Linking the Economy to the Environment: Using Remote Sensing and Payment for Environmental Services (PES) in Lake Naivasha Watershed, Kenya

PhD Research Proposal

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Abstract

There are a number of opportunities to pursue some of the core social science research issues more closely through remote sensing and geographical information system (GIS). Linking remote sensing and social science is a plausible approach to understand human impact on biophysical environment and to respond environmental impacts on human economic activities. Integration between social science and natural science is vital for better understanding of the economy that changed drastically and reflects complex socioeconomic settings. Lake Naivasha is one of the Ramsar sites being a wetland of international importance with a rich biodiversity and having the largest number of water bird species of any wetland area in Kenya. In contrast to its international importance, Lake Naivasha and its surrounding area face the current various treats to wetlands in developing world. It is under increasing pressure from anthropogenic activities, conversion of wetland areas to agricultural land, water withdrawals, population growth and settlements around the lake, and pollution as a result of nutrient runoff from intensive agricultural production. However, there is limited research outcome that applied remote sensing information in socioeconomic research in Lake Navaisha watershed to link the economy and the environment.

As a second line in this research, the watershed environmental services can be assessed and valued by means of interlocking system of environmental and economic models. Environmental models can quantify the pattern of different land use changes in upstream communities and estimate the biophysical environmental impacts on downstream communities. Preference and economic value of the watershed environmental services and compensation value to provide environmental services can be estimated by using economic models in order to establish a payment for environmental service (PES) scheme. However, the value to different attributes of the lake and surrounding ecosystem and the environmental and economic linkages between the upstream and downstream parts of Lake Naivasha through PES are not yet entirely addressed. Therefore, this study attempts to address the above mentioned research gaps.

The aim of this research is to integrate remote sensing information, socioeconomic and other environmental data to estimate socioeconomic indicators and to model socioeconomic activities thereby assessing the major socioeconomic driving forces of land use and land cover changes in Lake Navaisha watershed by using spatial and statistical analysis. In addition, this study employs a choice experiment method of environmental valuation to value environmental services and analyse PES livelihood impacts on environmental service providers (upstream communities) and receivers (downstream communities).

Key words: *Environmental-economic linkages, environmental valuation, remote sensing, socioeconomic indicators, socioeconomic activities, payment for environmental services (PES), choice experiment method.*

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Acronyms

CE: Choice experiment
CS: Consumer surplus
CM: Choice Modelling
CBA: Cost Benefit Analysis
CVM: Contingent Valuation Method
DMPS-OLS: Defense Meteorological Satellite Program-Operational Linescan System
EOIA: Earth Observation and Integrated Assessment
HELP: Hydrology for the Environment, Life and Policy
ILRI: International Livestock Research Institute
ISODATA: Iterative Self Organized Data Analysis and Transfer Algorithm
LNGG: Lake Naivasha Growers Group
LNRA: Lake Naivasha Riparian Association
LULC: Land Use and Land Cover
MEA: Millennium Ecosystem Assessment
PCA: Principal Component Analysis
PES: Payment for Environmental Services
PWS: Payment for watershed Services
RUT: Random Utility Theory
RP: Revealed Preferences
SA: Stakeholder Analysis
SP: Stated Preferences
SSA: Sub Saharan African
WWF EARPO: World Wildlife Fund Eastern Africa Regional Programme Office
WTA: Willingness to accept
WTP: Willingness to pay

I. Introduction

1.1 Background

"*Currently we know more about what could happen if key ecosystems services collapse than we know about how to manage the environment for their steady provision. The collapse knowledge is good to awaken society to the need to act. But the management knowledge is needed to act effectively.*"
(Gutman 2007)

Lake Naivasha is one of the Ramsar sites being a wetland of international importance with a rich biodiversity and having the largest number of water bird species of any wetland areas in Kenya, including some endangered species, and supports tourism and research activities. Wetlands are amongst the Earth's most productive ecosystems, providing divers array of important ecological functions and services, ranging from flood control and flow control to ground water recharge and discharge, water quality maintenance, habitat and nursery for plant and animal species, biodiversity, carbon sequestration and other life support functions (Birol et al. 2006). In contrast to their international importance, many wetlands have been treated as wasteland and drained or otherwise degraded. The resources in Lake Naivasha and its surrounding area face the current various threats to wetlands in developing world. Currently, the primary direct drivers of degradation and loss of wetlands includes infrastructural development, land conversion, water withdrawals, pollution, overharvesting and overexploitation, and the introduction of invasive alien species. Moreover, wetlands are under increasing pressure from anthropogenic activities, including conversion of wetlands to intensive agricultural use and to other industrial and residential uses, their drainage as excessive irrigation in agriculture; pollution as a result of nutrient runoff from intensive agricultural production and industry. Other factors considered to affect the management of wetlands include poverty and economic inequality, pressure from population growth, immigration and mass tourism, social and cultural conflicts (Skourtos et al. 2003).

Urban expansion in Kenya is closely associated with a tremendous increase in demand for land, which is highly related to population growth and movement. Naivasha is the fastest growing town in Kenya. The growth and the demand for land are fuelled by horticulture and floriculture farming business around the lake, which is labour intensive industry. Tourist activities in the region, rural-urban migration as a result of falling farm income from traditional cash crops, expansion of commercial enterprises and good prospects for job opportunities are other major factors for population pressure in the region (IUCN/LNRA 2005). Population growth and intense land utilization in the catchment are likely accelerating informal settlements in Naivasha town. In addition, demand for food increased and thus promoting intensive farming practice, increase destruction of forest cover to open steep slope cultivation, and charcoal burnings in the surrounding area. The Lake Naivasha drainage basin largely occupies traditional pastures of the pastoral Maasai. However, the basin became part of the so-called white highlands after colonization, areas where only European settlers were allowed to own land. The lake has a Ramsar Convention status since 1995, with most land within the Ramsar site being privately owned (Becht et al. 2005).

1.2 Justification

According to United Nation (UN) estimates the world urban population will increase by at least 3 billion in the next 50 years and world's urban population is growing twice as fast as the total population. The rapid urbanization, especially in developing countries will continue to be one of the crucial factors that must be taken into account in the human dimension of the 21st century (Torrey 1998). And yet, despite this growing global trend towards an urban society, how urban and suburban areas function as ecological systems is poorly known (Grove 1996).The lack of basic knowledge of the urbanization process and its ecological impacts has made us unable to asses, much less to manage and restore the urban ecosystem in both urban cores and suburban fringes. Population increase is often associated with urban sprawl, resulting in a decrease of agricultural land and forested areas, producing problems such as increased pressure on food security and loss of biodiversity. Increasing population has also generated great pressure on the sustainability of natural resources and environmental conditions. Thus, timely and accurate estimation of population distribution is of considerable significance for decision makers in urban land-use planning and for a better understanding of the interactions between population growth and social, economic and environmental conditions(Yu. and Changshan 2006).

Lake Naivasha is under various threats of nutrient enrichment and pollution from urban and agricultural activities in its catchment and surrounding land. The land below the riparian boundary is government land; given in custody to the riparian landowners and no permanent structures are allowed. A number of observed trends in Lake Naivasha watershed, movement of the flower industry from outdoors to indoor; fodder production replaced by vegetable production; and irrigated land being abandoned. The booming horticultural industry's influence on the local economy has never been studied in detail. What is certain, however, is that the floricultural business has attracted many people. However, there is a limited attempt to identify key stakeholders and the social and community involvement in the management of Lake Naivasha has been much more poorly studied (Becht et al. 2005; Billgren and Holmén 2008). Therefore, it is vital to assess major challenges of population growth and density, urban expansion and settlement, and the driving forces for changes in economic structure and land use and land cover in Naivasha region. In addition, the degradation of natural resources has provoked a concern to value and conserve the ecosystem services of Lake Naivasha watershed.

Economic valuation enables us to charge fair estimate for environmental (ecosystem) services, so as to promote a more rational use. Currently, valuation of environmental services is regarded as an important tool to assist policy makers to compare the benefits and costs to the society in formulating conservation and management policies and programmes to protect or restore ecosystem services. Once the ecosystem service is well identified and its price (or value) is fairly established through appropriate environmental valuation methods, a payment scheme and a way to pay for environmental services can be established. As a result, payment for environmental services (PES) schemes is used as a means for conservation activities, and to reduce poverty and to improve poor people's livelihoods in developing countries. Latin America has been particularly receptive to this approach (Pagiola et al. 2005). However, PES for watershed environmental services to conserve wetlands and how individuals value the multiple ecosystem services provided by wetlands in developing countries, particularly in Africa remains inadequately tested. Wetlands have several functions. Besides the benefits to the local population living in the periphery they also provide benefits to communities outside wetland areas. The protection of wetlands reflects the protection of numerous goods and services. Thus, this study will make an effort to fill this gap by providing a detail case study on Lake Naivasha watershed.

Payment for environmental services delivers a significant livelihood benefits to rural communities who provide the service as well as environmental benefits to downstream water users. A comprehensive PES programme for development, conservation and sustainable use of the biodiversity resources of the lake and for its surroundings ecosystem improvement should be integrated with people's preferences. Identifying attributes of the lake environment which are greatest contribution for community's welfare and their willingness to pay for improvements to take place for sustainable and wise use of the resources are vital. However, to our knowledge there is no study that tried to impute value for different attributes of the lake and the surrounding ecosystem in order to apply a feasible PES scheme[1]. Jones (2006) identified commercial floriculture and horticulture growers, Kenya Electricity Generation Company (KenGen), the Gilgil/Nakuru water service provider, tourists who visit the area and global consumers of Naivasha flower as a potential buyers of watershed services and presented values of PES implementation in Naivasha catchment. However, other potential watershed services beneficiaries and upstream people's preference for compensation to provide environmental services are not incorporated in PES scheme, which requires further detail study. Therefore, this study tries to fill this gap and estimate willingness to pay (WTP) for different attributes (ecosystem services) of Lake Naivasha watershed and value willingness to accept (WTA) a compensation for environmental services provision. This study also tries to assess the applicability of PES for watershed service (downstream water users paying for upstream land use and management practice concerned with their water resource management) and examine the livelihood impacts of a payment for environmental services program on upstream and downstream communities. Moreover, it is possible to provide policy makers with information on the public benefits generated from Lake Naivasha watershed in terms of its use and non-use values that accrue to the Kenya public at large.

[1] *The CARE Kenya and WWF-EARPO (World Wildlife Fund-Eastern Africa Regional Programme Office) work on a joint project to implement payments for watershed services (PWS) initiative in the Melewa river basin which is one of the main sources of water for Lake Naivasha. CARE Kenya and WWF EARPO initiative in Kenya is linked to a global PWS programme.*

1.3 Statement of the Problem

There are now a number of opportunities to pursue some of the core social science research issues more closely through remote sensing and GIS. Effort is made on issues of population, equity/ equality, institutions, democratization, (under) development and decision making as they relate to resource use and environment change (Liverman et al. 1998). Integration between social science and natural science is vital for better understanding of the economy that changed drastically and reflects complex socioeconomic settings. However, there is limited research that applied remote sensing information in socioeconomic research to link the economy and the environment. Thus, this study tries to fill this gap and estimate socioeconomic indicators and model socioeconomic activities in Lake Naivasha watershed, through the integration of remotely sensed information, socioeconomic and other environmental data in GIS format. Moreover, the growth of large commercial scale activities in form of the booming flower industry along with the existing small scale farms and settlements around the lake has implications on the demand for resources in Lake Naivasha ecosystem. The proposed research aims to address the major driving forces for growth and changes in economic structure and accompanying land use and land cover changes in upstream and downstream parts of the Naivasha basin.

As a second line in this research, because ecosystems have become degraded worldwide, and the valuable environmental services that they provide are lost or reduced, there has been a growing search for practical solutions. Among these, the payments for environmental services (PES) approach has been applied often in both developed and developing countries (Wunder et al. 2008). Lake Naivasha a well studied water body, the capacity of the lake ecosystem to provide environmental services is seriously at risk because of increasing environmental degradation and over-use (Permatasari 2004; Becht et al. 2005; Becht and Nyaoro 2006; Mohammedjemal 2006; Mpusia 2006). However, economic values of different attributes of Lake Naivasha and the surrounding ecosystem, and environmental and economic linkages between upstream and downstream communities through a market for environmental services and the livelihood impacts of PES are not yet entirely addressed. Thus, the proposed research tries to fill this gap.

1.4 Objective of the Study

The objective of this study is to link the economy to the environment using remote sensing and payment for environmental services (PES). The potential applicability of remote sensing information to estimate socioeconomic indicators and modelling of socioeconomic activities is explored for better understanding of socioeconomic structure in Lake Naivasha watershed. Environmental and economic linkages through the market for environmental services is analysed to value environmental (ecosystem) services in order to apply PES and to assess the impact of PES on livelihood outcomes in Lake Naivasha watershed, Kenya.

1.4.1 Specific Objectives:

- To assess socioeconomic driving forces of land use and land cover changes in Lake Naivasha watershed.
- To explore the applicability of remote sensing imagery as an alternative (additional source) to estimate socioeconomic indicators in Lake Naivasha watershed.
- To model socioeconomic activities using remote sensing information in Lake Naivasha watershed.
- To estimate the willingness to pay (WTP) for different attributes (ecosystem services) and willingness to accept (WTA) compensation in Lake Naivasha watershed services to apply payment for environmental services (PES).

1.5 Research Questions

Objective 1: To assess socioeconomic driving forces of land use and land cover changes in Lake Naivasha watershed.

- What changes have occurred in land use and land cover (LULC) due to population pressure, urbanization and large and small scale farms expansion in Naivasha region for the last three decades?
- What are the major socioeconomic driving forces for land use and land cover changes in Lake Naivasha watershed?
- How do changes in land use and land cover affect the livelihood of the people in upstream and downstream parts of Lake Naivasha watershed?

Objective 2: To explore the applicability of remote sensing imagery as an alternative (additional source) to estimate socioeconomic indicators in Lake Naivasha watershed.

- Is remote sensing imagery an alternative means (additional source) to estimate population in Lake Naivasha watershed?
- Is remote sensing imagery an alternative means (additional source) to estimate employment in Lake Naivasha watershed?
- What is the nature of population and employment density in Lake Naivasha watershed?

Objective 3: To model socioeconomic activities using remote sensing information in Lake Naivasha watershed.

- How do we link spatial data generated by remote sensing technology to model socioeconomic activities together with other environmental and socioeconomic variables in Lake Naivasha watershed?

Objective 4: To estimate the willingness to pay (WTP) for different attributes (ecosystem services) and willingness to accept (WTA) compensation in Lake Naivasha watershed services in order to apply payment for environmental services (PES).

- How much is the individual willing to pay (WTP) for different attributes (ecosystem services) in downstream parts of Lake Naivasha watershed?
- How much is the individual willing to accept (WTA) as a compensation for their environmental service provision in upstream parts of Lake Naivasha watershed?
- Is payment for environmental services (PES) applicable in Lake Naivasha watershed services?
- Are the livelihood (welfare of the poor) impacts of a payment for environmental services programme likely to be beneficial for upstream and downstream communities?
- What policy lessons can be learnt from the experience of Lake Naivasha watershed?

1.6 Theory and Concepts

1.6.1 Linking Remote Sensing and Social Science

There is increased interest today in making scientific progress through the use of remotely sensed data in social science research and can assist in answering research questions that are fundamental to the social sciences. This interdisciplinary approach in remote sensing and social science researchers, would lead scholars to raise the two basic questions: what can remote sensing do for social science and what can social science do for remote sensing. The benefits that could be derived from the combination of remote sensing and social science were discussed in (Liverman et al. 1998), providing a number of potential applications. The approach to link remote sensing and social science follows the concept of socializing the pixel and pixelizing the social (people and pixel). Socializing the pixel is to make remote sensing imagery beyond its use in the applied science and towards its application in addressing the concerns of social science. Pixelizing the social is spatial modelling of human behaviour and social structure, especially beyond the field of geography, and fostered modelling approaches that abstract from the essential spatial nature of the problem.

One rationale for linking people and pixel is that doing so might result in better social science research. This could happen in several ways, although the realistic potential for making these improvements is in some dispute. Remote sensing measuring the context of social phenomena and their effects, “Context” can denote a variety of entities, including an individual, a political or administrative unit, a social network, a school, or a racial or ethnic group. Remote sensing provides additional means of gathering contextual data, particularly in describing the biophysical context within which people live, work, and play. Remote sensing can provide important information on biophysical parameters such as slope, aspect, soil types, water bodies and vegetation cover, and, in some cases, infrastructure parameters such as roads, pipelines, or power lines, that can impact people’s decision-making or livelihood options. Remote sensing provide measures for a number of dependent variables associated with human activity-particularly regarding the environmental consequences of various social, economic and geographical process. For example, remote observations of land cover may show the footprints of agricultural intensification, urbanization and road development; observations of vegetation density may be related to the effect of fertilization, irrigation, and other agricultural practices; and observations of new building construction may be linked to the effects of local policies on land use and property taxation. And models that combine remote observation with ground based social data have the potential to improve understanding of various determinants of various land use changes (Liverman et al. 1998).

Remote sensing provides a time series data on socially relevant phenomena for comparability and modelling of human- environment interactions. For example, the use of remotely sensed data to model the effects of access to forest on out-migration and processes of land conversion to urban uses. Remote sensing providing additional measures for social science can sometimes provide highly aggregated data at less cost and may support social scientific measurements by improving on some measures and crosschecking others. Indicators from remote sensing can complement indicators from ground based sources. For instance, population density estimated from census, remote sensed data of fine spatial resolution might be used in statistical models to generate estimates of population counts and urbanization can be measured by counting building permits, sampling and observing city blocks, or remotely sensing the proportion of land covered by structures (ibid).

Alternatively, the interaction of social science with remote sensing has several scientific contributions. Such as, validating and interpretation of remote observations; remote sensing specialists are well aware of the need for ‘ground truthing’ that is validating remote observation against data collected on the ground. Remotely sensed data may provide a cost-effective method to reduce, but not replace, expensive ground data collection. Data confidentiality and public use, that is, social scientist have experience in dealing with issues of confidentiality in data collection and dissemination that may be of use to remote sensing specialists. However, several challenges arise for those who want to combine these two data set, such as finding appropriate spatial and temporal resolution (decision on data availability, scale and level of aggregation), linking people and pixel (decision where to georeference individual or other social units) and institutional issues (how to create productive community of scholars who combine social science and remote sensing). Thus, researchers working with social science and remote sensing data must make important decisions about the level of aggregation of both remotely sensed and social science data.

1.6.2 Economy –Environment Interdependence

In neoclassical economics, the term circular flow of model or circular flow of economics refers to a simple economic model which describes the economy into two sectors: production and consumption. The inter-dependent entities of producer and consumer are referred to as "firms" and "households", respectively. Exchange of goods and services in product market and factors of production in resource market taken place between these two sectors. Firms provide consumers with goods and services in exchange for consumer expenditure and buy "factors of production" from households in exchange for payment for factors. Such a picture illustrated in Figure 1, which describes the flow of resource, products, income and revenue among economic decision makers and how about economic decision makers interacts(William 2009). In the circular flow of economics[2], the environment, however, appears to have no place; but as stated before the economy produces goods services by transforming matter and energy (resources) and creates wastes in the process. The matter and energy are taken from the environment and the wastes are put back into the environment. In general, the natural environment may interacts with the economy in four major ways: as a source of raw material in to production (natural resource input/base), as a receptacle for the waste produced in consumption and production (waste sink), the natural environment provides recreational facilities and different sources of pleasure and well-being (amenity service base), and maintain an atmospheric condition suitable for life (global life support) (Perman et al. 2003). Thus, the standard circular flow of economics should be incorporated into the environmental system.

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[2] Here the circular flow of model (the circular flow of economics) explained by using only two sectors of the economy (firms and households).

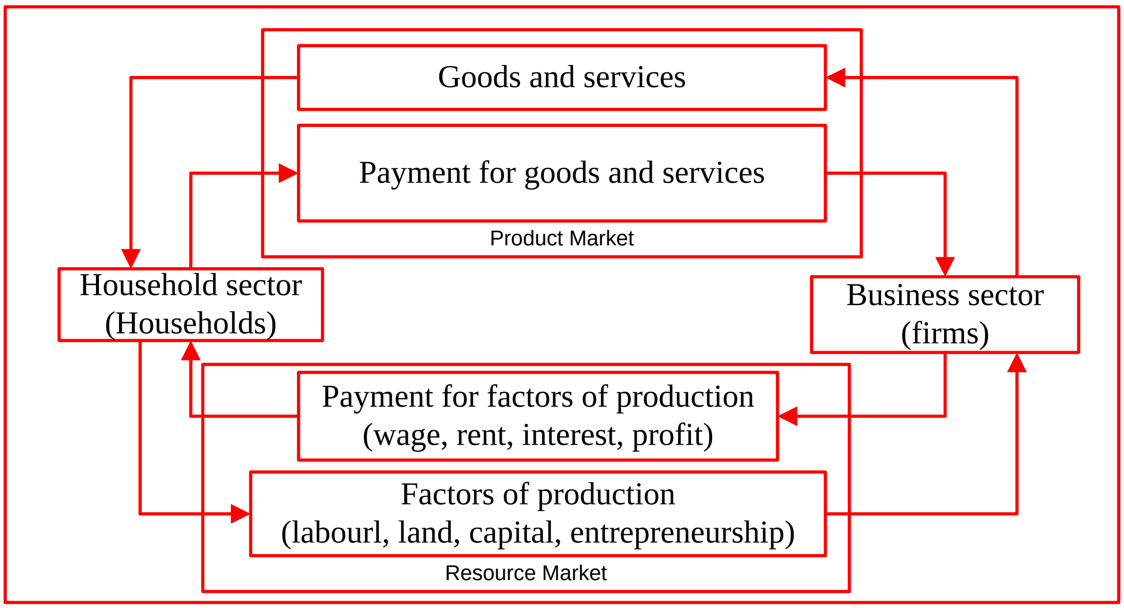

Figure 1: The simple circular flow of economics for households and firms adapted from(William 2009)

The relationship between the economy and the natural system is restricted by physical laws (laws of nature). The materials balance principle (the low of conservation of matter) states that matter can neither be created nor destroyed. It can only be transformed from one form into another. Economic activity essentially involves transforming matter extracted from the environment into valuable products. The first law of thermodynamics (The law of conservation of Energy) states that energy can neither be created nor destroyed. It can be converted from one form one to another. The economic transformation process, changes the quality, not the quantity, of the energy available to us. The second law of thermodynamics as "the entropy law" states that the conversion of energy from one form to another is not completely efficient. It follows that all conversions of energy from one form to another are less than 100% efficient (Perman et al. 2003). This indicates there is a close interdependence between the economy and the environment and the environment has implications on the economic system by two ways: environment imposes scarcity on the economy and waste is inevitable in economic activities.

Economic activity takes place within, and is part of, the system which is the earth and its atmosphere. This system we call "the natural environment" or more briefly "the environment'. This system itself has an environment, which is the rest of the universe. **Figure 2** is a schematic representation of the two way relationships between, the interdependence of, the economy and the environment. **In Figure 2** the outer lined represents the environment, which is thermodynamically closed system, in that it exchanges energy but not matter which its environment. The environment receives input from solar radiation. Some of the radiation is absorbed and drives environmental processes. Some is reflected back into space. This is represented by the arrows crossing the outer line at the top of the figure. Matter does not cross the line. The balance between energy absorption and reflection determines the way the global climate system functions. The energy in and out arrows are shown passing through three boxes, which represent three of the functions that the environment performs in relation to economic activity. The forth function, represented by the outer black lined box itself, is the provision of the life support services and those services which hold the whole functioning system together. The three boxes are intersected by the outer line; it indicates that the four functions of environment interact with one another (Perman et al. 2003).

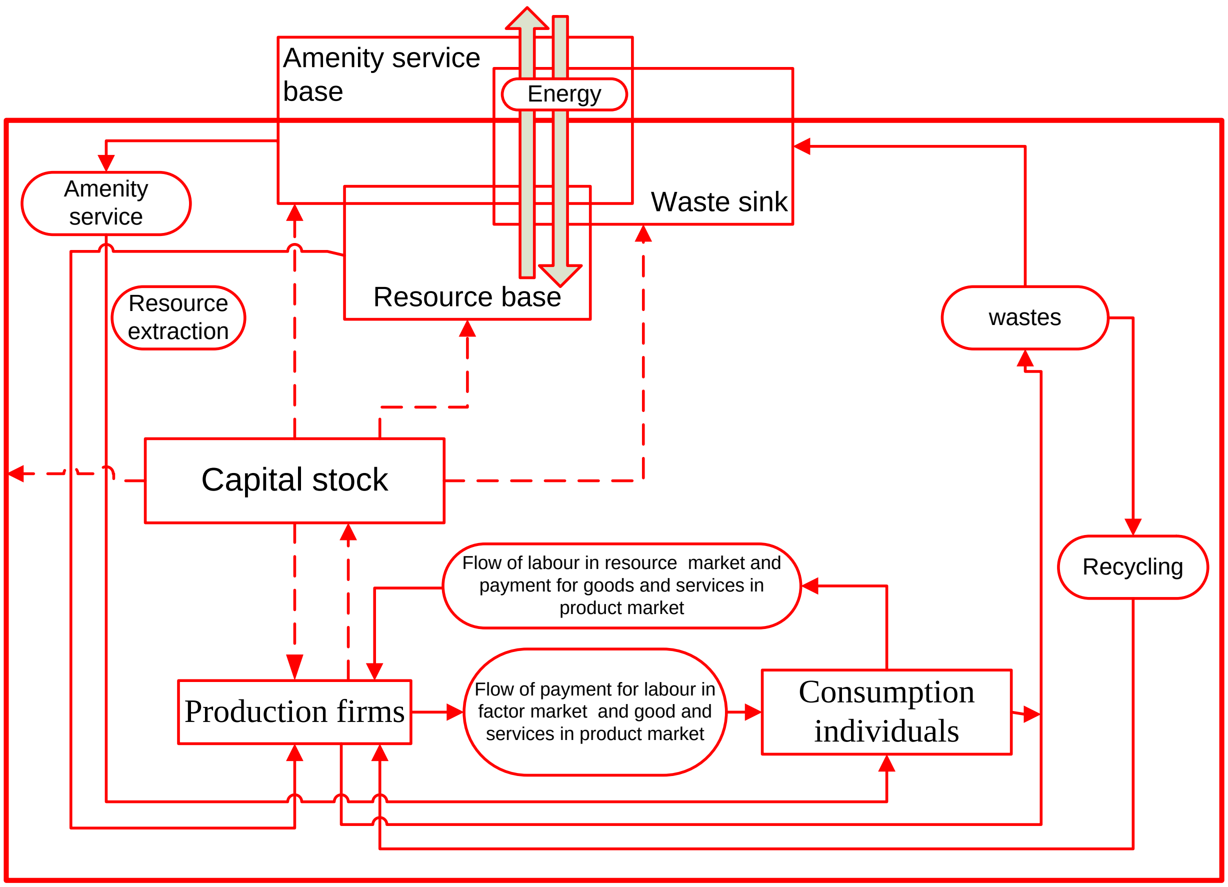

Figure 2: Economic activity in the natural Environment adapted from (Perman et al. 2003)

The above figure shows how economic activity is located within the environment and involving production and consumption, both of which draw upon environmental services, as shown by the solid lines inside the heavy lined box. Not all of production is consumed. Some of the output from production is added to the human-made, reproducible, capital stock, the services of which are used, together with labour services, in production. The figure shows production using a third type of input, resources extracted from the environment. Production gives rise to wastes inserted into the environment. So does consumption. Consumption also uses directly a flow of amenity services from the environment to individuals without the intermediation of productive activity but these services are unpriced by the market (ibid). The economic value of these environmental services can be measured or estimated by using environmental valuation methods. The economy-environment interdependence is discussed rigorously in (M.Common 1996).

1.6.3 Theory and Methods for Environmental Valuation

Environmental resources supply a flow of direct and indirect services to society. The service provided by ecosystem and biodiversity are numerous-ranging from basic life-support to the infiltration of non-point source of pollution from farm land. But while these resources provide a nearly limitless set of valuable attributes, many of their services remain unpriced by the market. For example, the market price for land does not generally account for the nutrient filtration and wildlife habitat services provided by Minnesota wetlands or a Scottish moor. This is also true for direct utility benefits provided by beautiful landscapes and wildlife species. The market undervalues wetlands services because the associated costs and benefits accrue to more than just the owner of the land. Water infiltration benefits all those downstream; wildlife does not stay within the confines of landowner property. This inability to exclude others from enjoying the benefits and suffering the cost prevent the market price from sending the current signal about the true economic value of the wetland. Environmental services/utility flows have economic value, despite often not having market value, is the fundamental insight of environmental economics. However, this introduces two problems; first how to conceptualize such values theoretically; and second, how to estimate them empirically(Nick Hanley et al. 2007).

Economists have a distinct definition of value based on the ideals of rationality and consumer sovereignty –an individual constantly knows what he or she wants and needs (rationality) and is best able to make choices that affect his or her own welfare (consumer sovereignty). If a change in an environmental service is a prospect (e.g a move to improve air quality in the city) such that the person believes she or he will be better off in some way, she or he may be willing to pay money to secure this improvement. This willingness to pay reflects her/his view of economic value for improved environmental services. Alternatively, if the change makes her (him) worse off (a fall in air quality), she (he) might be willing to accept compensation to allow this deterioration. Willingness to pay (WTP) and willingness to accept (WTA) represent the two general measures of economic value for an environmental service. These measures of values are what economists would like to estimate to that environmental service and other non-market goods can be included in policy decisions on how to prioritise and allocate public monies (ibid).

Figure 3: Preference, utility and consumers' surplus (Nick Hanley et al. 2007)

To better understand how economists think about valuing non-market goods, consider **Figure 3**. The theoretical bases for economic value are based on rational choice- the preference set, utility function and consumer surplus. An individual is assumed to have a set of preferences over goods and services that can be ordered in logical and consistent manner. The utility function is an ordinal representation of preferences that allow us to express the most preferred consumption bundles by the highest level of utility. Utility is unobservable, continuous index of preferences. If we impose a policy that changes the consumption bundle such that utility increases, then economist measure this change as consumer surplus-the money metric of the unobservable utility function. Consumer surplus can be either of the willingness to pay (WTP) or willingness to accept (WTA) measures noted above. To recap, we have preferences that are indexed by a utility, and changes in utility are captured by consumer surplus measures. With the appropriate restrictions, an individual's willingness to pay for a change in environmental quality is based on a theory of rational choice, and is therefore a consistent estimate of preference.

These values are estimated by using stated preference and revealed preference methods. Stated preference (SP) methods seek to measure individuals' preferences for environmental quality directly, by asking them to state their preferences for the environment. It includes contingent valuation and choice experiment model. Revealed preference (RP) methods differs from stated preference (SP) methods in that they use their data people's actual behaviour in real markets, rather than their conjectured behaviour in hypothetical markets. However, the behaviour we study occurs in markets which are only related to the environmental good in question: they do not exist for the environmental good, since by definition we are taking about non-market values here. For this reason, RP methods are sometimes known as indirect methods, since the analyst has to infer the value people place on non-market good indirectly from their behaviour in a market somehow related to that good. This method includes the travel cost method and hedonic pricing techniques (Nick Hanley et al. 2007).

The theoretical bases of environmental values explain divergences between willingness to pay and willingness to accept concepts of value; however, recently there are challenges to the standard theory of WTP/WTA framework in relation to non-compensatory preferences and preference construction. Vatn (2004) pointed out the anomalies in the valuation literature and the failure to draw on insights about the role of the social sphere in shaping both information problem and preferences formation. Information and information handling concerned on information problem; through cooperative production of knowledge and choice rules, the social sphere plays a crucial role in supporting individuals in understanding choice issues and in handling information problems (i.e. Knowledge is social). Choice involving great informational needs, the individual utilizes choice rules defined for situations, which are "similar" and classification influences the choice (i.e. Choosing is classifying and applying the right rule). The perceived quality of a good is influenced by the valuation of others (i.e. Prices inform preferences). Concerning preference and preference formation; the paper emphasized on preference is social, plural and ordered relative to the status quo. Preferences are the result of learning, aspect of fairness and have an autonomous influence on acts/bids (Preferences are social). Preferences are neither complete nor continuous; organized in class between which trade offs are blocked or heavily restricted (preferences are plural). No uniform set of individual preferences exists across various definitions of rights and incomes (Preferences are ordered relative to the status quo). Moreover, the paper pointed out environmental valuation theory purely based on individualistic; an individual is central object for economic research. However, it is lacking understanding of how individuals relate to each other and how social processes help the individual to act reasonably. As a result, Vatn (2004) proposed that it would be a great step in environmental valuation studies to incorporate the social dimension of preference construction; instead of being caught within the confines of traditional choice theory.

1.6.4 Payment for Environmental Services (PES)

Environmental services (Ecosystem services) are a key concept. Scientists and environmentalists have discussed ecosystem services for decades and the discussion is still ongoing. Many scholars have argued and discussed about ecosystem services, ecosystem assessment and ecosystem classification (Costanza et al. 1997; Costanza and Farber 2002; de Groot et al. 2002; Boyd and Banzhaf 2007; Wallace 2007; Fisher and Kerry Turner 2008). These services were popularized and their definitions formalized by the United Nations Millennium Ecosystem Assessment (MEA), a four-year study involving more than 1,300 scientists worldwide. According to the MEA (2005)[3] "ecosystem services are the benefits people obtain from ecosystems". MEA gives a great relevance to the usually called 'environmental services', 'ecosystem functions' or 'ecosystem services'. MEA categorizes ecosystem services into: regulating services, supporting services, provisioning services and cultural services. Currently, there is a considerable effort to conserve ecosystem services through payment for environmental services (PES) scheme. PES provides an economic incentive for those who manage ecosystems to improve the flow of environmental services.

The principle of PES is, a voluntary transaction in which defined environmental services (or a land use like to secure that service) is "bought" by a (minimum of one) buyer (those who benefit from environmental services pay for their provision), from a (minimum of one) provider (those who provide environmental service get paid), if and only if the provider continuously secures the provision of service (Conditionality) (Wunder 2005). Potential providers of environmental services are individuals or social groups who have land use rights over one or several resources. Beneficiaries are resource users with various rights but their access to resources depend on the activity of providers. Four types of environmental (ecosystem) services are concerned by market for environmental services; these are carbon sequestration, watershed services, biodiversity protection and landscape beauty.

Watershed environmental services can be assessed and valued by means of interlocking system of environmental model (understanding of the science) and economic models (understanding of the economics), **Figure 4**. Environmental model quantifying the pattern of different land use change in upstream and estimating the biophysical environment impacts on downstream area, such as, hydrological effect(water quality and availability), biodiversity conservation (fishery population, ecosystem health and biodiversity richness), and carbon sequestration (Carbon emission). In a subsequent step, in economy model the monetary values of the watershed services (charging values for services) and preference to accept compensation for various schemes of environmental services provision (paying service providers), and its impact on welfare of beneficiaries could be analysed through environmental valuation method in order to establish a PES system, which deals more on linkages between economy and environment. And developing or establishing institutional framework is essential to create enable environment. Thus, the design of PES schemes must necessarily be tailored to the local situation, not only in terms of

[3] A guide to Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Synthesis, Island Press, Washington, DC.*can access from http://www.millenniumassessment.org/en/index.aspx

the service traded, but also taking into account the current institutional constraints, as well as the capacity (financial and human) of potential suppliers and beneficiaries of the service.

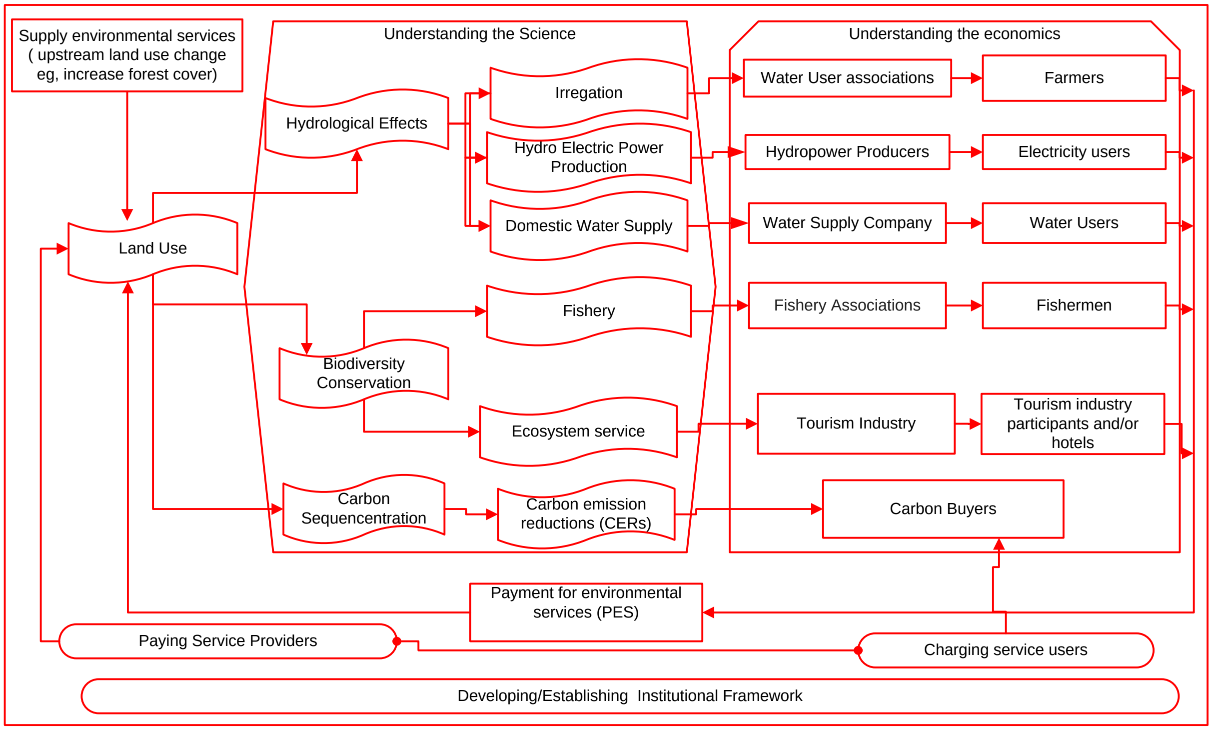

Figure 4: Developing PES from Theory to Practice (Pagiola S and Platias. G 2005)

Payments for environmental services (PES) are an innovative approach to conservation that has been applied increasingly often in both developed and developing countries (Echavarria 2004; Bennett 2008; Frost and Bond 2008; Pagiola 2008; Jack 2009). PES programs often differs substantially one from the other. Some of the differences reflect adaptation of the basic concept to very different ecological, socioeconomic, or institutional conditions; others reflect poor design, due to either mistakes or to the need to accommodate political pressures. In addition, Wunder et al(2008) indicated there is an important distinction between user-financed PES programs, in which the service buyers are the actual service users, and government-financed PES programs, in which the service buyers are a third party (typically the government). User financed PES programs are more likely efficient than government financed ones. User-financed programs are better targeted; more closely tailored to local conditions and needs, had better monitoring and a greater willingness to enforce conditionality, and had far fewer confounding side objectives than government-financed programs. Time and again, the design and operation of government-financed programs was found to be hijacked for many alternative purposes.

According to (Pagiola et al. 2005), PES helps to reduce poverty, by taking evidence from Latin America. The impact depends on how many PES participants are in fact poor, on the poor's ability to participate, and on the amount paid. PES programs are not a magic bullet for poverty reduction, but there can be important synergies when program design is well thought out and local conditions are favourable. Making the PES programme predominantly poverty reduction objective is understandably attractive while the programs will not be sustainable unless service recipients are satisfied that they are receiving the service they are paying for. Water has the potential to be “umbrella service” to other ecosystem services, in that efforts better manage and conserve water in mountain catchment (watersheds) and riparian cones result in conservation of other services provided by the improved health of the ecosystems. Thus, PES programmes to avoid adverse impacts, it needs a secure property rights and encourage labour-intensive practices. Making these services is labour-intensive and providing opportunities for poverty relief makes it more attractive (Turpie et al. 2008).

1.6.5 Livelihood: Concept and Definitions

The increased attention being given to livelihood in both research and policy follows from a wide recognition that few rural or urban households, especially poor households in middle and low-income countries, rely on single income generating activity to support themselves. The concept of a livelihood is widely used in contemporary writings on poverty and rural development, but its meaning can often appear elusive, either due to vagueness or to different definitions being encountered in different sources. Its dictionary definition is a “means of living”. There is a consensus that livelihood is about the ways and means of ‘making a living’. The most widely accepted definition of livelihood stems from (Chambers R. and G.Conway 1992) as ‘a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living’.

In Ellis (1998) a review is presented of ideas, propositions and policy inferences surrounding diversification as a livelihood strategy of rural families in developing countries defines ‘livelihood diversification as the process by which rural families construct a diverse portfolio of activities and social support capabilities in their struggle for survival and in order to improve their standard of living’. Ellis (2000) defined livelihood as: A livelihood comprises the assets (natural, physical, human, financial and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by individual or household. (Wallman 1984) use an approach to explain livelihood as a broad concept as ‘livelihood is never just a matter of finding or making shelter, transacting money, and preparing food to put on the table or exchange in the market place. It is equally a matter of the ownership and circulation of information, the management of relationships, the affirmation of personal significance and group identity, and the interrelation of each of those tasks to the other. All these productive tasks together constitute the work of livelihood’.

Following the widely accepted definition of livelihood, the Institute of Development studies (IDS) defines a sustainable livelihood as ‘a livelihood comprises the capabilities (including both materials and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base’. In this definition, the five key elements in sustainable livelihoods can be recognized, and each related to wider literature with, in some cases, established ways of assessing outcomes. These are creation of working days, poverty reduction, well-being and capabilities, livelihood adaptation, vulnerability and resilience and natural resource base sustainability. The first there focus on livelihoods, linking concerns over work and employment with poverty reduction with broader issues of adequacy, security, well-being and capability. The last two elements added the sustainability dimension. The natural resource base sustainability implies that most rural livelihoods are reliant on the natural resource base at least to some extent. Clearly these five indicators of sustainable livelihoods are quite different in scope, with the range from precise measures, amenable to quantitative assessment, to very broad and diffusive indicators requiring more qualitative techniques of assessment (Scoones 1998).

According to the UK‟s Department for International Development's (DFID) cited in (Stephen Morse et al. 2009) suggested the five important principal assets (or capitals) to livelihood. These capitals are natural capital that includes natural resource stock and environmental services. Social capital constitutes social resources (networks, social claims, social relations, affiliations and allocations). Human capital includes skills, knowledge, labour (includes good health and physical capability).Physical capital includes infrastructure, production equipment and technologies. And economic or financial capital comprises capital base (cash, credit/debt, saving and economic assets). Oderro (2006) introduce information is such a critical component in people's lives and add information as sixth capital in sustainable livelihood framework and extend the approach from asset pentagon to asset hexagon approach.

One feature that these definitions and interpretations have in common is that they eloquently underline the generally accepted idea that 'livelihood' deals with people, their resources and what they do with these resource. Livelihoods essentially revolve around resources (such as land, crops, seed, labour, knowledge, cattle, money, social relationships, and so on), but these resources cannot be disconnected from the issues and problems of access and changing political, economic and socio-cultural circumstances. In addition, livelihoods are also about creating and embracing new opportunities. While gaining a livelihood, or attempting to do so, people may, at the same time, have to cope with risks and uncertainties these uncertainties and presence of new emerging opportunities influence how resources are managed and used. Therefore, in this study PES as a development programme has a sustainable livelihood concern to improve welfare of the people and conserve natural resources and using PES to reduce the trade-off between livelihoods and conservation.

The major objective of PES programmes designed in developing countries is to diversify existing livelihood strategies and to improve ecosystem services. PES stewards a payment or preference for compensation for those willing to provide environmental services. It also assures the service provision for buyers of environmental service, for those who are willing to pay for the service. Individuals may decide to accept compensation; it indicates how much the cost to provide environmental services and indirectly measures welfare changes of service providers. The environmental services indicate individual's strategy to make a living through provision of environmental services; as a livelihood strategy. The buyers of environmental services may decide and willing to pay to get environmental services; those individuals may give up their income to secure the service in order to maximize her/his benefits. This would enable us to measure their welfare change or consumer surplus. Thus, PES programmes dealing with people and natural resources would be taken as an instrument to interlink environmental services as well as livelihood strategies of service providers and service recipients.

1.6.6 Conceptual Framework

In line with the above mentioned concepts, this study attempts to emphasize socioeconomic structure and environmental-economic linkages. The conceptual framework is presented in **Figure 5**. Linking remote sensing and social science (people and pixel) is a plausible approach to understand human impact on biophysical environment and to respond environmental impacts on human economic activities. Thus, it will enable us to estimate socioeconomic indicators and model socioeconomic activities through integration of remote sensing imagery and socioeconomic data in order to indicate the structure of the economy.

Environmental and economic linkages will follow the concept of interdependence between economy and environment, the underlying theory and methods in environmental valuation and the livelihood concepts and definitions. Consequently, watershed environmental services can be assessed and valued by means of interlocking system of environmental models and economic models. Environmental models quantifying the pattern of different land use change in upstream and estimating the biophysical environment impacts on downstream, such as, water quality and availability, fishery population and habitat improvement, and biodiversity richness (species diversity and population). Preference and economic values of the watershed environmental services, preference and values of compensation to provide environmental services can be estimated by using economic models (i.e. environmental valuation methods) in order to establish a PES scheme. Thus, it will be possible to analyse the livelihood impact of payment for environmental services (PES) on environmental service providers (sellers) and receivers (buyers) through payment receipt and improvement of environmental services, respectively.

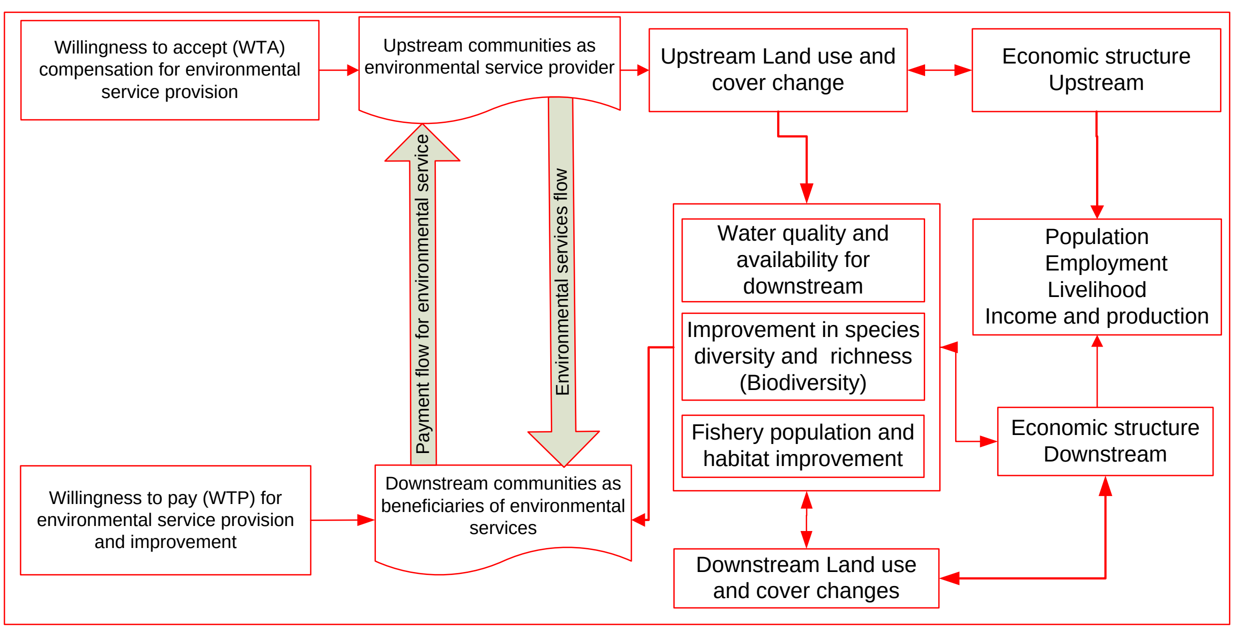

Figure 5: Conceptual framework for linking the economy to the environment.

1.7 Methodology

Objective 1: To assess socioeconomic driving forces of land use and land cover changes in Lake Naivasha watershed.

Land use practices generally develop over a long period of time under different environmental, political, demographic, and socio-economic conditions. These conditions often vary and have a direct impact on land use and land cover. The interaction of nature and society and their implications on land use and land cover is a very complex phenomenon that encompasses a wide range of social and natural processes. Growing human populations exert increasing pressure on the landscape as demand multiply for resources such as food, water, shelter, and fuel. These socioeconomic factors often dictate how land is used regionally as well as locally (Muttitanon and Tripathi 2005). Therefore, Land use and land cover changes have become a central component in current strategies for managing natural resources and monitoring environmental changes and also play a pivotal role in regional, social and economic development plans.

Land use and land-cover changes have impacts on a wide range of environmental and landscape attributes including the quality of water, land and air resources, ecosystem processes and functions, and the climate system itself through greenhouse gas fluxes and surface-albedo effects (Lambin et al. 2000). Land-use and land-cover change, as one of the main driving forces of global environmental change, is central to the sustainable development debate. As a result, monitoring and evaluating of sustainability indicators, for example; change in land use and settlement, social process, loss of natural vegetation cover, and pressure on land resource and ecosystems are required. The major goal of sustainability indicators is to show the state of human, environmental and economic conditions, to assess the trend of changes in these conditions and to identify issues that need to be addressed within each of these three pillars of sustainable development. These indicators also provide information crucial to decision on national and international policy.

In the face of a rapidly growing global population, increase in technological capacity and affluence, the Earth's land cover has been transformed especially in developing countries. At the same time, social organization, attitudes, and values have also undergone profound changes. In contemporary times, issues of sustainable development, pollution prevention, global environmental change and related issues of human-environment interaction have been a major concern of the global scientific community as well as citizens and policy makers of the world (Codjoe 2007). A quite number of research works was carried out to derive and assess the land use and cover changes from different sets of remotely sensed data (Mertens et al. 2000; Reid et al. 2000; Serneels and Lambin 2001; Xiuwan 2002; Krausmann et al. 2003; Campbell et al. 2005; Mundia and Aniya 2005; Muttitanon and Tripathi 2005; Xie et al. 2005; Yang and Liu 2005; Béland et al. 2006; Long et al. 2007; Nguyen 2008). Huang., Lui. et al (2008) examined the phases of urban expansion in Beijing by using spatial time series data from remote sensing imagery on land use changes and socioeconomic data from statistical reports. Wright and Samaniego (2008) explored the historical, demographic and economic correlates of land use changes in Panama forest cover by using multiple regression analysis and found trajectories of land use within Panama.

The current land use and land cover changes in developing countries taken as one of the most important variables of environmental threat and changes that has a direct and indirect impact on better living condition achievement, economic growth, production and improved infrastructures, which eventually changed the relationship between human and environment. Understanding the implications of past, present and future patterns of human land use for ecosystem and economic function is increasingly important. In particular, Lake Naivasha watershed has faced considerable treats during the past decade; this area has witnessed significant population and economic growth, new urban settlement and agricultural land expansions, hydrological alterations and direct habitat destruction throughout the watershed. Therefore, this study will try to analyse the impact of population pressure, urbanization and small and large scale agricultural farms expansion on land use and cover change in Naivasha watershed for the last three decades.

Landsat MSS, TM and ETM+ imagery for the periods 1979/1980,1989/1990, and 1999/2000, respectively and recent ASTAR image for the year 2009/2010 will be collected and employed for analyzing the spatial and temporal changes in land use land cover classification in the study area. Other available reference data such as aerial photography and topographic maps, and ancillary data will be collected and acquired. Food and Agricultural Organization (FAO) Africover data (ILRI data base) on land use and land cover classification for Kenya also collected. Furthermore, review of different documents on land management; conservation legislations in forest, watershed services, wetland management and urban development plan will support for better understanding and to get reference data on land use and land cover in the region. Moreover, participatory rural appraisal (PRA) tool will also be conducted with community to obtain a comprehensive data and to identify the land use and cover changes and patterns of the study area.

The image processing procedures that will be employed for this study includes image pre-processing, classification, and accuracy assessment. Geometric rectification and radiometric normalization will be attempt for image pre-processing. ISODATA algorithm will be adopted to identify clusters from image data. In ISODATA analysis, unsupervised classification will be first conducted to identify spatial clustering of different classes. Image is segmented into unknown classes depending on its statistical similarities by using a suitable clustering algorithm. LULC classes manually assigned to clusters produced, a process known as labelling. This is followed supervised classification, by taking sample points in stratified random sampling scheme for ground truth data and with the support of field knowledge and ancillary data the land use/cover classification will be identified.

Those classes will be labeled to the relevant land use/land cover patterns by a posteriori analysis. This technique implies a grouping of pixels in multi-spectral space. Pixels belonging to a particular cluster are therefore spectrally similar. In order to quantify this relationship Euclidean distance will be used as a similarity measure. Finally based on reference data which will be gathered during field work, accuracy assessment will be employed to measure the reliability or the overall accuracy of the classification. The reference classes will be compared with the result of classification and the ratios of correctly versus incorrectly classified pixels will be calculated for each class. The accuracy assessment will be conducted through a standard method described by (Congalton 1991).

Change detection based on remote sensing is highly effective for studying dynamics of land use and land cover changes. Particularly, for this study the classification will be based on high density urban use (commercial and industrial), and low density urban use (settlement areas), rural settlement, agricultural land (irrigated and cropland/grassland), wood land, bare land, water and forest cover. Post-classification method will be employed for the change detection. This technique readily provides a change matrix where different transfers from one land use and land cover types to another can be visually appreciated. This approach consists of a first step of classification which produces classified imagery, followed by a second step of comparison which identifies areas of change as pixel per pixel differences in class membership. Three change metrics for detecting land use and land cover change will be constructed between 1979/1980 and 1989/1990, between 1989/1990 and 1999/2000, and between 1999/2000 and 2009/2010 through pixel-to-pixel comparisons.

With spatial statistical analysis, major socioeconomic driving forces triggering land use and land cover changes will be explored using bivariate and multiple regression analysis. The spatial data sources for this study will be derived from remote sensing imagery particularly on land use and land cover changes. Other environmental and socioeconomic data, such as population count and density, gross value of agricultural output, gross value of industrial output, per capita income, and different sectors GDP contribution, employment opportunity, dry and liquid waste, deforestation, biomass energy consumption and their changes over time will be collected from different Bureaus, statistical and other reports. The overall methodological framework that will be employed for this study is presented in Figure **6**.

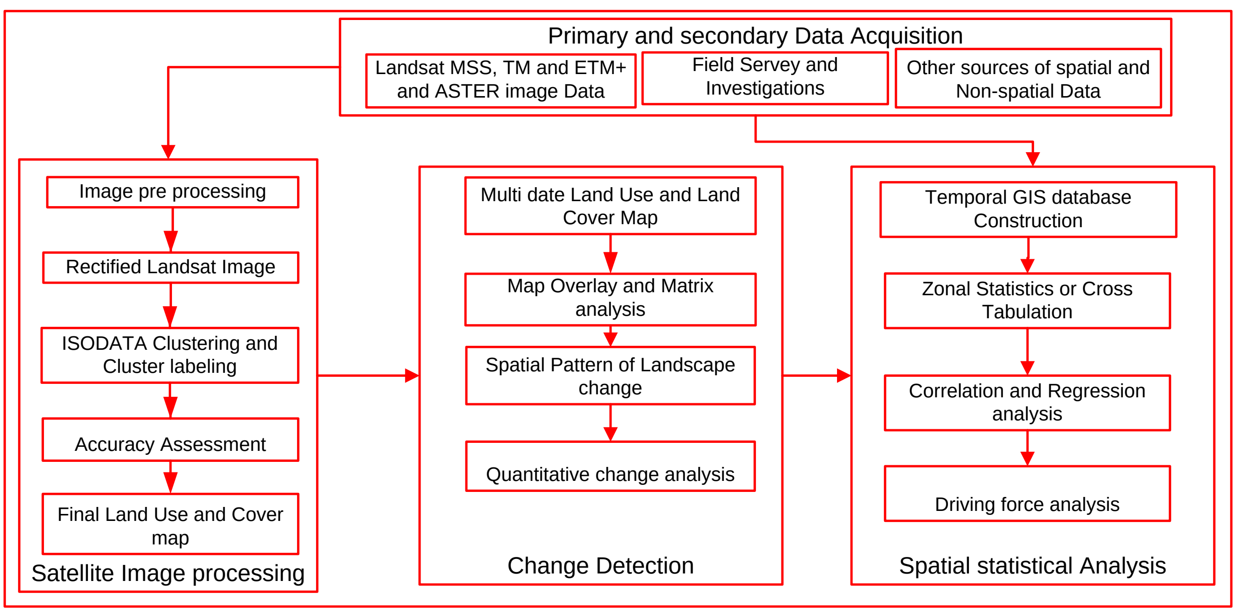

Figure 6: Methodological approach to analyse the driving forces of land use and Land cover changes adapted from (Mesev 2007)

Objective 2: To explore the applicability of remote sensing imagery as an alternative (additional sources) to estimate socioeconomic indicators in Lake Naivasha watershed.

The availability of accurate and timely population census data is essential to planning at national, regional, and local levels for both developed and developing countries. Unfortunately, the conventional population census is expensive, and is normally conducted only every ten years. In some developing countries, such regular population census are not affordable (Lo 1995). The traditional approach to population estimation is mainly based on a census, which is labour-intensive, time-consuming and costly, and also encounters difficulties in updating the database (Lu et al. 2006). Timely and accurate estimation of population distribution is of considerable significance for decision makers in urban land-use planning and for comprehensive assessment of interactions between population growth and social, economic and environmental conditions. Socioeconomic information such as census data cannot be obtained on a timely basis. Remote sensing imagery, however, can be obtained on a daily or monthly basis and thereby has the potential for providing updated socio economic information (Mesev 2007). However, there is a limited research outcome that has applied remote sensing information in socioeconomic research in developing countries to estimate socioeconomic indicators.

The advent of GIS and satellite imagery technology in recent years has presented both opportunities and challenges to understand changes in urban environment, population estimation (density) and settlement, employment estimation, and other associated socioeconomic characteristics. These technological advances also help to produce more accurate measurements that should allow the development of better theories in both science and social science (Lo 2004). A growing number of studies provide evidence that attempt to estimate and extract socioeconomic attributes directly from remote sensed data or indirectly by means of surrogate information derived from imagery. Iisaka and Hegedus (1982) proposed and apply mathematical model based on Landsat MSS data to estimate the population distribution in Tokyo, Japan. Understanding quality of life, for example, has been successfully analysed by using data generated by remote sensing imagery and socio economic variables (Lo 1997). Sutton (1998) model population density using night time imagery in USA. Lo(2002) estimated economic indicators in China using allometric growth model. Weber and Puissant (2003) analysed urbanization process and identify urban changes in Tunis, capital of Tunisia. Chen (2002) proposed an approach with different level to link remotely sensed data and areal census data in Sydney, Australia. Lo (2004) tested urban theories on spatial urban structure using remote sensing in Atlanta, USA.

Urban expansion in Kenya is closely associated with a tremendous increase in demand for land, which is highly related to population growth and movement. Naivasha is the fastest growing town in Kenya. The growth is fuelled by horticulture and floriculture farming businesses around the lake. Tourist activities in the region, rural-urban migration as a result of falling farm income from traditional cash crops, expansion of commercial enterprises and good prospects for job opportunities are other factors for population pressure in the region (IUCN/LNRA 2005). The rapid population growth in Naivasha town together with the increased standard of living and changes in economic activities of the region required timely estimation of socioeconomic parameters. Remote sensing imagery assist as a reliable resource for estimating socioeconomic information, and may also be used as a cross validation (Mesev 2007). However, applying remote sensing imagery to estimate socioeconomic indicators in Naivasha region has not entirely studied. Thus, the aim of this study is to explore the applicability of remote sensing imagery as an alternative (additional sources) to estimate socioeconomic indicators in Lake Naivasha region.

An enhanced equation is the allometric growth model, which has been successfully used in population estimation (Nordbeck 1971; Lo and Welch 1977; Lee 1989; Yuan et al. 1997; Lo 2002; Martín 2003). This model is well known as allometric growth model in biology but it is well known as Pareto's law in economics (Lee 1989). Lo (2004) applied allometric growth model to estimate employment density in terms of the number of employees per hectare using mean surface temperature from remote sensing imagery. The allometric growth model is also applied to estimate non agricultural population, gross domestic product (GDP), built-up areas, and electricity consumption from the radiance calibrated DMSP-OLS night-time images of the thirty five Chinese cities, using surface area and volume as independent variables (Lo 2002). This indicates that socioeconomic activities are closely related to physical environment, which has been given a way to successfully estimate socioeconomic indicators through regression analysis using data obtained from remote sensing imagery. For example, for population estimates the model takes the following form:

$$P = aA^b \qquad (1)$$

Where P is population and A is residential land/settlement area from satellite image. Its computation form is a logarithmic transformation as:

$$\log P = \log a + b \log A \qquad (2)$$

The logarithmic transformation of both the dependent and independent variables minimizes the problems caused by hetroscedasticity. **Equation 2** explains that the relative growth of population P is proportional to the relative growth of residential land/settlement area A, with b as a scaling factor. When the value of b is larger than 1, positive allometry occurs, implying that P increases at faster rate than A, if the value of b is smaller than 1, negative allometry result, suggesting that P increases at a slower rate than A. If the value of b is equal to 1, isometry results, indicating that both P and A increase at same rate. Finally, the coefficient a is known as the proportionality coefficient. Clearly, by rearranging the first equation:

$$a = \frac{P}{A^b} \qquad (3)$$

Equation 3 shows some form of residential population density or space standard (Mesev 2003). Thus, this study employs this model (Allometric growth model) to estimate socioeconomic indicators.

Focus will be given to estimate population and employment, using residential land area and surface temperature as independent variable, respectively. The first step is performing a comprehensive land use and land cover classification of the study area and extract the average surface temperature. Then, the zone-based approach will be established to explore the potential of remote sensed data to estimate socioeconomic indicators. Socioeconomic data will be collected at census tract level (sub-location level) in Naivahsa region based on the 1989, 1999 and 2009 population and housing census report of Kenya National Bureau of Statistics (KNBS). Figure **7** illustrates approach to use remote sensing to estimate socioeconomic information.

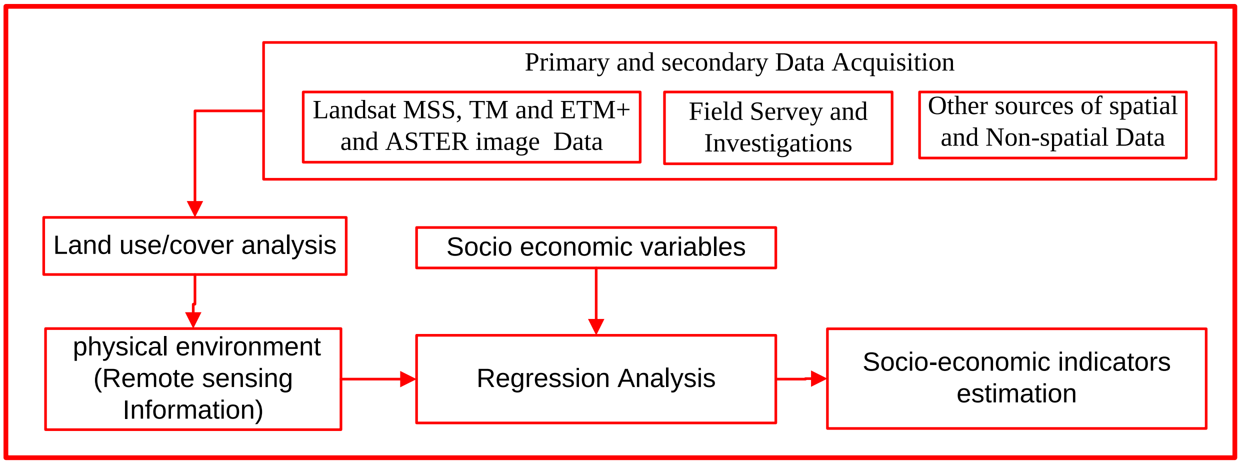

Figure 7: Approach to estimate socioeconomic indicators using remote sensing adapted from (Mesev 2007)

Objective 3: To model socioeconomic activities using remote sensing information in Lake Naivasha watershed.

In objective two we will try to generate specific information, which is unavailable, while socioeconomic modelling assumes the availability of specific socioeconomic information, and attempts to generate new information or discover the patterns and forces of socioeconomic activities with the help of remote sensing imagery. In addition to direct estimation of socioeconomic indices, remote sensing information has also been used to better understand and model socioeconomic phenomena. Remote sensing, as a means of acquiring information about the physical environment, cannot be directly applied for estimating or modelling socioeconomic activity. Socioeconomic activities conceptualized as socio cultural environment represent people's understanding of and reactions to physical environments. Therefore, socioeconomic activities are assumed to be closely related to physical environment, which have been successfully estimated from remote sensing imagery (Mesev 2007).

Remote sensing derived information has been applied in understanding population segregation and their environmental forces in Milwaukee county, Wisconsin and the fertility pattern and their changes analysed in Cairo, Egypt by (Yu. and Changshan 2004) and (Weeks et al. 2004), respectively. Yu. and Changshan (2006) incorporated remote sensing information in modelling house values. Yuan, Smith et al(1997) remodeled census population counts, and the census geographical entity map linked to the land use and land cover map to indicate the various land use and land cover type impact on population distribution. Lo (1997) explored quality of life index for Athens-Clarke county in Georgia USA and applied principal component analysis (PCA) using remote sensing data and socioeconomic variables. Tian et al(2005) investigated the relationship between land cover changes and other factors that affect population density in China. Therefore, integration of remote sensing information and other environmental and socioeconomic data enhance socioeconomic activity modelling. This will also enable us to better understand the region socioeconomic environment and to suggest possible measures that are crucial for sustainable utilization and management of existing resources of Lake Naivasha watershed, Figure 8.

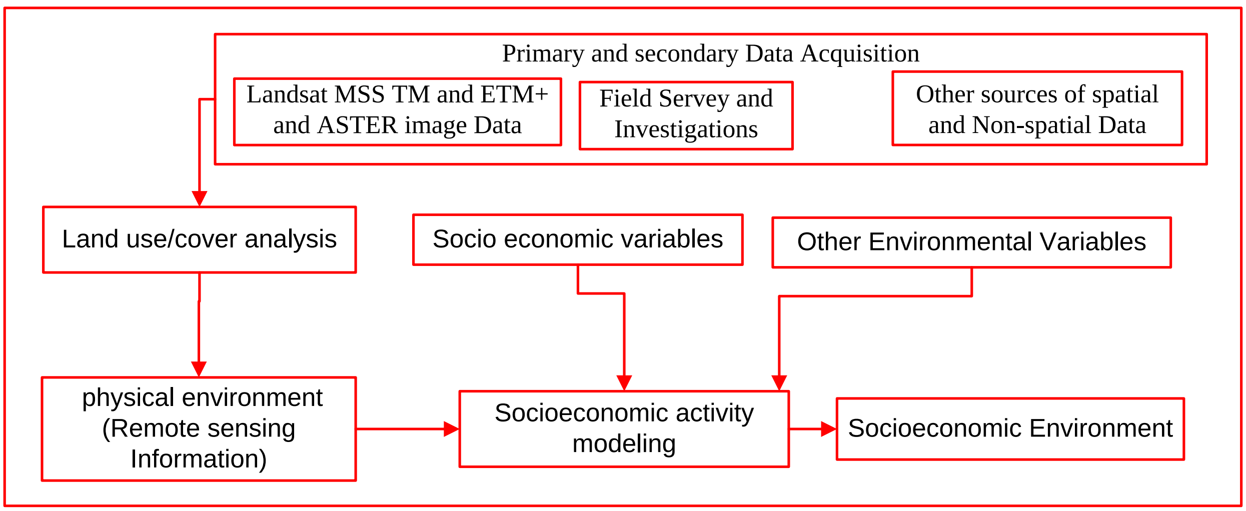

Figure 8: Approach to model socioeconomic activity using remote sensing adapted from (Mesev 2007)

The growth of large commercial scale activities in form of booming flower industry along with the existing small farms around the Naivasha lake have implications on the demand for resources of this ecosystem. The population benefits from the ecosystem services but also causes direct and indirect impacts on the ecosystem (WB 2005). Moreover, population size, growth, distribution and movement help to determine the relationship between people and their environments. Population pressure and informal settlement due to lucrative economic activity are the major challenges of the region economy and more people are being driven to the basin by labour-intensive agriculture practices of flower farms and cash crops. An estimated 75% of Kenya's horticultural exports and US$ 11.5 million annually from tourism originate from the Lake Naivasha basin. Lake Naivasha's economy is largely dependent on the basin's natural resources and agricultural activities(IUCN/LNRA 2005). These economic activities cause population pressure through generation of employment; people migrate to the region from different places of the country seeking employment opportunities. Therefore, this study tries to remodel the population distribution and analyses the patterns and forces of socioeconomic activities of Lake Naivasha region with the support of remote sensing imagery.

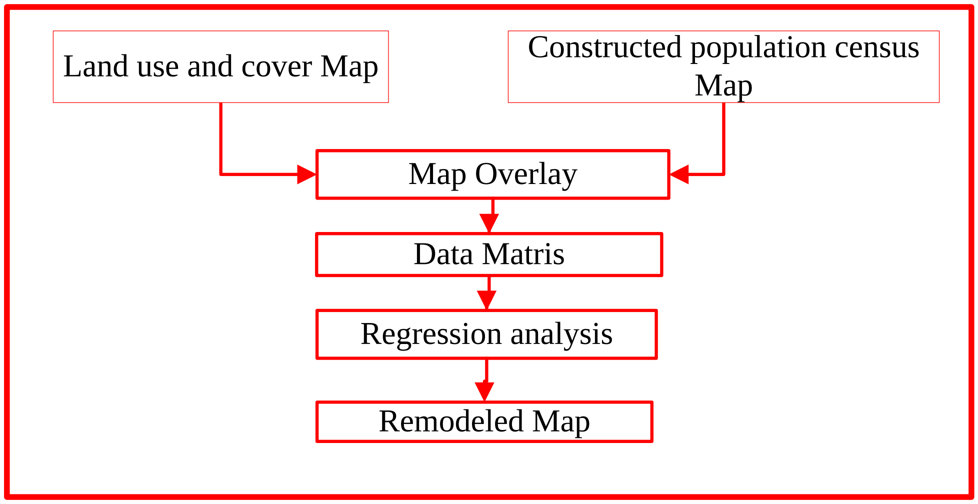

Figure 9: Approach to remodel population distribution (Yuan et al. 1997)

In our research using GIS, the census population map at sub-location level will be overlay on the land use and land cover map, illustrated in Figure 9. When the census population map considered as the source unit system, is overlay by the reclassified land use / land cover map, considered as the target unit system, each source unit is broken to smaller pieces. These small pieces are called subunits. These subunits are labelled by the combination of source unit code i and target unit code j. The result of the overlay operation is a map with a subunit system and data matrix. Let, the data matrix with m rows and n+ 1 column, where m is the number of source unit or census blocks (Sub-location) and n+1 column where n is the number of land use and land cover type and the first column is population count in census block. Then, regression analysis will be employed to assess the relationship between population and land use/cover and remodel the map to indicate the population distribution. Thus, the general linear model can be written as:

$$Y_i = \sum_{j=1}^{n} b_j X_{ij} + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..\ldots\ldots\ldots\ldots 1$$

Where Y_i is the total population count in subunit i, b_j is the mean (average) population density for the j^{th} land use/ land cover type, X_{ij} are the total areas for the j^{th} land cover/use type within the i^{th} subunit or census tracts (for this study sub location level) and n is the number of land use and land cover type in i and ε_i is the random error in population estimate of case i. The random errors represent the variation in population unexplained by the land use and land cover type within the subunit, and is assumed to be independently and identically normally distributed with constant variance. If the number of subunits/ census tracts is greater than or equal to the number of land use and land cover type, a regression process can be find the estimates of b_j. If the subunits are much greater than the land use and land cover classification the mean population density estimate will be more reliable. However, population distribution is not explained solely by land use and land cover type. For example, accessibility for public services (e.g. transport, access to potable water and electricity service), location features, neighbourhood land use variables, natural environment and socioeconomic settings have influence on population distribution. Thus, the current population distribution will be remodeled by adding more explanatory variables to assess the influence of other factors on population distribution. Statistical tests will be measured for goodness and reliability of the model and estimates to confirm the result.

Objective 4: To estimate the willingness to pay (WTP) for different attributes (ecosystem services) and willingness to accept (WTA) compensation in Lake Naivasha watershed services in order to apply payment for environmental services (PES)

Three broad categories of economic valuation are distinguished in literature: revealed preference (RP), stated preference (SP) and benefit transfer (BT), which relies on estimates from SP and/or RP studies. The array of economic valuation techniques ranges across RP and SP techniques. The revealed preference (i.e., indirect) approach infers value indirectly by observing individuals' behaviour in actual or simulated markets. On the other hand, stated preference methods attempt to elicit environmental values directly from respondents by asking them about their preferences for a given environmental good or service. At the present time, only SP methods can be used to estimate total economic value (i.e., use and non-use values), whereas RP methods are only restricted to estimating use values. The total gain in wellbeing arising from the project or policy and for any one individual is given by the individual's willingness to pay (WTP) or willingness to accept (WTA) for the change in question (WTP if the individual prefers a change to the status quo, WTA if the status quo is being preferred). The net sum of all the relevant WTPs and WTAs defines the total economic value(Bateman et al. 2002).

Cost benefit analysis (CBA) is an economic technique applied to public decision-making that attempts to quantify the advantages (benefits) and disadvantages (costs) associated with a particular policy or action. The primary objective of CBA is to determine whether society as a whole would benefit as a result of implementing a policy or action. CBA seeks to measure the benefits and costs of policy measures, projects and programmes and it adopt various decision rules. CBA is a decision procedure that is fully consistent with the use of WTP and WTA as measure of economic values. Economic valuation refers to the assignment of money values to non-marketed assets, goods and services, where the money values have a particular and precise meaning. If money is used as the standard to measure welfare, the measure of benefit is WTP to secure that benefit, or WTA compensation to forgo the same. Similarly, the measure of cost is WTA to suffer that cost, or WTP to avoid the same (Bateman et al. 2002).

A wide variety of non-market valuation techniques has evolved in environmental valuation literature. Each of these techniques has its own characteristics and hence capabilities. When using stated preferences, the main choice is between choice modelling (CM) and contingent valuation method (CVM). CVM should be chosen when the WTP for the environmental goods and services in total is needed, and CM when WTP for individual attributes is required. CM is also useful if information is needed in relative values for different attributes of an environmental good. CM is more recent than CVM and not all CM techniques are consistent with the underlining welfare theory if welfare consistent estimate are needed, choice experiments are preferable. CM offers a more 'efficient' means of sampling than CVM since; typically more responses are obtained from each individual with CM than with CVM. Choice modelling approach allow a more direct route to the valuation of the characteristics or attributes of the good, and of marginal changes in these characteristics, rather than the value of the good in *toto* (ibid).

Currently, the importance of wetlands is reflected by the growing number of valuation studies. Othman, Bennett et al.(2004) estimated the non-market values of Matang Mangrove wetlands under different management options to assist decision makers in determining optimal management strategy, using choice moddling application in Perak state, Malaysia. Birol, Karousakis et al.(2006) employed choice experiment modelling and estimate the benefits of the non-use values of the Cheimaditida wetland that accrue to the Greek people. Carlsson, Frykblom et al. (2003) identified what characteristics of wetlands, besides retention of nutrients, that an individual’s think are important using the model, and estimate marginal willingness to pay for different attributes of wetland area in Staffanstorp, Southern Sweden. Similarly, Wang, Bennett et al. (2007) and Brey, Riera et al. (2007) applied a choice experiment model to estimate non-market environmental benefits of the conservation of cropland to forest and grass land program in Loess plateau, China and the marginal economic value of several forest functions in Catalonia, Spain that was considering implementing an afforestation program, respectively. Hala Abou Ali and Carlsson (2004) analysed the welfare effects of improved health status through increased water quality using a choice experiment in Cairo, Egypt. Farber and Griner (2000) estimated multiple stream quality improvements in an acid-mine degraded watershed using conjoint analysis in Western Pennsylvania.

Sangkapitux (2009) estimated upstream resource managers’ willingness to accept compensation for adopting environment-friendly agricultural practices and determined downstream resource managers’ willingness to pay for water resource improvements through a change in upstream resource management in Mae Sa watershed, Thailand. This study focused on monetary compensation scheme, while preference for other compensation schemes in PES would be an incentive for environmental service provision. It considered only the socioeconomic determinant factors that affect people participation in the PES programme. Jones (2006) identified potential buyers of watershed service in Naivasha catchment and determined willingness to pay (WTP) for environmental service provision for tourists who visit the area and flower consumers in United Kingdom(UK). However, other potential watershed service beneficiaries, such as small scale farmers, fishermen and downstream household’s willingness to pay (WTP) for PES scheme was not incorporated and upstream people’s willingness to accept (WTA) compensation for environmental service provision, which requires further detail study.

Lake Naivasha is one of the few remaining freshwater lake in Kenya and provide several important ecological functions and it is a Ramsar site being a wetland of international importance. In contrast to their international importance, many wetlands have been treated as wasteland and drained or otherwise degraded (Barbier E.B et al. 1997). The resources in Lake Naivasha and its surrounding area face the current various threats to wetlands in developing world. The protection of wetlands reflects the protection of numerous goods and services that have an economic value not only to the local population living in their periphery but also to communities outside these wetland areas. Therefore, valuation of ecosystem services taken as an important tool to assist policy makers to compare the benefits and costs to the society in formulating conservation programmes and management policies, to protect or restore an ecosystem. It also helps to improve people livelihoods by using and selling ecosystem goods and services and enables to charge fair estimate for ecosystem services, so as to promote a more rational use.

Numerous economic valuation studies of wetlands around the world have been carried out; however, most of these studies have focused on wetlands in developed countries. On those studies carried out for developing countries, African wetlands are clearly underrepresented. At the same time, African wetlands are facing serious threats, and the importance of their protection for the survival of local people is increasingly recognized (Schuyt 2005).Therefore, this study tries to estimate the willingness to pay (WTP) for different attributes (ecosystem services) of Lake Naivasha, and downstream peoples' preferences for various ecosystem services improvement. Evaluate upstream service provider's preference towards different land management and reward schemes for environmental services provision, and to estimate their willingness to accept (WTA) compensation. In addition, the study tries to analyse the determinant factors that affect people participation on PES programme and its potential impact on livelihood outcome of both upstream and downstream communities using choice experiment (CE) method.

Recent years have seen considerable interest using PES to finance conservation programs; however, very few studies try to attempt PES in developing countries, particularly in Africa as a market based instruments, and remains inadequately tested in wetlands conservation. Frost and Bond (2008) explored some lesson learned from Zimbabwe's Communal Areas Management Programme for Indigenous Resources (CAMPFIRE), a community-based natural resource management programme in which Rural District Councils, on behalf of communities on communal land, are granted the authority to market access to wildlife in their district to safari operators. Jack (2009) developed and implemented an artefactual field experiment design to explore individual behaviour in PES like interactions in Nyanza province, Kenya. Turpie, Marais et al.(2008) gave attention to the role of water in improving biodiversity conservation through PES in South Africa to alleviate poverty and ecosystem service delivery. Fisher, Kulindwa et al (2010) discussed some of the key findings of the common pool resources (CPR) literature and how these related to key considerations for using PES as a management tool and attempt to look at the institutional issues of PES in East Africa, by taking Rufiji and Pangani basins as a case in Tanzania.

PES programmes have key challenges for their sustainability including lack of clearly defined property rights on land for both individual and communal tenure, lack of respect of the principles of volunteerism, and insufficient technical support and budgeting for local implementation costs, use of undifferentiated payments, and rural communities are poorly informed about the relationship between land use decisions and downstream water flows, or lack of information on how upstream investments might enhance downstream service provision. While PES initiated in Lake Naivasha watershed is at infant stage, mechanism to improve watershed service efficiency and participation of service providers, the programme livelihood outcomes and sensitivity of participants in this watershed service expected to share those key challenges. However, to our knowledge there is no study that tried to impute value to different attributes of the lake and the surrounding ecosystem in order to apply feasible PES scheme.

Cost-benefit analysis (CBA) is one technique derived from welfare economics for determining appropriate policy actions (such as project formulation) by aggregating costs and benefits into a single numerical measure. Techniques for environmental valuation based on CBA have been developed by environmental economists, such as a measurement of total economic value of resources. However, only measuring the total value of the environment may not be sufficient because those techniques not adequately consider the distribution of costs and benefits between different stakeholders. Equally importantly, they ignore the fact that different stakeholders are unlikely to perceive the same environmental problems, so they will seek different solutions and use differing criteria for assessing the desirability or worth of a given intervention (Grimble and Wellard 1997). The aim of stakeholder analysis are: first, to identify and categorize the stakeholders that may influence and perhaps transform an organization or a system, secondly, to develop an understanding of why change occur, followed by to establish who can make changes to happen, and finally to discern how to best manage, for instance, natural resources. Stakeholder analysis can be used to understand the environmental systems by defining the aspects of the system under study; identifying who has a stake and prioritizing stakeholders for involvement in decisions about those aspects of the system. However, the management of the area surrounding Lake Naivasha is a highly debatable issue and limited attempt tried to identify and analyse key stakeholders in management of the lake on their values, roles and activities (Billgren and Holmén 2008). Therefore, this study tries to assess the applicability of PES in Lake Naivasha watershed using stakeholder analysis.

Data source and Methods

As indicated in the research framework in **Figure 10**, the first step in valuation of environmental resource is to define the good to be valued and valuation method. By performing a literature review on valuation method and payment for environmental service (PES) threats, clearly defined research objective is identified. It will be followed by acquisition of primary and secondary data. Primary data will be collected from individual respondents through household survey and focus group discussion will be carried out with different community members. A series of in-depth interviews will be undertaken with key stakeholders, such as business sectors, appropriate governmental and non-governmental organizations representatives. These interviews and group discussions will provide for depth discussion with regard to the key research issues and will help to develop an ecosystem service attributes and their level. Secondary data will be collected from different bureaus, statistical, and other reports and publications. These include relevant environmental and socio-economic data that will support developing choice modelling scenario and better understanding of ecosystem services in the watershed. Data sources will be supported by of satellite imagery, field survey and investigation.

Based on scientific research conducted in the area, in consultation with ecologist, hydrologists, agricultural and environmental economist, and on the basis of existing studies; use and non-use values of environmental resources, PES and specific issues pertaining to Lake Naivasha watershed, and the levels of watershed management scenario attributes will be specified. Focus group discussion and pilot survey will be conducted to determine final scenario attributes and their level that are important for this watershed services. A brief summary of the pre-survey finding summarized, these include findings from focus group discussion and pilot survey. The major findings and how they affected the final questionnaire designed will be assessed. Finally, a main survey will be conducted on selected representative sample households from the target population through appropriate sampling technique.

Respondents in downstream area will be informed about the available land use management practices in upstream parts of the watershed. The initiated plan for PES and scenario developed to implement the program; how the upstream land allocates for conservation activities and its importance for downstream water quality and availability and ecosystem services and the feasibility of PES will be clearly presented. Respondents also clearly well informed about payment vehicle and sustainability of the program and also the payment flow that depend on the extent of environmental improvements. The program aimed to achieve in upstream land use and thereby positive environmental externalities to downstream ecosystem service users. Respondents will then have a choice set showing of various options of watershed services management scenario and payment vehicles. Hence, downstream people will be asked for their preferred choice from a set of alternatives to estimate their willingness to pay for different ecosystem service attributes and to determine watershed management scenario that maximizes people welfare.

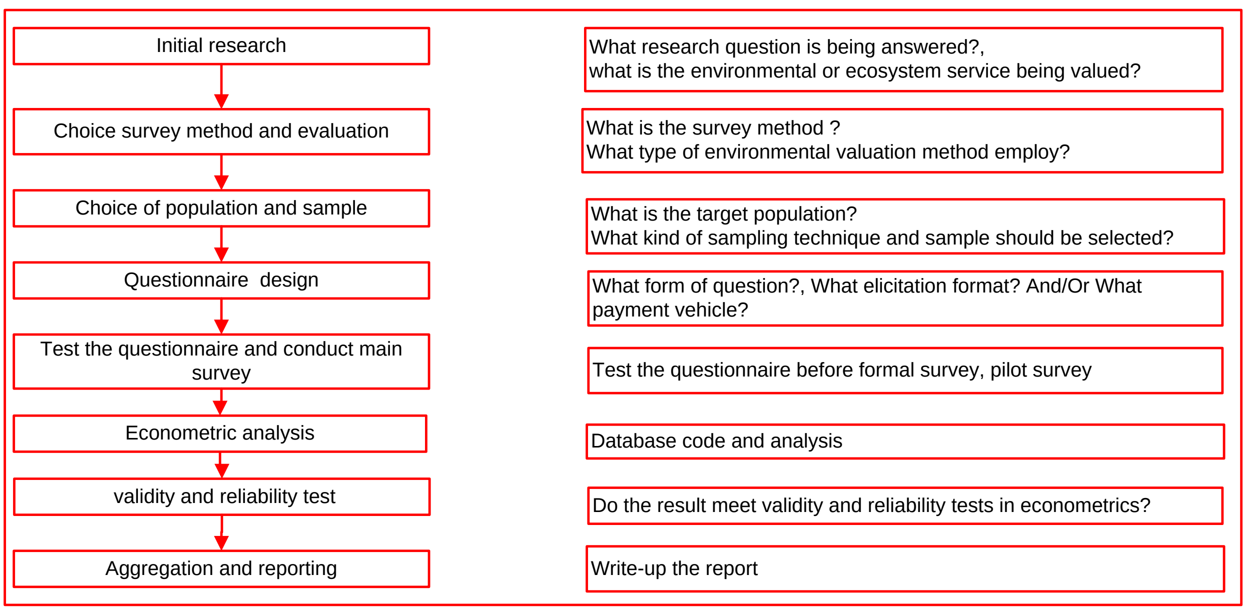

Figure 10: A typical stated preference (SP) study approach (Bateman et al. 2002)

Accordingly, the study applies the same data collection and methodological approach to estimate upstream people's willingness to accept (WTA) compensation for their environmental service provision. Environmental service provider's value and their preference over various land management option and environmental management practices expressed by different land management practices and reward schemes. Therefore, through discussion with community, stakeholders and in consultation with experts the upstream land management scenario attributes and their levels will be defined and data will be collected from selected representative sample upstream households through appropriate sampling techniques. The collected data will be analysed using econometric analysis of choice experiment modelling. STATA and LIMDEP statistical program will be used for statistical analysis.

Choice Experiment Method

The Choice Experiment (CE) method has its theoretical grounding in Lancaster's model of consumer choice (Lancaster 1966), and its econometric basis is Random utility model (RUT). Lancaster proposed that consumers derive satisfaction not from the goods themselves but from the attributes they provide. The CE method is a highly structured method of data generation(Hanley et al. 1998), relying on carefully designed experiment or tasks to reveal the factors that influence choice. As discussed above in detail about theory and methods of environmental valuation, there are pros and cons on consumer choice theory and environmental valuation studies (Hanley et al. 2001; Vatn 2004; Hanley and Shogren 2005; Nick Hanley et al. 2007). Dealing with those concepts is vital to develop a choice scenario that incorporates the social sphere shaping preference construction and information problems, and to include the potential environmental attributes and their level in the choice set. Environmental resource is defined in terms of its attributes and their level in different state of the world. One attribute is monetary one, which enables estimation of the value of the other attributes in terms of respondents' willingness to pay (Hanley et al. 2001; Birol et al. 2006). The random utility theory (RUT) is the theoretical bases for integrating behaviour with economic valuation in CE method which describes discrete choices in a utility maximization framework(Wang et al. 2007). Under RUT it is assumed that the Utility function U_i is assumed to be comprised of two parts:

$$U_i = V_i + \varepsilon_i \text{...} 1$$

Where V_i is the systematic and observable component of the latent utility for option i; and ε_i is the random or "unexplained" component. Because of the random component, the researcher can never expect to predict choices perfectly. Let an individual will choose alternative i if $U_i > U_k > \mathbf{U_k}$ for all k≠i. This leads to the expression for the probability of choice:

$$P_i = P(V_i + \varepsilon_i) > (V_k + \varepsilon_k); \forall k \in C \text{...} 2$$

For all available k option, where C is a complete choice set that includes all possible alternatives.
Therefore, consumers derive satisfaction not from goods themselves but from the attributes they provide and respondent assumed to have a utility function of the form:

$$U_{ij} = V(Z_j, S_i) + \varepsilon_{i.} \qquad \text{.........3}$$

Where for any respondent i, a given level of utility will be associated with any watershed management scenario alternative j. Utility derived from any of the watershed management scenario alternatives depends on the attributes Z_j of the watershed management scenario and the social, economic and attitudinal characteristics of the respondent S_i.

Different assumptions of the distribution of the random error term yield different models. And following the theoretical grounding in Lancaster's model of consumer's choice, the respondent utility function can be expanded to the following form:

$$U_{ij} = V(Z_j, S_i) + \varepsilon(Z_j, S_i) \qquad \text{.........4}$$

Choices made between alternatives are a function of the probability that utility associated with particular option j is higher than those other alternatives. Assuming that the relationship between utility and attributes is linear in the parameters and variable functions, and the random error term is distributed independently and identically (IID) with Weibull distribution, the probability of any particular alternative j being chosen can be expressed in terms of logistic distribution. Equation **4** can be estimated using conditional logit model (Birol et al. 2006), which takes the general form:

$$P_{ij} = \frac{\exp(V(Z_{ij}, S_i))}{\sum_{h \in C} \exp(V(Z_{ih}, S_i))} \qquad \text{.........5}$$

Where h is one of the possible watershed management alternatives in choice set C, which include all possible alternatives and the conditional indirect utility function generally estimated is:

$$V_{ij} = \beta + \beta_1 Z_1 + \beta_2 Z_2 + ... + \beta_n Z_n + \delta_1 S_1 + \delta_2 S_2 + ... + \delta_m S_m \qquad \text{.........6}$$

Where β is the alternative specific constant (ASC) which captures the effect on utility of any attributes not included in choice specific attributes. The number of watershed management scenario attributes considered is n and the number of social, economic and attitudinal characteristics of the respondent employed to explain the choice of watershed management scenario is m**.** The vectors of coefficients $\beta_1 to \beta_n$ and $\delta_1 to \delta_m$ are attached to the vector of attributes Z and the vector of interaction terms S that influence utility, respectively. Since social, economic and attitudinal characteristics are constant across choice occasions for any given respondent, they only enter as interaction terms with watershed management scenario attributes. The assumption in conditional logit model follows independence of irrelevant alternatives (IIA), which states that the probability of a particular alternative being chosen is independent of other alternatives. If IIA property of error term is violated then the conditional logit model results will be biased and hence a discrete choice model that does not require the IIA property, will apply, such as random parameter logit (RPL) model, should be used.

Inclusion of social, economic and attitudinal characteristics is also beneficial in avoiding IIA violations, since they are relevant to preferences of the respondents and can increase the deterministic component of utility while decreasing the error term (Bateman et al. 2002). Therefore, the use of social, economic and attitudinal characteristics helps to recognize conditional, observed heterogeneity, this method do not defect for unobserved heterogeneity. Unobserved heterogeneity in preferences across respondents can be accounted for in the RPL model. The random utility function of in the RPL model is given by:

$$U_{ij} = \left(V\left(Z_j\left(\beta + \tau_i\right)\right), S_i\right) + \varepsilon\left(Z_i, S_i\right) \qquad 7$$

Similarly to conditional logit model, utility is decomposed into a deterministic component V and an error term. Indirect utility is assumed to be a function of the choice attributes Z_j with parameters, which due to preference heterogeneity may vary across respondents by random component τ_i and of the social, economic and attitudinal characteristics S_i if included in the model. By accounting for unobserved heterogeneity, since the model is not restricted by the IIA assumption, the stochastic part of the utility may be correlated among alternatives and across the sequence of choices via the common influence of τ_i. Then equation **(5)** now becames:

$$P_{ij} = \frac{\exp\left(V\left(Z_j\left(\beta + \tau_i\right), S_i\right)\right)}{\sum_{h \varepsilon C} \exp\left(V\left(Z_h\left(\beta + \tau_i\right), S_i\right)\right)} \qquad 8$$

Even if unobserved heterogeneity can be accounted for the Random parametric logit (RPL) model, the model fails to explain the source of heterogeneity. One solution to detecting the sources of heterogeneity while accounting for unobserved heterogeneity is by including respondent characteristics in the utility function as interaction terms. This enables the RPL model to pick up preference variation in terms of both unconditional taste heterogeneity (random heterogeneity) and individual characteristics (conditional heterogeneity) and hence improve model fit (Train 1998). The conditional logit (CL) and Random parametric logit (RPL) model can be estimated by conventional maximum likelihood. Once the parameter estimates have been obtained, a willingness to pay (WTP) welfare measure for policy change that impact on the environmental good which confirms demand theory can be derived(Bateman et al. 2002). Let V^0 represent the utility of initial state and V^1 represent the utility of alternative state. The coefficient β_y gives the marginal utility of income and is the coefficient of the cost attribute:

$$WTP = \beta_y^{-1} \ln \frac{\sum_i \exp\left(V_i^1\right)}{\sum_i \exp\left(V_i^0\right)} \qquad 9$$

It is then straightforward to show that for the linear utility index the above formula can be simplified to the ratio of coefficients given by:

$$WTP = -1\left(\frac{\beta_c}{\beta_y}\right) \quad \text{.........} \quad 10$$

Where β_C is the coefficient on any of the attributes; these ratios are often known as implicit prices and show WTP for a change in any of the attributes. The implicit prices are useful in that they demonstrate the trade-off between individual attributes. They allow an analysis of the composition of potential alternative allocations of resources. A comparison of the implicit prices of attributes affords some understanding of the relative importance that respondents hold for them. On the basis of such comparisons, policy makers are in a better position to design resource use alternatives so as to favour those attributes which have higher (relative) implicit prices. Compensating surplus (CS) welfare measures can be obtained for different watershed management scenarios associated with multiple changes in attributes, it means that equation **10** simplifies to:

$$CS = \frac{-\left(V^0 - V^1\right)}{\beta_y} \quad \text{.........} \quad 11$$

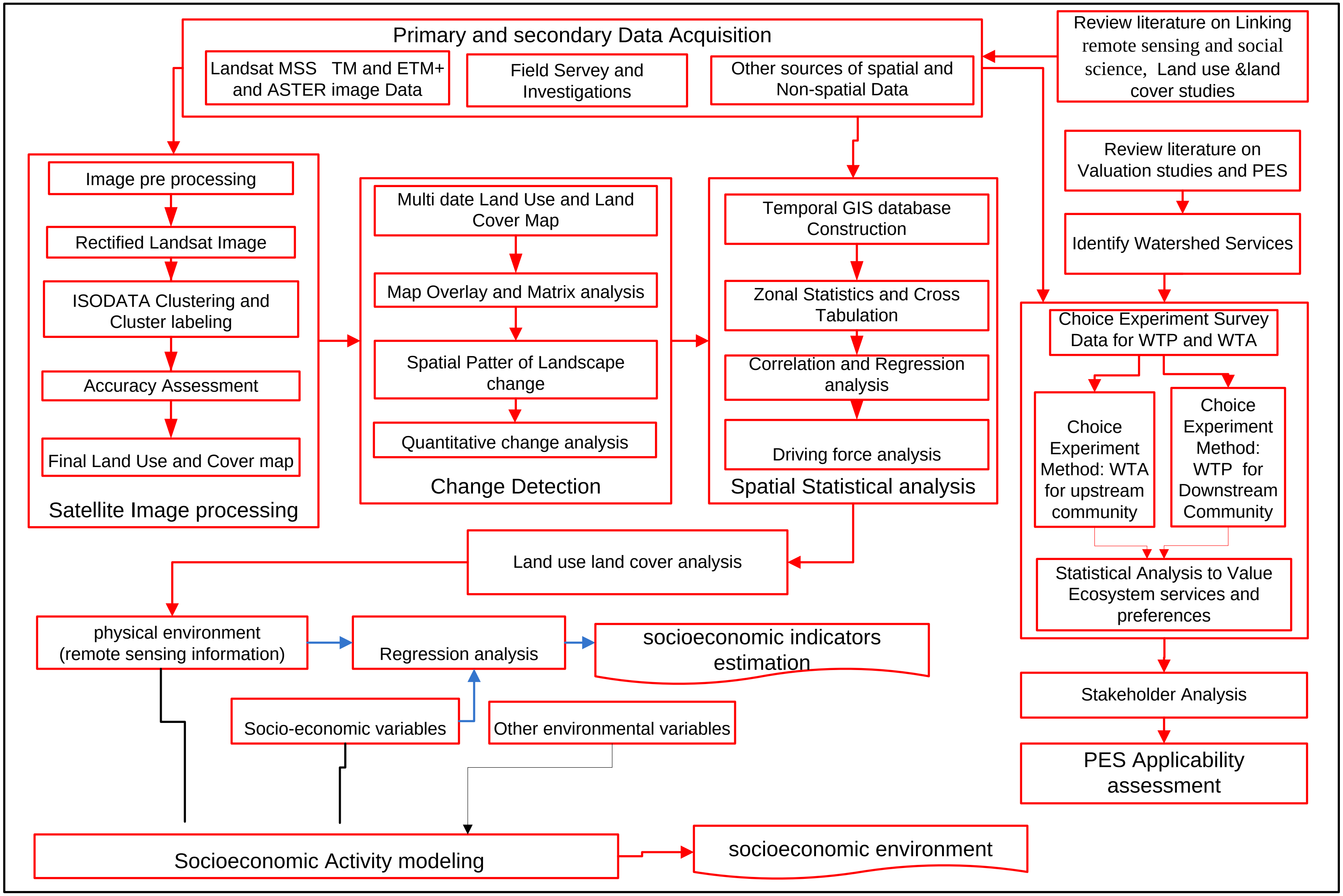

Figure 11: Summary of Proposed Methodological Framework

1.8 Main Data Requirements Summary

The types of data that will be collected and constructed in this research are the following:

- Landsat MSS, TM, ETM+ and avail ASTER satellite images for land use and land cover analysis and to extract time series remote sensed data.
- Socioeconomic and environmental data will be collected from Kenya National Bureau of Statistics (KNBS) and other relevant Bureaus to establish a time series and panel data for socioeconomic indicators estimation and modeling.
- Statistical data, reports and indicators on Kenyan forest, land, water, lakes and other natural resources will be collected from different level governmental and nongovernmental organizations.
- By employing focus group discussion and participatory rural appraisal (PRA) method with the community and apply well structured in depth interview with stakeholders to collect a comprehensive qualitative and quantitative data. These include various aspects in relation to natural resource, environmental degradations, societal, economical and biophysical factors of land use and land cover changes, and economic activities and challenges.
- Structured questionnaire will be prepared for household level survey to collect data for environmental valuation and PES. The household survey focus is on resource endowment, economic activity, wealth, demographic variables, their livelihood strategies, and perception towards ecosystem services. Willingness to pay and willingness to accept survey will be undertaken in upstream and downstream communities, respectively.

1.9 Expected Research Output

The expected output of this study is a research documents that link the economy to the environment using remote sensing technology and PES. Depending on initial findings of this study; discussions with communities, policy makers, and concerned institutions and stakeholders will assist their focus on the ongoing debates in natural resources use to meet sustainable development and indicates the applicability of PES programme in Naivasha watershed. It is also possible to come up with recommendations on approaches to link remote sensed data in socioeconomic field of studies. Thus, the paper will contribute on the following major research outputs:

- Indicate how timely and accurate socioeconomic indicators estimate obtained with the support of remote sensing technologies in developing countries.
- Enhance better understanding and modeling of socioeconomic activities through integration of remote sensing information and socioeconomic data.

- The study findings may point out the major socioeconomic driving forces of land use and land cover changes.

- Estimate downstream community's willingness to pay (WTP) for ecosystem services and, value the upstream community's willingness to accept (WTA) compensation for their land use practice to provide environmental services in Lake Naivasha watershed.

- Indicate the applicability of Payment for environmental (ecosystem) services schemes for sustainable natural resource management and its impact on people's livelihood.

- Provide useful information for policy makers concerning decisions both to improve ecosystem service and people livelihood in Lake Naivasha and its surroundings.

Those papers are supposed to be published on the following journals:

Journal of Remote Sensing
Urban Studies
Population and environment
Environmental Conservation
Ecological Economics
Ecology and Society
Global Environmental change
African Development

1.10 Motivation for Research

Understanding and controlling human impacts on biophysical environment, as well as anticipating and responding to environmental impacts on human activity requires a better collaboration between remote sensing specialists and social scientists that has been necessitated by a new and important set of intellectual and practical problems. Environmental quality has been a major concern of citizens and policy makers for over quarter-century, and there is a compelling need to understand human-environment interactions. Such understanding depends on better knowledge of biophysical systems, of human activity, and above all, of the relations between the two. Linking remote sensing and social science is a necessary part of developing this knowledge (Liverman et al. 1998). Therefore, this study attempts to integrate remote sensing information, socioeconomic and other environmental data to estimate socioeconomic indicators and model socioeconomic activities and also to assess the impact of socioeconomic activities on land use and land cover changes in Lake Navaisha watershed.

Wetlands have several functions. Besides the benefits to the local population living in the periphery they also provide benefits to communities outside wetland areas. The protection of wetlands reflects the protection of numerous goods and services. The economic value of these goods and services can be made more explicit through economic valuation studies. Numerous economic valuation studies of wetlands around the world have been carried out; however, most of these studies have focused on wetlands in developed countries. On those studies carried out for developing countries, African wetlands are clearly underrepresented. At the same time, African wetlands are facing serious threats, and the importance of their protection for the survival of local people is increasingly recognized (Schuyt 2005). Thus, valuation of different attributes of Lake Naivasha watershed ecosystem services and people preference for compensation to provide environmental services are vital to support the formulation and implementation of environmental service management plans in order to protect or conserve wetland areas.

Currently, there is a growing concern to conserve degraded natural resource, to meet sustainable development and poverty reduction. Payment for environmental services (PES) is a recent policy innovation that is attracting much attention in both developed and developing countries. PES enables the notion of rewarding the providers of environmental services, which until now have supplied services for free and it is a promising innovation in conservation programmes (Wunder and Wertz-Kanounnikoff 2009). However, the implication of PES on rural poor people, the different approaches to facilitate the implementation and applicability of PES schemes in different community settings and institutional arrangements are still not clear, thus, this study attempts to fill this gap.

1.11 Study Area

Lake Naivasha ($0^o45'S$, $36^o26'E$; altitude 1890 meters) lies on the floor of Africa's Eastern Rift Valley and, at approximately 160 km^2, forms the second-largest freshwater lake in Kenya. It is one of a series of 23 major lakes in the East Rift Valley – eight in central Ethiopia, a further eight in Kenya and seven in Tanzania – spanning latitudes from approximately 7^oN to 5^oS. Naivasha is suited 80km Northwest from Nairobi and the lake basin covers an area of approximately 3400 km2. Water inflow to the lake came from three rivers: Gilgel, Malawa and Kariti rivers. The lake has no surface outlet and, consequently, the natural lake level fluctuation is very high (Everard et al. 2002). Lake Naivasha is a highly significant national freshwater resource in an otherwise water deficit area. Apart from the invaluable freshwater it also supports large and vitally important economic activities mainly flower growing and geothermal power generation. The area is thus a major contributor to Kenya's GDP, for employment opportunities and socioeconomic development of the country as a whole. Lake Naivasha is also a Ramsar site being a wetland of international importance with a rich biodiversity, including some endangered species, and supports tourism and research activities.

Naivasha is unique because of its high population density and agricultural intensity and the catchment is the home for diverse flora and fauna, wildlife and bird's habitat that contribute for tourist destination and registered as international Ramsar site for wise use the wetland through local and national action and international cooperation to achieve sustainable development. However, with the growth of population and economic activities, the land use in Naivasha has changed drastically and the areas of land use in the whole basin have not yet been estimated. The local community is diverse of several different groups; the area is traditional Massai land, the Massaii people still depend on the lake for watering and grazing their cattle. However, currently around the lake the land is owned by white Kenyans(Becht et al. 2005). The Lake Naivasha basin covers two districts, Nyandarua and Nakuru. Activities of many Government Ministries are decentralized to the district level, thereby complicating an integrated catchment approach. Development plans are written for districts (District Development Plans), but these districts cross-cut the basin boundaries.

Tourism is one of the most important industries in Kenya and Naivasha is part of this industry as a well known tourist destination, although not a major one. There are two small national parks (Hells Gate and Longonot) in the vicinity of the lake and nearby Aberdare National Park. The area's beauty, the extent of the bird and wildlife, its proximity to Nairobi, and the many hotels, home stays and campsites at all budgetary levels, attract many visitors, both local and overseas and it is an easy "stop-over" place for many tourists travelling in Kenya. Moreover, there is a geothermal power plant suited south of the lake and currently producing 575 KW of power (ibid).

According to Hydrology for the Environment, Life and Policy (HELP)[4] report, the human population of the town of Naivasha and the lake hinterland has increased ten-fold over the past three decades as employment opportunities have become available in the very labour-intensive horticultural industry; from 7,000 in 1969 to 35,500 in 1989 and 67,000 in 2002. The industry employs about 25,000 labourers. Many of these live close to their work with their families on the southern side of the lake; three unplanned settlements have grown along this shoreline, and together with two major villages on horticultural farms which house their staff and the housing compound of geothermal power employees and associated company staff; there are six distinct, new, settlements that have grown in the past two decades. The number of inhabitants is not recorded in them, but it is at least 50,000 people in total; there are no waste treatment facilities beyond pit latrines and no piped water supply to the overwhelming majority of those.

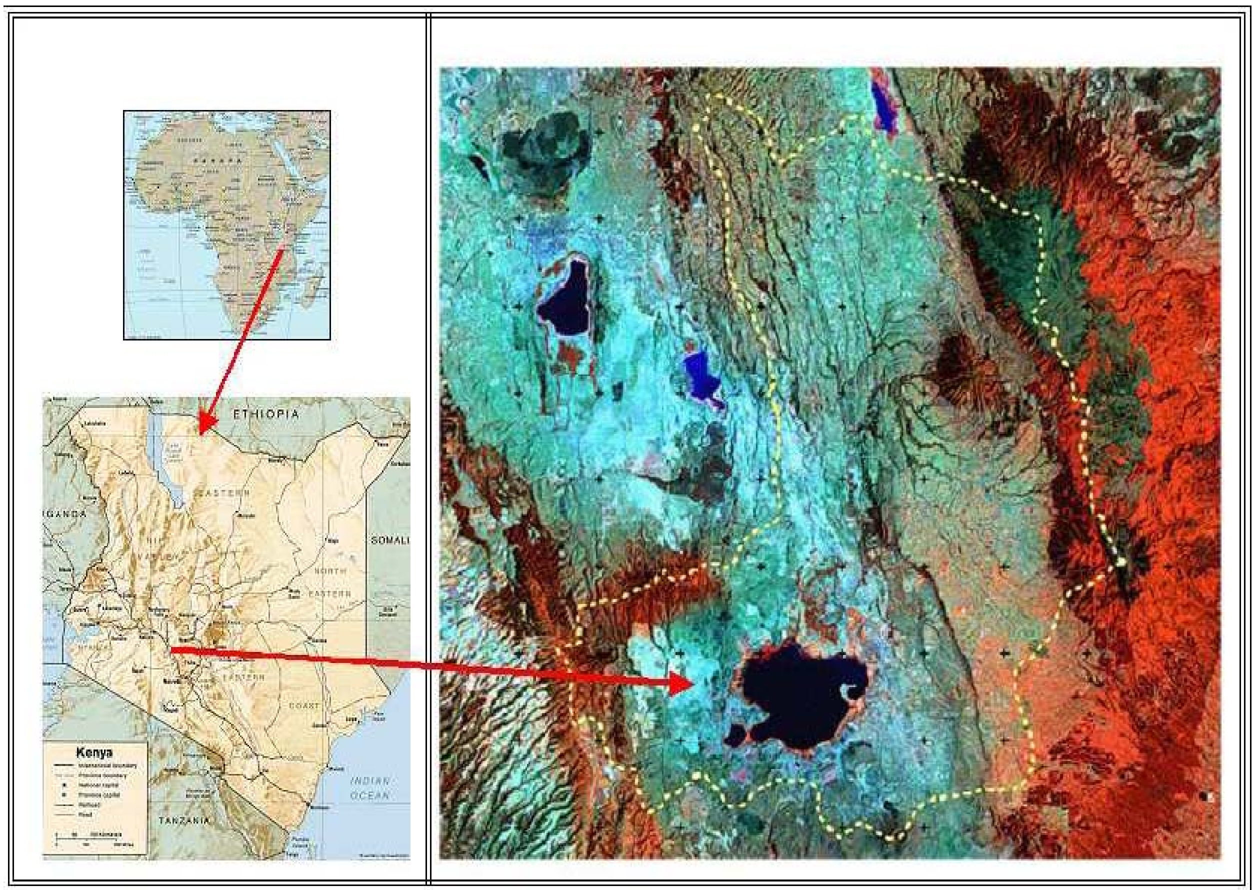

Figure 12: Lake Naivasha Watershed

Source: ITC Lake Naivasha database Image processing Laboratory (IPL) of ITC, Sept 1998.

4 http://helpforum.ning.com/group/afrnav

1.12 Proposed Research Process Summary

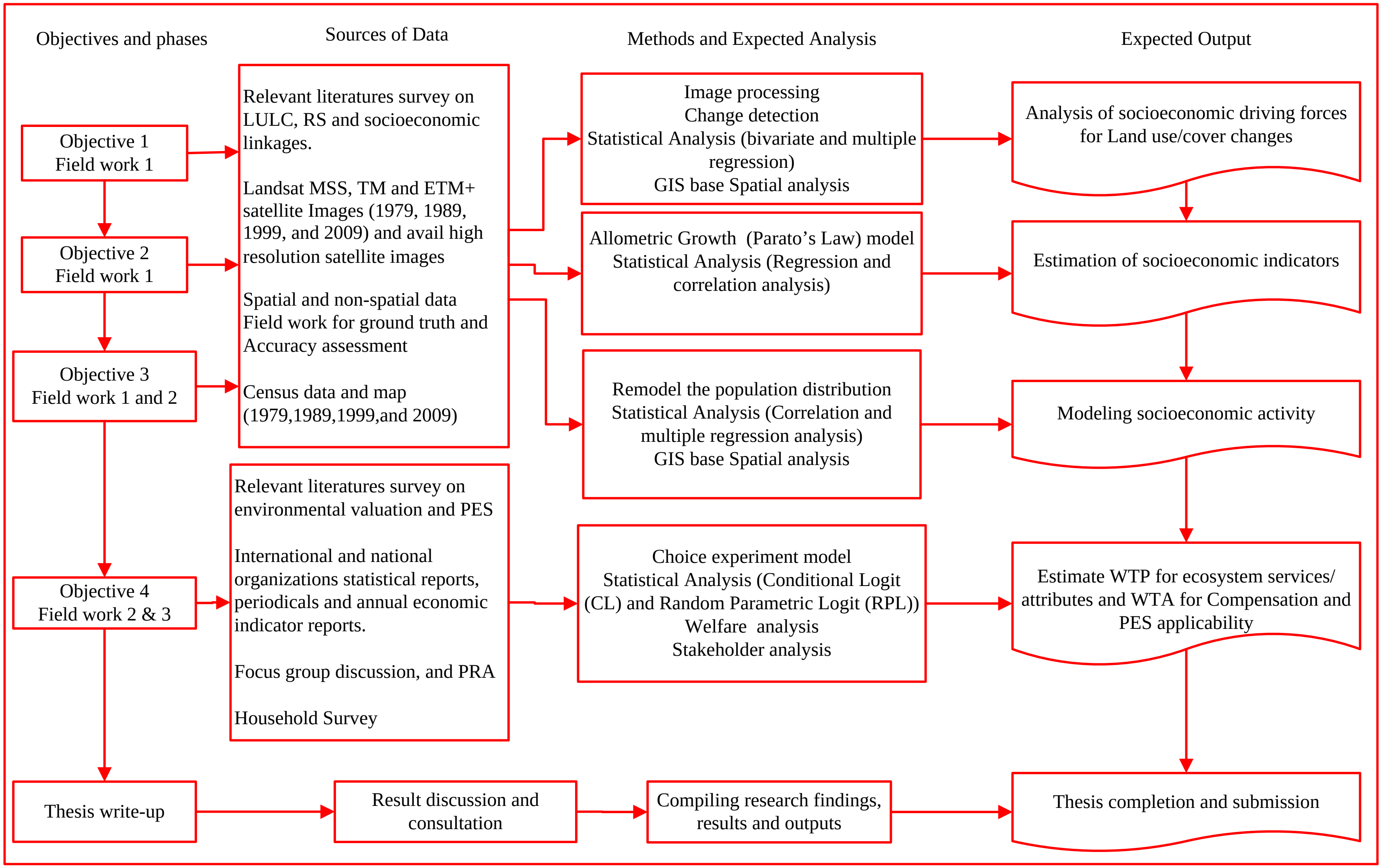

Figure 13: Proposed Research Process Summary

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Annex 1

Table 1: Tentative schedule or proposed work plan for PhD in Socioeconomics in EOIA project

No	Activities	2010				2011				2012				2013				2014		
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	J	F	M
1	PhD Proposal Preparation and Qualifier		■	■																
2	First round field work (Field work 1) EO, socioeconomic, other environmental and secondary data Collection				■	■														
3	Advance Course on RS and GIS • Remote sensing and Image processing						■													
4	Data analysis and first two objectives paper write-up						■	■	■											
5	Advanced Course on environmental valuation techniques and econometrics • Resource economics • Environmental Valuation • Choice Modelling									■										
6	Second round field work (Field work 2) data collection for PES and household survey										■	■	■							
7	Present findings of the first two papers, sending papers for comments and editing's, and for journals											■								
8	Data analysis and third objective paper write-up											■	■							
9	Data Analysis and final objective papers write-up												■	■	■	■				
10	Present findings of the 3rd and 4th objective paper, sending papers for comments and editing's, and as well for journals and final field work (Field work 3)														■	■	■			
11	Incorporate comments and suggestions																■	■		
12	Thesis Finalization																■	■	■	■