, which settles easily out of water. In flocculation basins, large paddles gently stir the water causing the floc to increase in size and density helping it to settle at the bottom of the basin.Next the water flows to settling basins. The sludge at the bottom of the basin is removed by scrapers and sent to the waste water system.The partially treated water flows to the filter beds. Chlorine is added to the water for disinfection. The water flows through layers of sand, gravel, and anthracite coal. The filters remove particles, such as viruses, cysts, bacteria and any remaining floc.Filters are cleaned by backwashing, in which clean water removes the collected sludge from the top of the filter to settling clarifiers. When the backwash water settles, the clear water is recycled into the water treatment process and the sludge is removed.Before water enters the distribution system, more chlorine is added to prevent bacteria, build up. Fluoride is also added to

fight tooth decay. Caustic soda is added to neutralize the acidity and prevent the corrosion of pipes. Finally, high service pumps push the treated water from a clear well reservoir into the distribution system.Nairobi Water and Sewerage Companymaintain a rigorous purification programme that meets and/or exceeds the regulations set by the WHO, Kenya Bureau of Statistics (KEBS), and the Department of Health.Water quality is strictly monitored at the NCWSC laboratories to make sure the water is safe and clean to drink byhighly trained chemists who test for bacteria, pH levels, turbidity, chlorine residual and other related analysis.The NCWSC conducts more than 70,000 tests annually to make sure all necessary drinking water regulations are met. As the water supplied must meet the WHO standards, it means that in case the water quality is low, then more chemicals must be used and hence more cost incurred in water supply.

2.5 Issues Affecting Thika dam and Neighbouring Community

Farmers and the community surrounding the dam have in the past, raised concerns that have been addressed in various meetings. Some of the issues relate to community expectations that were yet to be realized and disputes between them and NWSC as summarized in Table 2.1.

Table 2.1: Key highlights of issues affecting Thika dam and the community

	Issue	Details	Mitigation	Strategy
1	Seepage of effluents from the neighbouring shopping centre	Main shopping centre, Ndaka-ini, located next to the dam. It has no sewerage system so results to using septic tank that allows seepage to the dam	Provision of sewerage treatment facility	Relocate members from the centre and build sewerage treatment in other shopping centres
2	Soil erosion from different land uses	Siltation of rivers and dams	Construct coffer dam to control river flow and adopt best farm management practices	Desiltation should be carried out regularly in the dam
3	Depletion of raw water from competing uses	Result to low water levels in the dam	Assess water demands in all catchment areas, curb irrigated flower and other horticultural activities on the riparian areas of the dam and create awareness in designated water points	Water abstraction plan and enforcement
4	Unsustainable agricultural practices	Results to pollution from agrochemical siltation	Awareness creation on good conservation practices	Adopt best farming practices
5	Exotic tree species planted along the rivers	Eucalyptus trees planted along the rivers	Planting of trees friendly to water catchment conservation	Species site selection

Source: NDEKA, (2012)

In addition to the above issues, it has been reported that the community around the dam had raised issues of neighbours protecting the dam without payment or benefits, long standing land issues regarding ways of compensation for the acquired

land was carried out, boundary dispute between the dam and neighbouring farms, reconnection of water supply by Gatanga water and sewerage company – water supply was disrupted during dam construction resulting to most residents lacking tapped water supply and community were promised rural electrification at inception of the dam which they arestill waiting. These issues have over time affected the perception of the community towards the dam.

In addition,the following activities have in the past been proposed to stir growth in the area; commercial exploitation of the dam in form of water sports and general recreation, connection with electricity to facilitate industrialization, commercial farming, provision of piped water, primary schools and hospital/clinic, conservation of environment, leasing of land adjacent to the dam and settling compensation claims (NDEKA Report, 2012). The concerns from the neighbouring community as regards the dam, affects their attitude and perceptions and the future intervention measures on payment for ecosystem services.

Studies conducted onSasumua dam showed a similar situation like in Ndaka-ini in which the farmers neighbouring the dam have no direct benefit from it. However, a business case study showed that PES was a feasible option in Sasumua so long as the main user of water service agrees to plough back funds for conservation. A similar study in upper Tana along the KapingaziRiver showed that some farmers were receiving premium prices from coffee and tea from eco certified programme rainforest alliance in which soil and water conservation were part of the certified requirements (PRESA, 2011). Payment for ecosystem services in Ndaka-ini can contribute to adoption of good farming practices that would lead to reduced erosion, planting of conservation friendly

tree species along the rivers, support to community-based projects thus changing attitude of the community and capacity building.

2.6 Process in Development of PES Program

Studies carried out byLandell-mills &Porras(2002) in Asia showed that governance structures, population density, land tenure systems, lack of hydrological data and low level of awareness influenced PES development programmes. These factors are bound to influence development of PES programme in Kenya. The PES works out with a well-defined environmental service. The most common services offered under PES programme are; improved water yield, augmentation of seasonal river flow, improved water quality, general watershed rehabilitation and soil erosion control. In Ndaka-ini,the main ES is water that is used for domestic, industrial and power generation. In Asia, PES system was either state-controlled, private enterprise, or community managed. While the environment services are based purely on downstream hydrological needs, the actual PES mechanisms adopted is a factor of whether market mechanisms are at work or the state regulated goods and services. In Asia, the widespread lack of land tenure is cited as key constraint to PES (Landell-mills &Porras, 2002). The case in Kenya could be different as there are clear land tenure systems.

2.7 Institutional and legal Framework in PES

Development of institutional framework and reward system was a major factor for success of RUPES programme in Indonesia (Leimona& Lee, 2008). The regional institutions comprised joint committee which negotiated between buyers and sellers. The stakeholder process developed four principles for giving reward or compensation for ES namely; individual or community receiving benefits from ES, should pay, any

individual or community being affected by development activities that damage environment should get compensation, any individual or community that contributes to environmental enhancement should get rewards and any individual or community that contributed to environment damage should pay compensation.

The introduction of law regulating PES is a relative recent and innovative method and has worked out in Peru, Colombia and Mexico. This allows PES to operate and be funded by various parties but the legislation provides regulatory oversight that includes a national registry of the schemes (Climate and development knowledge network, 2012). The laws established in Peru and Colombia authorizes and promotes voluntary, decentralized development within regulatory limits, supports monitoring and enforcement and provides legal certainty for the parties. The main object In Kenya, there is need to develop institutional framework for reward as well as guidelines for PES.

The lessons from Indonesia can be used to develop institutional framework and national/site regulations in Kenya. Opportunity in Kenya is provided through Forest Act (2005) and the newly enacted ForestManagement and Conservation Act (2016) as well as Water Act (2002). The ForestManagement and Conservation Act (2016) section 48 provide for community participation in forestry and the process of their participation has been elaborated through Participatory Forest Management guidelines and subsidiary legislation (Forest Act, 2005; Participatory Forest Management Guidelines, (2007); Forest Subsidiary Legislation, (2010). In addition, the Act provided that the Cabinet secretary will develop regulations governing development of PES in the country. Water Act (2002) established the following autonomous institutions with specific roles in

management of water services in Kenya; Water Resource Management Authority (WRMA), Water Service Regulatory Board (WSRB), Water Resource Users Associations (WRUA), Water companies and the various regional water authorities like Tana-Athi Water Board. The regional boards are the asset developers and supervise the activities of the water companies in their area. Payment of water service should link all the institutions involved in water supply from the catchments areas in form of WRUA to water consumers.

2.8 Governance Arrangements

Case study of PES arrangements in Mexico shows that pre-existing local governance patterns, level of active forest management and links with outside socio-economic networks all greatly influencethe way in which programmeareimplemented and their long term-impacts(Shapiro, 2007). Payment for environmental services programme would have long term impacts when implemented in communities that: already have some form of sustainable forest management regime in place, have links with civil society organizations who can train them in the necessary management monitoring and marketing, have a solid and democratic internal governance structure in place (Shapiro, 2007). In Kenya, the community governance in form of Water Resource Users Association and Community Forest Association needs to be strengthened. A recent report indicated CFA faced following governance issues; decentralization had not lived to the expectations, discontent about slow pace of resolving issues of benefit sharing, integrity of some leaders wanting, corruption incidents and lack of compliance with forest rules and regulations (Ministry of Environment, Water and Natural Resources and UN-REDD programme, 2013). In Ndaka-ini, the main community

structures are the CFA, WRUA and NDEKA that operate independently though serving the same community. In addition, there are several CBOs engaged in rural development. There is need for continuous capacitybuilding for CFA and WRUA and other stakeholders involved in PES process.

2.9 Equity and Incentives in PES

The design of a performance-based payment scheme combines the land use index and associated cost of each land use. The underlying logic is that incentives offered to farmers to maintain or improve the environmental attributes of a particular land use should be positively correlated to the magnitude of the cost involved and most importantly, to the generation of the ES as reflected in the land use index (Francisco & Roger, 2008). Designed as targeted incentives, PES has the potential to become a highly cost-efficient environmental management tooland can attract new sources of conservation financing especially from the private sector (Wunder, 2007). Compensation for environmental services which uses same principle as PES presents opportunity for incentive-based conservation enabling livelihood and conservation goals to be more easily reconciled (Villamor et al., 2007). Part of the PES process is the signing of conservation incentive agreement between the buyers and the sellers. Conservation Incentives Agreements (CIAs) have to be evaluated on the basis not only on their efficiency to achieve conservation objectives but also on the criteria of equity (Karsenty, 2007).

According toPorras et al. (2013) PES lessons in Costa Rica showed it had positive impacts to forest cover from its inception in 1997. It had contributedto protection of more than 860,000 hectares of forest, reforestation of 60,000 hectares and

supported sustainable forest management in 30,000 ha while promoting natural regeneration in 10,000 hectares. In addition, it had contributed to planting of 4.4 million trees. It was implemented through National Forest Fund acting as intermediary. Funding was provided by the government through legislation, private sector, international banks and development partners. The PES in Cost Rica programme had been described as notjust a single economic instrument, but rather a‘policy mix’ (Barton et al., 2013).

A policy mix isa combination of policy instruments, which hasevolved to influence the quantity and quality ofbiodiversity conservation and ecosystem serviceprovision in public and private sectors (Ring&Schröter-Schlaack, 2011). The policy mix inthis case includes the Forest Law that createdthe PES, annual presidentialdecrees determining PES priorities, the PESOperational Manual, and other ‘soft’ instrumentslike regulatory plans and the determination ofbuffer and conservation areas. This was in line with the InstitutionalAnalysis and Design (IAD) framework developedby Ostrom (2005) and can be used to describe PESin terms of its ‘rules-in-use’ that can be bothformal and informal. ‘Rules-in-use’ provides an analytical framework forcharacterizing the institutional characteristics ofPES, extending the analysis of incentives for landuse management beyond only payment levels andsanctions (Barton et al., 2013).

2.10 Knowledge Gaps

There is need to develop action research to clearly understand how to design PES programme to effectively address watershed protection (Marjorie et al., 2007). An Overview of PES implementation in Kenya by Mwangi and Mutunga (2009), identified the following crosscutting issues in PES management: low government participation,

minimal capacity building inbuilt into projects, lack of strategic planning and institutional development, nature of deals unclear, lack of centralized information bureau, lack of market information, lack of existing or past viable models, private buyers not identified and mobilized. The report also identified the following emerging issues; weak legal and regulatory framework to address PES, lack of mechanism for demand largely due to lack of awareness, lack of specific clauses in environmental policy to ensure compliance, poor partnerships, poor dissemination of information, lack of scientific information, technical backstopping, land ownership, institutional issues, lack of capacity, lack of methodologies and models that may offer contextually relevant lessons. This study will contribute to solving challenges in institutional development, improving market information, identifying buyers and sellers, socioeconomic profiles of sellers and buyers and improving case studies for future reference.

Payment for water services will contribute to improved provision of water services to residents of Nairobi whosepopulation stands at 3.14 million inhabitants at night and this swell to about 5 million during the day, but only about 50 per cent have direct access to piped water. The rest obtain water from kiosks, vendors, illegal connections or from wells. Only about 40 per cent of those with access to piped water receive water 24 hours per day (Nairobi Water Company profile, 2011). On average, residents of Nairobi received water for only 11 hours per day in 2009/10, a level deemed unacceptable by the Water Sector Regulatory Board (Water Services Regulatory Board Impact Report, 2011).

This study will contribute to filling the identified gaps and willprovide link between land use cover, land use change and environmental services over time as a

basis for long- term monitoring. It will also provide producer–consumer linkages in ES provision that will in return lead to enhanced awareness on taking up positive measures towards environmental conservation. Additionally, the study will contribute to action research in PES, improve policy and institutional environment for PES implementation and develop feasibility model for PWS application in Kenya.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The study was carried out in the areas designated as catchment areas for Thika dam which is located in Gatanga and MaraguaSubcounty, Murang'aCounty as shown in Figure 3.1. Gatanga District lies in longitude 36^{o} 44' 39.46" E and 37^{o} 00' 58.03" E and latitude 0^{o} 42' 13.28" S and 1^{o} 01" 12.72" S. The altitude is 1,340 -2,190 metres above sea level. It is in agro ecological zones UH0, UH1, LM1, UM1 and UM2 (MoA, Gatanga District, 2010). Water catchment areas for the dam include the entire Sub- locations bordering the dam and those situated between the dam and the forest of which Kimakia and Gatare forests stations are covered. The area of studyincluded; Ndaka-ini, Makomboki, Kangari and Kariara sub-locations in Gatanga district and Makomboki and Kinyona sub-locations in Murang'a south district.

The study area is about 80 km north of Nairobi and 40 km west of Thika town on the slopes of Aberdare forest at the tip of Thika and Maragua districts in Murang'aCounty. The Thika dam (commonly referred to as Ndakaini) catchment area measures 75 square kilometres. It consists of Kimakia and Gatare Natural forests which form Aberdare Ranges. The main rivers that drain into the Dam from this catchment are Thika, Githika and Kayuyu. Thika drains 50%, Githika 30% and Kayuyu 20% of the catchment into the Dam respectively (Athi Water Profile, 2015). The catchment area also covered farmlands within Chaniaand Kiamariver and its tributaries from the forest to the point where it joins the Thika dam – Ngethu water treatment tunnel.

The study also captured the lower catchment area on the side of users of the service that is comprises ofKigoro, Kihumbu-ini and Kiunyu locations that are served by Gatanga Water and Sewerage Company. This covers farmlands from the dam to going all the way to blue post hotel. Six major rivers namely; Githika, Thika, Kayuyu, Kiama, Kimakia and Chania influence drainage patterns of the area. Total arable land in the district is 312.4 KM^2 and a population density of 362 persons per km^2 and anaverage smallholder farm size of 0.23 ha per person (MoA, 2010).

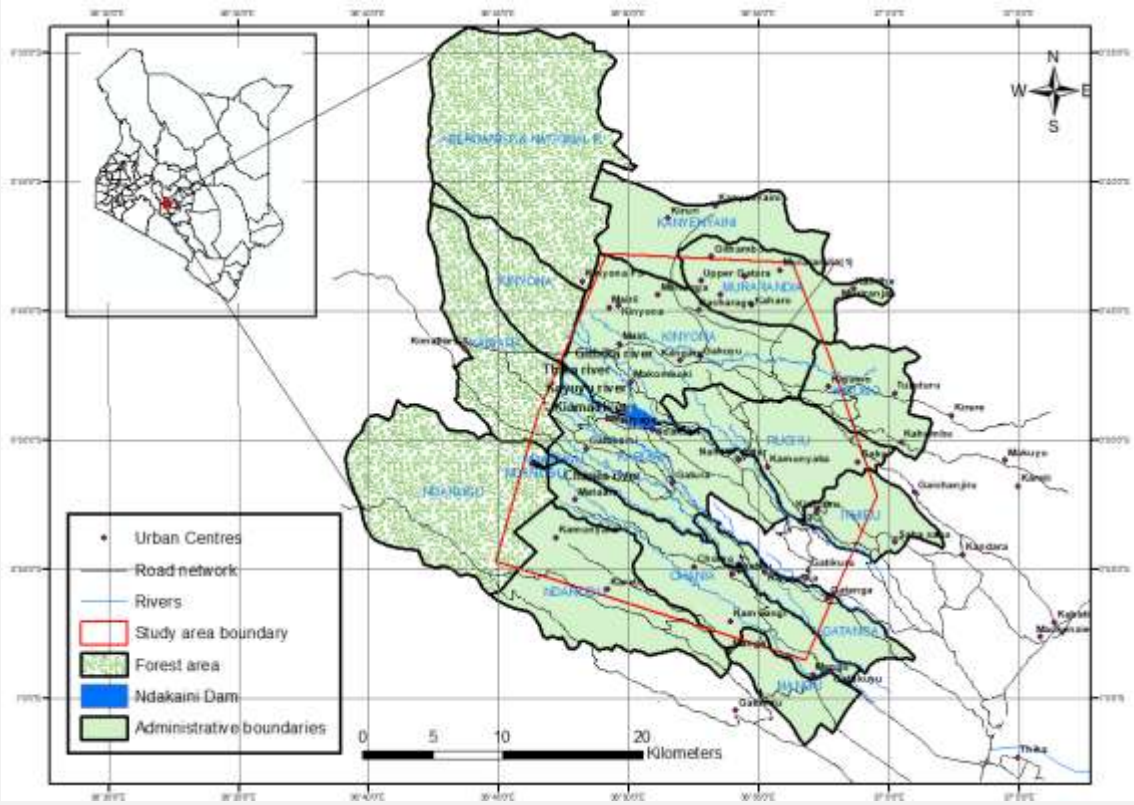

Figure 3.1: Location of the study area

Source: Kagombe and Kiama, (2012)

3.2 Genesis to Thika dam

In the year 1988, the Kenya Government compulsorily acquired approximately 485.62 hectares of land to create space for the construction of Thika Dam (Ndaka-ini) that was to supply portable water to the residents of Nairobi City and its environs. When it was filled, about 242 ha of land were inundated. The rest of the land was used to provide construction site for extraction of quarry stones at Kiruga construction site for the installation of Thika River gauging station for river compensation monitoring and construction sites for raw water intakes at Kiama river portal, Kimakia river shaft and Chania river outfall respectively.

The Dam construction was undertaken under the Third Nairobi Water Supply Project between 1989 and 1994. The contractor was M/SStrabag International and the Consultant Engineers were M/S Howard Humphreys(K) Ltd with funding from World Bank, Africa Development Bank (ADB), European Investment Bank and the Kenya Government, among others. The estimated total cost of the project stood at Kshs. 2 billion in 1994 (African Development Bank, 1998).

The key functions for the dam were: harness water from the dam's catchment to the reservoir, supply continuous reliable water to the City of Nairobi and its environs with minimum interruptions at regulated quantities and release regulated quantities of compensation water downstream to maintain the natural Thika river course. The dam has a reservoir volume of 70,000,000 m^3 with average depth of 65 metres, water surface area of 280 ha and a catchment area of 75 km^2consisting of Kimakia and Gatarenatural forests which are part of Aberdareranges. The dam is owned by Athi water board which has leased it to NCWSC(African Development Bank, 1998).

3.3 Physical Environment

3.3.1 Physiography

The dam lies in an area of three major physiographic regions. The first is a zone deeply incised by V- shaped valleys with slopes greater than 30% and is highly susceptible to soil erosion. This is the zone that covers the reservoir's catchment area, the forest reserve, Nyayo Tea Zone and the influent river zones. The second zone has a steep topography and soil erosion is of a major concern on arable land. The dam is located in a predominantly tea growing area, where the dam wall is located. The third zone is below the dam and is predominantly a coffee plantation zone all the way to the confluence of Chania River. It is also in this zone that the Ng'ethu Water Treatment Works is located(MoA, 2010).

3.3.2 Soils and Geology

The geology of the Ndaka-ini area is a series of pyroclastic flows associated with the volcanic activities of the eastern Rift Valley. The terrain is made up of a series of tuffs and ash-flows of varying thickness, depending on the duration of the volcanic event (MOA, 2010). The weathering grade depends on the time between the volcanic events. Thus, there is deposition of rocks consisting of materials laid down as fall or flow deposits which grade upwards from agglomerate base through lapilli tuffs to fine grained tuffs. The major soils are histols around the mountainous ranges and nitisols on the foot ridges to the dam site. The geology is associated with the volcanic activity of the East African Rift Valley (MOA, 2010).

3.3.3 Climate

The climate of the study area is cold and humid due to the influence of the Aberdare mountain ranges. The air temperature ranges between 9.5^0C to 24^0C while the water temperatures range between 14^0C and 18^0C. Rainfall amounts vary from 2000 to 2500 mm increasing up the catchment. Rain is in two seasons with short rains from October to December, and long rains from March to May (MOA, 2010).

3.4 Biological Environment

3.4.1 Flora

Apart from the phytoplankton, there are phragmites in the stilling basin and wide diversity of indigenous and exotic tree species in the fringes and the catchment area. These are the *Prunusafricana*, *Croton megalocarpus*, *Pinuspatula*, *Eucalyptus spp* wattles, and a myriad of forest shrubs and aquatic macrophytes especially *Typhadomingensis* and *Cypreus papyrus* on the influent fringes. The immediate catchment is covered by individual small-scale tea plantations and in some instances interspaced with blue gums and wattles with columns on napier grass making some of the bounders.

3.4.2 Fauna

Thika damreservoir has attracted a variety of birds, which include pelicans, Egyptian-geese, storks, crested cranes, weaver birds, swallows and a variety of grebes and coons. The birds are distributed throughout the reservoir but the highest densities are found in the influent river zones. The Coons and Egyptian geese are permanent

residents but there are also visitors like fish eagles whose number has increased after fish introduction. There are domestic animals including cows, goats, sheep and chicken(MoAGatanga District, 2010).

3.5 Socio- Economic Environment

3.5.1 Infrastructure

Most roads within and around dam catchmentareas were of tarmac with asphalt. The road around the dam covers a distance of about 35 kms. There were schools that have sprung around the dam, and several markets with a police station at the site. In addition, there were several industries in the area that process tea for export and are well serviced with electricity and telephone services(MoAGatanga District, 2010).

3.5.2 Demography

The dam catchment area has high population density, where many small towns and market centres have sprung up. This has led to land fragmentation and dwindling land sizes.The study area consists of 7484 households comprisingof; 2204, 1797, 943, 723, 703, 684, 412, 18 in Makomboki, Kinyona, Kimandi, Karangi, Mbugiti, Ndaka-ini, Kanunga and Kimakia sub-locations respectively. Average population density is 390 persons per km square (KNBS, 2010).

3.5.3 Land Use

The upper dam catchment is the forest reserve, which is managed by the Kenya Forest Service and below it is the Nyayo Tea Zone. Below the tea zone are the smallholder tea farms, with intensive tea farming and animal husbandry. There are

alsosmallholder farms with kales(*sukuma wiki*) and other vegetable varieties. Coffee growing and subsistence farming is practiced in the lower parts of the dam.

3.6 Research Design

According to Salzman and Modecai, (2009) there are five questions to be answered in design of any PES transactions. The first is what specific service needs to be provided and whether landscape management can provide that service. The second question focuses on providers and beneficiaries of ES as they have to be discrete for PES to work. Third question address level of service to be provided and if it can be adequately monitored as the linkage between the provider and buyer leads to improved confidence. The fourth question addresses the type of payment mechanism that is most appropriate. Fifth question concerns the type of institutions in place to support PES.

The design and implementation of PES scheme has five broad phases; identifying a saleable ES and prospective buyers and sellers, establishing PES scheme principles and resolve technical issues, negotiate and implement agreements, monitor evaluate and review implementation and finally consider opportunities for multiple benefits in PES (Department for environment food and rural affairs, 2013).

Research design involved understanding the changes that have taken place within the landscape and its effect of ES as a way of justifying need for PES. This was done through analysis of land use and land cover changes over a period of 30 years. This was followed by identifying farmer's conservation practices and WTA for PES. This was compared with WTP by consumers as well as identifying incentives they are willing to give. Finally,analyse policy, legal and institutional frameworks for PES.

3.6.1 Household Sampling

The study area included government forested area, individual farmers in the water catchment areas situated in the upper side of the dam classified as water producers and farms in the lower catchments classified as water consumer upper Thika. The catchment includes farm areas from the dam to the forest area. It also includes farmlands covered by tributaries of river Chania located between the forest edge and the point where it joins the tunnel feeding water to Ngethu treatment plantand also farmlands covered in the upper catchment, sampling used households within one kilometre from the dam and ridges from the dam to the forest area.Systematic sampling was used to choose households choosing every 5^{th} homestead. The size of the sample size was determined as described by Mugenda and Mugenda (2003).

In the lower catchment areas, cluster sampling was used based on the data of water users that was obtained from Gatanga Water and Sewerage Company. The sampling frame was the number of water users supplied by Gatanga Water and Sewerage Company in the lower catchment of the dam.

3.7 Research Method

The study used survey method targeting households within the catchment, main institutions using water from the dam, tea factories within the area and water provisions institutions. The data collection approach was adapted was from Waage et al., (2005)and Ruhweza and Wage (2002) whose main steps are: value chain approach to environmental service, demand analysis, contingent valuation to determine non-market ecosystem values, willingness to accept, cost-benefit analysis and benefit transfer methods. The key data collection methods was reconnaissance visit to test the questionnaire and make contacts with farmers, collection of secondary data to show

patterns of weather and socio-economic trends in the area, mapping out areas of study site using Geographical Information System (GIS) to show extent and guide in determination of sampling frame, acquisition and analysis of satellite imagery for interpretation to show trends of vegetation cover in the area for the last 30 years followed by ground truthing. Semi-structured interviews were conducted to farmers in the upper and lower catchment areas. On the other hand, specific checklists were used to interview and collect data on trends in land uses, from KTDA factories, Nairobi Water and Sewerage Company, institutions consuming large quantities of water and organized community groups.

3.8 Research Tools

3.8.1 GIS Mapping

Thika damcatchment area was mapped to capture rivers that feed the dam, conservation activities, and land use through GIS. This was done through acquiring Landsat imageries (TM and ETM^{+}) between 1985 and 2011 over WRS-2 path/row path 168 and 061 corresponding to the study area that were downloaded from Global Land Cover Facility (GLCF) and USGS website. This was supplemented by data collected in the field where GPS position of study sites were collected and uploaded in arch GIS 2010 software. Data from GIS was used to generate Figure 1 that describes the study area that later guided in sampling households and relating the land use practices to the water reservoir.

3.8.2 Trend Analysis

Data was collected on land use change inNdaka-ini in the following periods: before the dam was excavated (1979), during construction of dam from 1989 to 1994, and every ten years after construction of the dam (1999 and 2009). Land use changes and factors affecting it was guided by; analysis of satellite imagery within the specified time, review of development plans, review of census data and ground truthing to verify satellite imagery and maps information. This was supplemented by secondary data on growth of the area in terms of population, economy and infrastructure. Data on water intake and outflow of Thika damfrom 1995 - 2016 were collected from NWSC and Kenya Meteorological services. In addition, primary data were captured through survey on farmers' perceptions to changes within the study sites.

3.8.3 Land use Change Analysis

Landsat imageries consisting of Thematic Mapper (TM) andEnhanced Thematic Mapper Plus (ETM+) acquired between 1987 and 2009 over WRS-2 path/row path 168 and 061 and corresponding to the study area was downloaded from Global Land Cover Facility (GLCF) and United States Geological Survey (USGS) website. Cloud and cloud-shadows posed a major problem as most of the available images were contaminated over most of the study area, thus limiting their use. Being a tropical humid-highland, it would normally be clouded over most part of the year, a problem also noted by Mas (1999) in his study over the Gulf of Mexico. The initial plan was to get images after every five-year interval, but due to cloud problem, it was only possible to get images dated outside the previously defined interval. In the end, images corresponding to four year-specific periods (referred to as anniversaries) - 1987, 1995, 1999 and 2009 were selected (Table 3.1).

Besides the satellite imagery, other data such as administrative maps, boundary maps, road network, and urban centres were also used. The images were imported into ArcGIS 2010 software where they were converted into user-friendly format that allowed assessing quality of the images, pre-processing and implementing digital land-cover classification. The images were already geometrically rectified and projected to Universal Transverse Mercator (UTM)projection;hence no further geometric rectification was needed apart from checking that they registered correctly to each other and to the ancillary data. However, radiometric and atmospheric corrections were necessary.

Table 3.1: Description of selected images in Ndaka-ini catchment area

Acquisition date	Julian day (JD)	Landsat sensor/ satellite	Final use of the image
1985-Jan-18	18	TM5	Final analysis
1987-Feb-25	56	TM5	Correcting cloud and shadow of 1985
1993-Feb-17	48	TM4	Correcting cloud and shadow of 1995
1995-Jan-30	30	TM5	Final analysis
2000-Feb-21	52	$ETM^{+}7$	Final analysis
2005-Feb-18	49	$ETM^{+}7$	Final analysis
2010-Feb-08	39	TM5	Correcting cloud and shadow of 2011
2011-Jan-10	10	TM5	Final analysis

Some images had few patches of cloud/shadow over the study area. Cloud detection followed the approach employed by Martinuzzi et al.,(2006) with some modifications. Landsat image bands 1 and 6 were used to detect pixels that were contaminated by clouds through thresh-holding technique and Boolean operations.

Landsat Multispectral Scanner (MSS) images consist of four spectral bands with 60-meter spatial resolution. Approximate scene size is 170 km north-south by 185

km east-west (106 mi by 115 mi). Specific band designations differ from Landsat 1-3 to Landsat *4*-5 with a resolution of 60 metres. On the other hand, Landsat **Thematic Mapper (TM)** images consist of seven spectral bands with a spatial resolution of 30 metres for Bands 1 to 5 and 7. Spatial resolution for Band 6 (thermal infrared) is 120 metres but is re-sampled to 30-metres pixels. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi).

Landsat Enhanced Thematic Mapper Plus (ETM+) images consist of eight spectral bands with a spatial resolution of 30 metres for Bands 1 to 7. The resolution for band 8 (panchromatic) is 15 metres. All bands can collect one of two gain settings (high or low) for increased radiometric sensitivity and dynamic range, while band 6 collects both high and low gain for all scenes. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi).

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images consist of nine spectral bands with a spatial resolution of 30 metres for bands 1 to 7 and 9. New band 1 (ultra-blue) is useful for coastal and aerosol studies. New band 9 is useful for cirrus cloud detection. The resolution for band 8 (panchromatic) is 15 metres. Thermal bands 10 and 11 are useful in providing more accurate surface temperatures and are collected at 100 metres. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi).Principal component analysis was run using band 10 and 11 and the first component employed to detect cloud-contaminated pixels. With respect to identification of cloud-shadow pixels, a simple algorithm based on bands 3 and 4 as employed by Meng et al., (2009) was used.

The algorithm follows the presumption that deep and clear water bodies have relatively similar spectral characteristic as the cloud-shadows.

While water bodies reflect equal amount of radiation in bands 3 and 4, cloud-shadows on the other hand tend to reflect more energy in band 4 than in band 3. Thus, based on the ratio of band 4 to band 3, water pixels having a ratio close to unity were masked off and a mask of cloud-shadow pixels with a ratio about 1.3 generated. Both masks of cloud-covered pixels and pixels contaminated by cloud-shadows were mosaiced, the product then used to mask off co-located pixels in each band resulting in cloud-free and cloud-shadow-free image bands. These procedures were implemented for each of the contaminated images, using image-based threshold. Image gap-filling in the respective anniversaries was not possible as the available images with co-located clean pixels were of different season and therefore, could not temporally match. Since the gaps were few and small in size, it was assumed that land cover change analysis would be less affected by eliminating such co-located gaps/pixels from the analysis.

Conversion of images,Digital Numbers (DN) representing measured radiance of the earth surface back into absolute radiance was necessary with the objective of performing comparative analysis of several images acquired at different times. Subsequent conversion to radiance to top-of-atmosphere reflectance was needed for a more accurate comparison of images across different dates. The procedure applied by Sobrino et al., (2004) andChander et al. (2009) was followed, using calibration coefficients included in each scene's metafile and also available in the look-up table.

The flowchart in Figure.3.2 illustrates the approach/framework followed in land-cover change analysis.

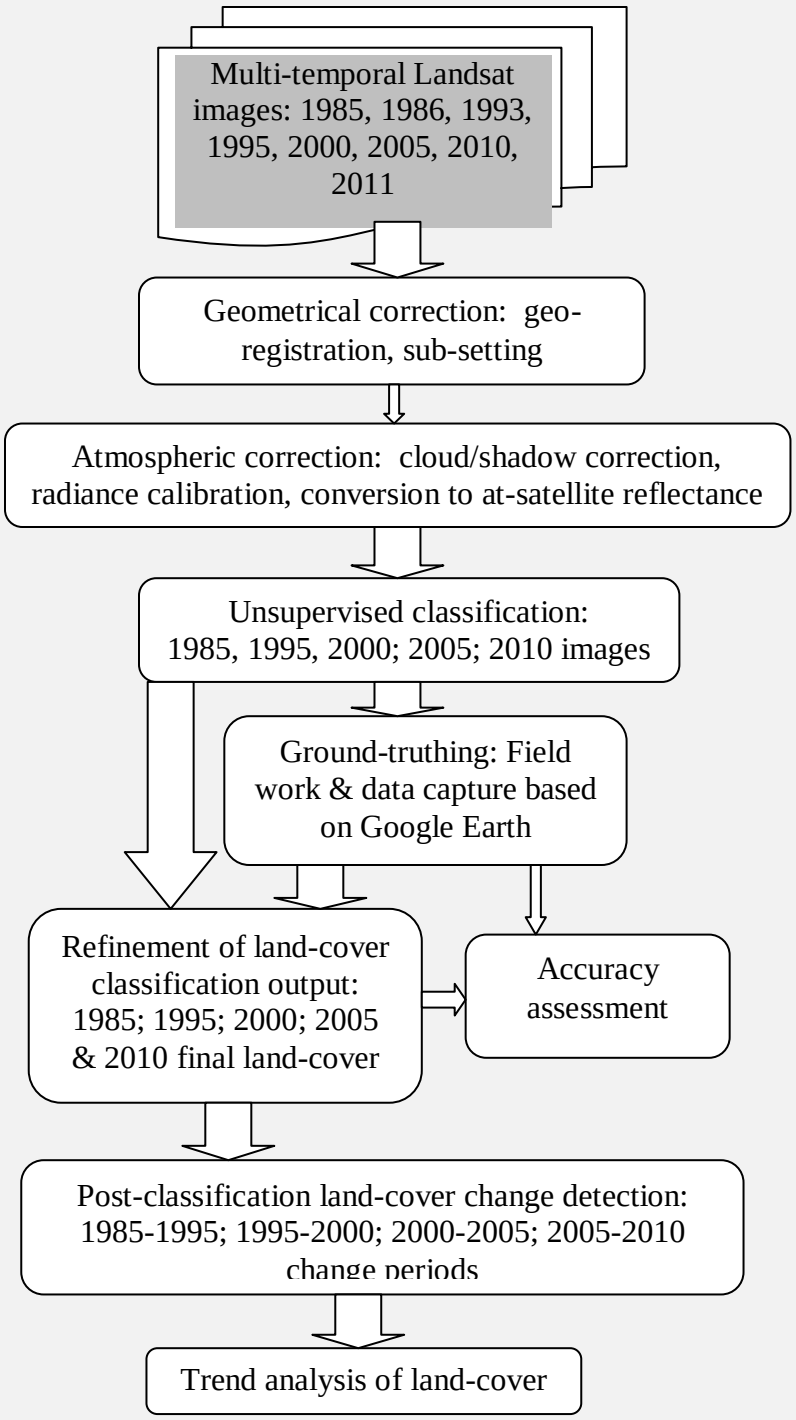

Figure 3.2: Flowchart illustrating land-cover change analysis approach

Source: Kiama and Kagombe, (2012)

Reference data were needed to train the supervised classification algorithm as well as assessing the accuracy of generated maps. Prior to field campaign, Landsat image of January 2009 was used to run ISODATA unsupervised classification, generating six (6) classified land cover classes as potential types that had been determined during an earlier reconnaissance field visit in January 2012. These classes were forest/woodlots; tea farms; water bodies; moisture deficit vegetation; dry/senesced vegetation; and bareland.

The first field campaign was conducted during the dry season of February 2012, complemented by later efforts in February 2013. Although the study area does not experience severe dry spells, it was possible to discriminate annuals from perennials. However, due to the small sizes of the crop fields against the spatial resolution of Landsat images, the final scheme for each target anniversary was aggregated into three major land cover classes, namely; forest or woodlots, tea plantation and others. A total of 74 reference sites were visited being representative of these land-cover types. Google Earth (having IKONOS image acquired in 2000 as the background) was also used to capture additional data from 374 sample sites (mainly tea plantation and forest/woodlot) meant to complement the ground-truth data.

Development of reference data for other historical anniversaries followed the approach employed by Yuan et al., (2005) by examining the correspondence between the reference data and respective images to be certain that the general land cover class was the same. Areas that were not similar or could not be ascertained were discarded from the reference data of the target historical anniversary. For each anniversary, the respective final reference data were randomly split into two sets (training and accuracy

assessment) using ArcGIS tools. The training set was employed to run supervised classification using Maximum Likelihood algorithm implemented in ArcGIS while the other set was used to independently assess the accuracy of the output land cover map. The use of producersusers and overall accuracy has often been used as robust measure of accuracy and assessment of error patterns of the classification maps generated from digital image classification (Mas, 1999; Xie et al., 2008; Nori et al., 2008). Similarly, in this study, respective confusion matrices were generated as a way of measuring the accuracy of the maps.

As noted earlier, post-classification land-cover change analysis was undertaken between target anniversaries but ignoring those co-located pixels that were contaminated by cloud/shadow. Three periods were targeted for change analysis beginning with the anniversary acquired at an early stage during dam construction to as late as 2009 anniversary, thus 1987 to 1995; 1995 to 1999; and 1999 to 2009 anniversary periods. The analysis focused on establishing the change in extent of surface areas of key land cover types and determining where there was occurrence of land cover change and between which land cover categories.

3.8.4 Interview Schedule

The socio-economic survey was used to collect information on the willingness of farmers to adopt conservation activities that would improve watershed management and also the willingness of downstream users to pay for the conservation activities. In considering the willingness of the consumers to pay for conservation, the target consumers of water included individuals, industries and institutions. Data collected included socio-economic status, costs, and conservation activities. In addition,

opportunity costs for conservation activities were determined through contingent valuation method which is a survey-based approach, used to measure the non-market values of environmental or public goods based on how an individual responds to a question on his/her WTP to environmental changes (Hoevenagel, 1994; Stewart & Khan, 2006). The two principal assumptions underlying this method are: (1) that people have well-ordered, but hidden, preferences for all kinds of environmental goods; and (2) that people are capable of transforming these preferences into monetary values (Hoevenagel, 1994). On the basis of these assumptions, the CV method elicits values for environmental goods by presenting respondents with a description of a proposed hypothetical scenario or environmental change and asks the respondents to express (in monetary terms) their maximum willingness–To-Pay (WTP) to enjoy a positive change or the minimum compensation they would demand, Willingness –To –Accept (WTA) to reduce a negative change.The interview schedule used is in Appendix 1, 2 and 3.

3.8.5 Focus Group Discussions

The key stakeholders in Watershed Protection were brought together to elicit their views in protection of the environment and incentives that could be put in place to enhance their efforts.A facilitator moderated each focus group discussion. Each FGD had ten 10 to 15 participants selected from the leaders of the group. The FGD were held at the offices or designated meeting point for the group. A checklist for the interview is in Appendices 4 and 6.

3.8.6 Transect Walks

River-line transect walk was carried out in the three main rivers;Kayuyu, Thika and Githiga that supply water to Thika dam. Transect walk was done from the dam to the edge of the forest. Information on the width of the river, trees speciesplanted type of vegetation and crops plantedupto five metres from the river, and distance from the river to the nearest cash crop and soil conservation measures were collected after every 500 meters. Data collection points were geo-referenced. The aim was to get a view of the conservation status as a precursor to PES in the area.

3.8.7 Policy Analysis, Legal and Institutional Framework Analysis

A detailed analysis of existing policies, legal and institutional framework required to support PES for watershed protection was carried out through review of policy documents related to natural resource management. This identified main strengths, weaknesses, and opportunities in PES implementation.This was supplemented by discussions with key officers in the Ministry ofEnvironment, Water and Natural Resources on the implementation of related policies. The PES analysis also compared best practices in other countries where PES has been implemented. Analysis of policy, legal and institutional frameworks was guided by a checklist in appendix 5.

3.8.8 Data Analysis

Data collected on trends were analysed using Autoregressive Integrated Moving Average (ARIMA) model of time series that focus on seasonality and moving averages, to determine trends and changes(Asteriou et al., 2011). Parametric and non-parametric data collected during surveys were analysed, first by descriptive statistics, correlations

analysis, causal analysis and significance of the differences determined. The data were then scored and ranked and then scores/ranks converted to mean scores so as to use one –way analysis of variance (ANOVA) for 2 independent variables. Mann Whitney U test was used to compare 2 independent variables, while Kruskall Wallis test was used to compare more than two independent variables. A generalized linear regression model was used to relate water quality and quantity with conservation efforts. Econometric model was used to relate variables contributing to WTA and WTP.

3.8.9 Satellite Data Image Interpretation

The Forest Cover Change (FCC) Landsat data over a period of25 years were interpreted on the computer screen based upon spectral patterns withvisual features classified by interpretation elements (shape, size, texture, location, association and pattern) using approach used by Nori et al., (2008). Thematic scenes arising from the visual interpretation were digitised using Geovis software. Ground truthing and use of local knowledge of the area as well asAfricover Land cover/use was used to validate the information generated from satellite imagery. Land use and land cover maps for the 30 years under consideration bearing major classes such as woodlands, shrubs; grasslands among others were generated. Finally, a spatial analysis was done to reveal land cover/use changes over the years.

3.9 Sources of Data

The study used both primary and secondary data sources. Primary data were obtained from the study sites by use of semi-structured interview schedule, questionnaire and Geographical Information System (GIS). Primary data included; socio-economics household information, land use changes, conservation activities,

willingness to adopt conservation practices, willingness to pay for ES, institutional and legal framework for PES.

Interviews were administered to land users and foresters in the dam catchments area, water users, key informants, managers of institutions supplying water, large consumers of water, tea factories and water treatment companies. The issues captured during water supplier interviews included socio-economic data affecting the households, land use practices, conservation activities, threat to water catchments, incentives to conservation, farm size changes over time and level of soil and water conservation related activities. On the user side, issues captured for consumer included; socio-economic household data that affect economic decision, quantity of water consumed per household, alternative water sources, reliability of water source, quality of water, relation of water supply and conservation activities and willingness of the water user to pay for conservation of watershed.

Secondary data was collected from reports, books, public records, data sets held by institutions. These included; rainfall trends, intake and outtake of water in the dam, development planning, on-farm tree planting, infrastructure growth, community structures, livelihood options for the farmers, policy and legal frameworks, household characteristics, history of the dam, trends of water use by consumers and challenges in water provision.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 General Overview

This chapter covers results of data collected from the field and the discussion of the same findings. The main objective of the study was to evaluate the potential of payment for watershed protection in Thika dam catchment, Gatanga Sub-County, Murang'aCounty. The chapter is organized into six sections as follows; demographic information of the study respondents, land use trends in the area and effect on water flow and quality, catchments conservation activities and willingness of farmers to accept payment, conservation of watersheds and willingness of water consumers to pay for management of watershed, economic incentives provided by consumers to farmers in support of watershed protection and finally institutional, policies and legal framework in place to support PES work in Kenya.Results obtained are presented by use of bar charts, pie charts, tables of frequency distributions, and the findingsare discussed in relation to the objectives.

4.2 Demographic Data of the Respondents

4.2.1 Gender and Age of the Respondent in the Study Area

The study targeted a sample of 337 heads of households from upper Thika dam catchment and 339 water consumers in the lowerparts of the dam. In addition, the study covered institutions in Thika that consume large quantities of water, CBOs within the area, tea factories and institutions dealing with water supply and treatment. Out of the

337 heads of households in upper catchment, 54.3% were males while 45.7% were females as shown in Table 4.1.

Age	Gender				Total	
	Male		Female			%
	n	%	n	%	n	
18 – 25	9	3	3	0	12	3.6
26 – 30	20	6	15	4	35	10.4
31 – 40	42	12	50	15	92	27.3
41 – 50	52	15	41	12	93	27.6
51 – 60	36	11	28	8	64	19
Above 60	24	7	17	5	41	12.2
Total	**183**	**54**	**154**	**46**	**337**	**100**

Table 4.1: Gender and age of heads of households in the upper Ndaka-ini catchment

As shown in Table 4.1, majority of the respondents (69%) were 50years and below, with about 55% in the 31 to 50 years age bracket. Few youthsin the age bracket (18-25) years comprising 3.6% of the respondents participated in the survey.

4.2.2 Education Level of Respondents

Table 4.2 shows that most household heads had attained either primaryor secondary education level, with 47.8% heads of households with primary education while 37.7% had secondary education.Chi-square test showed that there was no gender differences in education level attained, at $p<0.05$ level. This shows that both males and

females did not differ significantly in education level attained. The community had high literacy level with only 4.2%respondents with no formal education.

Table 4.2: Heads of household's education level versus gender in Ndaka-ini

Education level	Gender				Total		Chi- square statistics
	Male n	%	Female n	%	n	%	
No formal education	6	2	8	2	14	4.2	χ^2=5.513
Primary	80	24	81	24	161	47.8	
Secondary	73	22	54	16	127	37.7	df=4
College	22	6.5	10	3	32	9.5	
University	2	0.5	1	0	3	0.9	
Total	**183**	**54**	**154**	**46**	**337**	**100**	Sig.=0.239

Not significant at p<0.05 level

Farmers' ability to acquire, process and use information can be increased by educationwhich has been shown to be positively correlated with farmers Willingness-To- Pay (WTP) and Willingness-To-Compensate (WTC) for improved land and water management practices (Tegegne, 1999; Asrat et al.,2004). Education is expected to reflect acquired knowledge of environmental amenities and as established byZbinden and Lee (2005), level of education of the household decision maker determines their ability to obtain and process information and to implement knowledge intensive conservation practices and agricultural technologies.

4.2.3 Household size in Ndaka-ini Water Catchment

Results from Table 4.3 show that 41.5% of respondents were living with 6-10 people, 39.2% were living with 1-5 people in their houses, while 5.6% indicated that they lived with more than 15 people in their houses.

Table 4.3: Household size for farmers in Ndaka-ini water catchment area

Household size	n	%
1-5	132	39.2
6-10	140	41.5
11-15	46	13.6
Above 15	19	5.6
Total	**337**	**100.0**

Household size was below the ones reported in 2009 population census that indicated50.4% of households in Murang'a county had 1-3 persons per household (Wiesmann et al., 2014). Size of household is related to number of children per household. Household sizes have been shown to have a direct positive effect on the household water consumption (Hanke&Maré, 1984; Lyman, 1992).

4.2.4 Main Occupation of Respondents

The main occupation of house headsas presented in Figure 4.1 showed that 92.0% of the respondents were farmers, 4.2% were government employees whereas 0.6% were employed in the private sector. The survey targeted farmers and farming practices implying that majority of respondents were the desired target and so the follow-up responses were likely to achieve desired results. Farmers are the key determinants in success of PES as they are expected to make major decisions on willingness to accept incentives in conservation.

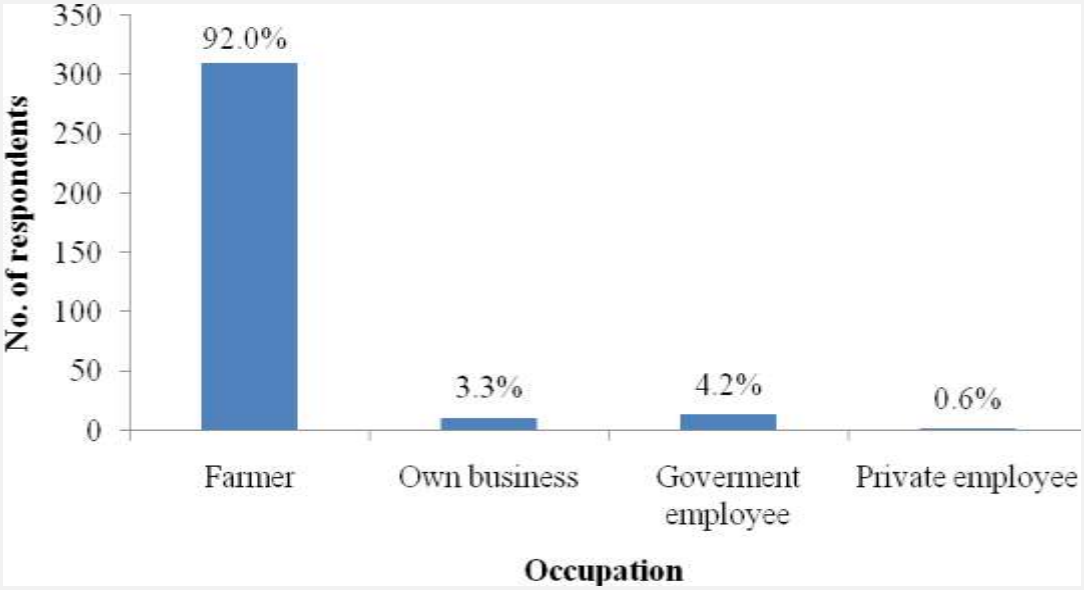

Figure 4.1: Main occupation of the heads of households in Ndaka-ini

4.2.5 Food Security in Ndaka-ini Water Catchment

The survey sought the livelihood position of farmers from the perspective of households' food sufficiently as shown in Table 4.4.

Table 4.4: Food security perception for the household in Ndaka-ini within the year

Description of households food security	**n**	**%**
Dependent on season (require food only when crop season fails)	261	77.5
Have sufficient food all the year round	63	18.7
Need food support all the year round (needs food support in all seasons)	13	3.9
Total	**337**	**100.0**

As shown in Table 4.4, 77.5% heads of households reported that their food supply for their families was dependent on the season, 18.7% had sufficient food while

3.9% needed food support all the year round. This is an indication of livelihood base of the community as majority depend on what they harvest from the farms with few having alternative livelihood base. Farmers in the area depend on rain-fed agriculture and failure of rains may haveled to food insecurity.

4.2.6 Main Crops Grown in Thika dam Catchment

Results in Table 4.5 showed the main crops grown by the households in the farms, segregated into crops grown next to the river, those grown in the mid-slopes and those grown in upper slope. Main crops grown next to the river were trees and vegetables, while tea and maize were grown in mid-slope and upper slope. Results showed that, for those who planted crops next to the river, 25.5% planted trees, 24% planted vegetables and 13.6% planted tea. For those who planted crops in the mid slope, 34.7% farmers planted tea, 29.7% planted maize and 15.7% planted trees. Among the respondents who planted their crops in the upper slopes, 37.7% planted tea, 35.9% planted maize and 9.2% planted trees. Most respondents (72.4%) planted tea in mid and upper slope, while trees and vegetables were planted along the river.

Table 4.5: Proportion of Vegetation grown in Thika

Position in the slope	Proportion of vegetation (%)						Total
	Tea	Maize	Vegetables	Napier grass	Trees	Others	
Next to river	13.6	10.1	24	12.8	25.5	14	100
Mid slope	34.7	29.7	1.5	9.5	15.7	8.9	100
Upper slope	37.7	35.9	0.6	7.4	9.2	9.2	100

Table 4.6: Crops grown in different parts of the farm in the study site

Crops grown next to the river	a) Crops grown in the mid slope						Total No	% No.	Chi-square statistics
	Tea	Maize	Vegetables	Napier grass	Trees	Others			
Tea	15	17	1	1	12	0	**46**	**13.6**	χ^2=379.882
Maize	5	2	1	0	26	0	**34**	**10.1**	
Vegetables	22	34	2	9	14	0	**81**	**24**	
Napier grass	19	21	0	3	0	0	**43**	**12.8**	
Trees	53	13	1	19	0	0	**86**	**25.5**	df= 25
Others	3	13	0	0	1	30	**47**	**14**	
Total	**117**	**100**	**5**	**32**	**53**	**30**	**337**	**100**	Sig.=0.000 *

Next to the river	b) Crops grown in the upper slope							Total No.	% No.	Chi-square statistics
	Tea	Maize	Vegetables	Napier grass	Trees	Coffee	Others			
Tea	15	23	0	6	2	0	0	46	13.6	χ^2=354.108
Maize	4	13	1	1	15	0	0	34	10.1	
Vegetables	41	30	0	9	1	0	0	81	24	
Napier grass	2	27	1	0	13	0	0	43	12.8	
Trees	50	27	0	9	0	0	0	86	25.5	df= 30
Others	15	1	0	0	0	1	30	47	14	
Total	**127**	**121**	**2**	**25**	**31**	**1**	**30**	**337**	**100**	Sig.=0.000 *

In the mid slope	c) Crops grown in the upper slope							Total	% No.	Chi-square statistics
	Tea	Maize	Vegetables	Napier grass	Trees	Coffee	Others			
Tea	67	32	1	2	14	1	0	117	34.7	χ^2=510.179
Maize	51	41	1	6	1	0	0	100	29.7	
Vegetables	1	4	0	0	0	0	0	5	1.5	
Napier grass	4	12	0	16	0	0	0	32	9.5	df=30
Trees	4	32	0	1	16	0	0	53	15.7	
Others	0	0	0	0	0	0	30	30	8.9	
Total	**127**	**121**	**2**	**25**	**31**	**1**	**30**	**337**	**100**	Sig.=0.000 *
%	**37.7**	**35.9**	**0.6**	**7.4**	**9.2**	**0.3**	**8.9**	**100**		

***Significant at $p<0.05$ level**

A cross tabulation was done to compare vegetation grown next to the river with mid slope and upper slope; and then vegetation in mid slope and that in upper slope as shown in Table 4.6.Chi-square test results showed significant differences in crops grown next to the river, in the mid slope and in the upper slope, at $p<0.05$ level. Location of crops within the slope is likely to have implication on sediment load going into the rivers due to the tilling method applied and resultant soil erosion after the rains. Soil conservation measures such as grass strips lead to reduced sediment load to the rivers (PRESA, 2011). The main challenge in the area was vegetation planted along the rivers as the mid and upper slopes were mainly covered by tea. Payment for ecosystem service in the area should address interventions that reduce sediment loads focusing mainly in vegetation planted along the rivers and soil conservation measures practised in the farm.

4.2.7 Land Ownership Status in the Study Area

Results on land ownership in the area as shown in Table 4.7indicated that majority (97.6%) of the respondents owned individual land parcels while 1.8% had family land, with very little land under communal ownership. Land tenure has been shown to have influence on management of natural resources with many environmental problems such as soil degradation and forest depletion characterized as a result of incomplete, inconsistent and non-enforceable property right (Bromley&Cernea, 1989; Watchter, 1992). In addition, potential for PES is more favourable in individual land ownership as it gives continuity of service provision for a long time (Wunder et al.,

2005). This shows that land ownership in Ndaka-ini was favourable to PES implementation.

Table 4.7: Land ownership status per household in Ndaka-ini catchment

Land ownership	n	%
Individual	329	97.6
Family	6	1.8
Leased	1	0.3
communal	1	0.3
Total	337	100

4.2.8 Location of Farms from the Dam and Forest Edge

The study sought to find out the location of respondent farms from the dam and the forestedge as shown in Table 4.8. Majority of respondents' farms (54.3%) were located within 5kmfrom the dam while 19.3% were located in between 6 to 10 km from the dam. On the other hand, 38%, of respondents' farms were located within 5km from the forest edge while 22.2% were located within 6 to 10 km from the forest edge. Chi-square test results shown in Table 4.8 revealed that there was a significant relationship between distance of the farm from Thika dam edge and forest reserve border, at $p<0.05$ level. This implies that majority of the farmers were not far from the Thika dam and forest reserve border. Proximity from the dam and forest could determine the farmer dependency on the ecosystem with those near the forest being more dependants. It could also affect the sediment load going to the dam that is due to farmers' farming practices. On the other hand, proximity to the dam may affect respondents understanding of the relationship of the dam to livelihood of the community and their understanding on the same. While the distance from the dam to the forest is about seven kilometres, some of the sampled farmers were more than seven kilometres from the forest. These were

farmers in the catchment area of Kiama and Chania rivers that supplement water from the dam through their connection with Thika – Ngethu tunnel.

Table 4.8: Distance from Respondent Farm to Forest Reserve and Thika dam

Distance of farms from the Dam (KM)	Distance of farms from forest reserve border (KM)						Total No.	% Total	Chi-square statistics
	1 to 5	6 to 10	11 to 15	16 to 20	21 to 25	26<			
1 to 5	91	46	18	11	5	12	**183**	**54.3**	χ^2=121.773
6 to 10	27	12	13	11	2	0	**65**	**19.3**	
11 to 15	3	9	12	14	7	0	**45**	**13.3**	
15 to 20	2	4	8	7	2	2	**25**	**7.4**	df=25
21 to 25	3	1	1	1	6	0	**12**	**3.6**	
26 and above	2	3	0	2	0	0	**7**	**2.1**	
Total	**128**	**75**	**52**	**46**	**22**	**14**	**337**		Sig.=0.000*
% total	**38**	**22.2**	**15.4**	**13.6**	**6.5**		**4.2**	**100**	

***Significant at p<0.05 level**

4.2.9 Soil Conservation Measures in Thika dam Catchment

The study revealed different types of soil conservation measures are practised in the study area as shown in Table 4.9. Results showed that 22.6%, 18.1%, and 14.5% of the respondents are engaged in tree planting, terraces and contour planting respectively. Other conservation measures practised were hedge row planting, grass strips farming and contour digging. Results showed that at least 91.1% of the respondents were practising some form of conservation in their farms.

Table 4.9: Type of Conservation Measures Farmers are Practicing in the Study Area

Type of conservation measures	n	%
Tree planting	76	22.6
Terraces	61	18.1
Contour farming	49	14.5
Hedge rows planting	43	12.8
Grass strip planting	39	11.6
Contour digging	39	11.6
No response	30	8.9
Total	**337**	**100.0**

For PES to be successful there is need to consider conservation preferences of landholders and land managers targeted for participation (Kaczan et al., 2012).Environmental management measures that are locally prioritized and implemented using participatory approach have been shown to be effective in tackling environmental problems(Balana et al., 2010; Baland&Platteau, 1996; Herath, 2004; Ostrom, 1990). Studies in Kapingazi showed that farmers preferred adoption of riparian area management by removing eucalyptus trees planted along the rivers, capacity building on good environmental practices and diversification of income base by introducing nature-based enterprises like bee keeping that would lead to a win-win in economic and environmental impacts (Balana et al., 2011).

Conservation practice in place may determine the adoption rate of introduced technology due to the past experiences farmers will have gained on the same. Payment for environmental service is dependent on farmers adopting best management practices

that can improve soil conservation practice and lead to reduced sediment load (PRESA, 2011). Studies in Sasumua showed that contour farming combined with grass strips had highest effects of reducing sediment load, followed by terracing, contour farming and grasses waterway (Namirembe et al., 2013). As a result, working with farmers who had prior knowledge on conservation practices as depicted was a good entry point for PES.

4.3 Water Consumers in the Downstream of the dam

The study targeted water consumers within GatangaWater and Sewerage Company area.Water consumers included individual households in Gatangaand large institutions within and aroundThika town. Out of the 339 water consumers interviewed, 59% were males and41% were females. Table 4.10 shows age of the water consumers.

Table 4.10: Age of Water Consumers respondents in Gatanga

Age in years	n	%
18 – 25	8	2.4
26 – 30	56	16.5
31 – 40	61	18.0
41 – 50	112	33.0
51 – 60	63	18.6
Above 60	39	11.5
Total	**339**	**100.0**

As shown in Table 4.10, 33.0% of the respondents were aged 41 to 50, 18.6% between 51 – 50 years and 18% were between 31-40 years old. Overall, 69.9% of respondents were 50 years and below. A study by Grafton et al., (2009) haveshown thathousehold characteristics that include the number of people in the household (adults and children), size of household, level of education and household income has statistically significant and positiveeffects on household water consumption.

As shown in Table 4.11, 58.1% of the respondents in Gatangahad attained primary education, 30.7% had attained secondary education while 6.2% had attained tertiary education. This indicates a community with high literacy level with only 5% of respondents without formal education. The results correspondwith 2009 census data that showedMurangaCounty had high Literacy level (KNBS, 2010).

Table 4.11: Level of Education of Water Consumers in Gatanga

Level of formal education	n	%
Primary	197	58.1
Secondary	104	30.7
College	17	5.0
University	4	1.2
No formal education	17	5.0
Total	**339**	**100.0**

The survey sought to identify the occupation of the consumers of water in the study are as shown in Table 4.12. Results showed that 87.9% of respondents were farmers, 9.7% owned business and 1.5% were government employees.

Table 4.12: Water Consumers' Main Occupation in Gatanga Water Company Supply Zone

Occupation of household	n	%
Farmer	298	87.9
Own business	33	9.7
Government employee	5	1.5
Private employee	2	0.6
Pastoralist	1	0.3
Total	**339**	**100.0**

The main occupation of respondents was farming hence the respondents could make decisions on conservation practices within the homestead. It also shows that the respondents had narrow stream of income source as they were predominantly dependent on farming. This may lead to a challenge in payment for ES due to low income level of respondents which could affect their ability to contribute to PES.

To get an insight on level of understanding on trends in conservation and water use, respondents were asked to state the period they had lived within the area (Table 4.13).

Table 4.13: Number of Years Lived Within Gatanga Water Company Supply Zone

Years	n	%
1 – 5	3	0.9
6 – 10	18	5.3
11 – 15	59	17.4
16 – 20	129	38.1
21 – 25	90	26.5
Above 26 years	40	11.8
Total	339	100.0

Table 4.13 shows that, 38.1% of the respondents had lived in that locality for 16-20 years, 26.5% for 21-25 years, 17.4% for 11-15 yearsand 11.8% had lived in the locality for more than 26 years. This implies that majority of the water consumers had lived in the locality for over 16 years and therefore, had better understanding of trends in the area. Years of farming experience influence the production efficiency as well as the marketing links and skills a farmer can possibly have while reducing the mistakes a farmer makes in production thus improving the performance of such a farm (Mwangi et al., 2015). Table 4.14 shows reasons as to why the respondents (water consumers) and their familyhad lived inthe area.

Table 4.14: Reasons as to Why Water Consumers Lived in the Gatanga Area

Reason for staying	**n**	**%**
Born in the area	236	69.6
Marriage	54	15.9
Economic reason	10	2.9
Political reason	13	3.8
Bought land	21	6.2
Rented house	5	1.5
Total	**339**	**100.0**

Table4.14 shows that 69.6% water consumers indicated that they were born in the community, 15.9% were married in the area, 6.2% had bought land and 1.5% had rented houses in the community. Duration of time spent in the area was important in answering trend analysis questions probed during the survey. Respondents who have

stayed in the locality for a long time are likely to give more information on the trends in land use changes as this happened during their lifetime.

4.3.1 Large-scaleWater Users

Among the 30 large-scale water users sampled inThika, 46.7% were industries, 16.7% were educational institutions, 16.7% were catering providers, 10.0% were health institutions and 10% were rental units. All the institutions were supplied with tapped water. Table 4.15 shows average water bill per institution.

Table 4.15: Average Water Bill per Month for Institutions within Thika town

Amount in Kshs.	n	%
5001 - 50,000	16	53.3
50,000 - 100,000	6	20.0
100,001 - 150,000	2	6.7
150,001 - 250,000	6	20.0
Total	**30**	**100.0**

Results as shown in Table 4.15indicate that most (53.3%) of the institutions were paying an average bill of Kshs. 5,001-50,000 per month while an additional 20% were paying between 50,000 to 100,000 per month. Water bill paid by an institution could be an indicator of their dependence on water source and their likelihood to support conservation effort in the catchment areas.

Figure 4.2 shows that 23.3% of the water managers interviewed reported that the approximate distance from their institutions to the water source was 1-5 km, 56.7% indicated 6-10 km while 20.0% indicated that it was approximately 11-15 km. The researcher further sought to find out sources of water in those institutions. In response

to this, all the managers cited Thika Water and Sewerage Company (THIWASCO) and Chaniariver as their water service provider and the main source of water supply respectively. All the managers indicated that there was a link between water they get in their institutions to conservation of water sources as shown in Figure 4.2. This offers useful link for PES introduction in the area.

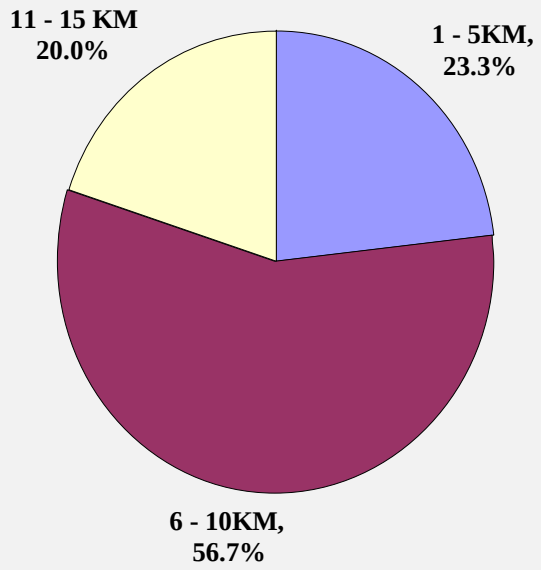

Figure 4.2: Approximate distance of the institution in Thika from the water source

The managers of institutions further reported that there was a link between the quantities of water supplied to conservation activities as shown in Table 4.16. Main link was bills they received for water supplied and tree planting/reforestation activities.The other link was conservation of water catchment areas (20.1%) and afforestation (20%) followed by creating awareness on good water conservation activities and efficient use of water resources. This provides a leeway for PES as conservation and tree planting activities together contribute to 40.1% that could be tied to the incentive provided through payment of water bills.

Table 4.16: Link between Water Supplied in the Institution to Conservation of Water Sources

	n	%
Paying bills	10	33.3
Afforestation/ planting of trees	6	20.0
Better conservation of water catchment areas	6	20.1
Efficient use of water resources	2	6.7
Awareness	2	6.7
Total	**30**	**100.0**

These links could build a case for the conditions that may be attached to PES as they are likely to influence the water institutions in supporting conservation practices. The users of water services are likely to support incentives aimed at sustaining and/or strengthening an identified link. While a third of the users could connect water supplied with water bills, the other two thirds indicated a connection of water supplied to conservation efforts. This means that activities aimed at improving conservation would be welcome by consumers.The managers of the institutions indicated that there are major threats to water catchment areas as shown in Table 4.17.

Table 4.17: Institutions Perception on Threats to Ndaka-ini Water Catchment Areas

Threats	n	%
Pollution	9	30.0
Mis-management of farms	6	20.0
Deforestation and forest encroachment	6	20.0
Climate change	4	13.3
Ignorance	2	6.7
Illegal water connections	2	6.7
Land use change	1	3.3
Total	**30**	**100.0**

As shown in Table 4.17, the respondents indicated that the main threats to water catchment areas were; pollution (30%), mismanagement of farms(20%), deforestation and forest encroachment (20%). This indicates that there are areas PES could intervene to improve the catchment areas. All the managers agreed that they had a role to play in order to improve water supply in the institutions and also contribute towards conservation activities. The response from managers reflected challenges faced by water catchment areas as contained in Kenya Water Masterplan that include;Land degradation and soil erosion, poor management of water resources, water insecurity, poor waste management and livelihood insecurity stemming from land degradation of water catchment areas among other (MENR, 2012).

The institutions were willing to provide incentives towards conservation of water sources as shown in Figure 4.3.

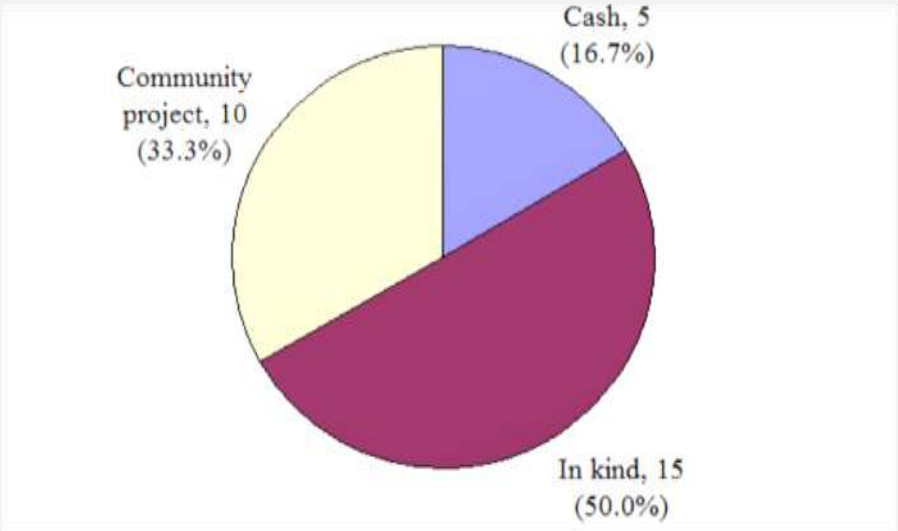

Figure 4.3: Types of incentives managers are willing to give to support conservation activities in Ndaka-ini

Among the 30 managers who took part in the study, 50.0% were willing to offer support in kind, 33.3% were willing to support community project while 16.7% were willing to give cash. Further enquiry showed that cash of incentivesmanagers were willing to provide per month varied from Kshs. 1,000 to 200,000 as shown in Table 4.18.

Table 4.18: Cash incentives managers in Thika were willing to give to support conservation

Amount in Kshs. Per month	n	%
1000 – 10,000	8	26.7
10,001 – 30,000	16	53.3
30,001 – 50,000	1	3.3
50,001 – 75,000	3	10.0
150,001 - 200,000	2	6.7
Total	**30**	**100.0**

As shown in Table 4.18, over 50.0% of the managers were willing to offer over Kshs. 10,000 per month to support water conservation activities. In return to supporting conservation activities, the institutions attached conditions as shown in table 4.19

Table 4.19: Condition attached to incentive by main water users in Thika

Condition	**n**	**%**
Conservation efforts	13	43.3
Constant water supply	8	26.6
Collective responsibility	6	20.0
Maintain planted trees	2	6.7
Reduction in water bills	1	3.3
Total	**30**	**100.0**

As shown in Table 4.19, the main conditions managers were attaching to the incentives they were willing to provide were to see efforts put in place for water conservation activities (43.3%), having constant water supply (26.6%) and the collective responsibility of the water consumers (20.0%). Conditions attached were in line with enhancing conservation and improving water supply. Study conducted in East Usambara showed that there was a trade-off between the conditionality level and paymentrequired to encourage participation (Karczan et al., 2012).

To get a trend of water demand in future, the managers gave the projected growth of their institutions in the next five years as shown in Table 4.20

Table 4.20: Projected growth of large-scale water users' institution in Thika for the next 5 years

Growth	n	%
1 - 10%	10	33.3
11 - 20%	16	53.3
21 - 30%	4	13.3
Total	**30**	**100.0**

In the next 5 years, 53.3% of water institutions consuming water in Thika indicated that their growth would range from 11-20%, 33.3% of the managers stated that the projected growth in their institutions would range between 1 and 10%, while 13.3% reported that it would range from 21-30%. To accommodate this growth, 80.0% of the managers reported that the projected water demand would be 1-10% while the remaining 20.0% indicated that it would be 11-20%. This means there is need to increase water supply to meet the demand.

4.3.2 Tea FactorieswithinNdaka-ini Area

The main farm occupation in the study area is tea farming which is also the main source of income. As such any consideration for PES must consider returns farmers get from tea. In addition, tea factories are the main contributors to decreased tree cover through the ever-increasingfuel wood demand. Ndaka-ini area and its environments are serviced by four tea factories, namely; Makomboki, Njunu, Mataara and Ngeere. Focus group discussions highlighted the following main environmental issues attributed to the factories; encroachment of riparian areas, intensive use of chemicals fertilizers, over-harvesting of trees arising from high demand of firewood, wastewater management, soil erosion arising from cultivating on steep terrain and planting of exotic eucalyptus

species planted along the river bank. In addition, the managers of factories reported that in 2011, there was frost that led to reduction of tea production by about 35%.

Results from survey showed that all the four tea factories have put in place measures to reduce environmental degradation within the area mainly through the rain forest certification processwhich is implemented through Kenya Tea Development Agency (KTDA). The tea factories are at various levels ofRain ForestCertification whose aim is to promote international standards on best farming practices. Rain Forest Certification target producers as well as factories to adhere to the 10 principles advocated by the standards. The 10 principles are:

i. Environmental protection
ii. Ecosystem conservation
iii. Wildlife protection
iv. Water conservation
v. Fair treatment of employees
vi. Occupation, health and safety
vii. Community relations
viii. Integrated crop management
ix. Soil management and conservation
x. Integrated waste management

The accreditation is done through external audits that have to reach 100% of the producers. The Rainforest Alliance works to conserve biodiversity and ensure sustainable livelihoods by transforming land-use practices, business practices and consumer behaviour (Laurie, 2009).

The factory management develops guidelines aimed at compliance that can give restriction to non-compliant farmers who is denied opportunity of delivering harvested tea to the factory. Conservation practices that are currently carried out by tea factories in the area are summarized in Table 4.21.

Table 4.21: Conservation practices promoted by tea factories within Gatanga

Activity	Implementation status
Capacity building	• Farmers trained on sustainable agriculture through integration of agricultural activities in the whole farming systems • Farmers advised on optimum fertilizer application that results in a reduction of fertilizer application per bush per year
Conservation gains	• Supported enforcement of river bank conservation • Riverline conservation that led to recovery streams of dried up streams(e.g. Nyabui and Karangi) • Improved conservation thorough planting of indigenous trees and crops diversification • Improved tea yield production
Tea processing	• Tea curing changed from use of furnace oil to firewood as its cost is effective and leads to better tea quality. As a result, tea factories provide tree seedlings to farmers to plant in their farms
Firewood supply	• Decreased due to conversion to tea estates and cutting of eucalyptus planted along the rivers
Firewood demand	• Increased leading to factories establishing their own wood lots. Makomboki had bought 40 acres, Ngeere 25 acres,Njunu 296 acres and Mataara 106 acres
Trends in Fertilizer application	• Had a decline from 500 to 700 bushes per one 50kg bag. In addition, fertilizers applied do not have sulphur. Farmers encouraged to use farm manure.

Factory managers reported that the impact of Thika dam on tea production in the area had mainly been positive due to cool conditions arising from high humidity levels. However, the gain made in high tea weight was lost in the factory as more energy is used to dry it.

Tea factories in the study area have over time changed from use of furnace oil to fuelwood in production of steam that is used in tea curing as its cost is effective and produces tea of high quality. Cost of firewood per kilogram of made tea was Kshs 6 compared to cost of furnace oil per made one kilogram that stood at Kshs 18.Some factories had encouraged farmers to plant trees within the tea plantation as wind breaks. Factories faced challenges of sustainability of firewood provision due to rising cost of firewood and transportation expenses. Further interviews with factory managers reviewed that factories had procured land for woodlotplanting as follows; Makomboki, Njunu, Ngeere, and Mataara had bought 40, 296, 25 and 106 acres respectively. They intended to purchase more land for the same.

Payment for Ecosystem Services concept was well received within the tea factory as an idea that can help small-scale tea farmers to forgo activities that are detrimental to environment and create ownership in environmental conservation. However, criteria for computation of compensation should be worked out well. Kenya Tea Development Agencystructure and institutional framework could be used to manage PES scheme as the agency was willing to be intermediary in the scheme as it has formal structures up to the grassroots. Rain Forest Certification was a plus in PES scheme as its activities support environmental conservation and also has means of monitoring as well as compliance enforcement. Tea factories can act as intermediary in PES as tea is main farm occupation covering 80% by farm use and farmers with tea bushes constitute 90% of the population. For PES to work, there is need to increase incentives to participating farmers due to their low economic level, making conservation not a key priority. Incentives in kind were most preferred. Farmers had

prepared a set of by laws for its members along the principles of sustainable agriculture for each tea buying centre.

Fertilizer application in the tea bushes had a decline from 500 to 700 tea bushes per one 50kg bag. This was achieved through improved crop husbandry by proper weather timing while applying soil conservation practices in the farms and riparian areas. In addition, fertilizers applied do not have sulphur and farmers were encouraged to use farm manure. Factory management recognize that fertilizer application had negative effect due to residual effect. This was controlled through minimal level of application, leaving buffer zones along the rivers, and applying when rainfall is not high to avoid leaching effect.

Further interviews with tea managers in the area reviewed a negative trend in tree planting due to conversion to tea bushes. This was also supported by data analysed on land use changes. However, there was an increase in planting fruit trees especially macadamia and avocado. Eucalyptus trees were cleared in riparian areas but are increasingly being planted in upper areas. Main trees planted in tea estate include Grevillea, casuarina and *Hageniaabysinicca.* Fuel wood demand increased with reduced supply leading to shortage as a result of conversion of furnace oil to fuel wood boilers with firewood constituting 80%. This has increased distance and cost of firewood procurement with some factories buying fuelwoodfrom as far as Olkalao and Naivasha.By the time of the survey, the tea factories in the area had bought 106 acres of land in Olkalao and planted eucalyptus fuel wood. Firewood demandincreased further due to high requirements from BIDCO Companythat was sourcing from the same area. Main link of tea factories to PES is the high consumption of fuelwood that can reduce

tree cover in the area hence negatively affecting proposed conservation efforts. The factories can partner with PES implementers to enforce conservation farming as tea is the main land use in the area through rainforest certification process that was adopted by all factories.

4.4 Land Use Changes and Effects on Water Flow and Qualityin Thika dam

4.4.1 Trends in Rainfall and Dam Water Levels

Thika dam reservoir heavily depends on the rainfall in the catchment areas which in turn determine its water level. Rainfall varies during the year and has had variations over the years as shown in Figure 4.4.

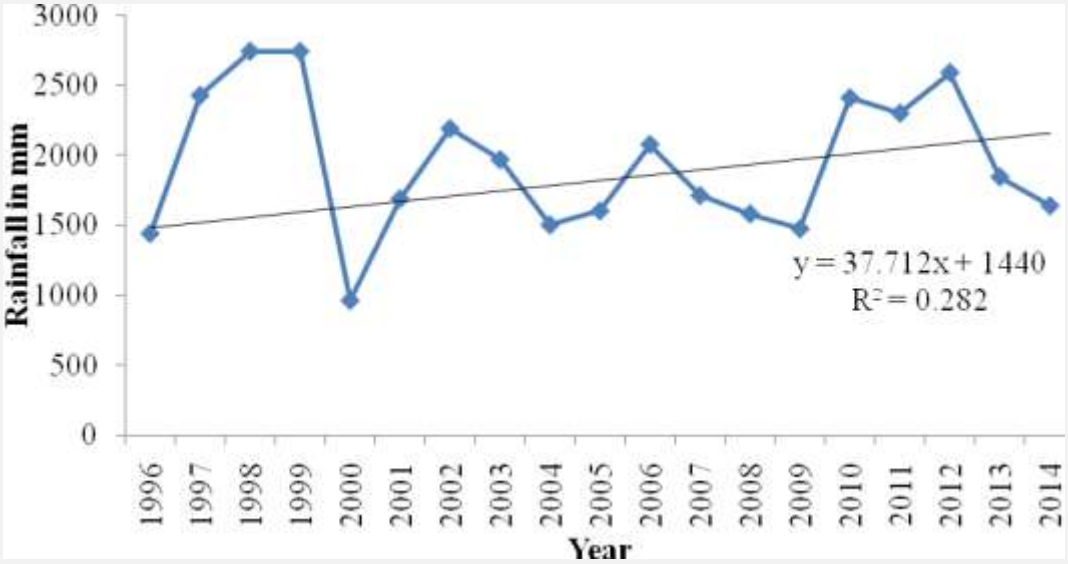

Figure 4.4: Trend in annual rainfall over time in Ndaka-ini

Source:Field analysed data from Nairobi Water and Sewerage Company,(2015)

The catchment has had bimodal rainfall pattern with main peaks in April and November.Results show a slight overall increase in rainfall but the pattern is erratic. However, there seems to be a pattern of low rainfall after every four to five years. Lowest rainfall was recorded in year 2000. Results further showed that rainfall varies

per month as shown in Table 4.22. The purpose of the reservoir is to store water for use by the consumers even in the months where there is no rainfall. This requires planning to ensure continuous flow during dry period. In the past water rationing is done during dry period.

Table 4.22: Yearly and monthly rainfall trends in Ndaka-ini in mm

Year/ Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual rainfall
1996	29.9	126.7	145.1	238.6	274.7	133.5	52.6	29.6	44.8	50.8	218.1	95.9	1440.3
1997	39.5	0	94.5	592.1	269.1	106.3	59.9	52.5	8.4	478.5	574	149.8	2424.6
1998	543.6	237.3	224.1	470.4	552.6	155.7	58.5	71.7	76.4	57.5	271.1	19.3	2738.2
1999	70.7	9.7	255.5	315.6	99.2	11.1	63.8	54.9	26.8	89.7	411.8	462.4	1871.2
2000	5.6	4.2	62	161.3	105.2	34.1	37.2	30.9	48.3	33.3	268.8	172.8	963.7
2001	329.3	26.3	224.3	298.3	237.2	85.8	15.5	38.5	6.4	58.6	258.3	109.3	1687.8
2002	92.4	34.6	158.6	574.6	323.5	45.7	80.2	28.7	75.0	257.3	247.3	270.4	2188.3
2003	39.2	1.7	113.5	342.8	452.7	191.5	14	165.7	52.1	194.4	294.8	104.7	1967.1
2004	93.5	129.4	125.7	395.2	150.8	16.2	7.6	14.3	55.3	197.7	229.6	86.8	1502.1
2005	73.9	10.8	84.1	267.5	558.7	85.3	83.0	35.0	21.7	165.7	204.2	12.1	1602
2006	25.8	8.1	161.8	381.8	529.8	35.1	47.2	107.9	48.2	131.7	332.2	265.1	2074.7
2007	63.5	41	106.8	401.2	314.1	121.6	106.5	128.9	52.5	204.1	130.6	41.1	1711.9
2008	71.9	64.4	204.8	374.9	68.5	24.7	44.1	42.8	33.9	301.6	346.9	2.1	1580.6
2009	49.3	16.8	113.9	212.2	187	18.9	6.3	32.2	62.5	376.1	246	153.5	1474.7
2010	327.5	55.8	353.7	388.5	379.7	84.1	43.2	56.7	14.8	262.6	161.4	178.8	2406.8
2011	13.6	75.4	231.3	384.1	222.5	118.6	49.5	82	112.7	406.9	362.9	238.7	2298.24
2012	18.2	74.8	0	559.6	866.6	94.3	43.5	51.1	16.5	253.5	231.7	377.4	2587.2
2013	150.1	9.3	201.7	674.6	107.5	70.1	32.5	83.8	68.6	20.9	163.4	261.7	1844.2
2014	21.2	160.4	207	171.9	110.3	151.7	31.8	102.2	95.5	208.6	301.3	77.4	1639.3
Mean	**108.4**	**57.2**	**161.5**	**379.2**	**305.8**	**83.4**	**46.2**	**63.7**	**48.4**	**197.3**	**276.5**	**162.1**	**1894.9**
Std	**140.6**	**64.7**	**81.5**	**144.3**	**208.9**	**53.3**	**26.3**	**39.5**	**29.3**	**131.7**	**101.6**	**125.1**	**456.6**
Min	**5.6**	**0**	**0**	**161.3**	**68.5**	**11.1**	**6.3**	**14.3**	**6.4**	**20.9**	**130.6**	**2.1**	**963.7**
Max	**543.6**	**237.3**	**353.7**	**674.6**	**866.6**	**191.5**	**106.5**	**165.7**	**112.7**	**478.5**	**574**	**462.4**	**2738.2**

Source: Nairobi Water and Sewerage Company, (2015)

The level of water in the dam has varied from time of construction and also within specific years. The critical point is the lowest level limit (35,000 million meter cubic) beyond which continuous water flow is disrupted. The dam level reached critical low level in year 2000 and 2009. In specific months within the years, the dam also gets to critical level resulting to water rationing as shown in Table 4.23. The dam level may

be directly related with rainfall trends in the area. As specified earlier, there are two rainfall seasons in the area with peaks in April and October. Timing of the rains within the year is important as in the case of 2009 that was marked as one of the years that dam reached low level, but later in the last three months of the year, heavy rains was experienced thus raising average rainfall for the year.

Table 4.23: Average percentage level of water in Thika dam Level

Year	Month												Year average
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	
1995	99.5	99.1	99.9	100	100	100	100	100	99.8	99.7	100	100	**99.8**
1996	98.8	98	95	98.3	100	99.8	99.1	98.3	96.5	92.5	89.2	92.1	**96.5**
1997	92.8	88.3	80.3	99.7	100	100	100	100	99.9	99.8	100	100	**96.7**
1998	99.9	100	100	100.7	101	99	99	98.5	94.3	87.9	82.1	78.9	**95.1**
1999	74.5	65.7	57.3	54.8	66	75.3	74.1	69.2	63.9	56.8	51	72.9	**65.1**
2000	80.7	76.4	68.1	60.3	55.2	50.7	46.4	42.7	39.1	35.5	33.8	37	**52.2**
2001	46.9	64.5	65.2	66.7	98.2	100	99.2	96.1	90.5	83.8	79.8	79.7	**80.9**
2002	76.3	70.9	65.5	61.4	95.7	100	99.3	95.9	90.9	84.1	88.9	100	**85.7**
2003	100	99.5	95.1	90.5	98.9	100	100	100	98.4	94.7	97.7	100	**97.9**
2004	98.3	94.8	88.8	92.1	100	99.8	97.9	92.6	85.5	78.4	85.1	93.7	**92.3**
2005	94.2	91.1	84.5	82.7	94	100	100	100	99.7	94.7	92.5	89.7	**93.6**
2006	84.6	76.8	69.1	63.8	86.9	100	98.1	93.5	86.8	79.6	77.3	92.5	**84.1**
2007	100	99.7	96.6	93	99.6	100	100	100	100	100	100	99.4	**99.0**
2008	95.3	88.5	78.8	72.9	77.8	77.6	74.8	70.5	65.9	63.8	69.4	75.7	**75.9**
2009	72.3	65.6	57.1	50.1	47.5	48.1	47.1	45.5	43.5	44.5	60.4	73	**54.6**
2010	83.4	92.1	97.1	100	100	100	100	98.1	94.2	90.6	97.9	100	**96.1**
2011	99	95.7	99.7	99.8	99.8	99.9	100	99.9	99.9	100	100	100	**99.5**
2012	100	100	99.8	100	100	100	100	100	100	100	100	100	**100**
2013	100	100	100	100	100	100	100	99.9	99.8	99.7	99.7	99.7	**99.9**
2014	99.8	99.8	99.7	99.7	99.8	99.9	99.9	99.9	99.9	99.8	99.9	100	**99.8**
Monthly average	**89.8**	**88.3**	**84.9**	**84.3**	**91.0**	**92.5**	**91.7**	**90.0**	**87.4**	**84.3**	**85.2**	**89.2**	**88.2**
Min Level	**46.9**	**64.5**	**57.1**	**50.1**	**47.5**	**48.1**	**46.4**	**42.7**	**39.1**	**35.5**	**33.8**	**37**	**52.2**
Max	**100**	**100**	**100**	**100.7**	**101**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: Nairobi Water and Sewerage Company, (2015)

Results show that the dam had the lowest water level in theyear 2000 (52.2%) followed by 2009 (54.6%). The average dam level over the years was 88.2% with variation during the months. The critical point is the low level volume that varied within the month. In November 2000, the dam recorded the lowest level 33.8% followed by October 2000 when the lowest dam level was 35.5%. The NWSC results to water rationing when the dam level is low that affects the users of the services, hence one condition tied to PES is regular water supply. Figure 4.5 shows variation in high and low water levels in the dam over the years. The dam had lowest level in year 2000 that correspond with low rainfall recorded in the same year. The purpose of the dam is to hold water that is used during the dry spell. Forest regulates seasonal flow of rivers thus ensuring continued supply during dry period. They create soil-protective and infiltrative conditions conducive to the water-holding capacity and slow release of water to the catchments which results in a more even distribution flow throughout the year (UNEP, 2012).

The dam level reached the lowest level since its construction in April 2017 as shown in plate 1.

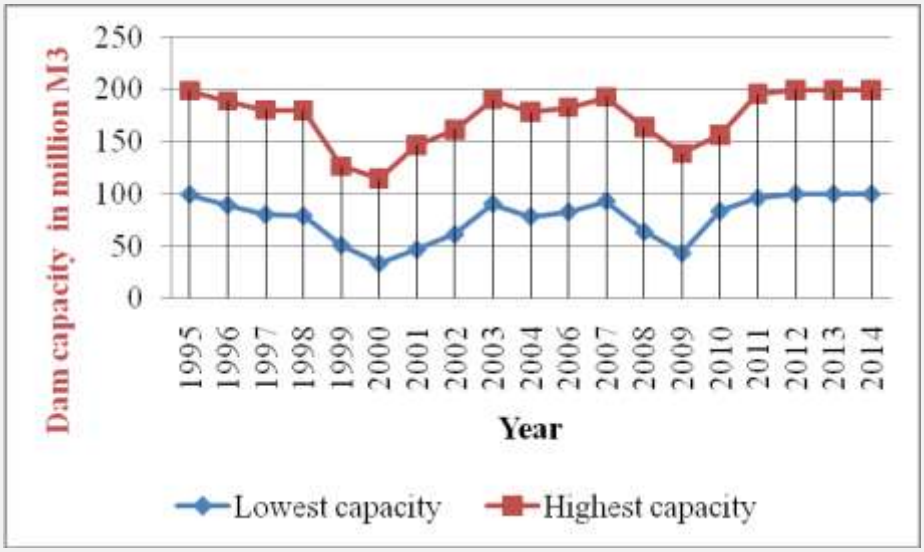

Figure 4.5: Variation of Thika dam level over time

Source: Nairobi Water and Sewerage Company, (2015)

Plate 1: Flutuation in Thika dam water levels

Conservation efforts through PES can contribute to improved dam levels especially during dry spell through regulation of water flow hence providing water for longer period and consequently reducing duration of rationing.

4.4.2 Land Cover Mapping and Change Analysis in Thika dam Catchment Area

The dam construction brought about land use changes within the catchment area excavated as well as resultant changes in land use and land cover in the surroundings. The study used land cover mapping to investigate land cover changes over time from the time the dam was constructed. To quantify land cover change results, the approach used by Nori et al., (2008) was applied where total surface area for each land use/cover types was tabulated and the respective trends across the years examined, demonstrating the kind of land cover changes that occurred during the period of analysis, namely; "from-to" information. Based on the analysis, there was evidence of spatial and temporal land use dynamics especially among the three major land cover classes, all differing in their respective general trend of change as shown in Tables 4.24& 4. 25.

Table 4.24: Analysis of vegetation cover change in hectares within Ndaka-ini

Land cover type	1987	% change	1995	% change	1999	% change	2009	% change
Forest or woodlot	4,076	8	5,486	10	2,927	5	3,344	6
Tea plantation	20,525	39	17,192	32	24,624	46	15,649	29
Others annual crops	28,372	54	30,578	57	25,865	48	34,302	64
Total	52,973	100	53,256	100	53,416	100	53,295	100

Table 4.25: Extent of key land cover types in selected anniversaries in Ndaka-ini

Change analysis period	1987-1995	1995-1999	1999-2009	Average
Gain/loss of tea plantation areas (Ha)	-3,334	7,432	-8,975	-1,625
Gain/loss of forest/woodlot areas (Ha)	1,411	-2,559	417	-244
Gain/loss of areas under annual crops (others) (Ha)	2,207	-4,714	8,437	1,977

Based on zonal analysis, protected forest areas remained relatively stable between 1987 and 2009, while on-farm or within settlement area was occasioned by dynamics related to forest or woodlot cover as well as other two categories as shown in Table4.26. Area under tea reduced in the period 1987 to 1995 due to loss occasioned by dam construction. Area under tea increased in the period 1995 -1999 in contrast to the area occupied by trees and annual crops. However, this was reversed in the next time period, 1999-2009, when area under tea reduced relative to trees and annual crops.

Table 4.26: Zonal analysis of forest/woodlot dynamics in Ndaka-ini

Anniversary	On-farm forest (Ha)	Protected forest (Ha)	Total (Ha)
1987	2,347	1,715	4,062
1995	3,755	1,716	5,471
1999	1,096	1,818	2,914
2009	1,607	1,725	3,332

There was an increase in area under forest/woodlots as well as ‘others’ category, with corresponding decline in area under tea between 1987 and 1995. Increased demand for both food security and fuel-wood may have contributed to significant

portion of tea plantation being converted to crop fields as well as woodlots. Between 1995 and 1999, forest/woodlot cover and 'others' category declined while tea plantation cover increased. This was the period when Nyayo Tea ZoneDevelopment Corporation promoted establishment of tea belt along the forest edges which meant substantial increase in tea cover and loss of forest cover and 'others' category. In the same period, Thika dam was completed in 1994 and may have replaced substantial vegetation between 1995 and 1999. Results of zonal analysis indicated that in 1995, the areal extent of 'others' category was about 8.5 ha while tea plantation was merely 1 hectare and may also explain the nature of dynamics observed in this period.

The areal extent of forest/woodlots, increased while that of teaplantation declined, between 1999 and 2009. In the same period, increase in forest/woodlot cover was occasioned by on-farm trees growing and reduced use of protected forest.In this period, an electric fence was constructed around the forest through the efforts of Rhino Ark project. The limited access to the protected forest as a result of an electric fence, may have served as an incentive for land users to establish woodlots as well as fodder for their livestock on parcels previously under tea plantation. In addition,on-farm tree planting increased due to high demand occasioned by the timber ban from forest plantation that was imposed in 2000, that made farmers appreciate potential of tree farming as a business (KFWG, 2005).

Examination of the differing intensity of inter-class conversion evidenced among the three land cover classes may provide additional insight about the nature of the spatial and temporal land cover/land use dynamics in the study area. Table 4.27is a summary of these inter-class conversions. Apparently, in spite of the evidenced

dynamics, the areal extent of the three main land cover categories in the study area that remained generally stable, correctly implying that the general land cover/land use of the area did not radically shift between 1987 and 2009.

Table 4.27: Trend of land use/land cover dynamics and evolving inter-class conversion in Ndaka-ini

Land cover dynamics /conversion	1987-1995 (Ha)	1995-1999 (Ha)	1999-2009 (Ha)
Target land cover class/ category: Tea plantation			
Remained unchanged	11,174	12,455	12,490
Changed to forest/woodlot	709	1,462	378
Changed to other annual crop-fields	5,220	10,670	2,768
Changed to water body	63		
Target land cover class: Forest/woodlot			
Remained unchanged	2,390	2,111	2,120
Changed to tea plantation	1,426	436	472
Changed to other annual crop-fields	1,420	357	748
Changed to water body	243		
Target land cover class: Others cover types			
Remained unchanged	21,594	19,524	22,217
Changed to tea plantation	7,769	4,286	11,635
Changed to forest/woodlot	910	1,908	403
Changed to water body	249		

The result of unsupervised classification was used to guide the field campaign which was conducted during the dry season of February 2012. Though the study area does not experience severe dry spells, it was all the same possible to discriminate annuals from perennials. For a period of three days, a total of 74 sample points representative of all typical land cover classes were collected, the current cover type recorded and where possible inquired the type of cover type that was there during the same period/season in 2011. This was especially the case for fields occupied by annuals. In many of these fields, it was notpossible to get enough information.

Final land cover map for the study area was generated by employing and /or refining unsupervised classification. Part of the data from the field campaign for ground-truthing was superimposed onto the unsupervised classification land cover map of 2011. The main assumption was that some land cover types such as woodlots/forest, water bodies, perennial crops like tea were very likely to have existed even in 2011 same as they were observed in February 2012 during the campaign. Some other cover types such as annual crops (maize, vegetables, napier grass) may not have been there in 2011 so, co-located cover types were designated as 'others' in the training signature. Following the refinement of the signature, unsupervised classification was re-run and respective map generated. Due to the problem of cloud and shadow contaminated pixels (remaining even after applying the filling masks), post-classification land cover change analysis was undertaken between target anniversaries based on co-located pixels that were cloud/shadow free. Four periods were targeted for analysis beginning with the anniversary prior to dam construction to as late as 2010/2011 anniversary, thus 1985 to 1995; 1995 to 2000; 2000 to 2005; and 2005 to 2010/2011 anniversary periods. The analysis focused on establishing the change in extent of surface areas of key land cover types and determining where there was occurrence of land cover change and between which land cover categories.

Being a tropical humid highland, Thika dam and its environsare usually engulfed in cloud and cloud-shadows most of the time even during the supposed dry season. This presented a challenge to the application of optical remote sensing as both clouds and shadows contaminate the signal from the land surface. In this study, images that had minimal contamination were selected and correction implemented using co-

located images closely matching the temporal range of the respective target anniversaries. The selected images representing 1985, 1995 and 2011 anniversaries had 28%, 5% and 43% of the study area contaminated respectively. By implementing cloud and cloud-shadow correction, the gaps were reduced immensely (e.g. 90% for the 1985 image and 82% for the 2011 image). Figure4.6 shows the improvement achieved after implementing cloud and shadow correction in the selected image of 1985 anniversary.

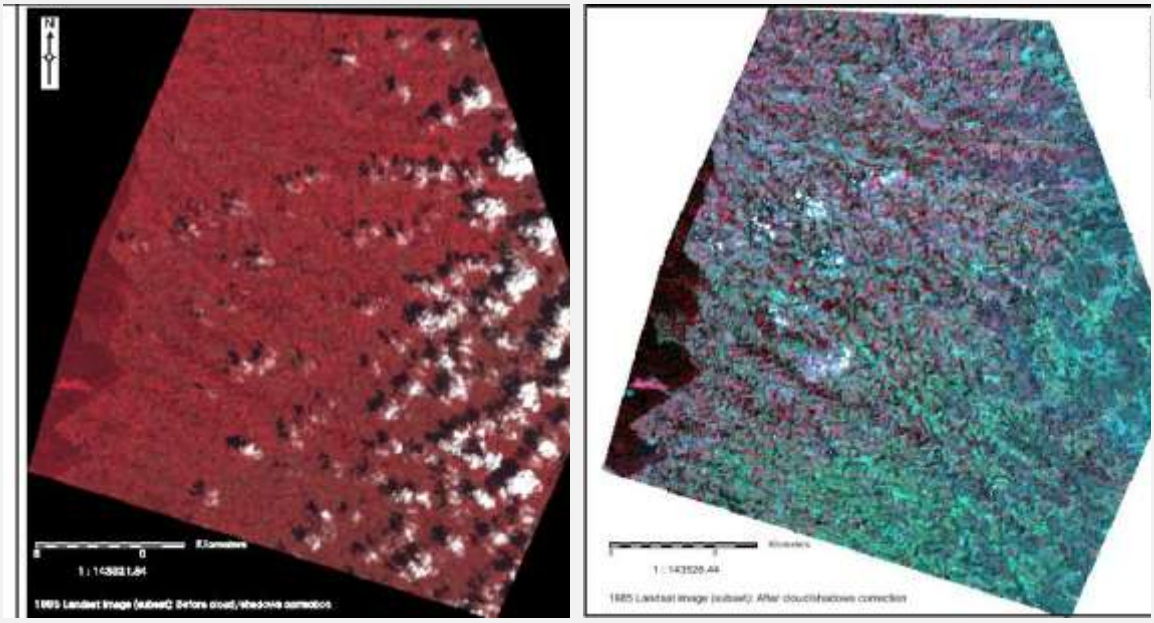

Figure 4.6: Effect of cloud correction of Landsat TM image (subset) of Jan. 1985, (from left to right: before and after correction for Ndaka-ini

Fig. 4.7 shows the distribution of ground-truthing points collected from field campaign as well as Google Earth environment. A total of 278 points were used to assess the accuracy of each of the generated land cover map and the result is summarized in Table 4.28.

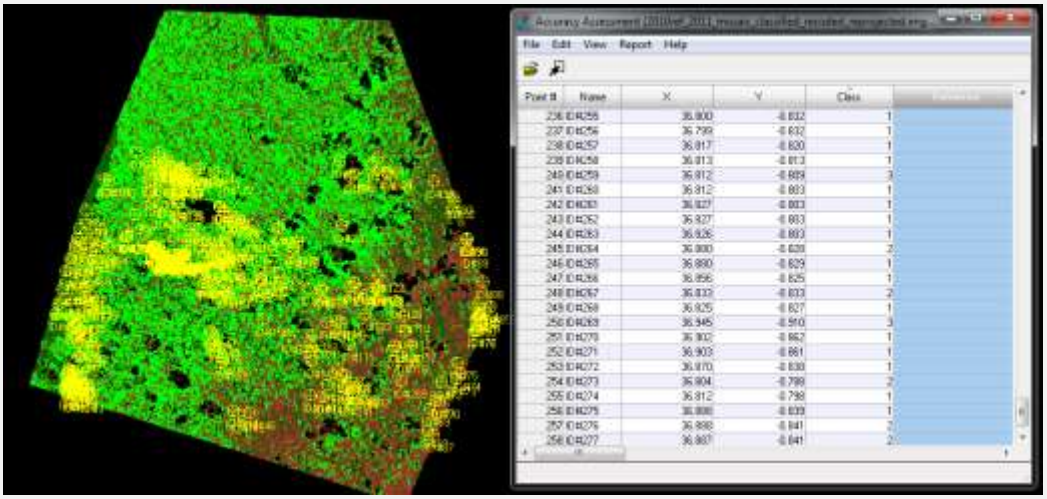

Figure 4.7: Distributions of ground-truth points (based on field campaign and Google Earth)

Table 4.28: Accuracy measures of generated land cover maps for Ndaka-ini catchment

	Producers Accuracy (%)	**Users Accuracy (%)**	**KAPPA (K^) STATISTICS**
January 18, 1985 (cloud/shadows corrected)			
Tea Plantation	79%	45%	0.25
Forest/woodlots	69%	76%	0.64
Others	42%	71%	0.51
	Overall Accuracy = 60%		**Overall Kappa Statistics = 0.42**
January 30, 1995 (cloud/shadows corrected)			
Tea Plantation	86%	44%	0.23
Forest/woodlots	77%	79%	0.69
Others	30%	74%	0.56
	Overall Accuracy = 60%		**Overall Kappa Statistics = 0.42**
February 21, 2000			
Tea Plantation	86%	45%	0.25
Forest/woodlots	79%	83%	0.75
Others	38%	83%	0.71
	Overall Accuracy = 64%		**Overall Kappa Statistics = 0.47**
February 18, 2005			
Tea Plantation	97%	67%	0.55
Forest/woodlots	70%	80%	0.71
Others	74%	92%	0.87
	Overall Accuracy = 79%		**Overall Kappa Statistics = 0.69**
February 08, 2010 (cloud/shadows corrected)			
Tea Plantation	95%	57%	0.40
Forest/woodlots	58%	76%	0.65
Others	58%	81%	0.69
	Overall Accuracy = 68%		**Overall Kappa Statistics = 0.53**

Table 4.28 shows that land cover classification outputs of 2000, 2005 and 2010 had fairly high level of overall accuracy (64%, 79% and 68% respectively) and Kappa statistic (0.47, 0.69 and 0.53 respectively) compared to similar measures in 1985 and 1995 classification outputs. Having used ground-truth data collected from field campaign of 2011 and those captured from Google Environment whose background image was a very high-resolution image acquired over the study area in 2000, the extent to which these data matched the imaged realities in respective anniversaries can be associated to the reflected accuracy measure of respective anniversaries. Land use, unlike geology, is seasonally dynamic and indeed more changing (Sreenivasulu et al., 2010). Thus, likely mismatches are expected to be more predominant and sharp in 1985 and 1995 but less sharper in 2000, 2005 and 2010 anniversaries. Mis-match is expected to be relatively higher in land use/land cover category experiencing intense land use/cover dynamics such as seasonal/annuals (or others), suggesting why the producers accuracy of this category was indeed low in 1985, 1995 and even 2000 anniversaries (42%, 30% and 38% respectively).

4.4.3 Land Use / Land Cover Changes

Historical analysis of time series of Landsat images proved valuable in providing insights about the evolving land use dynamics in Ndaka-ini area. To quantify land cover change results, a similar approach used by Nori et al., (2008) was applied where total surface area for each land use/cover types was tabulated and the respective trends across the years examined, demonstrating the kind of land cover changes that occurred during the period of analysis, namely; “from-to” information. Analysis of multi-temporal images of 1985, 1995, 2000, 2005 and 2010/11 points to a glaring

evidence of spatial and temporal land use dynamics especially among three major land cover classes, namely; tea plantation, forest or woodlots and annual crop fields, all differing in their respective general trend of change and with regard to the intensity of inter-class conversion. A summary of these trends is captured in Figure 4.8.

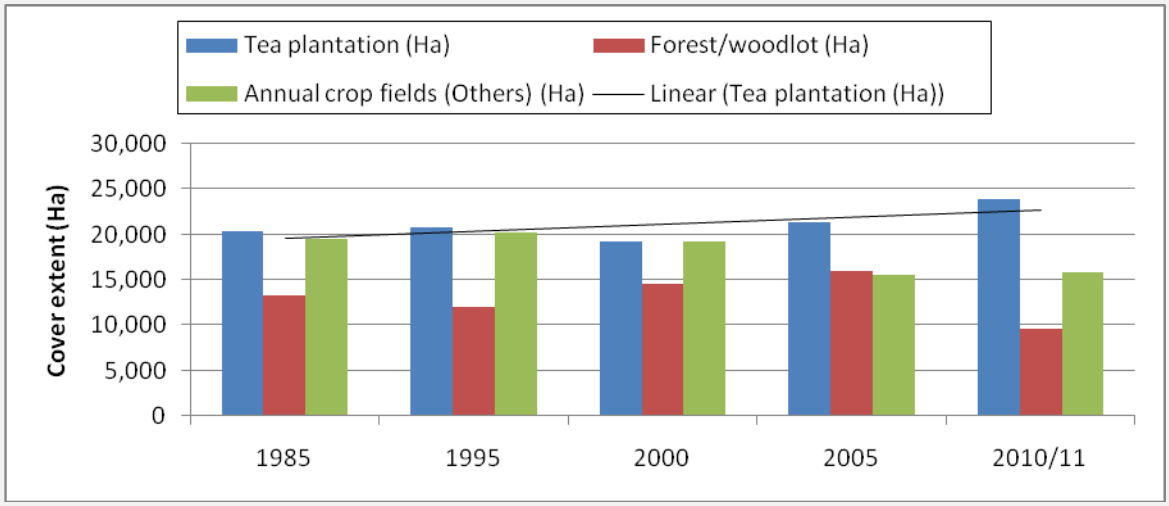

Figure 4.8: General land cover change trend among categories in Ndaka-ini

The overall extent of tea plantation seemed to have increased between 1985 and 2010/11, with minimum and maximum range being 20,368 ha in 1985 and 23,872 ha in 2010/11 respectively. Apart from the 1995-2000 period where the extent of tea plantation apparently decreased by 7% (1,482 ha), the other change analysis periods showed an increase; 2% (370 ha) in 1985-1995 period, 11% (2,164 ha) in 2000-2005 period and 11% (2,452 ha) in 2005-2010/11 periods. Figure 4.9 shows spatial changes in area under tea. Tea remains the main cash crop in the area, hence farmers have increased area under the crop as source of income. The reason behind the decrease in the period 1995 – 2000 was likely due to constructionof Thika dam. The dam was

completed in 1994 but took 2 years to fill up. As the water was filling up the dam, it was replacing area occupied by tea in the areas that were compulsory acquired.

The dynamics of forest/woodlot cover showed an intermittent increase and decrease but accumulating to an overall decline from 13,332 ha to 9,543 ha between 1985 and 2010/11 respectively. While the period between 1985 and 1995 was apparently occasioned by 9% (1,236 ha) loss of forest cover, the dynamics were of different trends in 1995-2000 and 2000-2005 change analysis period, typified by increase of the extent of forest/woodlot cover by about 21% (2,513 ha) and 9% (1,376 ha) respectively. In the subsequent period between 2005 and 2010/11, however, the trend took a negative direction, reflected by an accelerated loss of forest/woodlot cover by about 40% (6,342 ha). Figure 4.10 illustrates these dynamics evidenced in forest/woodlot cover, showing the spatial distribution of the respective gain or loss while Table4.22 summarizes the land use/cover dynamics/conversion. The increase in woodlot between 1985 and 1995 was a result of intensified efforts in woodlot development and promotion of the same as alternative livelihood option. High woodlot cover reduction from 2000 – 2010 was occasioned by a number of factors key one being; the ban of timber harvesting from government forests thus leading to high demand from the farms, increasing prices of tree products and demand from tea factories occasioned by change of energy source from furnace oil to firewood in their kilns. Tea factories remain a major consumer of woodlots in the area at a level that is not sustainable. Interview with tea managers during the study revealed that, a number of factories have acquired land to plant woodlots for their future use in other parts of Central Kenya.

Similar to forest/woodlot cover, the dynamics of annual crop fields and other cover types was also occasioned by intermittent increase and decrease accumulating to an overall decline from 19,550 ha to 15,800 ha between 1985 and 2010/11 respectively. Between 1985 and 1995, the land use dynamics apparently reflected a 3% (678 ha) slight increase in the extent of annual crop fields (others), but later evolving a negative trend in the subsequent change analysis periods, i.e. a decline by 5% (1,050 ha) between 1995 and 2000 and 19% (3,607 ha) between 2000 and 2005. In the 2005-2010/11 period, however, the trend reflected a slight increase (1%, 229 ha) in the extent of areas under annual crops (others). Figures 4.11 illustrates these dynamics evidenced in annual crop cover (others), showing the spatial distribution of the respective gain or loss while Table 4.29 summarizes the land use/cover dynamics/conversion.

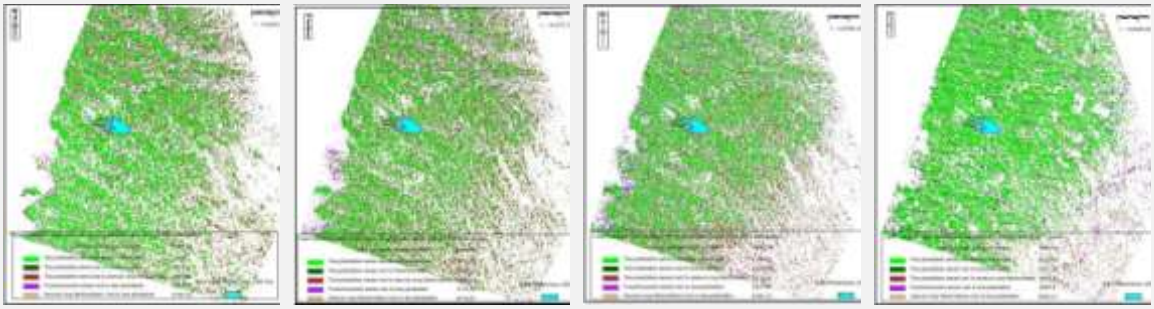

Figure 4.9: Land use/land cover dynamics in tea plantation areas (from left to right: 1985-1995, 1995-2000, 2000-2005, 2005-2010/11) in Ndaka-ini

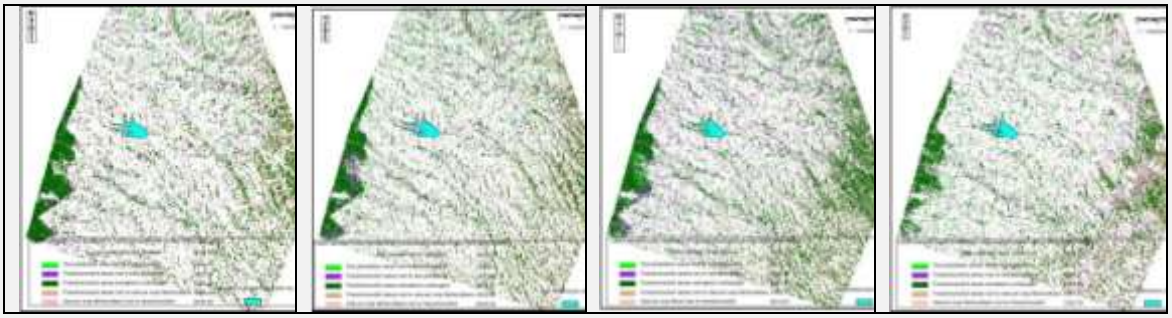

Figure 4.10: Land use/land cover dynamics in forest/woodlot areas (from left to right: 1985-1995, 1995-2000, 2000-2005, 2005-2010/11) in Ndaka-ini

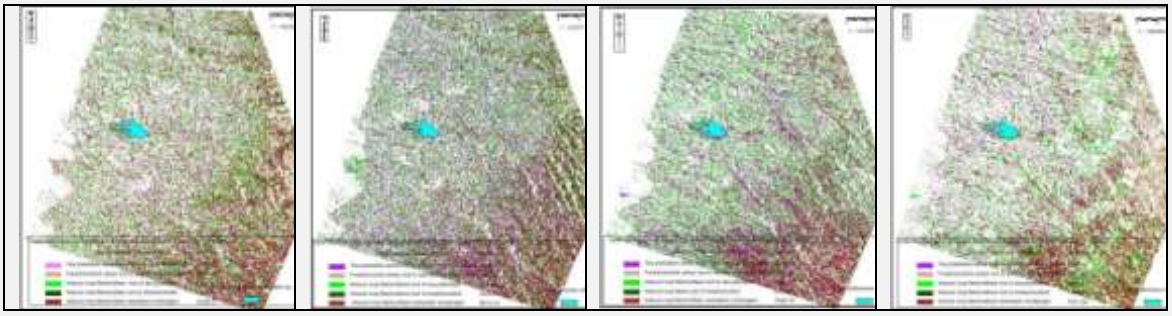

Figure 4.11: Land use/land cover dynamics in annual crop fields (others) areas (from left to right: 1985-1995, 1995-2000, 2000-2005, 2005-2010/11) in Ndaka-ini

Table 4.29: Trend of land use/land cover dynamics and evolving inter-class conversion in Ndaka-ini

Land cover dynamics /conversion	1985-1995 (Ha)	1995-2000 (Ha)	2000-2005 (Ha)	2005-2010/11 (Ha)
Target land cover class/ category: Tea plantation				
Remained unchanged	13,135	11,163	11,961	16,075
Changed to forest/woodlot	1,330	2,549	2,030	1,547
Changed to other annual crop-fields	5,832	6,897	5,214	2,574
Changed to water body	66			
Target land cover class: Forest/woodlot				
Remained unchanged	7,329	6,406	8,887	6,710
Changed to tea plantation	1,857	2,174	3,242	2,486
Changed to other annual crop-fields	4,089	3,203	2,402	5,381
Changed to water body	58			
Target land cover class: Annual crop fields				
Remained unchanged	10,306	8,913	7,948	7,831
Changed to tea plantation	5,746	5,775	6,185	5,262
Changed to forest/woodlot	3,436	5,408	5,011	1,353
Changed to water body	25			

From the foregoing, it was clear that the three land uses/cover followed different and inconsistent temporal land use dynamics across the change-analysis periods, while experiencing different intensity of dynamics. A comparison of the intensity of the temporal land use dynamics among the three main land use /land cover types is summarized by Figure 4.12.

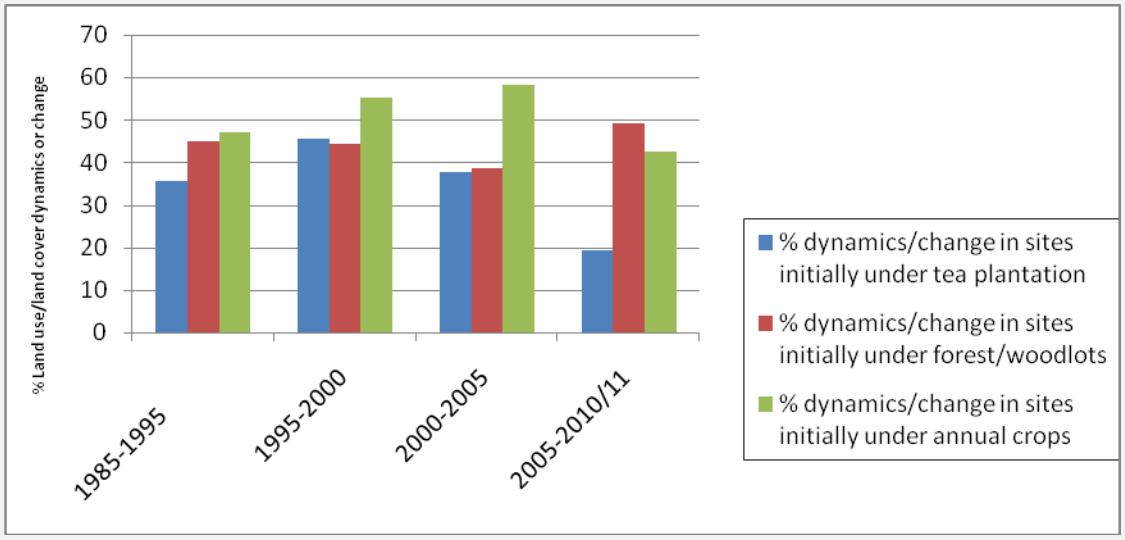

Figure 4.12: A comparison of the intensity of the temporal land use dynamics among the three main land use /land cover types in Ndaka-ini

In 1985-1995 change-analysis period, land use dynamics were substantially intensive in sites previously under annual crop fields (others) and forest /woodlots (47% and 45% respectively) but moderate in sites under tea plantation (35%). In 1995-2000 change-analysis periods, land use dynamic was more intensive in sites previously under annual crop fields compared to those under forest /woodlots and tea plantation (55%, 44%, and 46% respectively). A similar scenario was evidenced in 2000-2005 change-analysis period, where the intensity of dynamics ranged at 58%, 39%, and 38% respectively. In 2005-2010/11 change-analysis period, land use dynamic was substantially low in previous sites under tea plantation but moderate in those under annual crop fields and forest/woodlots (19%, 42% and 49% respectively).

The ongoing temporal land use dynamics generate land cover matrices with evolving loss or gain in the extent of key land cover classes with losers and gainers varying and again inconsistent across change-analysis periods. The translating rate of

gain/loss is equally inconsistent as shown in Table 4.30. During the change-analysis period of 1985-1995, forest/woodlot cover experienced an overall spatial loss (about 9%) while the other two covers (tea plantation and annual crop fields) experienced an overall spatial increment (2% and 3% respectively). In 1995-2000 change analysis period, forest/woodlot cover experienced an overall spatial increment (21%) while tea plantation and annual crop fields experienced an overall spatial decrement (7% and 5% respectively). In 2000-2005 change-analysis period, both tea plantation and forest/woodlot cover experienced a spatial increment (11% and 9% respectively) while annual crop fields experienced a spatial decrement (19%). In 2005-20010/11 change-analysis period, forest/woodlot cover experienced a huge spatial decrement (40%) while tea plantation and annual crop fields experienced a spatial increment (11% and 1% respectively).

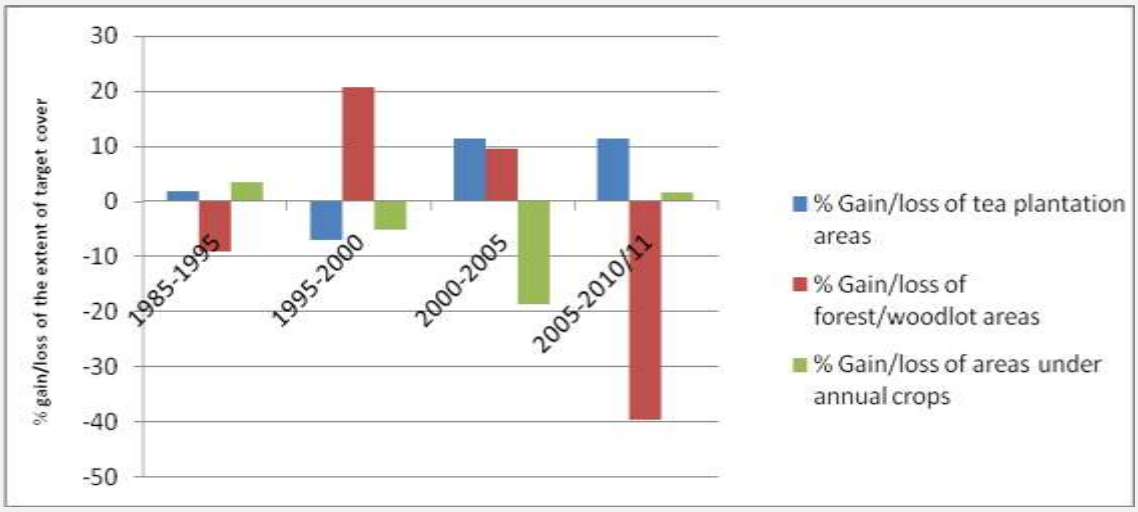

Figure 4.13: Evolving loss or gain in the extent of key land cover classes across change-analysis period in Ndaka-ini

Table 4.30: Estimated rate of gain/loss of extent of target cover across change-analysis periods

Change analysis period	1985-1995 (Ha.)	1995-2000 (Ha.)	2000-2005 (Ha.)	2005-2010 (Ha.)	Average (Ha.)
Annual rate of gain/loss of tea plantation areas	37	-296	433	490	166
Annual rate of gain/loss of forest areas	-124	503	275	-1298	-154
Annual rate of gain/loss of area under annual crop (Others)	68	-210	-721	46	-204

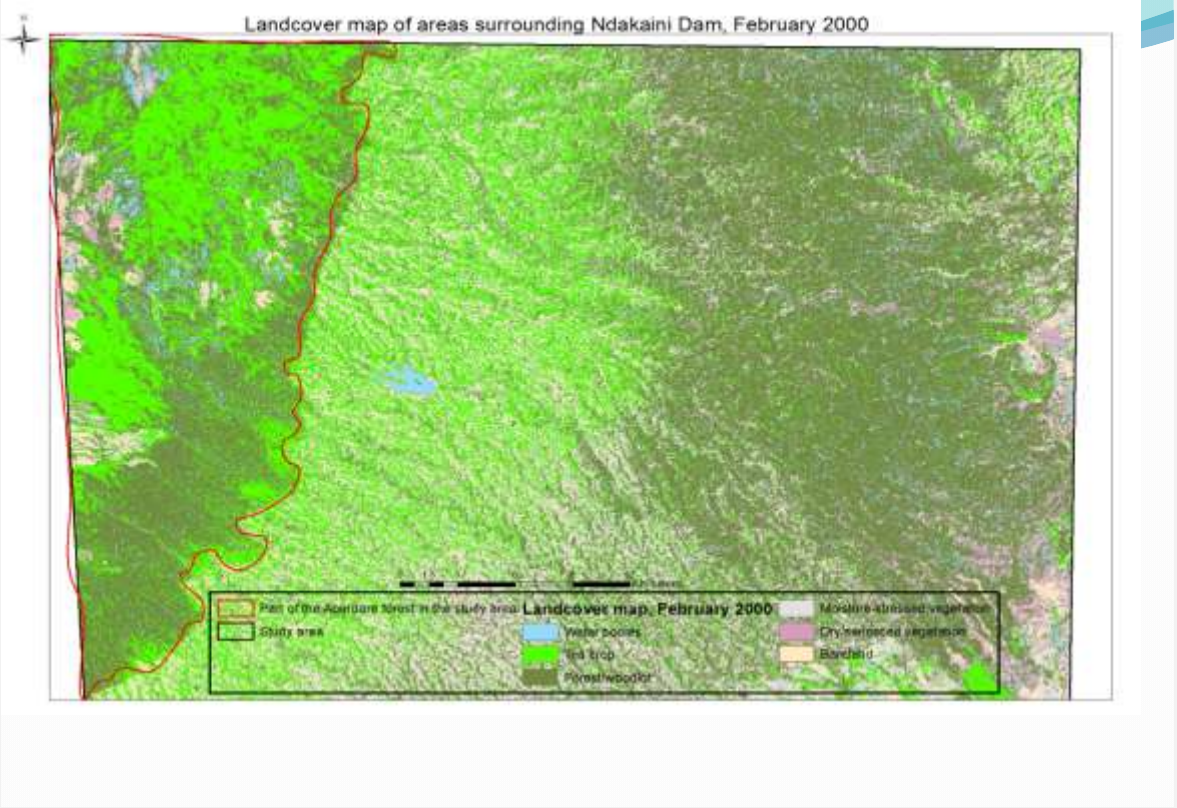

Figure 4.14: Land cover map of Ndaka-ini in 2000

Results obtained in the study compare well with land use changes as reported in Water Towers Master Plan, (2012) which depicts an overall -12.05% trend in areas under forestry in the period 1990 to 2010. Indigenous forest reduced by -5%, open

woodlands -5%, public plantations by -3.15%. There was 1% increase in area under private plantations.

4.4.4 Perception of Residents on Land Use Changes

To show the trend analysis of crops grown by farmers living in Ndaka-ini area, the household heads were asked to indicate types of crops they were growing 20 years ago, 10 years ago and 2012. They were required to base their responses in relation to farm use by area, by investment or through subsistence use. Table 4.31 shows crops grown by farmers in consideration of farm area in spans of ten years from 2012.

Table 4.31: Farmer recall of land use by area in 2012, 2002 and 1992 in Ndaka-ini

Farm use by area in 2012	**Farm use by area 2002**					**Total**	**Chi-square statistics**
	Maize	**Fodder**	**Pasture**	**Tea**	**Trees**		
Maize	5	0	0	4	0	9	χ^2=539.710
Fodder	0	1	0	0	0	1	
Tea	3	0	4	302	13	322	df =12
Trees	0	0	0	0	5	5	
Total	**8**	**1**	**4**	**306**	**18**	**337**	Sig.=0.000*
Farm use by area in 2012	**Farm use by area 1992**					**Total**	**Chi-square statistics**
	Maize	**Fodder**	**Pasture**	**Tea**	**Trees**		
Maize	0	7	0	2	0	9	χ^2=280.708
Fodder	0	1	0	0	0	1	
Tea	7	0	5	244	66	322	df =12
Trees	0	0	0	1	4	5	
Total	**7**	**8**	**5**	**247**	**70**	**337**	Sig.=0.000*
Farm use by area 2002	**Farm use by area in 1992**					**Total**	**Chi-square statistics**
	Maize	**Fodder**	**Pasture**	**Tea**	**Trees**		
Maize	1	3	0	4	0	8	χ^2=277.535
Fodder	0	1	0	0	0	1	
Pasture	0	0	3	1	0	4	df =16
Tea	6	4	2	238	56	306	
Trees	0	0	0	4	14	18	Sig.=0.000*
Total	**7**	**8**	**5**	**247**	**70**	**337**	

Table 4.31 shows that considering the planted area per crop, majority of the farmers' planted tea in large areas in comparison with other crops such as maize,

fodder, trees and pasture. Results showed that 20 years ago, 73.3% farmers planted tea, in 10 years ago, the number increased to 90.8% farmers and in 2012, the number of farmers planting tea was 95.5%. This shows that there was a gradual increase in the number of farmers growing tea in Ndaka-ini catchment area. Despite the increase of the farmers growing tea, the number of farmers growing fodder decreased at the same time. Chi-square test results indicated that there weresignificant differences among farmers growing tea in the year 2012 compared to those growing the same plantation 10 years ago and 20 years ago respectively, at $p<0.05$ level of significance. Further focus group discussion with farmers indicated a decrease in dairy farming after the dam was developed. This could be attributed to changing weather patterns that resulted to more cold spells due to the large water mass. Table 4.32 shows trends in crop farming based on investment.

Table 4.32: Crops grown by investment in 2012, 2002 and 1992 in Ndaka-ini

Crops grown 2012	**Ten year span (2002)**				Total	Chi-square statistics
	Maize	Beans	Tea	Trees		
Maize	3	0	0	3	6	χ^2=67.054
Tea	9	1	307	14	331	df =3
Total	12	1	307	17	337	Sig.=0.000*
Crops grown 2012	**20yrs span (1992)**				Total	Chi-square statistics
	Maize	Pasture	Tea	Trees		
Maize	0	6	0	0	6	χ^2=222.630
Tea	7	3	257	64	331	df =3
Total	7	9	257	64	337	Sig.=0.000*
Crops grown 2002	**20yrs span (1992)**				Total	Chi-square statistics
	Maize	Pasture	Tea	Trees		
Maize	6	5	1	0	12	χ^2=337.148
Beans	1	0	0	0	1	
Tea	0	1	256	50	307	df =9
Trees	0	3	0	14	17	
Total	7	9	257	64	337	Sig.=0.000*

As shown in Table 4.32, 20 years ago, 76.3% were growing tea, 19.0% were growing trees while 2.1% farmers were investing in maize. In 10 years ago, the number of farmers growing maize increased to 3.6% while that of farmers growing tea increased to 91.1%. However, the number of farmers growing trees decreased to 5.0% after 10 years. Results in 2012 showed that the number of farmers investing in maize decreased to 1.8% whereas that of farmers investing in tea increased to 98.2%. None of the farmer currently invested in trees. This implies that majority of the farmers living around Ndaka-ini catchment area invested in tea plantation. Chi-square statistics results illustrated that there were significant differences among farmers in terms of crops grown by investment from year 1992 to year 2012. The findings revealed that while the number of farmers growing trees was declining with time from 64 in 1992 to none in 2012, those investing in tea were increasing (257 in 1992 and 331 in 2012). Table 4.33 shows different crops grown by farmers for subsistence use.

Table 4.33: Crops grown for subsistence in 2012, 2002 and 1992 in Ndaka-ini

Crops grown 2012	**10 yrs. ago (2002)**					**Total**	**Chi-square statistics**
	Maize	**Beans**	**Potatoes**	**Pasture**	**Tea**		
Maize	274	4	2	1	11	292	χ^2=261.452
Beans	2	0	0	0	1	3	
Potatoes	1	0	2	0	0	3	df= 20
Fodder	9	0	0	0	4	13	
Pasture	5	0	0	1	0	6	
Tea	5	0	0	0	15	20	Sig.=0.000*
Total	296	4	4	2	31	337	

Crops grown 2012	**20 yrs. ago (1992)**						Total	Chi-square statistics
	Maize	Beans	Potatoes	Pasture	Tea	Trees		
Maize	271	5	0	1	11	4	292	χ^2=287.904
Beans	3	0	0	0	0	0	3	
Potatoes	1	0	2	0	0	0	3	df =25
Fodder	9	0	0	0	4	0	13	
Pasture	5	0	0	1	0	0	6	
Tea	14	0	0	0	6	0	20	Sig.=0.000*
Total	303	5	2	2	21	4	337	

Crops grown 10 yrs.Ago	**20 yrs. ago (1992)**						Total	Chi-square statistics
	Maize	Beans	Potatoes	Pasture	Tea	Trees		
Maize	286	2	0	0	6	2	296	χ^2=700.977
Beans	3	1	0	0	0	0	4	
Potatoes	0	2	2	0	0	0	4	df =20
Pasture	0	0	0	2	0	0	2	
Tea	14	0	0	0	15	2	31	Sig.=0.000*
Total	303	5	2	2	21	4	337	

*Significant at $p<0.05$ level

From Table 4.33, it can be observed that majority of the farmers grew maize for subsistence use. Chi-square test revealed that the number of farmers growing maize differed significantly from year 1992 to year 2012, at $p<0.05$ level. In particular, the result showed that in 1992, the number of farmers growing maize was 89.9%; in2002, the number slightly decreased to 87.8% whereas in 2012, the number decreased to 86.6%. Results further revealed that that in 1992 and 2002 respectively, none of the

farmers were growing fodder for subsistence use. This means that some of the farmers growing maize have engaged in other subsistence activities such as growing fodders and pasture.

4.4.5 Trends in Water Quality and Treatment Cost

Data on quantities and cost of chemicals used in water treatment were synthesised and analysed for Ngethu treatment works and later compared with Thika water and sewerage treatment. Figure 4.15 shows that Chlorine powder and liquid were most used followed by soda and then alum. There was a steady increase in chemicals used for treating water from 2005 to 2007, and then it stabilised from 2007 to 2011 with a slight decline in 2009 and 2011. The trend then showed a slight increase from 2011 to 2014. Environmental services that could be provided through PES are water quality improvement and regulated water flow during the dry season. Chemicals used in treatment may be influenced by rainfall trends and conservation practices. Increased sedimentation load that results from poor soil conservation practices lead to more use of alum as it is used in settling the sediments (Gathenya et al., 2009).

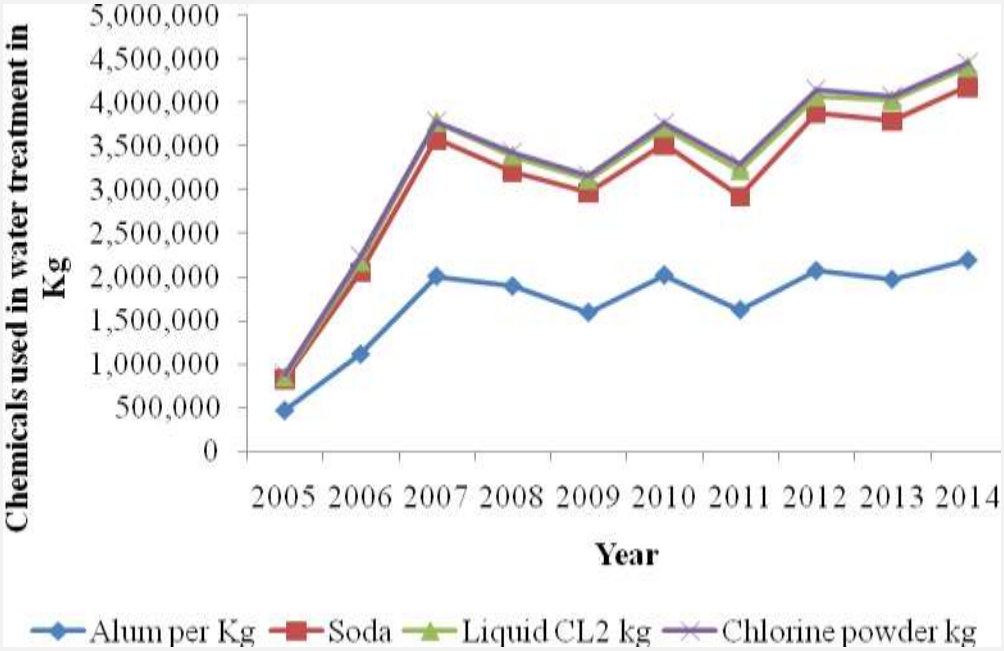

Figure 4.15: Trend analysis of various chemicals used in water treatment at Ngethu plant

Regression analysis was carried out to establish relationship of rainfall and chemical used in water treatment. In performing this analysis, a linear relationship of the form *alum = constant + b*rain* is assumed where: alum is the amount of chemical used to treat 1 kg of water, rain is the amount of rainfall in millilitres on a given month, constant is the intercept regression term, b is the coefficient of rain. The results are shown in tables 4.34 and 4.35.

Table 4.34: Results of regression analysis on alum used in water treatment in Ndaka-ini

Source	SS	Df	MS	F Value	P Value
Model	5298.41	1	5298.41	26.32	0.001
Residual	10871.66	54	210.33		
Total	16170.07	55			

Table 4.35: Model showing relationship of alum used and rainfall in Ndaka-ini

Alum	Coef.	Std. Err.	T	P>t	[95% Conf.	Interval]
Rain	-0.07248	0.0141276	-5.13	0	-0.1008	-0.04415
_cons	84.58946	2.867246	29.5	0	78.84098	90.33795

Thus *alum = 84.59 – 0.072*rain*

This indicates that when rain increases, the amount of water treated by 1kg of alum reduces. With a probability value of 0.001, this relationship is significant. Increased rainfall could lead to higher sediments due to soil erosion which will in turn lead to use of more chemicals for water treatment. This compares well with a similar study conducted in Sasumua watershed that showed that NWSC spent 15 million Kenya shillings per year on alum while good soil conservation practices contributed to 85% reduction of sediment yield per year. Policy brief proposed that the costs in treatment could be reduced substantially by developing partnerships on sustainable land management practices with up-stream farmers (PRESA, 2011). Amount of chemical used in water treatment and related cost is an indirect indicator of water quality from the water catchment. This comes from the fact that water distributed to consumers must meet WHO standards and this means in case water is of low quality, more chemicals will be used to treat it before it's discharged to consumers.

One of the necessary conditions for the PES design is a clear relationship between the conservation being promoted and its contribution to provision of ecosystem services. Results showed a significant relationship of rainfall trend and chemical used in the treatment of water. In addition, there was land use change that has taken place in the area as evidenced from satellite imagery and respondent perceptions. The 'buyer' needs to establish the baseline level of ecosystem services in order to have a benchmark

against which provision of the additional paid-for services will be assessed. This calls for a clear understanding of the ecological functions which govern service quantity and quality and the associated land use and management practices which can affect those functions. An effective and ideal payment system requires that the linkages from inputs (actions by the provider) to outputs (ecosystem services required by the beneficiary) are reasonably understood by all parties. When this condition is met, it is possible for the beneficiary to contract for the specific services that are required and for the provider to undertake the appropriate, contracted actions to ensure the outputs are delivered (or at least that land use changes likely to enhance target services are undertaken). As described by Engel et al., (2008), this enables 'conditionality' of payment to be based directly on the services provided. Results from the study showed this relationship.

4.5 Conservation of Watersheds and Willingness of Water Consumers to Pay for Management of Watershed

The second objective of this study was to find out whether downstream water consumers were able to link water they consumed to conservation of watersheds and their willingness to pay for management of watersheds. To address this objective, study respondents were asked to indicate main sources of water for household use. Table 4.36shows water consumers' responses on the main sources of water for households use.

Table4.36: Main sources of water for household use in Lower Ndaka-ini

Sources of water	n	%
Tapped water	116	34.2
Borehole	93	27.4
River/streams	73	21.5
Shallow well	33	9.7
Rain water	24	7.1
Total	**339**	**100.0**

As shown in Table 4.36, 34.2%, water consumers used tapped water in their homes; 27.4% used borehole, 21.5% used river/streams while 7.1% used rain water. This implied that most of the households in the lower catchment Ndaka-inicatchment were not supplied with tapped water. As a result, significant proportions of them opted to use ground water sources such as boreholes, shallow well and stream water. It further emerged that in some areas where good quality water was lacking, farmers harvested rain water for domestic use.

The study sought to determine whether consumers with piped/tapped water were aware of the sources of water supplied in their homesteads. In response, 98.3% reported that they were aware as shown in Figure 4.16.

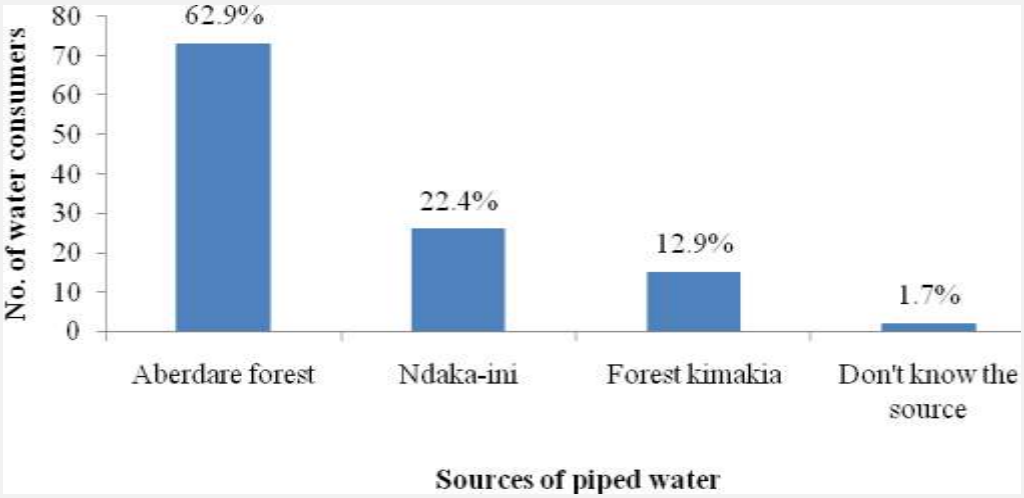

Figure 4.16: Sources of piped water for consumers in lower parts of Thika dam

As shown in Figure 4.16, 62.9% of the respondents indicated that they consumed water from Aberdare forest, 22.4% stated Thika dam whereas 12.9% indicated Kimakia forest. This response is positive for water consumers as they could link conservation of catchment areas to water supplied to their homestead. The study sought to know regularity of water supplied to the household. Table 4.37 shows consumers' responses on frequency of water supplied to their homesteads.

Table 4.37: Frequency of water supplied to consumers in lower parts of Thika dam

Water supply	**n**	**%**
Everyday	8	6.9
Once per week	38	32.8
2 days per week	25	21.6
Once per month	33	28.4
3 days per month	12	10.3
Total	**116**	**100.0**

Table 4.37 shows that 32.8% got water once per week, 28.4% had water once per month, 21.6% were supplied with water two days a week, and 10.3% three days per

month while only 6.9% of water consumers were supplied with water every day. This implied that most households were not frequently supplied with water resulting to them exploring alternative sources. Irregular supply could be associated with shortage of water from catchment areas, high population of water consumers in the community and also poor water supply management.

To establish respondents' level of awareness on water supply information, the researcher asked respondents to indicate whether there was a link between water supplied in their homesteads and conservation of water sources. In response, 58.6% consumers confirmed that there was a link while 41.4% consumers felt that there was no link between the two. Further, those who indicated there was a link gave details of the connection of household water and conservation as in Table 4.38.

Table 4.38: Connection of household water source and conservation activities

Link	n	%
Tree planting	22	19.0
Aberdare forest	16	13.8
Water catchment conservation	15	12.9
Riparian area conservation	11	9.5
Farming systems	4	3.4
No link	48	41.4
Total	**116**	**100.0**

Table 4.38 shows that 19.0% of the consumers indicated that the link between water supply and water source conservations was through tree planting (19%), Aberdare forest (13.8%), water catchment conservation (12.9%) whereas 9.5% consumers were of the view that conservation of riparian areas had a positive effect on water sources. Results

showed that 41.4% of respondents had no link between water and conservation activity. This could have adverse effect on any conservation linked efforts as they may not support such activity. Awareness creation on payment for ecosystem service will provide this vital link to enable households to appreciate that positive conservation activity can lead to improved water services. A review of operation of water fund showed that one way of achieving long term protection of watershed is ensuring goodconservation management and providing incentives sufficient to discourage further encroachment on and degradation of natural ecosystems (Rebecca et al., 2012).

The study sought to know threats to conservation of water catchment areas as shown in Table 4.39.

Table 4.39: Consumer response to threats on water catchment areas in lower parts Thika dam

Threats to water catchment areas	n	n
Unfriendly trees	29	25.0
Climate change	19	16.4
Drought	15	12.9
Deforestation	14	12.1
Riparian cultivation	12	10.3
Lack of awareness	12	10.3
Poor farming practices	6	5.2
Land size	4	3.4
Pollution	3	2.6
Policies	2	1.7
Total	**116**	**100.0**

As shown in Table 4.39, 25.0% of the water consumers reported that major challenge faced at water catchment areas was environment unfriendly tree species like *Eucalyptus* that led to drying up of water catchment areas. It also led to reduction of

aquatic organisms that depend on critical thresholds of water (Bunn &Arthington, 2002; Dugan et al., 2010). Irregular weather change was another threat that was reported by most farmers. According to 16.4% of the water consumers, climatic change threatens the survival of species and the integrity of ecosystem. For instance, global warming has led to increased rainfall in some areas, with others experiencing severe droughts. An increasing frequency of climate extremes like floods and drought is aggravating the state of the available freshwater resources. Furthermore, two similar proportions (10.3%) of the respondents indicated that cultivation of riparian areas and lack of awareness among farmers, were other major threats at water catchment areas respectively. This implied that lack of awareness among the community members on importance of conservation of catchment areas negatively influenced farmers' utilization of watershed resources.

To establish farmers' willingness to adopt conservation methods in return to incentive, farmers were presented with four hypothetical options and requested to rate the option they could adopt. The four options are presented in Table 4.40.

Table 4.40: Land use options presented to farmers in Ndaka-ini

Attributes	**Options**			
	Option 1	**Option 2**	**Option 3**	**Option 4**
1. Land area to be committed	10% of your land	20% of your land	40% of your land	10% of the land
2. Length of commitment period	5 years	15 years	30 years	30years
3. Right to harvest products (grass/fodder/beekeeping)	Permitted	Partially permitted	Not permitted	Not permitted
4. Reward scheme/incentive scheme	Provide and/or waive annual **water cost** for domestic use and/or irrigation per acre of land committed	Provide **micro-scale electricity** and/or waive 50% of your annual electricity cost per acre of land committed	Direct annual cash payment of Kshs. 4500 per acre of land committed	Paid carbon fund for every tree existing
5.Local scheme administering agent	Water Resource Users Association	Focal Development Area Committee	Community Forest Association	CFA
6. Required free labour contribution related to the contractual scheme (training, attending scheme meetings; etc.) per month	1 day	2 days	3 days	3days

The participants in the survey rated the hypothetical options presented to them as shown in Table 4.41.The rating of the hypothetical land management arrangement were:. for option 1, 28.8% respondents would not undertake such an agreement under any circumstances, 24.3% stated that the agreement was good and they would undertake one or two whereas 29.1% stated that they would definitely undertake such an agreement. With regard to the 2nd option, most (69.1%) of the respondents indicated that they would not undertake such an agreement under any circumstances while 18.7% felt

that the agreement was not acceptable but had one or two good points. However, 1.5% respondents confirmed that they would definitely undertake such an agreement.

Table 4.41: Ratings of hypothetical land management by farmers in Ndaka-ini

In conjoint survey	Take option 1		Take option 2		Take option 3		Take option 4	
	n	%	n	%	n	%	n	%
I would not undertake such an agreement under any circumstances	97	28.8	233	69.1	278	82.5	267	79.2
The agreement is not acceptable, but has one or two good points	40	11.9	63	18.7	36	10.7	46	13.6
I am indifferent to the agreement.	20	5.9	23	6.8	15	4.5	13	3.9
The agreement is good and Iwould undertake it if one or two points are changed	82	24.3	13	3.9	5	1.5	4	1.2
I would definitely undertake such an agreement.	98	29.1	5	1.5	3	0.9	7	2.1

In relation to the 3rd option, majority (82.5%) of the respondents would not undertake such an agreement under any circumstances, 10.7% stated that the agreement was not acceptable but had one or two good points. For option 4, a large proportion (79.2%) of the respondents reported that they would not undertake such an agreement under any circumstances.

Comparing results with options presented in Table 4.40, it emerged that most of the farmers indicated that they would commit to an agreement if given the first option attributes, that is, commitment of 10.0% of the land for a period of 5 years with the right of harvesting farm products, waiver of annual water cost for domestic use and/or irrigation per acre of land committed, ensuring that they use local scheme administering agent and attending scheme meetings or training one day per month. However, majority

of the respondents stated that they would not undertake such an agreement under any circumstances if given options two, three and four. Results showed that farmers go for a package of incentives but not necessarily just cash especially those that can raise their farm productivity. A similar study in East UsambaraMountains in Tanzania showed that the nature of payment greatly influences likely participation rate. Individual payment was found to be more effective than group payments. A similar study showed required amount of payment was highly variable between farmers (Kaczan et al., 2012).The results are in line with studies conducted in Kapingazi, Embu Kenya that showed farmers' preference was dependent on size of land area to be committed for conservation, length of scheme and restrictions on right to harvest produce from the farm (Balana et al.,2011).

Researchers in PES argue that of the five mechanisms available for ensuring the provision of ecosystem services – prescription, penalties, persuasion, property rights and payments – only payments are likely to be effective at the global level. To distribute the funds, the researchers recommend a system modelled on Brazil's ICMS Ecológico 2, which they consider cost-effective and successful. Under this intergovernmental fiscal transfer system, Brazilian states return 25% of revenue from sales taxes to the municipalities. Some states use this to pay for ecosystem services. For example, the state of Parana awards 5% of this revenue each year to municipalities in proportion to their protection of watersheds and conservation areas. This has created incentives for municipalities in Parana to develop well-managed protected areas, especially as only the best efforts are rewarded, so municipalities in effect compete with each other for the funds. As has been the case for the ICMS Ecológico, criteria can be simple in the initial

stages but improved over time as data and information improve. They argue that whatever approach is taken, payments should target bundled services as this can be substantially more cost-effective. Provision of services and productsusing PES can offer multiple benefits for forests by generating revenues for sustainableforest management initiatives and promote behaviors that protect forest communities fromsome of the threats that they are currently facing (Hoogeveen et al., 2008).

Duration of commitment influences acceptance with most farmers preferring short-time commitment. Further results showed that most farmers were willing to participate in a form of scheme that relates to PES as shown in Table 4.42 but differ in details of implementation.

Table 4.42: Participation rate in contingent valuation scenario for farmers in Ndaka-ini

Would you participate in the scheme?	**n**	**%**
Yes	279	82.8
No	58	17.2
Total	**337**	**100.0**

As shown in Table 4.42, majority (82.8%) of the farmers were willing to participate in the scheme while 17.2% were not willing to participate. This showed PES was received positively in the area but details of the mode of the concept engagement required to be worked out. This compares well with study conducted in Sasumua that showed that 91% of community members were willing to accept payment of US$938/ha/year (Namirembe et al., 2013).

Significant number of farmers in Thika dam catchment area would accept environmentally friendly conservation practices in exchange of incentives provided by water providers and consumers. The hypothetical ratings conducted to three groups of farmers showed their preferred options as shown in Table 4.43. These are the same options presented in Table 4.40.Results from Table 4.43 showed that 67.7% of farmers would not take an agreement under any circumstance, 12.4% stated that they would not take option 3, 68 stated option 4 while 62 cited option 2. Among the 28 who would take an agreement, majority of them (21) indicated that they would take an agreement if given first option attributes; that is, commitment of 10.0% of the land for a period of 5 years with the right of harvesting farm products, waive annual water cost for domestic use and/or irrigation per acre of land committed, ensuring that they use local scheme administering agent and attending scheme meetings or training one day per month.

Table 4.43: Analysis of ratings of hypothetical land management options by farmers in Ndaka-ini

	Presented option				**Total**		**Chi-square statistics**
	Option 1	**Option 2**	**Option 3**	**Option 4**		**%**	
Would not take	22	62	76	68	228	67.7	χ^2=135.076
Agree with two points	13	17	7	5	42	12.4	
Indifferent	8	4	0	4	16	4.7	df=12
Agree with most points	20	1	0	2	23	6.8	
Would undertake	21	0	1	6	28	8.3	
Total	**84**	**84**	**84**	**85**	**337**		Sig.=0.000 *

*Significant at p<0.05 level

A Chi-square test was used to find out whether there was a significant relationship between farmers acceptance of environmentally conservation practices and incentives given by water providers. The results of the analysis revealed that there was a significant relationship (χ^2=135.076, df=12, p=0.000). This implies that farmers' acceptance offer of setting aside a riparian buffer zone is greatly influenced by the incentives given by water providers.

In an attempt to probe acceptable amount of cash incentive, farmers were required to indicate levels of incentives that would make them take PES initiative as shown in Table 4.44.

Table 4.44: Amount farmers were willing to be compensated to participate in the PES scheme in Ndaka-ini

Amount compensated per year	Yes		No		Not applicable	
	n	%	n	%	n	%
Kshs 5, 000	0	0.0	279	82.8	58	17.2
Kshs 10, 000	13	3.9	266	78.9	58	17.2
Kshs 20, 000	21	6.2	258	76.6	58	17.2

Table 4.44 shows the amount of money farmers would like to be compensated in order to participate in the scheme. All the farmers who were willing to participate in the scheme reported that they would not participate if compensated Kshs. 5,000 per year. However, 3.9% farmers reported that they would participate if compensated 10, 000 while 6.2% farmers indicated that they would participate if compensated Kshs. 20,000. This showed that the amounts of money farmers werecompensated had a great impact towards their willingness to participate in the scheme. This related to the annual income of households in the area who are predominantly in tea farming which gives high returns. A similar study conducted in Nairobi showed the mean WTP was about

Kshs. 275 per month, approximately equivalent to US$3. This was almost 25% of the average survey household's monthly water bill. This apparently large WTP value reflected the extent of water shortages in the survey area and people's preferences to pay for reliable water supply. The study showed a wide variation households' water bills (from Kshs. 120 -900 i.e., approximately from US$ 1.5 to 11.25 per month) and likewise a wide variation in WTP (Balana&Catacutan, 2012).

Farmers were more willing to accept rewards in kind as shown in Table 4.45.

Table 4.45: Incentives farmers were willing to take to participate in conservation in Ndaka-ini

Reward system	n	%
Water supply	161	47.8
Carbon credit	37	11.0
Power supply	36	10.7
Firewood provision	33	9.8
Tree seedlings	26	7.7
Fodder provision	23	6.8
Water pumps and storage tanks	21	6.2
Total	**337**	**100.0**

Table 4.45 shows proposed reward system that gives farmers incentives to participate in conservation activities. Majority (47.8%) of the farmers reported that provision of water supply could influence their participation in water conservation activities, 11.0% indicated carbon credit while 10.7% indicated power supply. Other reward systems mentioned included water pumps and storage tanks, fodder provision, tree seedlings and firewood supply. The type of reward was consistent with earlier

baseline information that showed that most of farmers around the dam were not connected with tapped water.

4.6 Catchments conservation activities and costs involved

The third objective of the study was to find out farmers willingness to practice catchments conservation activities and their willingness to accept incentives that would lead them to adopt friendly conservation practices. To address this objective, water consumers were asked to indicate effects of conservation activities on water quality and water flow. Results are shown in Figure 4.17.

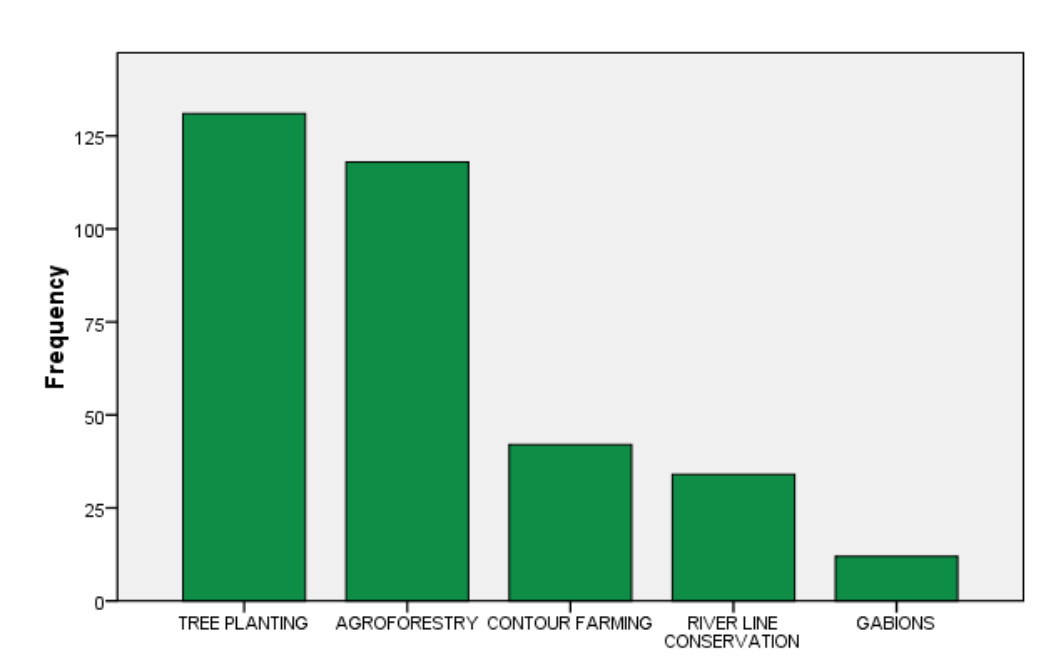

Figure 4.17: Soil and water conservation activities practiced by farmers in Ndaka-ini

The main conservation practice was tree planting in form of woodlot followed by agroforestry, contour farming, riverside conservation and putting up of gabions. Conservation innovation activities have been widely introduced to farmers cultivating sloping lands in other parts of the world. They vary from mechanical methods such as

terrace construction to biological erosion control using planted multi-purpose tree and grass hedgerows (DENR and IIRR,1992). Studies in Indonesia showed that vegetative soil conservation measures proved advantageous compared to mechanical methods because of their potential to improve the physical, chemical and biological status of the soil (Sukmana and Suwardjo, 1991). In addition, they require less labour and capital (PURC, 1990). Among the vegetative measures, contour hedgerow intercropping with leguminous trees has been widely promoted by government agencies and non-governmental organizations (PCARRD, 1997; Kinama et al. (2007). Further investigation was done on the effect of conservation activity on river flow and quality and results are shown in Table 4.46.

Table 4.46: Effect of conservation activities on water flow and quality in Ndaka-ini

Conservation activity	Effect on water flow						Effect on water quality					
	Positive		Negative		No change		Positive		Negative		No change	
	n	%	N	%	n	%	n	%	n	%	n	%
Agroforestry	40	11.9	48	14.2	249	73.9	0	0.0	0	0.0	337	100.0
Tree planting	98	29.1	7	2.1	232	68.8	101	30.0	0	0.0	236	70.0
Terracing	42	12.5	1	0.3	294	87.2	11	3.3	6	1.8	320	95.0
Contour farming	133	39.5	0	0.0	204	60.5	85	25.2	2	0.6	250	74.2

As shown in Table 4.46, majority of the respondents felt that conservation activities practiced by farmers did not have any effect on water flow and water quality. However, a notable number of the respondents felt that tree planting had a positive impact on water flow (29.1%) and water quality (30.0%). Kirsch *et al*. (2002) showed improved tillage practices could result in reduced sediment yields of almost 20% in the Rock River inWisconsin.This is because trees help in prevention of soil erosion,

recharge of the underground water and also rain attraction. It also emerged that 39.5% and 25.2% of the consumers were of the view that contour farming had a positive impact towards water flow and water quality respectively. Contour farming activity maintains a living or dead vegetation cover or barrier hence reducing the force of falling raindrops and water runoff. Gathenya et.al (2009) indicated that parallel terraces had the greatest effect on sediment yield reduction as theyreduce the slope length of the cultivated field hence the erosive power of surface runoff. In addition,they reduce surface runoff volume by impounding water in small depressions and increase settling ofsediments in surface runoff.

Table 4.47 compares the crops grown in the upper zone with conservation measure adopted by the household. Main conservation practice in tea areas was tree planting (17.3%) followed by hedge rows (15.3%). In maize areas, tree planting and contour farming were the main conservation practice while in coffee areas, the predominant conservation measure was *fanyachini.* This shows there was a relationship between the crop grown and conservation measure adopted by the household.

Table 4.47: Cross tabulation of conservation measures practiced and crop types in Ndaka-ini

Crops in the upper slope	Types of conservation measures in percent						
	Fanyajuu	*Fanyachini*	Grass strip planting	Hedge rows planting	Contour planting	Contour digging	Tree planting
Tea	14.2	7.8	14.2	16.5	15	15	17.3
Maize	9.9	10.7	8.4	10.7	16.5	10.7	33.1
Vegetables	0	0	0	50	50	0	0
Napier grass	8	0	32	4	16	16	24
Trees	9.6	6.5	9.6	22.5	16.1	9.6	25.8

The researcher sought to get the views of respondents on the effect of inorganic in-organic fertilizer on water quality considering that inorganic fertilizer application was commonly used to increase tea yields as well as in other agricultural crops. Majority of respondents (99.7%) indicated thatinorganic fertilizer had negative effect on water quality. This is an area of concern since fertilizer application is prevalent in the main land use type (tea farming) as a way of increasing production. Further interviews with crop officers in the tea factories confirmed that they were aware of adverse effects of fertilizer application. To reduce this effect, they advised farmers to apply fertilizers at the onset of rains, thus enabling more uptake as opposed to leaching when rainfall is high. Farmers were also encouraged to apply organic manure instead of chemical fertilizers. Farmers were further required to indicate constraints to conservation as shown in Table 4.48.

Table 4.48: Constraints to environmental conservation within Thika dam catchment

Environmental conservation constraints	n	%
Lack of awareness	56	16.6
Conflicting policies	45	13.4
Lack of incentives	41	12.2
Population increase	37	11.0
Alternative energy sources	35	10.4
Deforestation	27	8.0
Lack of finances/poverty	26	7.7
Poor agricultural activities	24	7.1
Land sizes	20	5.9
Corruption	9	2.7
Lack of government initiative	7	2.1
Lack of participation	4	1.2
Wildlife damage	2	0.6
Labour force shortage	2	0.6
Weather conditions	2	0.6
Total	**337**	**100.0**

Table 4.48shows factors which undermine environmental conservation in Ndaka-ini catchment area. Lack of awareness among community members emerged as the greatest hindrance to the environmental conservation (16.6%), while13.4% of the respondents reported that there were conflicting policies in the sector hence negatively influencing proper management of water projects. Another factor that was mentioned was lack of incentives (12.2%). Further, 11.0% of the respondents indicated that high population densities in the society have affected environmental conservation. This is because as the population increases the land size decreases hence leading to other challenges such as cultivation of riparian areas and deforestation (8.0%). Consequently, this lead to diminishing of the water resources at the catchment areas such as Thika dam which eventually leads to water rationing among the consumers. Other mentioned challenges by a small number of respondents included; climatic change, labour force shortage, wildlife damage, lack of government initiative and corruption. The actors in environmental conservation should address constraints mentioned through capacity building, providing alternatives energy sources, introducing incentives to conservation, improved farm productivity, engaging farmers in conservation and addressing governance issues. Payment for environment services approach should in addition to providing incentivesbe combined with efforts to address the constraints in conservation.

Table 4.49 shows constraints experienced at water catchment areas.

Table 4.49: Constraints in water catchments areas in Ndaka-ini

Water catchment constraints	n	%
Shortage of water	45	13.4
Lack of awareness	40	11.9
Cultivation on riparian areas/encroachment	40	11.9
Deforestation	39	11.6
Population increase	29	8.6
Unfriendly tree species	28	8.3
Policy bottlenecks	22	6.5
Pollution/anthropogenic activities	16	4.7
Lack of finances	16	4.7
Poor agricultural activities	15	4.5
Weather changes	8	2.4
Land size	8	2.4
Tea farming	8	2.4
Minimal participation in conservation	8	2.4
Corruption	8	2.4
Illegal abstraction	7	2.1
Total	**337**	**100.0**

As shown in Table 4.49, the main challenges experienced in the water catchment areas were shortage of water (13.4%), lack of awareness (11.9%), cultivation on riparian areas (11.9%) and deforestation (11.6%). Forests are the basis of water catchment areas hence clearing of the forests (deforestation) increases water shortage in the catchment areas since one of the major purpose of forest in catchment areas was rain attraction and prevention of soil erosion. Study done in Sasumua watersheds showed that , unsustainable agricultural practices and deforestation were major contributors to land degradation in form of increased soil erosion and soil fertility loss, which in return affected quality and supply of water resources downstream (FAO, 2013a). Another major challenge was lack of awareness among farmers on importance of water catchment areas protection. This negatively influenced farmers to cultivate on riparian

areas hence destroying the health of aquatic organisms in water catchments areas due to soil erosion and also poor water quality. Unfriendly tree species around the catchment areas had also led to drying up of water catchments/water sources leading to shortage of water in the community. Other challenges that were mentioned included; corruption, weather changes, poor agricultural activities, lack of finances and pollution.

4.6.1 Assessment of riparian vegetation in the dam catchment areas

Results from transect walk along the three main rivers feeding the dam showed that *Eucalyptus* was the main tree species grown as indicated in Table 4.50.

Table 4.50: Natural vegetation along Thika, Githika and Kayuyu rivers in Gatanga sub-county

Vegetation type	Thika		Githika		Kayuyu	
	No. of units	%	No. of units	%	No. of units	%
Eucalyptus	42	30.4	63	33	22	22.0
Other exotic trees	34	24.6	34	17.8	16	16.0
Indigenous trees	19	13.8	24	12.6	5	5.0
Grass	13	9.4	35	18.3	11	11.0
Shrub/bushes	13	9.4	8	4.2	21	21.0
Tea	12	8.7	13	6.8	21	21.0
Bamboo	2	1.4	4	2.1	4	4.0
Fern	3	2.2	10	5.2		
Total	**138**	**100**	**191**	**100**	**100**	**100.0**

The main vegetation cover along the three rivers was exotic tree species with *Eucalyptus* being the dominant one. Exotic tree species cover constituted about half of all the units assessed. Other vegetation within the rivers was grass, shrubs, bamboo and fern. The type of natural vegetation along the rivers can be used as an indicator of conservation effort. Indigenous tree cover, grass, shrubs, bamboo and fern were more

desired vegetation as compared to growing of exotic trees. In addition, the type of farming activity along the river would be an indicator of conservation effort. Results from transect walk showed that 71.4% of the plots were cultivated while 28.6% were not cultivated. Table 4.51 show the main crops harvested along the river-line.

Table 4.51: Main crops cultivated along the riverine feeding into Thika dam

Main crops	Most common crop in all plots				Total	
	Left		Right			
	Mode	%	Mode	%	Mode	%
Maize	11	31.4	10	32.3	21	31.8
Beans	7	20.0	8	25.8	15	22.7
Cabbage	8	22.9	4	12.9	12	18.2
Kales	5	14.3	3	9.7	8	12.1
Arrowroots	1	2.9	5	16.1	6	9.1
Bananas	3	8.6	1	3.2	4	6.1
Total	**35**	**100.0**	**31**	**100.0**	**66**	**100.0**

Out of 30 plots that were cultivated, maize was the most common crop in those plots followed by beans, cabbages and then kales. Other crops that were grown included bananas, and arrowroots. Conservation efforts should aim at replacing cultivation along the riparian area with better management practices. This could include planting of perennial vegetation that reduces sediment load to the rivers that would with time replace annual crops.

4.7 Economic Incentives Provided by Consumers to Farmers in Support of Watershed Protection

The fourth study objective was to find out economic incentives provided by the consumers to farmers in support of watershed protection. To respond to this objective, water consumers were asked to indicate whether they were willing to support

conservation activities. In response, all (100.0%) respondents reported that they were ready to offer their support in order to ensure there is continued water supply in homesteads. Figure 4.18 illustrates incentives given to support conservation activities.

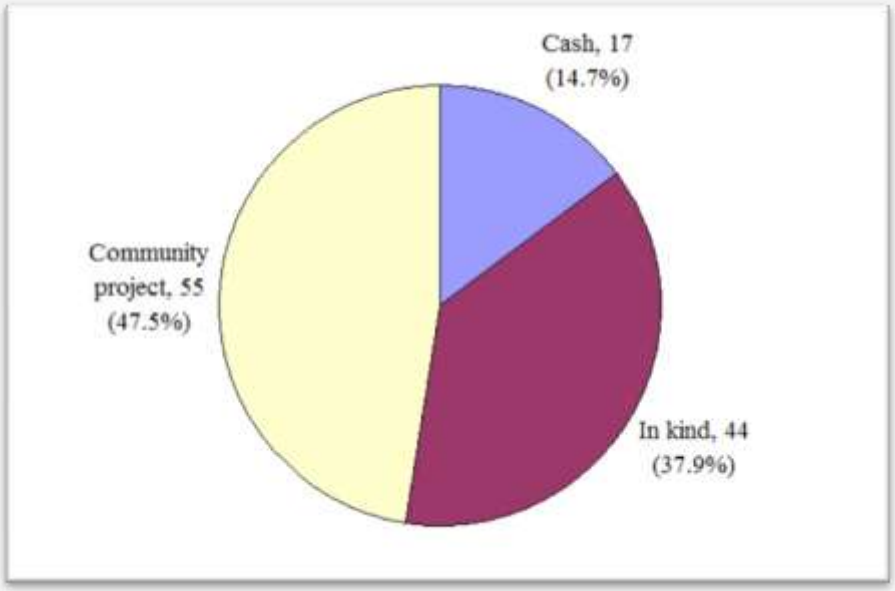

Figure 4.18: Incentives given to support conservation activities by consumers in Gatanga

As shown in Figure 4.24, 47.5% water consumers would support community projects, 37.9% support in kind support whereas 14.7% consumers would offer their support through giving out money. Table 4.52 shows the amount of financial support users of the water service were willing to provide. A survey conducted by Kerr et al., (2014) showed that cash incentive is well suited to conditionality in which land managers receive payment if they comply with the agreement; otherwise payment is withheld. It is easy to understand this condition anddelivering cash payments have low transaction costs and can be discontinued for non-compliance. In a group setting, it can be distributed commensurate with effort or opportunity cost. The use of in-kind

development benefits as a form of payment would require delivering them with the threat of removal if the environmental service is not provided. In case where they are government managed such an arrangement questions might arise regarding why those benefits should be conditional on environmental service delivery (Sommerville et al., 2010). However, there may be cases where development benefits fit better into a PES setting, for example by offering additional employment benefits with an explicit link to natural resource protection, or by offering a bonus to an existing development budget. On the other side development assistance in the form of durable infrastructure faces the obvious concern that it cannot necessarily be withdrawn in the event of non-compliance. Payment in the form of an expensive infrastructure investment, equivalent in value to many years of the environmental service, would constitute full payment in advance without leverage to ensure service delivery. In contrast, a piece of infrastructure commensurate in value with the annual value of the environmental service could have similar implications for conditionality as a cash payment.

Table 4.52: Financial support consumers are willing to give in Gatanga sub County

Amount per month	n	%
50 – 100	18	15.5
101 – 300	34	29.3
301 – 500	1	0.9
Never support	63	54.3
Total	**116**	**100.0**

As shown in Table 4.52, 15.5% consumers reported that they could support conservation activities by paying Kshs 50-100 per month, 29.3% supported by paying

Kshs 101-300 monthly while 0.9% consumer indicated Kshs 301-500. However, 54.3% consumers never supported conservation activities. This shows that less than half of the respondents were willing to pay the amount specified for watershed protection. Further analysis revealed a relationship between the amounts of money farmers are willing to give in support of conservation activity to the main source of household water as shown in Table 4.53.

Table 4.53: Main sources of water for household use and amount of money water consumers are willing to give to support conservation activities

Main sources of water	Amount of money willing to give to support conservation activities in Kshs.				Total	Chi-square statistics
	None	50 - 100	101 - 300	301 - 500		
Rain water	16	2	5	1	24	χ^2=103.719
River/streams	45	18	10	0	73	
Tapped water	9	31	67	9	116	df =12
Borehole	54	17	22	0	93	
Shallow well	18	8	7	0	33	Sig.=0.000*
Total	**142**	**76**	**111**	**10**	**339**	

***Significant at *p*<0.05 level**

As shown in Table 4.53, results revealed that there was a significant relationship between farmers sources of water and the amount of money they were willing to give to support conservation activities (χ^2=103.719, df=12, p=0.000). In particular, among the 24 farmers who harvested rain water for domestic use, 16 were not willing to support conservation activities, 2 reported that they would support with Kshs. 50-100, 5 would support with Kshs. 101-300 , with only 1 indicating Ksh.301 -500. Among the 116 with tapped water, majority (67) of them reported that they would support with Ksh.101-300.

This shows that farmers with tapped water were more likely to support conservation activities compared to those whose sources of water were rain, river/streams, borehole and shallow well. Similar study conducted in Sasumua showed that water users in Nairobi were willing to pay an incremental US$1.25 over their normal water tariff to support conservation activities (FAO, 2013(a)).

Consumers of water who were willing to give incentives in support of conservation activities attached conditions for their support as shown in Table 4.54.

Table 4.54: Conditions attached to incentive provided by consumers in Gatanga Sub-County

Conditions attached to incentives	n	%
Clean water	15	12.9
Regular water supply	22	19.0
Irrigation water	11	9.5
Alternative water projects	5	4.3
Not applicable	63	54.3
Total	**116**	**100.0**

Table 4.54 shows that 19.0 % stated that they would support conservation activity in return to regularwater supply, 12.9% gave clean water at their homesteads as condition, whereas 9.5% of consumers preferred irrigation water projects.A key aspect of PES is the extent of conditionality as it is the main key differentiating feature between PES and other non-coercive conservation approachessuch as integrated conservation, development projects, and community based natural resource management (Ferraro and Kiss, 2002). However, conditionality can be applied at different levels. Van Noordwijk and Leimona (2010) defined conditionality on a

spectrum, where payment can be linked to (1) the consequence of an improved ecosystem service (for example, cleaner water), (2) improved system performance (for example, increased tree cover), (3) improved actions (for example, replanting in the runoff zone), (4) improved management plans (for example, an intent to replant in the runoff zone), or (5) improved management objectives. Choosing the extent of conditionality required to deliver fully the required ecosystem service at the least cost to farmers is an important component of PES design.The merits of conditionality are clear: it ensuresservice provision or, alternatively, avoids wasting resourcesby paying 'money for nothing' (Ferraro & Pattanayak,2006), and it ensures that the practices paid for generate netbenefits for users, as presumably the latter would otherwisenot be willing to purchase those services at the given price.

On the other hand, among the 54.3% water consumers who reported that they never supported conservation activities, 45.7% indicated that the major factor which hindered them was lack of finances whereas 8.6% reported that services offered were very poor.

Table 4.55 illustrates group incentives household heads are willing to participate in conservation activities.

Table 4.55: Group incentives identified by consumers in Gatanga

Group incentives	n	%
Improvement in road network	29	8.6
Putting up of schools	54	16.0
Provision of tapped water	88	26.1
Improve on health facility	56	16.6
Electricity provision	56	16.6
Capacity building	24	7.1
Provision of seedlings	30	8.9
Total	**337**	**100.0**

Table 4.55 shows group incentives households would engage in return to conservation. Results showed that 8.6% households identified improvement of the road network, 26.1% provision of tapped water, 16.6% activities that would improve health facility and 16.6% capacity building and 8.9% households were willing to participate in provision of seedlings. As earlier discussed the main problem with group incentives is tying them to conditionality especially for long term projects. However, some of identified incentives could by conditional like provision of tree nurseries and capacity building.

Figure 4.19 shows the type of incentive farmers expectin order for them to participate in PES. Water provision was rated highest followed by firewood supply, power supply and carbon credit. Despite the catchment being the source of water for Nairobi, the community is still under supplied with water showing an inequity in natural resource distribution. This negatively affects the community view of the dam and so more efforts aimed at enhancing incentive is required in the area. As a result, the most

preferred individual and group reward incentive was provision of water. The main group incentive was provision of tapped water as shown in Figure 4.20. The other group incentives preferred were schools, health facilities, supply of electricity, capacity building, improved road network and provision of seedling. There is need to balance individual and group incentives as both are key to conservation. The results compare well with a recent study which showed that the most preferred reward systems were in kind and an emerging paradigm shift towards co-investment instead of payment (Namirembe et al., 2014). Co-investment would bridge the gap in rewards given that it is difficult to drive PES using contributions from consumers alone as they are far below the opportunity cost of the producer. Lessons from Naivashawas that PES has potential to be used as a vehicle to create local markets for environmental good through contribution of high value fruit trees and fodder crops that has led to improved livelihoods for the WRUA and farmers those areas. The additional income through improved farm production were more than what farmers received directly as incentive in PES (FAO, 2013b).

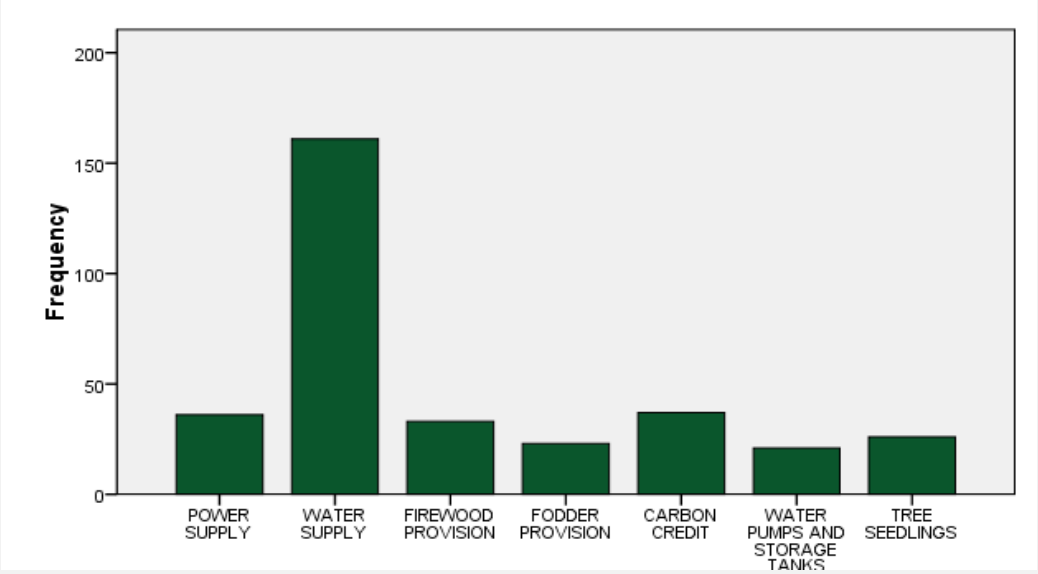

Figure 4.19: Proposed reward system to participate in conservation in Ndaka-ini

Studies conducted in Naivasha showed that farmers wanted to see direct benefits from their own efforts, not just hearing about how conservation is important to the wider area, or to downstream stakeholders. The economic case for conservation should be used to promote more sustainable farming practices (carrots instead of sticks). Roger and Risk (2012) noted that extension agents and NGOs need to think about how they communicate the conservation message to farmers as it may be more effective to talk with farmers about 'boosting production through good practices', than about conservation especially when initially conservational benefits are not clearly understood and a loss of productive land may be feared. This is the case for Ndaka-ini where more efforts should be put to direct benefits for farmers that can in return give them motivation to support conservation activities.

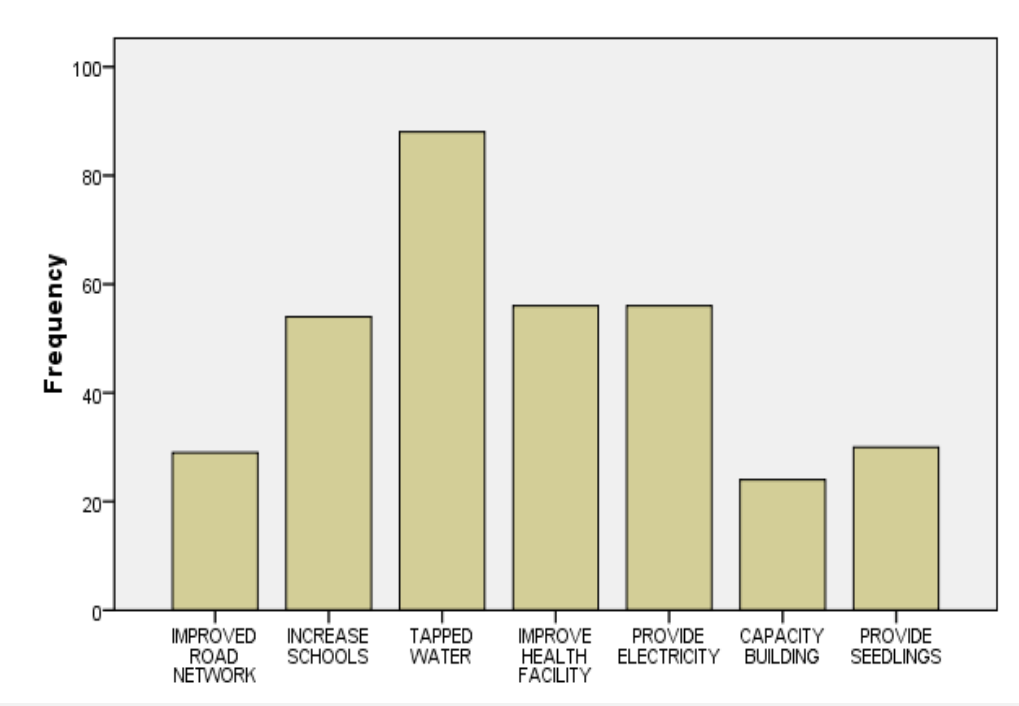

Figure 4.20: Group incentives demanded for conservation of Ndaka-ini catchment

The type of incentive is likely to be influenced by the income level of the household and this led to assessment of net income levels of the respondent as shown in Table 4.56.

Table 4.56: Net income generated by the farmers through cropping activities and livestock products

Net income through cropping activities	Farmers' net income through livestock products in Kshs.									Total
	20,000 - 50,000	50,001 - 100,000	100,001 - 150,000	150,001 - 200,000	200,000 - 300,000	300,001 - 400,000	400,001-500,000	500,000 and above	None	
20,000 - 50,000	3	0	0	0	1	0	0	0	10	14
50,001 - 100,000	2	8	4	1	4	0	0	0	11	30
100,001 - 150,000	12	6	12	9	3	1	1	0	18	62
150,001 - 200,000	13	12	9	11	2	8	0	2	14	71
200,000 - 300,000	7	3	7	6	2	5	0	2	10	42
300,001 - 400,000	4	4	12	9	2	2	0	4	7	44
400,001-500,000	6	3	6	6	2	3	0	5	6	37
500,000 and above	5	4	11	4	1	0	1	0	7	33
None	0	0	0	1	0	0	0	0	3	4
Total	**52**	**40**	**61**	**47**	**17**	**19**	**2**	**13**	**86**	**337**

χ^2=97.356, df=64, Sig. = 0.005* (Measured at p<0.05 level of significance)

As indicated in Table 4.56, in the last 12 months, 4.2% respondents had a net income of Ksh.20, 000-50, 000 in the cropping activities: 21.1% had a net income of Ksh.150,001-200,000, 13.1% had an income of Ksh.300,001 to 400,000 while 9.8% made an income of Ksh.500,000 and above. In relation to livestock activities, 15.4% respondents made an income of Ksh.20,000 – 50,000, 18.1% made an income of

Ksh.100,001-150,000, 5.6% made a net income of Ksh.300,001-400,000 while 3.9% made an income of Ksh.500,000 and above.

Chi-square test results revealed that there were significant differences among the farmers level of income generated through cropping activities and livestock product per year (χ^2=97.356, df=64, p=0.005). The findings showed that while majority of the farmers were getting a net income ranging from Kshs. 20,0000 to 200,000 from livestock products, most of those engaging in cropping activities were getting a net income of Kshs. 100,000 to 400,000 as shown in Table 4.57.

Table 4.57: Farmers' net income from off farm sources and other sources in Gatanga

Net income (Kshs) Per month	Off farm sources		Other sources	
	n	%	n	%
1,000 - 5,000	27	8.0	30	8.9
5,001 - 10,000	31	9.2	17	5.0
10,001 - 15,000	18	5.3	18	5.3
15,001 -20,000	20	5.9	5	1.5
20,001 - 30,000	13	3.9	8	2.4
30,001 -40,000	7	2.1	0	0.0
40,001- 50,000	4	1.2	0	0.0
50,001 - 100,000	17	5.0	1	0.3
None	200	59.3	258	76.6
Total	**337**	**100.0**	**337**	**100.0**

As shown in Table 4.57, majority of the households did not get any net income from off farm sources and other sources (off farm sources (59.30%) and other sources (76.6%)). Among the few respondents who made net income, 8.0% made a net income of Ksh.1,000-5,000 from off farm sources, 5.9% made an income of Ksh.15,001-20,000

whereas 5% made a net income of Ksh.50,001-100,000. From other sources, 8.9% household heads made a net income of Ksh.1,000-5,000, and 5.3% made Ksh.10,001-15,000, with only 0.3% household head reporting that they made an income of Ksh.50,001-100,000. This calls for diversification of income sources.

4.7.1 Effects of the Dam on Community Livelihoods

The study further sought to determine effects of the dam on livelihoods. To address this, household heads were asked to indicate whether they benefited from the dam or not. In response, 16.9% respondents reported that they benefited while 83.1% respondents indicated that they never benefited. Table 4.58 shows the positive effects of the dam.

Table 4.58: Positive effect of Thika dam on the neighboring community

Positive effects of dam	n	%
Infrastructure development	34	10.1
Water supply	16	4.7
Tourism	4	1.2
Employment	3	0.9
None	280	83.1
Total	**337**	**100.0**

As indicated in Table 4.58, some respondents indicated that the major positive effects of the dam were infrastructural development (10.1%), water supply (4.7%) and attraction of tourist (1.2%). However, 83.1% indicated that there was no positive effect of the dam. This is a major area of concern as it relates to the perception of the community neighbouring the dam. In one of the interview with a farmer neighbouring

the dam, he indicated that they do not see any benefit from the dam and went ahead to suggest that they would be better off if the dam was drained off. The NWSC in partnership with other agencies managing the resource should address the issue by developing community outreach programs. Payment for environmental services could provide a good entry point towards providing incentives which would improve linkage of the community and the water resource. Table 4.59 illustrates the negative effects of the dam.

Table 4.59: Negative effect of the Thika dam to the neighboring community

Negative effects of dam	n	%
Extreme coldness	200	59.3
Reduced land size	55	16.3
Malaria preference	43	12.8
Damage food crops	32	9.5
Security threat	7	2.1
Total	**337**	**100.0**

As shown in Table 4.59, 59.3% of the respondents indicated that extreme coldness was one of the negative impacts of the dam. Other negative impacts mentioned were; reduced land size, malaria preference, damage of the food crops and security threat. In a focus group discussion with CFA members, they indicated that due to change in weather pattern, they no longer plant crops like cabbages that used to do well in the area before. Keeping of livestock has also reduced and those who keep them incur higher cost of treatment. The dam also separated community members who used to reside together and cut them off from schools, health centres and shopping centres.

There were earlier promises to set up schools and health centres but these are yet to be actualized.

Table 4.60 provide the opportunities of the dam to the improvement of the life of the community.

Table 4.60: Opportunity of the Thika dam to the improvement of the livelihood of neighboring community

Opportunities	n	%
Domestic water supply	174	51.6
Power supply	86	25.5
Fish provision	35	10.4
Eco- tourism	14	4.2
Water for irrigation	13	3.9
Health centres	10	3.0
School bursaries	5	1.5
Total	**337**	**100.0**

The improvement of the dam has brought about some opportunities in the community. As reported by the household heads, 51.6% indicated that construction of the dam has led to water supply in the community, 25.5% indicated it has led to power supply while 10.4% indicated that it created jobs since some members of the community engaged in fishing activities.

4.8 Institutional Policies and LegislationsPut in Place to Support PES Work in Kenya

The fifth objective of the study was to find out institutional policies and legislations put in place to support PES work in Kenya. This was addressed through discussions with key institutions dealing with water sector and analysis of legislations

covering water abstraction and conservation of catchment areas.The PES will work when policy and legal mechanisms support implementation. This will enable implementation by consumers across the landscape by setting up institutional framework for collecting incentives and ploughing back to the producers of ES. A form of agreement by both parties is required and this would work well when it's enforceable through legal means. Institutions governing PES schemes need to understand the system in question and demonstrate to policy makers and users of the resource the effectiveness of the scheme through successful monitoring.

4.8.1 Policy, Legal and Institutional Frameworks

The study used a checklist to investigate existence of supporting policy, legal and institutional frameworks as well as identify gaps. Government and its agencies have a key role in facilitating and removing barriers to markets which can bring providers and beneficiaries together, build capacity for such approaches and help to deal with the various information failures that can hold back such approaches (Dunn, 2011). In particular, the study evaluated the Constitution of Kenya (2010), Environmental Management and Conservation Act (EMCA), Forest conservation and Management Act No. 34 (2016), Water Act, No. 43 of 2016,Land ActNo. 6 (2012), Climate Change Act, No. 11 of 2016and Agriculture, Fisheries and Food Authority Act, No. 13 of 2013.

The Constitution of Kenya addresses issues of environmental governance, giving the environment and its management due prominence in the preamble, which as a rule provides the background within which the specific constitutional provisions are to be interpreted and applied. Table 4.61 shows the key sections in the constitution that support PES.

Table 4.61: Sections in constitution that support payment for environmental services

Sections	Citation	Implication to PES
Preamble	Kenya's environment is her heritage and should be sustained for the benefit of future generations	Provides good guideline for interpretation of benefit flow to Kenyans
Section 69	State shall ensure sustainable exploitation, utilization, management and conservation of the environment and natural resources, and ensure the equitable sharing of the accruing benefits.	Forms basis for sustainable utilization of natural resources and benefit sharing
Article 42	Every person has a right to a clean and healthy environment	Supports provision of regular and clean water
43(d)	gives every person *right* to clean and safe water in adequate quantities	Support efforts towards conservation practices that contribute to provision of clean water
Article 174 (*g*)	Identifies one objective of devolved governance as to ensure equitable sharing of national and local resources throughout Kenya	Provides basis for sharing of resources between the national government and the counties
Fourth Schedule	Spells out the distribution of functions between the National Government and County Governments	Identify roles of national and County government in management of resources

The preamble to the Constitution notes that Kenya's environment and by implication her water catchment areas is her heritage and should be sustained for the benefit of future generations. As catchment areas serve critical functions in maintaining the country's water supply, it is important that they are conserved to guarantee the availability of quality water for both present and future generations.Section 69, gives the state responsibility of ensuring sustainable exploitation, utilization, management, conservation of natural resources and equitable sharing of the accruing benefits. The state is expected to utilize the environment and natural resources for the benefit of the

people of Kenya. The responsibility of the citizen is to cooperate with State organs and other persons to protect, conserve the environment and ensure ecologically sustainable development and use of natural resources. Article 42 of the constitution gives every person a right to a clean and healthy environment while Article 43(d) gives every personright to clean and safe water in adequate quantities.Both article 42 and 43 are part of bill of rights that every Kenyan is supposed to enjoy without restriction. Article 69 (1) (d) obliges the state to involve the public in the management, protection and conservation of the environment while Article 69 (2) bestows upon every citizen the duty to cooperate with state organs and other persons to protect and conserve the environment and to ensure ecologically sustainable development and use of natural resources. Article 174 (*g*) identifies one objective of devolved governance as to ensure equitable sharing of national and local resources throughout Kenya (Constitution of Kenya, 2010). The Fourth Schedule of the Constitution of Kenya, (2010) spells out the distribution of functions between the National Government and County Governments. The National Government is responsible for formulating the Agricultural Policy and for the protection of the environment and natural resources with a view to establishing a durable and sustainable system of development, including, water protection and securing sufficient residual water. The County governments are in charge of promoting socio-economic development in line with specific government policies on agriculture, natural resources and environmental conservation, including soil and water conservation and forestry.

The constitution of Kenya, (2010) does not make reference to PES but indirectly supports it as it underpins the concept of equitable sharing of benefits arising from natural resource management while conserving the resources for the benefit of all Kenyans.The Constitution has changed the nature of governance in Kenya to a devolved

government, and this means that policies will be implemented at the National and County levels. Devolution is geared towards promoting democracy and accountability, promoting the involvement of people in their governance, enhancing equitable sharing of resources, and facilitating decentralization of state organs and their functions and services. In accordance with the division of functions between national and county governments, as detailed in the Fourth Schedule of the Constitution, the Water Master Plan proposes avenues for the conservation of water catchment areas at national and county levels. These focus on enhancing conservation through proximate and accessible institutions and with the active participation of citizens at local levels.

The Constitution recognizes three land tenure modes; community, private and public land holdings, but regardless of the tenure regime, it requires that the land be held, used and managed equitably, efficiently, productively and sustainably, and that ecologically-sensitive areas be conserved and protected. The public land in the constitution includes rivers, lakes, the territorial sea and other water bodies, exclusive economic zone, sea bed, continental shelf and land between the high and low water marks. By recognizing the right to water, the Bill of Rights puts an obligation on the State to ensure that water is conserved and available, and that every person has access to sufficient clean and safe water. In view of the role played by water catchment areas in ensuring availability of water, it is undeniable that they are instrumental in guaranteeing the right to clean and safe water, and therefore need to be protected. Conservation of natural resources and equitable sharing of accruing benefits can be considered supportive of the PES mechanism and can be used to implement PES. Indeed, the objective of the new constitution was to give power of self-governance to the

communities and to enhance their participation in decision making and development within their areas of interest.

There is no legislation specifically dealing with PES in Kenya, butit's elementsare covered under Water Policy (2013), Water Act (2016),Environmental Management Coordination Act(2015) and Forests Conservation and Management Act (2016).However,Asquith et al. (2007) indicated that PES may not require a specific law to operationalize though such a law would be an added advantage. In practice, there are no policy, legal and regulatory changes that are always required to establish a PWS scheme. Rather, PWS schemes need to be developed to fit their particular contexts. In practice, working with existing law is usually the best course — at least initially".

4.8.1.1 Environmental Management and Coordination, 1999 and Environmental Management and Coordination (Amendment) Act, No. 5 of 2015

The Actprovides an overarching legal and institutional framework for the management and coordination of the environment. It guarantees every Kenyan the right to a clean and healthy environment and obligates citizens to conserve the environment.The Act provides a framework for the implementation and enforcement by establishing the National Environmental Management Authority (NEMA) as the principal body for supervising and coordinating environmental management and implementing government policies on the environment. The Act as the framework law in environmental matters is relevant to the governance of water catchment areas, addressing the conservation of wetlands in Section 42, and the protection of hilltops, hillsides, mountain areas and forests in Section 44. The latter Section requires NEMA, in consultation with lead agencies, to develop issue and implement regulations,

procedures, guidelines and measures for the sustainable use of hillsides, hilltops, mountain areas and forests.The Act requires the conduct of Environmental Impact Assessment (EIA) in conversion of land use from one type to another. The Act also provides for polluter pay principle in form of ensuring restoration of degraded areas. Table 4.62 provides key sections in the Act and how it affects PES implementation.

Table 4.62: Sections in EMCA Act that supports PES implementation

Section	Main emphasis/quotation	Effect to PES
preamble	Framework law in environmental governance in Kenya	Most suitable to anchor PES as its cross sectoral
Section 42	protection of hilltops, hillsides, mountain areas and forests	Support conservation efforts in the catchment areas
Section 44	NEMA, in consultation with lead agencies, to develop issue and implement regulations, procedures, guidelines and measures for the sustainable use of hillsides, hilltops, mountain areas and forests	Guidelines could include PES guidelines to be used by providers and users of ES
9(i)	Encourage voluntary environmentalconservation practices and naturalresource conservancies, easements, leases, payments for ecosystemservices and other such instrumentsand in this regard, develop guidelines.	Gives room for PES and other incentive mechanisms

4.8.1.2 Water Act (2016)

Water Act (2016), align the water sector to the constitution whichacknowledged that access to clean and safe water is a basic human right and assigned the responsibility of water and sanitation service provision to the 47 County governments. The Water Act recognizes water related function are a shared responsibility between National and County government. The Act has no mention of PES but creates national institutions namely; WaterSector Trust Fund (WSTF) for supporting conservation and protection of water resources, Water Resources Authority (WRA) for managing water sector, National Water storage authority and Water Tribunal. At the regional level the Water

Act creates basin Water Resource Committees and water works development agencies. The act finally creates Water Resource Users associations (WRUAS) and Water Service Providers at the local level.

Section 44 gives WRA authority to oversee conservation of water catchment areasand develop guidelines and principles of allocation of water resources, regulate and protect water resources, manage and protect water catchments, gather and maintain information on water resources among others. This information is synthesized under national water management strategy that is implemented through respective catchment management strategy. The water service regulatory board(WSRB) issues licenses for water provision, determine standards of water to be supplied to residents, establishes procedures for water complaints, monitors and regulates licenses, develops guidelines for fixing water tariffs and its responsible for efficient and economical provision of water services. The water act decentralized water services to 117 water service providers which are linked with regional water service boards through service provision agreement.

In trying to structure watershed PES through action research in Sasumua, PRESAproject encountered policy-related obstacles, especially in identifying buyers and attracting sustainable financing. For example, although the Nairobi Water and Sewerage Company benefits from improved land-use practices in the watershed, it could not finance PES as a buyer for two reasons; the Company pays abstraction fees to WRMA and levies to Kenya Forest Service and Athi Water Services Board hence it can only implement PES if it is clearly stipulated as a policy requirement. An alternative way of financing PES in areas where there is no private sector buyer is through the

WSTF, but being a public fund meant for capacity building, getting into PES and paying farmers would take it into the private realm, which is outside its mandate (Mwangi et al., 2011).

The Act creates a National water harvesting and storage authority that will develop public water works for water resources storage and flood control. The Legislation establishes Water Sector Trust Fund to be used to support conservation activities whose mandate is to support provision for Community level initiatives for the sustainable management of water resources which allows the fund to participate in water resources management at community level. The funding sources have also increased under the devolved form of government and it can now receive funds from the equalization fund and from County governments meaning PES can be funded by County governments.

4.8.1.3 Forest Act, 2005 and Forests Conservation and Management Act (2016) No. 34 of 2016

The Forests Act,2005was established to give effect to article 69 of constitution with regard to forest resources, to provide for development and sustainable use and support participation of stakeholders in the conservation and management of the forest resources through collaborative management. The recognition of forest adjacent communities as key stakeholders and users of natural resources is considered vital if successful management is to be attained. The Act provides for communities living adjacent to forests to enter into collaborative management agreements with Kenya Forest Service (KFS) through Community Forest Associations (CFAs). Section 47 (1) confers the CFA with the following forest user rights: collection of medicinal herbs,

harvesting of honey, harvesting of timber or fuel wood, grass harvesting and grazing, collection of forest products for community based industries, ecotourism and recreational activities, scientific and education activities, plantation establishment through non-resident cultivation, contracts to carry out silvicultural operations and development of community wood and non-wood forest based industries. The Act provides for preparation and gazettement of Rules to enforce the law.

The Forests (Participation in Sustainable Forest Management) Rules, 2009 were gazetted via Legal Notice No. 165 of 2009. The Rules apply to participation of the private sector and forest communities in sustainable management of State forests and may, with the necessary modifications, be applied by a Local Authority, with the consent of the Minister responsible for Local Authorities, to the participation of the private sector and forest communities in the management of Local Authority forests. Under the rules, KFS may issue authorisations for forestry activities in the form of a permit, timber license, special-use license, contract, joint management agreement or concession agreement of a specified forest area. The CFA enters into a Forest management agreement with the service for use of the forest. The primary purpose of a joint management agreement is to conserve the forest and allow non-consumptive uses. However, an agreement may also allow limited consumptive use of forest resources if sustainable. Benefits accruing from PES should be factored in the forest management agreement especially for the activities that will take place inside the forest. The other activities covered under the management plan and agreement that take place outside the forest can form part of the additional rewards in PES.Some of the KFS/CFA agreements have provisions in relation to Reduced Emission from Deforestation and Degradation

plus (REDD+) benefits. For instance, the Green Belt Movement (GBM) has an agreement with KFS that allows CFA and GBM to share benefits accruing from carbon credits in Aberdares Forest.

The FCMA (2005) mandates the KFS to charge an annual land rent and way leave fee to beneficiaries of forest services including water abstractors. The Act promotes community participation in forest conservation with envisaged benefits to the forest adjacent community. Community participation has improved resource conservation in most areas and sense of ownership but it has faced challenges arising from lack of clear cost benefit sharing mechanisms between the KFS and the CFAs. The Act does not give mechanisms to plough back funds for conservation but creates Forest conservation Fund whose function is to support conservation related activities. However, the fund is yet to be fully operationalized.

Forests Act (2005)has been revised to the now enacted Forest Conservation and Management Act, (2016)to be in line with constitution. The Act was assented as No. 34 of 2016 on 31st August, 2016 and became active on 31st March 2017 when the Cabinet Secretary gave a gazette notice of its implementation date.The Act provides for the sustainable exploitation, utilization, management and conservation of the forests and forest resources, and ensure the equitable sharing of the accruing benefits. The Act address issues of benefit sharing by aligning it to the Land Act 2012. The Act under Section 55 mandates the Cabinet Secretary in charge of the environment to develop guidelines and regulations on PES indicating institutional frameworks, engagement modalities, benefit flow mechanisms, funding mechanisms and sustainability of the programme. In addition, section 56 empowers the Cabinet Secretary in charge of the

National Treasury to propose tax and other financial incentives to encourage investment in forest so as to promote forest conservation and management. Such measures include customs and excise waivers, exemption from paying all or part of land rates, tax deductions and a provision for PES from public goods derived from forests. The Act gives the Cabinet Secretary in charge of environment the mandate to formulate guidelines on incentives and benefit sharing, in addition to prescribing measures to enhance community participation in forest conservation and management.

The reviewed legislation mentions PES as a mechanism for promoting conservation activity without giving details as to how it will be operationalised. It is expected that the details will be contained in subsequent subsidiary legislation. The government should seek to harmonize Water and the Forestry Legislation with a view of creating one-stop levies so that the Forest Management and Conservation Fund will not exercise its prerogative to seek payments for dams and other water infrastructure within forest boundaries. This will avoid second tier payments above the Water Resources Management Authority levy which currently makes it difficult to raise funds for PES from the private sector who consider it double payment. However once payment is made for water services, part of this fund should be ploughed back to support conservation activities in the catchment areas.

4.8.1.4 Agriculture, Fisheries and Food Authority Act No. 13 of 2013, (2013).

Despite the far-reaching and punitive implications within the corpus of Agriculture and Livestock related Acts, it is generally conceded that they have not been successful in slowing land degradation, owing in part to; lack of resources to monitor and sanction land use, and failure by the law to involve communities in decision making

in the management of agricultural resources. There is widespread evidence of non-adherence of agriculture rules especially those related to conservation of riparian areas. There are also conflicting guidelines on riparian areas ownership between agriculture act and land act.

The Section 23 on the land preservation provides that Cabinet Secretary may give guidelines for purpose of conservation of the soil or prevention of adverse effects of soil erosion that could prohibit or regulate agriculture activities which are detrimental to the degradation and protection of water catchment areas. In addition, it providesfor guidelines regulating or controlling afforestation or reforestation, drainage of land including construction, maintenance or repair of drains, gullies, contour banks, terraces and diversion ditches. It also provides for uprooting or destruction without payment of any vegetation planted in contravention of the Act.The Agriculture rules provide for farmer planting 10% of the land with trees that implement provision in the constitution.

Agriculture is a devolved c function and so the main implementing role will be County Government. For PES to work, there must be close coordination with implementers of Agriculture legislation as most interventions will be carried out onfarm.

4.8.1.4 Kenya Water Towers Agency

The Legal Notice No. 27 of 13th April 2012 under the State Corporation Act Cap 446 established the Kenya Water Towers Agency (KWTA) which is a body corporate with the following functions:

(a) co-ordinate and oversee the protection, rehabilitation, conservation, and sustainable management of water towers;

(b) co-ordinate and oversee the recovery and restoration of forest lands, wetlands and biodiversity hot spots;

(c) promote the implementation of sustainable livelihood programmes in the water towers in accordance with natural resource conservation;

(d) mobilize resources from the Government, development partners and other stakeholders as well as through payment for environmental services, including carbon reservoirs and sequestration;

(e) in consultation with the relevant stakeholders, identify water towers and watersheds for protection;

(f) assess and monitor rehabilitation, conservation and management activities in the water towers; and

(g) perform such other functions as the Minister may, from time to time, assign to the Agency.

The legal notice expanded the water towers from original five to 18 water towers and gave the agency powers to continue identifying other water towers. Kenya Water Towers Agency can play an important coordination role of various agencies concerned with water towers management. It can also coordinate payment for water services by ensuring guidelines are developed for plough back mechanisms.

Payment for ecosystem service pilot projects in Kenya operates with no clear administrative rules hinged in any legislation. Most legislation cover goods and services that are traded in the market. While PES may not be covered under a specific legislation, it needsto be included in different sectoral laws. This will support

implementation of incentive mechanisms in conservation by rewarding participating parties.

4.8.2 Land Laws and Policies

The National Land Policy (2009), recognizes and protects the rights of forest dependent or other natural resources dependent communities and facilitates their access, co-management and derivation of benefits from the resources. The Policy states that the Government shall:

- Align, to the greatest extent possible; tenure to land based natural resources to the different land categories, namely, public, community, and private, establish legal frameworks to recognise community and private rights over renewable and non-renewable land-based natural resources, and incorporate procedures for access to and sustainable use of these resources by communities and private entities,
- Put in place legislative and administrative mechanisms for determining and sharing of benefits emanating from land based natural resources by communities and individuals where applicable,
- Make benefit-sharing mandatory where land-based resources of communities and individuals are managed by national authorities for posterity, and
- Ensure the management and utilization of land-based natural resources involves all stakeholders.

To implement the National Land Policy three legislations were enacted namely, Land Acts, (2012), the National Land Commission Act (2012), Land Registration Act (2012)and Community land Act (2016).Land registration Act (2012) providesprovision

for issuing title to owners and upholds their rights or interest on the land (Article 8 (3)). Overriding rights are also safeguarded for light, air, water and support for registered land including private land (Article 28).

Payment for ecosystem service operate well where there is a clear ownership hence titles provided under land registration are key to participation by individualland users. The National Land Commission (NLC) Act (2012) established the Commission whose functions include management of public land on behalf of the National and County Governments, making recommendations on a National Land Policy to the National Government and to monitor and have oversight responsibilities over land use planning throughout the country. The Act charges NLC to investigate and recommend appropriate redress for historical land injustices. NLC is charged with developing legislation on historical land injustices within two years. This provision may confer rights to communities who may have been deprived of their land. This Act provides NLC to implement settlement programmes through a settlement fund to be created by NLC.The Land Act (2012), under Article 19 states that NLC will provide:

- Incentives for communities and individuals to invest in income generating natural resource management programmes,
- Measures to facilitate the access, use and co-management of forests, water and other resources by communities who have customary rights to these resources,
- Procedures on the involvement of stakeholders in management of land based natural resources,

- Rules and regulations as measures to ensure benefit sharing to affected communities.

Of particular importance in this Act is the issue of gender equity vis-à-vis carbon rights. The Land Act in its list of guiding values and principles includes "*equitable access*" and "*elimination of gender discrimination in law, customs and practices related to land property in Land*". The Land Act supports PES as it provides for incentives in conservation and measures to facilitate access and use of the resources, in addition to providing for regulations that guides in benefit sharing.

4.8.3 Institutional Framework for PES

Payment for environmental services would work best with a clear institution framework. However,PES institutions in Kenya are undeveloped at all levels (Mwangi et al.;2011). Results from study area showed that there were community-based organizations dealing with sectorial issues like Community Forest Association (CFA), Water Resources Users Association (WRUA), Saving and Credit Corporative Organizationsamong others. The main CBOs in Ndaka-ini wereWRUA, CFA and Thika dam Environmental Conservation Association (NDEKA). The main private organization wasKTDA thatbuys, process and markets tea from small-scale tea farmers who constitute 90% by land occupation. Public institutions included KFS, NEMA, Primary and secondary schools, government line ministries and WRMA. Nairobi Water and Sewerage Company, a semi- public institution was the main beneficiary of water as it has leased the dam from AthiWater Board.The other main beneficiary of water is KENGEN, a semi-autonomous government organization charged with responsibility of harnessing electric power. The main source of hydropower in Kenya is the seven forks

dams whose main catchment is Aberdares and Mt. Kenya ecosystems. Other institutions involved in water sector include WSRB that determines water tariff, water companies and water service boards like Athi and Tana who are the resource owners of the dams. The main institution involved in conservation of water catchment is KFS for the area in the forest and ministry of agriculture in watershed areas within the farms. On the other hand,the main institution in water abstraction and treatment is NWSC working closely with WRMA. In addition to the above institutions, the County government has a big stake in water issues as the water reservoirs and catchment areas are located within their boundaries.

The Ministry of Environment and Natural Resources togetherwith Ministry of Water and Irrigation are responsible for management of water catchment areas. The main implementing agencies for the ministry are KFS, NEMA, WRMA, KEFRI and Kenya Water Towers Authority. Under the devolved government, the County government will play a major role in conservation and management of water as they are expected to develop legislation aimed at improved conservation of the environment. In addition, water service boards, agriculture, forest extension and most rural based development activities have been devolved to the counties. Development of PES structure requires close linkage between the National and County government as water resources transect to different counties.A past study by Balana B. and Catacutan D. (2012) showed that key challenge in implementing market-based catchment conservation inSasumua was lack of a viable institutional and administrative set-up to manage a PES scheme with the public expressing distrust with entities entrusted with

water provision. This calls for an honest intermediary in PES that would build public trust.

An effective PES structure requires sellers of ES to be connected to buyers through intermediaries. Theseintermediaries are in charge of finance, identification of sellers/buyers, negotiation, bundling services, support/advisory/capacity building services and organizing roundtable forum to inform potential buyers and sellers. In the case of Ndaka-ini, the main institution for PES should be WRMA working closely with WRUA. WRMA will coordinate conservation activities with farmers who are members of WRUA. In addition to WRUA, the communities are also represented by CFA who are charged with conservation of forest through participatory forest management. It's important for WRUA to work closely with CFA to create synergy other than competition in natural resource management. A study done in Sasumua showed that overwhelming majority of the respondents (nearly 90%) identified the lack of an accountable and honest administrative and institutional regime for delivering the proposed schemes for enhancing reliable water supply in Nairobi as the main challenge. Inaddition, there was general public distrust and suspicion on use of funds for conservation (Bedru and Delia, 2012). It's important then to identify a credible institution that can act as intermediary. KTDA could play a major role as intermediary as it promotes conservation friendly activities through rain forest certification program and is well spread out in the area as tea farming is the maineconomic farm use in the area.

Management of water catchment areas is vested within KFS, WRMA, KWS, NEMA and KWTA. These institutions have overlapping mandates as they are all

charged with managing the catchment which isalsoforest reserves and habitat for wildlife. This has created conflict in resource management in the past especially between KFS and KWS, and it's bound to recur in future with introduction of new actors. This calls for harmonization of roles and responsibilities to avoid conflict while promoting closer working relationships. The main agency in water catchment within the farms is Ministry of Agriculture and Livestock and its agencies like KTDA, as it has responsibility of ensuring soil and water conservation practices are adhered to in the farmlands. The ministry of Agriculture working closely with Ministry of Environment, Water and Natural Resource is expected to spearhead the constitution requirement of achieving 10% tree cover within the farmlands. One major institutional constraint is inadequate collaboration between the lineMinistries dealing with crop and tree growing. This can be promoted through joint action plans targeting agro-forestry species.

Payment for ecosystem service within Ndaka-ini should be established at regional scale to capture the buyers and sellers. This requires concerted effort of National and County government. Efforts should gear towards efficiency of institutional framework through reduction of transaction costs and clarification of roles and responsibilities of each partner.The Kenya Water Master Plan, (2013) identified challenges facing governance arrangements in water sector to beweak institutional linkages and synergies. It noted that despite the existence of a wide array of institutions relevant to the management of water catchment areas, there are very few linkages and synergies between these institutions. The lack of an integrated approach in the management of water catchment areas has resulted in their encroachment as well as massive deforestation. What this demonstrates is the lack of clarity on the overall

institutional responsibility for the conservation of water catchment areas or a proper framework for harmonization and coordination of mandates. The provisions within EMCA, though useful, are not adequate to fully deliver the required harmonization and coordination(Kenya WaterMasterplan, 2013).

4.8.4 Property Rights Issues Considered in PES

The farmlands in the project area are private farms while the forest that forms the catchment area is public land. Water as a resource is owned by the state but the ecosystem services are jointly contributed by state and private owners. Trees and accompanying vegetation in the farmlands is privately owned, however ES in the land is public good as no one can lay claim to water. In a few cases, the owner of the farm leases them to other persons for tea farming. Most of the land parcels are ancestral land meaning that they are passed over from generation to generation. This is a challenge as the land units gets subdivided every time they are passed over and may end up with economically unviable units. Land use change and subdivision require prior approval though there are no strict mechanisms for enforcing the same. Subdivision will require approval for the owners to get separate title deeds. However, the practice is for the family head to subdivide the land informally amongst the siblings, who process title documents later. In a number of cases this is not done but the land remains divided on the ground. Land use change and limits for subdivision will in future attract more attention with the enactment of Land Registration Act,(2012). The land is protected from activities that can have negative effects through provision of Environmental Impact Assessment and Environmental Audits provided for under EMCA. The Act

stipulates the activities that require EIA and outlines mandatory requirements to be carried out prior to commencement of a project.

4.8.5 Negotiation in PES

Payment for environmental services is still under-developed in Kenya. In Naivasha a pilot PES scheme between the WRUAs in upper Turasha and Wanjohi and the flower farm in Naivasha has progressed to a level of agreement. Another case of PES negotiated agreement is carbon project implemented by carbon wildlife works in Voi that is an international agreement. There are no formal negotiated agreements as the process is developing but experience from the pilot areas would help in developing guidelines on negotiations. However, the country requires capacity at all levels as negotiation capacity is low.

4.8.6 Contractual Issues in PES

One condition under PES is an agreed contract between the provider of the service and the user binding both parties to the agreement. This means that all parties involved in PES should have capacity to enter into a legal contract. In most cases, individuals and organizations have the right but not necessarily for the communities as they lack legal structures. This calls for capacity building towards community-based organizations processes bringing together communities to form legally binding community-based organizations. Legal nature of the contract depends on whether it's a private or public contract. In case of private contract, applicable provisions depend on whether the contract is an input-oriented contract (only a certain land use/land use change is owed) or an output-oriented contract (a result is owed, e.g. increased

amount/improved quality). The contract should have clear objectives and obligations for the different parties. The contract should also specify levels of payment and who to be paid; individuals or the community. Where applicable, payment should fit in an existing scheme and clearly spell out benefit sharing mechanisms. The parties involved should determine type of payment to be done and timing.

4.8.7 Monitoring, Non-compliance and Enforcement in PES

One main feature of PES is the conditionality, meaning that payment is tied to continued supply of product or service. This calls for establishment of an effective monitoring system that tracks provision of the ES. Baseline information is important for tracking progress. Both parties should agree the entity to monitor compliance and indicators to be used. In most cases the buyer, public institution or an independent verifier is used in monitoring.Monitoringsystem adopted should balance between effectiveness and affordability. Adequate structures should be put in place to avoid corruption during monitoring. Field assessment to be clear in what to be measured and procedures agreed that include: legal authority for inspections, frequency of inspections, consequences of refusing inspection, right of entry to inspectors, whether notifications is required and what documents to be examined. Self-assessment is commonly used in which reports from such assessment are verified by verifiers. The buyers and providers of the ES make joint visits to the areas under PES to monitor progress towards implementation. In cases of non-compliance, reasons should be given and ways for correcting it identified.

4.8.8 Dispute Resolution in PES

Dispute in PES are sorted out according to the legislation in place. In Kenya there is no specific legislation on PES but elements of the dispute can be sorted out through environmental court or relevant sectoral law.The parties can also decide to submit dispute to arbitral tribunal or to mediation. The process of development of the PES should be guided by consultation and public participation that is a requirement under the constitution. This will avoid disputes that would arise from inadequate information

4.8.9 Role of Environment and Land Court in PES

This court was established in 2011 by the Environment and Land Court Act, to give effect to Article 162(2) (***b***) of the Constitution (Environmental and Land Court Act, 2011). It establishes a superior court with both original and appellate jurisdiction to hear and determine disputes relating to the environment and the use and occupation of, and title to, land, and to make provision for its jurisdiction functions and powers. The court is to be guided by a number of principles, including: -

- public participation in the development of policies, plans and processes for the management of the environment and land;
- cultural and social principles traditionally applied by any community in Kenya for the management of the environment or natural resources in so far as the same are relevant and not inconsistent with any written law;
- international co-operation in the management of environmental resources shared by two or more states;

- intergenerational and intra-generational equity;
- polluter-pays principle; and
- pre-cautionary principle

These principles could help ensure entrenchment of environmental sustainability in the determination of disputes relating to land, forests and the environment.

In addition, the court's jurisdictionhas a direct bearing on forest governance and thus has implications for PES. For instance, the court has jurisdiction over disputes relating to environmental planning and protection, climate issues, land use planning, title, tenure, boundaries, rates, rents, valuations, mining, minerals and other natural resources. The court also has powers to hear and determine disputes relating to compulsory acquisition of forest lands, since the Act gives it jurisdiction over disputes relating to compulsory acquisition of land. The court also has jurisdiction over disputes relating to land administration and management; public, private and community land; and any other dispute relating to environment and land. The court thus has a big role to play in forests management since forests may fall under any of these categories of land.

4.8.10 Funding PES from the Government-Established Funds

Various funds have been established to support conservation of water catchment areas, and there are other funds established for other purposes but which can still be used for the protection of water catchment areas. Some of these potential sources of funds for restoration include the:

i. Water Towers Conservation Fund, established on 23 July 2010, is part of the Mau Complex Forest Interim Coordinating Secretariat's mandate "to

develop the framework for long-term measures to restore and sustainably manage the Mau Forest Complex and other water towers". This fund is managed by a National Water Towers Management Committee.

ii. Forest Management and Conservation Fund, established under the Forests Act 2005, is managed by a Finance Committee appointed and empowered by the KFS Board. Some of the functions of the Board include the maintenance and conservation of indigenous forests, rehabilitation of forests, management of unique forests for biodiversity conservation, and establishment of nurseries and production of seedlings.

iii. Water Services Trust Fund, established under the Water Act 2002, whose objective is to assist in financing the provision of water to areas of Kenya with inadequate water supply

iv. National Environment Trust Fund established under EMCA 1999 and managed by a Board of Trustees.

v. National Restoration Fund vested in NEMA with the objective of supplementing insurance for the mitigation and control of environmental degradation.

vi. Kenya Wildlife Service Fund established under the Wildlife (Conservation and Management) Act and managed by the Kenya Wildlife Act (KWS) Board of Trustees.

vii. National Consolidated Fund and the County Government Revenue Fund established by the Constitution of Kenya 2010.

viii. Constituency Development Fund (CDF) established by the CDF Act

ix. Water fund established by The Nature Conservancy working closely with other stakeholders created an Eendowment Fund—a fund whose capital is invested in order to generate a steady annual stream of income. Only the investment interest and earnings are spent, while the principal is either maintained or increased. In addition, they established a Sinking Fund—a fund designed to disburse its entire capital plus its investment income over a designated period of time and a Revolving Fund—a fund that periodically (e.g., annually) is replenished through fees collected and/or through donor contributions (TNC, 2015)

In-spite of existing funds that can support of conservation, very few are in operation and those in use have had little impact on conservation. As a result, they require reorganization especially to factor in conditionality that is a key requirement in PES. This will ensure that an incentive in conservation it tied to additionally in provision of the ES.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The study was conducted in GatangaSub-County in Murang'aCountytargeting small-scalefarmers, small scale water users in the upstream and downstream andlarge-scale water users inThika townin KiambuCounty.The main objectives of the study were; to identify land use and socio-economic changes in Thika dam watershed for the last 30 years and their effects on water flow and quality, find out the willingness of the downstream buyers to pay for watershed protection services and socio-economic factors influencing their ability, identify and cost the environmental services farmers in Ndaka-ini area were willing to offer for conservation and their related cost, identify economic incentives buyers were willing to offer for conservation of Ndaka-ini watershed and the willingness of producers to accept specified incentives and evaluate existing policies, legal and institution framework required for PES implementation in Kenya.

The finding for objectiveoneforms the basis for PES schemeand builds on the justification for establishing a monitoring system. Main land use change was development of the dam that resulted indisplacement of people and had major effects on infrastructure. The main land use in the area issmall scale tea plantation that has had significant increase (from 2 to 11%) while maize and tree growing decreased. There wasslight increase in rainfall over time with periodic fluctuations, which at times resulted to critical low dam levels resulting to water rationing. Lowest water level was experienced from June to October and January to February. The unit cost for water treatment increased with a significant relationship between the cost and amount of

rainfall. It was shown that NWSC stands to gain from reduced costs of treatment if better framing practices are adopted. In addition, there was a linkage between conservation practices and resultant water quality thus providing basis for PES.

The second objective was to evaluate the willingness of downstream consumers to pay for watershed protection. Majority of consumers were willing to participate in a scheme aimed at providing incentives to upstream farmers. The results showed a relationship between willingness of farmers to accept conservation activities in return to incentives provided. There was a significant relationship between the consumers source of water to the amount they were willing to give to conservation activities with farmers who were connected with water from the Ndaka-ini catchment willing to give more. In addition, large water consumers were willing to give incentives in conservation in return to being assured of reliable water supply. However, there was no framework in which consumers willing to pay could use to provide incentives to the providers of environmental services. The study indicated that majority of respondent, both small-scale and large-scale water users were willing to pay additional fees that would go to conservation. The mechanism for such payment must be worked out jointly by the users, Water provider Companiesand Water Regulatory Service Board.

The third objective was to identify the environmental services farmers in Ndaka-ini area were willing to offer for conservation. Results showed that farmerswere willing to accept incentives in return to adoption of environmentally friendly conservation practices. It was established that farmers would generally go for a package of incentives but not necessarily cash especially incentives that could increase their farm productivity. The duration of commitment in a conservation initiative affected

acceptance level with most farmers preferring short periods. There was significant relationship between farmers' acceptance of conservation practice and incentives provided. However,thecost incurred by farmers in adopting the friendly environmental practices was much higher than possible incentives. This called for a combination of reward with additional incentives especially those that could lead to improved productivity at the household level. Land tenure was favorable to PES as97.6% of land wasprivately owned.

The fourthobjective was to identify incentives consumers were willing to provide to farmers in return to improved conservation practices.In conclusion, the main incentives offered by users of water were in support of community projects (47%), in kind (38%) and in cash (15%). There was a significant relationship between the source of water in the household and willingness to supportconservation, with household with tapped water supply more willing to provide incentives. This relates well with providers of ES whose main preferred group incentive was provision of tapped water to the households.

The fifth objective was to review policy, legal and institutional framework for operationalizing PES in Kenya.While the Kenya Constitution (2010) is supportive of PES, the supportive legislations are not explicit in PES. However,the new reviewed legislations mention PES but leaving details of its implementation to subsidiary legislations that will be developed later. In-spite of existing funds that can support conservation in current legislations, very few are in operation and those in use have had little impact on conservation. As a result, they require reorganization to factor in

conditionality that is a key requirement in PES. This will ensure that an incentive in conservation is tied to a condition or additionality in provision of the ES.

5.2 Conclusion

1. There has been land use change in the catchment area which has contributed to increased cost of water treatment. Land use practices affect sediment load and hence cost of treatment of water. A linear regression was established on chemical used in water treatment and rainfall in the area indicating more alum was used during rainy season.
2. Consumers of water services are able to link water they consume to conservation and are willing to pay for enhanced water with a significant relationship between farmers' source of water and amount they can donate. Main incentives preferred are community projects and incentive in kind rather than cash reward.
3. Farmers are willing to accept incentives in return to adoption conservation farming but WTA is higher than consumers WTP.
4. Consumers willing to provide incentives in kind and those that support community projects other than cash rewards.
5. Constitution support PES but specific legislations not clear on frameworks for operationalization

5.3 Recommendations

5.3.1 Business Case for PES: A business model for adopting improved land use practice andits relationship to reduced cost of water treatment should be carried out. This would be used to sell the idea to NWSC participation in PES in Ndaka-ini. To monitor land

use changes and effects on water flow and quality, additional measuringrain gauges should be put along the rivers.

5.3.2 FarmersEngagement**:** Engage farmers in PES using a combination incentive in-kind supported by a proportion of cash rewards. Conservation practices that should be sold out to farmers are terracing, contour farming, planting of grass-strips and planting bamboo along the rivers. Farmers' awareness towards conservation should be enhanced to improve uptake of PES packages. In addition, cost benefit analysis for adopting different conservation practicesshould be carried out.

5.3.3 Payment for ecosystem service in the area should address interventions that reduce sediment loads focusing mainly in vegetation planted along the rivers and soil conservation measures practiced in the farm. In addition, explore if tea farming has adverse effect on regulation of water flow water and resultant quality.

5.3.4 Mechanism for passing on incentives:The collection point for the incentive would be through water bills charged by Nairobi Water and Sewerage Company. To reach the supplier of the service, there would be need to develop a very clear mechanism on how the incentives will be passed over while also developing a monitoring system to ensure compliance. Experience from Brazil showed that payment was the most effective tool with 25% of revenue being reinvested to support PES.

5.3.5 Types of incentives:Promote PES using existing rewards in conservation but reorganize them to include conditionality so as to gain the additionality out of

the provided incentives. To meet the difference of WTA and WTP, government and development partners should give additional incentives that will enable takeoff of PES in the area. In addition,there is need to develop a framework for tapping incentives provided by users and another one for giving back to the providers. Where possible, promote bundled approach in ES as it'smore cost effective.

5.3.6 Policy and Legal Framework for PES:Payment of Environmental Services should be promoted as a policy reform to address activities within critical watershed. Development partners should continue supporting communities whose sustainable conservation practices have contributed to the global environmental benefits. This could serve as an incentive for other communities to adopt similar practices. Information, education and communication campaigns may provide awareness to relevant groups regarding threats to the water supply and how it is linked with various activities or land uses in the water catchment areas. Since most farmers were unable to link water supply with good watershed management, activities geared towards informing and educating the public must be carried out.

5.3.7 Legislation Review:There is need to provide for legislative support to PES in the subsidiary legislation of the reviewed Acts. These should explicitlymention PES as an incentive approach to conservation. The legislations should also develop institutional frameworks to support PES that will ensure proper linkages amongst various actors in PES. In addition,it's important to mainstream PES in

sectoral laws and County laws. Finally, the stakeholders in PES should lobby in support for a public PES scheme in the country.

5.3.8 Recommendation for Further Research:Further studies need to be conducted on mechanisms for financing PES, combining public and private sector inputs. Public financing modelled around the one for Brazil to be explored. In addition, develop mechanisms for pooling resources from the willing individuals and corporations ready to support PES that would go towards supporting a voluntary scheme. Further, National and County governments to set aside funds that would support PES implementation.

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DATA COLLECTION TOOLS

Appendix 1: Household Survey Questionnaire for Farmers in Ndaka-ini Catchment Area.

Questionnaire no:…….

Introduction: Water is an important household commodity that we use every day and is one of the environmental services traded in the market. With increasing population, scarcity of water is evident. The questionnaire aims at assessing the linkage of water in the household to environmental conservation. Response from the study will be used for the purpose of the study, which aims at investigating the potential of payment for environmental services in Thika dam catchment area as an incentive to regular and quality water flow to users, and sustainable conservation of the catchment area. The data collected will be handled in confidence and will not in any way link the respondent to responses**.**

Name of Interviewer;……..

Date……

Sign…….

Name of Supervisor.....

Date .....

Sign.....

A. PERSONAL INFORMATION

Location of Interview

1. Name of household

   head……

2. Village …….

3. District.....

4. Division.....

5. Location.....

6. Sub- Location……..

7. GPS; Alt. _____

8. Longitude. _____

9. Latitude _____

SECTION 1

B. Baseline socio-economic data

1. Name of person interviewed if not household head; .....

2. Relation with household head…1. Spouse…2. Child 3. Employee 4. Relative

   5. Other (Specify)……..

3. Age of interviewee; 1.18-25 2. 26-30 . 3. 31-40. 4. 41- 50 5. 51-60. 6. >60.....

4. Sex; 1. Male 2. Female _____

5. Household size; _____Adults.....Children.....

6. Marital status of head of respondent. 1=Married 2=Single 3=Widowed 4=Divorced/Separated

7. Level of formal education received by respondent... . 1. None 2. Primary 3. Secondary 4. College 5. University _____ Other …....……

8. What is the main occupation of the respondent? (*Tick one)*

1=Farmer 2=Own business 3=Government employee 4=Private employee

5=Forest product gatherer (herbs) 6=Charcoal burner

=7 Other (specify)…….

9. What are the main crops grown by the household?

Crop type	Where planted within the farm (next to the river, in the upper slopes, Mid slope etc.)	Area acres or (M^2)
Tea		
Coffee		
Maize		
Vegetables		
Napier grass		
Trees		
Others		

10. What role do you play in the community?

1=Chief/Assistant chief 2=group leader 3=church leader 4=Councillor

5=member 6=Elder 7=Other (specify) ……

11. What caused your family to live in this community? .....

1=Born here 2=Marriage 3=Economic reasons (jobs, land) 4=Political reasons 5=Bought land 6 =Other (specify) ……

12. Which category BEST describes you and your household?……

1=I have sufficient food all the year round 2=I need food during bad season 3=I want food all the year round 4=Dependent on season 5=Other (specify)……

13. Indicate the type of housing. Fill table below

Type	Number
1=non-durable shelter (grass, mud house)	
2=semi durable shelter (timber, offcuts, mabati)	
3=durable shelter (stone)	
4= makeshift (temporary)	

14. Land ownership. 1. Communal 2. Individual 3. Leased 4. Institutional 5. Family land

15. If individual with title deed? 1, Yes2. No

16. How long have you lived in the farm?_____ Years

18. Approximate distance from the forest reserve boundary in km.....

19. Approximate distance from Thika dam edge to your home in km.....

20. Types of soil conservation measures within the farm

1. Fanyajuuterraces, ...2. Fanyachiniterraces.....3. Grass strip planting... 4. Hedge rows planting.....5. Contour planting.....6. Contour digging.....7. others

21. Do you experience the problem of soil and water erosion.....1. Yes....2. No.....
22. Does your farm touch any river? 1. Yes.....2. No.....
23. If yes, give the name of the river.....
24. Do you cultivate next to the river? 1. Yes..... 2. No.....
25. If yes, what are the crops cultivated? 1. Vegetables.....2. Maize.....3. Beans..... 4. Trees.....5. Others.....
26. Is there a buffer zone between your farm and the river? 1. Yes..... 2. No.....
27. How many metres are there between the cultivated area and the river?

C. Land use changes

2. List and describe the characteristics the first three Natural Resources within your area

Natural Resource	Do you practice the below NR 1. Yes 2. No	Uses	Resource status change for 20 year period	Explain the changes in resource status	Constraints to the resource
Cattle					
Goats					
Sheep					
Tea					
Trees					
Water					
Others (specify)					

*__Codes for Uses__: 1 Domestic; 2 Commercial; 3 commercial/domestic 3. Other (specify).....

Codes for resource status changes: 1. Increased 2. Decreased 3.Remained constant;

2.0 **Land use changes**

Describe land use changes in your farm over time

Priority in farm use	Current Farm use by **area**	Current Farm use by **investment return**	Current Farm use by **subsistence use**	Farm use by **area10 years ago**	Farm use by **size 20 yrs. ago**	Farm use by **investment return 10 years ago**	Farm use by **investment return 20 years ago**	Farm use by **subsistence 10 years ago**	Farm use by **subsistence 20 years ago**
First									
Second									
Third									
Fourth									

Codes 1.Maize, 2.Beans, 3 potatoes, 4.Fodder, 5.Pasture, 6.Tea, 7.Trees, 8.Settlement 9. Furrow 10 cabbage 11 Arrow roots

3.0 To give an impression on the effect of environmental changes to the community's livelihoods, please complete the table

Environmental change	**State the trend (*Tick appropriately*) 1. Increased 2. Decreased 3 no change**	**Cause(s)**	**Codes for various changes**
1.Woodland			1. Settlement 2. Tree planting 3. farming 4. Protection 5. Charcoal burning 6. Medicinal use 7. Diseases 8. Drought 9. Destroyed by animals 10. Better farming system
2.Fuelwood			
3.Livestock health			
4.Livestock numbers			
7.Pasture /fodder condition			
8. Food/crops			
9. crops pest and diseases			

10.Human wildlife conflict			11. Conflicting policies 12. Farm size decrease 13. Better feeding 14. Population increase 15. Presence of dam 16. Economic reasons 17. Weather change 18. Electric fence 19. Other (specify) ……
11. Water			
12. Tea production			
13. Storage facilities			

4.0 In your own view, indicate the growth of the following land uses over ten year time

Item	Growth	Reasons
Roads		
Schools		
Shopping centres		
Water sources		
Land size		

Key 1 Improved 2. Not improved 3. Remained the same 4 Worse

5. Tree cover on farms – Indicate percentage tree cover in your farm

…….. .

6. Compare tree cover over ten years period 1.Has increased 2. Decreased 3 remain constant

7. What factors have contributed to the changes in tree cover?……

……..

D. Conservation activities in the private farms along the rivers that supply the dam

1. Indicate conservation practices in your farm and the effects they have on conservation activities, especially those linked to water supply and quality

a) Which conservation activity do you practice in your farm…….

Codes of conservation activities: 1. Tree planting 2 Contourfarming 3 river line conservation 4 agro forestry 5 Terracing 6 Soil fertility improvement 7 Grass strips

b) What is the effect of the practiced conservation activity on water flow and quality?

Conservation activity	**Effect on water flow** **1 positive** **2 negative** **3 no change**	**Effect on water quality** **positive** **2 negative** **3 no change**
Agroforestry		
Tree planting		
River line conservation		
Terracing		
Grass strips		
Other (specify)		

Codes of effects: 1. Positive 2.negative 3. no change

2. Identify and cost activities in farms that negatively affects water quality.

Activity	Effect on water flow	Effect on water quality	Cost of control/lost opportunity per season
Use of fertilizer			
Cultivation on riparian areas			
Use of chemicals			
Others (Specify)			

Codes of effects: 1. Positive 2.negative 3. No change

3. Constraints to environmental conservation – list 4 major constraints to conservation activities

…….

……...

……..

……

4. Constraints to water catchments – list 4 major constraints to water catchments

……

…….

…….

……..

5. Soil and water conservation related activities practices in the farm

……..

……..

Codes 1. Tree planting 2 Contour farming 3 river line conservation 4 agro forestry 5. Others (specify)……..

6. Are there any incentives to conservation activities? 1. Yes 2.No
7. If yes, list 3 current incentives to conservation.
    a. ……..
    b. ……..
    c. ……
8. Are they adequate? 1. Yes 2. No
9. If no , propose ways for improving conservation incentives

……

……

……

……..

E: Land and livestock

1. What is your Land size? 1. Less than 1 acre. 2. 1-3 acres…….3. 4-5acres...5-10 acres 5. > 10 acres…….

. Land use by the household (in acres): ……

(a) crop land_____acres (b)Pasture/fodder…….acres (c)cash crops……..acres (d) Homestead……acres (e) woodland ……..acres (f) Others……acre (specify)

2. What proportion of your land do you perceive as a poor quality land? Less than 1/3 =1; between 1/3 and 2/3 = 2; More than 2/3 =3. _____

3. Do you have access to any communal land (for grazing, farming, and forest products) other than the land you mentioned above? Yes=1; No=2 _____

4. Do you grow tea in your farm?.....1. Yes 2. No

5. Do you apply fertilizer to your tea to enhance production?.....1. Yes 2. No Ifyes,

6. How much fertilizer do you apply……. (No. of 50 Kg bags)

7. Number of tea stems you have……

8. Have you had any natural/environmental resource management practices on your private land? Yes= 1; No= 2 _____. If **Yes**, we would like to know the investment

you made on your private land in the last 12 months on natural/environmental resource development. If **No**, give reasons (question 8)

1. Type of activity or investment	Do you practice below activity 1 Yes 2 No	2. How much labour time and money (in Kshs.) did you spend?			
		Family labour (days per year)	Hired labour (days per year)	Wage paid for hired labour (per year	Money spent other than labour (per year)
Terracing					
Water harvesting					
Fencing open areas					
Forest restoration					
Commercial plantation					
Soil fertility improvement					

Others (specify)					

8. Reasons for not investing environment management practice

Shortage of labour =1; Shortage of finance=2; shortage of land =3; Not profitable=4;

Lack of awareness=5; Insecure land tenure=6; Free-rider (public good) problem=7;

Others=8, specify_____

F) Effect of the dam on livelihoods

1. Have you benefited from the dam? Yes = 1; No = 2. _____ If yes, how have you benefited?

Positive effects of the dam to the community

……

……

……code 1 –employment, 2. Social facilities,

3.Infrastructure development, 4 Tourism, 5.

None……

……..

2 Negative effects of the dam to the community

……

……

……

……

……

code 1 –Increase in diseases, 2 –extreme cold 3 –power supply, 4 –Fish provision 5 – reduce land size, 6, others

(specify)……

……

……

3 Opportunity of the dam to the improvement of the life of the community

……

……

……code 1

Ecotourism, 2water supply 3 power supply, 4 fish farming, water for irrigation

G: Local membership/participation status and access

1. Are you a member of/ participating in any of the following organizations and which one do you participate in its activities

Farmers body	Do you participate **Yes=1 No=2**	Are you a member **Yes=1 No=2**
Farmers‟ co-operative/union		
Farmers Producers‟ organization		
Community Forest Association (CFA)		
Agro-forestry scheme		
Water Resource Users Association (WRUA)		
NDEKA		
Self-help group		

Other organization or environmental initiative (specify)		

2. Has your household got access to local financial institution (credit and/or saving)? Yes = 1; No =2.

3. How do you evaluate the degree of your or your household access to market? Poor access = 1; Good access =2. _____

4. Do you have any prior information about market-based provision of environmental services? Yes = 1; No = 2. _____

SECTION 2

H. Conjoint survey

Now, you are going to start the conjoint questionnaire. Inform the respondent that this part of the survey you are interested in knowing the respondent's preferences for various hypothetical land management arrangements.

Section G1 Description of the situation

Please consider the following situation in which you own land currently under agricultural use. Note that the land parcel you owned is part of the larger Aberdare catchments ecosystem unit, where the environmental functions are interconnected. Effective ecosystem management requires planning on broad spatial and temporal scales beyond the bounds of individual private ownership. Co-operative land management wherein individual landowners collaborate to manage their land as part of a larger system is a key component in accomplishing management objectives.

Management objective is to reduce downstream sedimentation of reservoirs, rivers and waterways, increase stream base flow, enhance water availability and improve livelihoods. You are specifically required to agree to set aside a certain proportion of your land as a riparian buffer zone, or establish farm field buffer strip along the lower side your field boundary (water flow direction). Please consider the options, each of which is set of activities that can be implemented on your land committed to the scheme. Each arrangement has a reward based on the level of activity you undertake.

Please consider and compare the arrangements presented and indicate how you would rate each on a scale of [1-5]. Use [5] for arrangements, if any, that you would definitely undertake. Use [1] for arrangements, if any, that you would definitely not undertake. If you are not sure, use [2 through 4] to indicate how likely you would be undertaking each option.

1= I would not undertake such an agreement under any circumstances

2= The agreement is not acceptable, but has one or two good points

3= I am indifferent to the agreement

4= The agreement is good and I would undertake it if one or two points were changed

5 = I would definitely undertake such an agreement **Attributes**	**Levels**			
	Option 1	**Option 2**	**Option 3**	**Option 4**
1. Land area to be committed	10% of your land	20% of your land	40% of your land	10% of the land

2. Length of commitment period	5 years	15 years	30 years	30years
3. Right to harvest products (grass/fodder/beekeeping)	Permitted	Partially permitted	Not permitted	Not permitted
4. Reward scheme/incentive scheme	Provide and/or waive annual **water cost** for domestic use and/or irrigation per acre of land committed	Provide **micro-scale electricity** and/or waive 50% of your annual electricity cost per acre of land committed	Direct annual cash payment of Kshs. 4500 per acre of land committed	Paid carbon fund for every tree existing
5.Local scheme administering agent	Water Resource Users Association (WRUA)	Focal Development Area Committee (FDAC)	Community Forest Association (CFA)	CFA
6. Required free labour contribution related to the contractual scheme (training, attending	1 day	2 days	3 days	3

scheme meetings; etc.) per month				
RATING				

Indicate other reward systems that would give incentive to your participation in conservation

……

……

……

……

PART. H2 Contingent Valuation Survey
The Contingent Valuation Scenario

Your community has got the opportunity to get involved in the production of watershed services and get compensated for the supply of the services. Consider the following situation in which you own land currently under agricultural use. Please note that the land parcel you own is part of the larger Aberdare catchment and forms part of the farms in the neighborhood of Thika dam where environmental functions are interconnected.

Effective ecosystem management requires planning on broad spatial and temporal scales beyond the bounds of individual private ownership. Co-operative land management wherein individual landowners collaborate to manage their land as part of a larger system is a key component in accomplishing management objectives. Management objective is to reduce downstream sedimentation of reservoirs, rivers and

waterways, increase stream base flows, enhance water availability and improve livelihoods. You are specifically required to agree to set aside a certain proportion of your land as a riparian buffer zone (if your land is located in riparian area) or establish farm field buffer strip along the lower side your field boundary (water flow direction).

Suppose that you are asked to participate in the community level co-operative management scheme for the purpose of managing your land as part of a larger unit. The major cost related to this activity is loss of farm income from the land committed to this arrangement. The decision to participate is voluntary. We want to know if you are willing or not willing to participate in the scheme for which you will be compensated if you participate. The compensation will be made each year before your main harvest season. Compensation payments for the scheme will be in the form of direct cash transfer/payment channeled through your local banking at your nearest collection point. Note that the land ownership does not change, it remains yours and all what you are being asked is to participate in the scheme.

1. Would you like to participate in the scheme? Yes = 1; No = 2. _____

2. If you get compensated Kshs. _____annually per acre of land committed per year, would you be willing to accept (WTA) the money? Yes = 1; No = 2. _____

Bid values: **[Kshs 5000 Ksh.10000 Kshs 15000 Kshs 20000 Kshs 25000]**

Choose any value randomly from the list given as starting point except the two extreme values and then increase the value/decrease the value on the basis of first response.

□□If **YES**: ask the respondent **ONE LEVEL LOWER** value than the starting value. i.e. Kshs._____; 1 = Yes; 2= No. _____

□□If **NO**: ask the respondent **ONE LEVEL HIGHER** value than the starting value. i.e., Kshs. _____; 1= Yes; 2 = No. _____

Acceptable bid …….

3. What group incentive are you willing to accept to participate in conservation activities?

1. Improvement in road network. 2. Putting up of schools 3. Provision of tapped water, 4 Electricity provision. 5 school bursaries. 6. Health facility. 7 capacities building 8 Others (specify)

4 How much net income (estimated value of consumed, sold, and in stock) did your household make in the last 12 months from the following sources?

- From cropping activities: Kshs _____
- From livestock activities (sale of livestock and livestock products): Kshs._____
- From off-farm sources (such as self-employments, petty-trades, casual works, informal businesses): Kshs._____
- From other sources (such as transfers, gifts, remittances, pension, interest income, etc.): Kshs._____

----------Thank you very much for your cooperation

QUESTIONS FOR THE INTERVIEWER

1) Do you consider the answers give to be genuine? ……..1=Yes 0=No
2) List any questions that are not flowing?……..

3) How can this the questions be improved?……

……

…….

4) Are there any expectations the respondent has raised about your visit?…….

……

……

5) Please, can you state any visual observation of the respondent's environment?……. ……

6) Are there any further comments?

……

7) Interviewer's Name(s); _____

Date of Interview _____

Time Interview Began _____

Time Interview ended _____

Appendix 2: Questionnaire to the users of water services: Socio-economic baseline information for the consumer

1.0 Introduction

Water is an important household commodity that we use every day. With increasing population, scarcity of water is evident. Water is one of the environmental services traded in the market. The questionnaire aims at assessing the linkage of water in the household to environmental conservation. Response from the study will be used for the purpose of the study, which aims at investigating the potential of payment for environmental services in Thika dam catchment area as an alternative to regular and quality water flow to users, and sustainable conservation of the catchment area. The data collected will be handled in confidence and will not in any way link the respondent with responses**.**

PERSONAL INFORMATION

2.1 Name of household head……

Sex…….

Age…….

Village …….

Location……..

Sub- Location……..

Division……

District……

County……

Marital status of head of household. 1=Married 2=Single 3=Widowed 4=Divorced/Separated

2.2 Indicate the type of housing. Fill table below

Type	**Number**
1 = Non-durable shelter	
2 = Semi durable shelter	
3 = Durable shelter	

2.3 Complete the table to indicate the family size in your household

Category	**Able persons**		**Disabled persons**		TOTAL
	Male	**Female**	**Male**	**Female**	
Elderly (>55 years)					
Older (40 – 55 years)					
Middle age 31-39 years					
Youth (18 – 30 years)					
Teens 13-19					
Children (<13 years)					
TOTAL					

2.4 Level of formal education received by head of household..…….....…….

What is main occupation of head of household? (*Tick one)*

1=Farmer 2=Own business 3=Government employee 4=Private employee 5=pastoralist 6=Artisan (Wood carving) 7=Forest product gatherer (herbs) 8=Charcoal burner 9=Others (specify)

2.5 Where does your main occupation activity primarily take place?

1= Forest buffer zones 2=Within the forest 3=Outside the forest reserve 4=within estate 5 City/town 6 peri-urban

2.6 How long has your family lived in this locality? .....……. years

2.7 What role do you play in the community?

1=Leader 2=employee 3=Tenant 4=Owner 5=member 6=Elder 7=Others (specify) ……

2.8 What caused your family to live in this community? .....

1=Born here 2=Marriage 3=Economic reasons (jobs, land) 4=Political reasons 5=Bought land 6=rented house 7 =Others (specify)

……

2.9 Which category BEST describes you and your household?……

1=I have sufficient food all the year round 2=I need food during bad season 3=I want food all the year round 4=Dependent on season 5=Other (specify)……

3.0 WATER SUPPLY DEMAND ISSUES

3.1 What are your main sources of water for household use? 1. Rain water 2. River/streams 3. Tapped water 4. Borehole 5 Shallow well 6. others (Specify)

3.2 What are your main source of water for drinking? 1. Tap water 2. Rivers/streams 3. Borehole 4. Bottled water 5. Boiled water 6. Treat raw water at home before drinking 7. Others (specify)……

3.3 How regular is your water supply 1. Every day 2. ……days in a week 3. monthly (……..days in a month)

3.4 What are the alternative water supplies available to you? 1. Borehole 2. Buying water 3. Harvest rain water 4. Swallow well 5. Get from neighbour 6. Others (specify)……

3.5 Give an indication of average quantity of water consumed by your household per day in litres …….

3.6 What is the average cost of water consumed per month

3.7 Give an indication of quality of water supplied to your household

3.8 Give 3 main water uses in your household

3.8.1 ……..

3.8.2 ……

3.8.3 ……

3.9 What is the proportionate cost of alternative water sources

3.10 What is the approximate distance of your house from your main water supply source in kilometres…….

4.0 **CONNECTION OF WATER TO CONSERVATION ACTIVITIES (Question to be answered by consumers with piped water)**

4.1 Who provides water to your household (Name of the water service provider)……..

4.2 Do you know the source of water supplied your household? 1. Yes 2 No

4.3 If yes where is the source ……

4.4 Do you think there a link between water in your household to conservation of water sources? 1. Yes 2. No

4.5 If yes which is the link……

4.6 Can you identify 2 threats to water catchment areas

4.6.1 …….

4.6.2 …….

4.7 Are you willing to contribute to supporting conservation activities as a way of ensuring continued regular water supply in your household? 1. Yes 2. No

4.8 What type of incentive are you willing to give to support conservation activities? 1. Cash 2. In-kind 3. Community project 4. Others (specify)…….

4.9 If Yes, How much are you willing to give per month to support conservation activities……

4.10 What condition would you attach to the incentive provided……

4.11 If no give reasons for declining to contribute toward conservation……

4.12 Give any other ideas on how relationship between producer of water service and the consumer can be improved

……

QUESTIONS FOR THE INTERVIEWER

8) Do you consider the answers give to be genuine? ……..1=Yes 0=No

9) List any questions that are not

flowing?……..

10) How can these the questions be

improved?……

……

…….

11) Are there any expectations the respondent has raised about your visit?…1 Yes 2. No

If yes which ones…….

……

……

12) Please, can you state any visual observation of the respondent's

environment?……. ……

13) Are there any further comments?

……

14) Interviewer's Name(s); _____

Date of Interview _____

Time Interview Began _____

Time Interview ended _____

Appendix 3: Checklist for interview with water providers

1. Area of operation – administrative area
2. Source of water – river and forest catchment area
3. No. of customers within the area
4. Water supply information, past and future trends
5. Process and cost of water treatment
6. Cost of maintenance of the dam/water project trends of cost of operation and maintenance for 10 year period
7. Conservation activities around the dam/catchment area and costs of the same
8. Relationship between the service provider and the catchment area farmers
9. Plough back mechanisms in place or other benefits the farmers in the catchment derive from service provider
10. Threat to conservation activities within the catchment area
11. Trends of water intake and outtake of the dam/intake for the past 10 years
12. Trends of water quality and costs of treatment for 10 year period
13. Willingness of Water Company to invest in conservation activities within the water catchment area
14. Projection of supply and demand for the next 5 years
15. Institutional frameworks in place for water provision
16. Costs of maintenance of dam especially those related to removal of sedimentation
17. Effects of reforms in water sector and their contribution to water provision and quality
18. Recommend ways of improving policy, legislations and institutional framework

Appendix 4: Checklist for interview with water users Institutions

Questionnaire no:…….

Introduction:

Water is an important household commodity that we use every day and is one of the environmental services traded in the market. With increasing population, scarcity of water is evident. The questionnaire aims at assessing the linkage of water in the household to environmental conservation. Response from the study will be used for the purpose of the study, which aims at investigating the potential of payment for environmental services in Thika dam catchment area as an incentive to regular and quality water flow to users, and sustainable conservation of the catchment area. The data collected will be handled in confidence and will not in any way link the respondent with responses**.**

Name of Interviewer;……..

Date……

Sign…….

Name of Supervisor.....

Date .....

Sign.....

1. Name of institution…….
2. Type of institution 1 Educational, 2. Health 3 industry 4, Catering 5 Rental 6 others (specify).....
3. Name of person interviewed…….
4. Position in the institution…….

5. Area of operation – administrative area
    - County……..
    - District……..
    - Location……..
    - Sub location…….

A) Water Supply Demand Issues

6. Source of water – (If from different sources indicate percentage from each source)
    - Tapped water ……
    - Borehole…….
    - Pump from river…….
    - Rain harvesting…….
    - Mobile Water tracks…….
    - Any other (specify)……..
7. Water consumption pattern
    - Population of the institution……
    - No of units with water connection……
    - Average water bill per month……
    - Average extra water cost per month…….
8. Water supply information, past and future trends
    - Trend in water supply over the last 5 years
        - 1)Increased2) Decreased 3) Constant
    - Trend in water quality for the last five years
        - 1)Better 2) Inferior 3) Constant

9. How reliable is the water supply?

    - Get water on a daily basis
    - Have water less than 3 days in a week
    - Have water more than 3 days in a week
    - Can stay for more than a week without water
    - Water supply intermittent and unreliable

10. What is the approximate distance of your institution from your main water supply source in kilometres?…….

B) Connection of Water to Conservation Activities

9. Who provides water to your institution? (Name of the water service provider)……..

- Do you know the source of water supplied your institution? 1. Yes 2 No
- If Yes where is the source ……
    - Name of river……..
    - Source of the river……..
- Do you think there is a link between water in your institution to conservation of water sources? 1. Yes 2. No
- If yes which is the link……

10. Can you identify 2 threats to water catchment sources?

    i. …….

    ii. …….

11. Do you feel you have a role to contribute to improved water supply and quality in your institution? 1. Yes 2. No

12. Are you and /or is your institution willing to contribute to supporting conservation activities as a way of ensuring continued regular water supply in your institution? 1. Yes 2. No
13. What type of incentive are you and /or is your willing to give to support conservation activities? 1. Cash 2. In-Kind 3. Community project 4. Others (specify)…….
    a. If yes, How much are you willing to give per month to support conservation activities?……
    b. What condition would you attach to the incentive provided?
    ……..
    c. If No give reasons for declining to contribute toward conservation?
    ……
14. Give any other ideas on how relationship between producer of water service and the consumer can be improved
    ……
    ……
    ……
    ……
15. Projection of supply and demand for the next 5 years
    a. What is the projected growth in your institution in the next five years?……
    ……..

b. What will be the projected demand of water to accommodate this growth?

……

……

c. What are the projected sources of this additional water?

……

……

Appendix 5: Questionnaire guideline for PES policy, legal and institutional frameworks

1. Introduction

Payment for Environmental Services is a new approach in sustainable management of natural resource, that aims to (1) transfer a positive incentive to the environmental service providers that are (2) conditional on the provision of the service, where successful implementation is based on consideration of additionally and varying institutional contexts. The use of positive incentives, including and not limited to payment is the core ideology of PES. The current study aims at exploring the feasibility of PES as an alternative option in conservation of Thika dam water catchment areas that will ensure regular and quality flow of water to Nairobi residents. Successful PES implementation requires supporting policy, legal and institutional frameworks. This checklist aims at soliciting information to investigate existence of supporting policy, legal and institutional frameworks as well as identify gaps.

2. Legal and institutional framework regarding PES schemes

2.1 Legal framework

- Is PES in compliance with the Kenya constitution?
- Are there specific legislation providing legal basis for PES?
- Are there administrative rules and responsibilities for PES?
- Do the potential parties have capacity to enter into agreements (individuals, communities, private companies, municipalities, governments)?
- Are there legislations that address PES and market instruments?
- Does the country have environmental framework law?

- Is there planning law (integrated water resource mgmt., forest planning, zonation)?
- Existence of indirect relevant legislation which encourage use of economic instruments or create incentives; development law, mining law, procurement law, land property law, trade law and liability law.
- Explore other future legislation proposals in design or under development.

- Review of Pros and cons of having/not-having a specific PES legislation:
  - Greater stability of PES schemes because of political and public acceptability of the law
  - Greater legal certainty (e.g., legal standing of PES parties and institutions, enforceability of contracts)

2.2 Institutional Framework

- Identify institutions involved in PES at all levels
  - Public institutions: e.g., agencies that exist to regulate and manage the ecosystem services (e.g. carbon office, EIA office, etc.), mapping of ecosystem services or of demand for ecosystem services, certification bodies, funding agencies, national/local registries for land rights and ecosystem services, etc.
  - Private institutions: NGOs (national or international), civil society organizations, private business
  - Intermediaries: in charge of finance, identification of sellers/buyers, negotiation, bundling services, support/advisory/capacity building services, roundtables to inform potential buyers and sellers

- Role of the different institutions (who plays the leading role and who should play this role?) .
- Their jurisdiction (legal and institutional form, legal and institutional requirements they have to fulfill).
- Potential conflicts/gaps, possible solutions/needed institutions.
- Assess current situation and identify how to ensure collaboration.between/integration of different institutions (Ministry of Finance, Agriculture, Forest, Water, Planning, other Environmental/Management Authorities).
- At what scale can or should PES be established?
    - Local: at the micro-watershed level.
    - Regional: involving two or even more provinces.
    - National: initiated by the central government and its institutions (e.g. through the water law).
    - Trans-national: between neighboring countries (possibility of bi-lateral agreements).
    - Analysis of the scales at which PES schemes already exist, obstacles to the establishment of PES schemes at other levels (e.g., different water visions within the country might be a barrier to PES at regional and national levels)
    - How to achieve efficiency of the institutional framework through reduction of transaction costs, clarification of roles and responsibilities.

2.3 Property rights issues

- What does the law say regarding land rights?

- Who owns the land, who owns the natural resources of the land and who owns the ecosystem services of the land?
- Address this question for individuals and communities (do only individuals hold rights, or also communities)
- Is there a possibility to have a right to use the ecosystem services without being the owner of the land?
- Is there a possibility to have a right to derive income from the ecosystem services without being the owner of the land (which will enable you to enter into PES contracts)?
- Is there a possibility to transfer the right to derive income to others, either permanently, or for a limited time (such as through a lease) which might enable continuity?
- Will the right to derive income from ecosystem services be passed down to one's successors (the right of descendants to inherit land or resource rights) which will ensure continuity?
- Are customary rights recognized by the legislation?
- Is there a customary right to access the land and enjoy extractive benefits without being owner or tenant (e.g., indigenous peoples having customary access rights)?
- Does land use change require prior approval, and are there limits to dividing land rights?
- How is the land protected from illegal exploitation of the resource?
- What is practice like?

- If different rights/titles exist regarding the resource, does this lead to conflicts, because one might be able to benefit more from the payments than the other person?
- Are the rights given for a sufficient period of time, and over a sufficient size of land?
- If the land of each single individual is too small (to provide the ecosystem service), will they be able to enter into joint agreements?

- How to deal with unclear rights?
  - Can PES be a means to solve the problem of unclear titles?
  - Do other means exist to clarify rights?

2.4 Negotiation

- Is there a case of PES negotiated agreement in the country?
- How are PES contracts negotiated in the country?
- Participants in these processes: Reflections on the ability/capacity of the institutions for negotiation
- Pro bono legal expertise available in country?
- Guidelines and other support tools
- Are tender/bidding processes being used?
- Potential sellers calculate how much it would cost them to undertake the management interventions that ensure ecosystem services, and submit a formal bid for funding. Each landholder bid is then divided by its 'environmental

benefit' score and the bids with the lowest cost per unit of environmental outcome are selected, until the available budget is exhausted.

- Are conflict resolution processes being used?

2.5 Contractual issues

- Parties to the contract
  - Seller/supplier of the environmental service as well as buyer/beneficiary
  - Notion of authority: representation by “honest brokers”
  - All parties to PES must have legal capacity to enter into contracts
    - Individuals and organizations might have the right, but not necessarily communities
- Legal nature of the contract
  - Objective regulated by the contract
  - Explanation of the significant water management problem
  - Definition of the water-related ecosystem service which solves this problem
- Obligations of the parties
  - Identification of obligations on seller’s side
    - Input-oriented obligation (certain behavior is owed) or output-oriented (result is owed)
    - Possibility to refer to a management plan annexed to the contract, including baseline, indicators, clauses prohibiting leakages etc.
  - Level of “payments” has to be specified
    - Payments can be made to a number of individuals or their community

- Especially in cases where indigenous communities are involved, payments need to fit into the existing socio-cultural environment (e.g., if a few individuals receive payments while others do not, the risk of disrupting a community which is based on strong cooperative bonds is created)
- Where land ownership is communal but individuals have long-term rights to use, it may even be necessary to involve both levels
- Benefit sharing arrangements and practices

- Definition of payments/benefit sharing arrangements and practices
  - Parties have to determine whether the payments will be in kind or in cash
  - Additionally, the specific amount has to be agreed on
- When will the payments be made
  - Important to set the right timeframe and sequence for the payments
  - If all or majority of the payments are already made at an early stage of the contract, possibilities to enforce contractual obligations over the full contract period will decrease

will come automatically, if the PES scheme is well designed

2.6. Monitoring, non-compliance and enforcement

How will the provision of services be monitored?

- Definition how contractual compliance will be determined
  - In order to do so, the baseline has to be set from which the evaluation of the seller's performance can start

□Authority to monitor the seller's activities

o Granted to the buyer or

o Granted to a public institution or

o Granted to an independent verifier

o Adequate structure to avoid corruption must exist

□Decision on a clear and affordable monitoring process

o Field inspections:

□Specific, field-level assessments are defined.

□Exactly what will be inspected and what test methods will be used are defined.

□Inspection procedures are agreed and include: the legal authority for inspections; the frequency of inspections; the consequences of refusing inspection; rights of entry for inspectors; whether notification is needed and what documents may be examined.

o Self-assessments:

□Reports based on self-monitoring and record-keeping by service sellers and buyers are monitored.

□Information in these reports is then used either as a direct basis for enforcement actions, or to target inspections.

□A clearly defined, standard procedure is again required, including the method, schedule and format for reporting.

□Data requirements and how long records must be kept must be defined, and whether reports will be made public should be agreed.

o Inspections by the buyers (e.g., water guardians)

Non-compliance

- Reasons for non-compliance
  - o Lack of trust between the parties
  - o Possibility to free ride
  - o Unfair valuation of the ecosystem services provided
  - o Lack of authority in the field (possibility to get away with violations)
  - o Lack of (effective) enforcement mechanisms (no deterrence/penalties are too low)
- If an effective contract law is in place, a comprehensive non-compliance regime already exists by law
- If this is not the case, or parties wish to include individual responses to non-compliance, further instruments can be included
  - o E.g., contractual penalties
- Enforcement instruments: carrots and sticks
  - o Sticks require credibility (meaning that there is a high chance violations will be detected and that responses to violations will be swift and predictable) and disincentives for non-compliance (appropriate sanctions)

2.7 Dispute resolution

- According to the legislation in place, such disputes will probably already fall under the competence of a particular court (which one?)
- However, the parties can also decide to submit the dispute to an arbitral tribunal or to mediation, if this is preferred

o Consideration should then be given to submitting the disputes to arbitration under the 2001 Permanent Court of Arbitration Optional Rules for Arbitration of Disputes Relating to Natural Resources and/or the Environment

o It has to be ensured that both sides of the contract have locus *standi*(legal personality before the court/tribunal)

Good governance

Public participation

- Through consultations or negotiations that bring the parties to one table
- Through formal (written) comments within a limited period of time after the public has been officially informed of a draft scheme
- Through field testing by volunteers to determine whether the scheme is effective and efficient or not

Appendix 6: Trend analysis data sheet

This sheet provides details of the information to be captured in the study of the potential of PES in providing water services in Thika dam. The data collected will provide trend analysis of land use change and productivity for a period lasting 20 years. Data collected are as follows:

1. Land cover changes and land use changes

- Analysis of satellite imagery for the last 26 years
    - 1985
    - 1990
    - 2000
    - 2005
    - 2010
- Factors to consider during the analysis:
    - land use changes – Satellite imagery analysis, questionnaire to farmers, focus group discussions
    - land cover changes, - satellite imagery analysis
    - farm size changes, satellite imagery and top maps, survey of Kenya land record, questionnaire and focus group discussions
    - population growth- Census data
    - infrastructure growth, - satellite imagery, Focus Group Discussions (FGD), questionnaire
    - tree cover on farms, - satellite imagery, FGD, top maps
    - forest cover in gazetted areas, - Satellite imagery, KFS maps and records

- growth of town centres – Development plans, satellite imagery, FGD
- changes in socio-economic factors especially those that affects livelihood of the farmers – Development plans record, questionnaire, FGD
- Ground truthing – Transect walks analysis.
- Water intake and outtake from Thika dam – records from Nairobi water company.
- Rainfall and temp data – Met data and records from Nairobi water company.
- Data on river flow changes – records from Nairobi water company.
- Effect of dam construction – FGD, satellite imagery, dam environmental audits.

Appendix 7: Checklist for Focus group discussions:

To be guided by the following key issues

Focus group discussion was based on the following guiding questions.

1. Name of organization
2. Main focus of the organization and extent of their catchment
3. Key local environmental problems within the catchment: What are the major environmental problems in the local area? Are these problems only local or having implication to wider society?
4. What are the main causes/drivers of these problems?
5. In general, how do you evaluate the state of the trends of environmental changes/conditions in your area over the last 20-30 years?
6. Which land use and agricultural practices deemed to be environmentally harmful? Which land uses or management practices do you perceive environmentally friendly for land and water resources?
7. How to tackle/reduce land degradation (building some physical structures? Changing land uses? Adoption new management practices? etc.). i.e., What are the feasible set of options to tackle the general environmental problems (water and land degradation)?
8. What are your environmental priorities?
9. In your view, what are the major benefits conserving/managing your environment?
10. What are your major constraints to adopting land use and management practices environmentally friendly?

11. How do you perceive reward mechanism for environmental services as an alternative remedial measure for the environmental problems?
12. What are your current/Previous soil and water conservation experience? Have you participated or practiced any natural resource and environmental management activity?
13. What are the limitations and strengths of your community as a group in terms of local natural resource and environmental management?

14. Document institutions and their linkages and identify strengths and gaps.

Appendix 8: Checklist for interviews with KTDA factories within the area

1. Name of factory
2. Area of operation i.e. catchment area
3. Green tea annual production trends for the last 10 years
4. Key environmental problems in the catchment area
5. Causes and drivers for the key environmental problems
6. Trends in environmental conditions for the last 20 years
7. Efforts by the factory to improve environmental conservation in the area
8. Trends in fertilizer application in the area and effects of the same in water quality
9. Effect of the dam on tea production
10. Tree cover in the farms and trends over time including tree planting within tea farms
11. Effects of use of firewood in tea factories on the tree cover within the farms
    a. Fuelwood demand trend
    b. Sources of fuelwood
    c. Sustainability of fuelwood sources
12. Effect of climate change on tea farming
    a. Trends of frost in the area
    b. Cost of recent frost
    c. Interventions to reduce negative effects of climate change
13. Payment for environmental services
    a. View of its usefulness in environmental conservation
    b. Structures that can support PES
    c. CSR initiatives within the area
    d. Possible incentives mechanisms to the farmers
    e. Role of the factory in enforcing conservation of riparian areas

Appendix 9: Conservation activities within the gazetted catchments areas, potential and threats to these activities

- Name of forest
- Status of forest management and conservation
- Main species in water conservation area
- Area of forest by forest types
- Extent of degraded areas
- Threats to conservation
- Rivers originating from the forest
- Activities that can improve water flow and quality
- Level of water abstraction in the station and revenue collected
- Relationship between conservation activities and water flow

Appendix 10: Checklist for interview with water providers

11. Name of institution…….

12. Type of institution 1 Educational, 2. health 3 industry 4, catering 5 rental

13. Area of operation – administrative area

    - County……..
    - District……..
    - Location……..
    - Sub location…….

Water Supply Demand Issues

14. Source of water – If from different sources indicate percentage from each source

    - Tapped water ……
    - Borehole…….
    - Pump from river…….
    - Rain harvesting…….
    - Mobile Water tracks…….
    - Any other (specify)……..

15. Water consumption pattern

    - Population of the institution……
    - No of units with water connection……
    - Average water bill per month……
    - Average extra water cost per month…….

16. Water supply information, past and future trends

    - Trend in water supply over last 5 years

- 1)increased 2) Decreased 3) constant

17. How reliable is the water supply

    - Get water on a daily basis
    - Have water less than 3 days in a week
    - Have water more than 3 days in a week
    - Can stay for more than week without water
    - Water supply intermittent and unreliable

18. What is the approximate distance of your institution from your main water supply source in kilometres…….

B) Connection of Water to Conservation Activities

9. Who provides water to your institution (Name of the water service provider)……..

- Do you know the source of water supplied your institution? 1. Yes 2 No
- If Yes where is the source ……
- Do you think there a link between water in your institution to conservation of water sources? 1. Yes 2. No
- If yes which is the link……

16. Can you identify 2 threats to water catchment areas

    i. …….

    ii. …….

17. Are you willing to contribute to supporting conservation activities as a way of ensuring continued regular water supply in your institution? 1. Yes 2. No

18. What type of incentive are you willing to give to support conservation activities?

    1. Cash 2. In-Kind 3. Community project 4. Other (specify)…….

        a. If Yes, How much are you willing to give per month to support conservation activities……

        b. What condition would you attach to the incentive provided……
        …

        c. If No give reasons for declining to contribute toward conservation……

19. Give any other ideas on how relationship between producer of water service and the consumer can be improved…….

20. Projection of supply and demand for the next 5 years

    a. What is the projected growth in your institution in the next five years

    b. What will be the projected demand of water to accommodate this growth

    c. What are the projected sources of this water